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Liverpool Bay Sanitary Survey

Review

September 2013

Food
Standards
Agency

Cover photo: Low tide at Holylake on the North Wirral shore

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STATEMENT OF USE: Under EC Regulation 854/2004 which lays down specific rules for official controls on products of animal origin intended for human consumption a sanitary survey relevant to bivalve mollusc beds in Liverpool Bay was undertaken in 2011. This provided an appropriate hygiene classification zoning and monitoring plan based on the best available information with detailed supporting evidence. The FSA is committed to reviewing sanitary surveys every six years or sooner if significant changes in pollution sources or the fishery have occurred that may require revision of the sampling plan. This report provides a review of information and recommendations for a revised sampling plan following an application for classification of subtidal clam species north of Hoyle Bank in 2012. The Centre for Environment, Fisheries & Aquaculture Science (Cefas) undertook this work on behalf of the Food Standards Agency (FSA).

CONSULTATION:

Consultee	Date of consultation	Date of response
Environment Agency	09/07/2013	06/08/2013
North West IFCA	01/10/2013	01/10/2013
Mersey Port Health Authority	09/07/2013	07/08/13
United Utilities Plc	24/07/2013	None

RECOMMENDED BIBLIOGRAPHIC REFERENCE: Cefas, 2013. Review of the Liverpool Bay 2011 Sanitary Survey. 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 EC Regulation No. 854/2004.

Contents

1. Introduction

1.1. Background

The Centre for Environment, Fisheries & Aquaculture Science (Cefas) is performing sanitary surveys for new bivalve mollusc production areas (BMPAs) in England and Wales, on behalf of the Food Standards Agency (FSA). The purposes of the sanitary surveys are to demonstrate compliance with the requirements stated in Annex II (Chapter II paragraph 6) of EC Regulation 854/2004, whereby 'if the competent authority decides in principle to classify a production or relay area it must:

(a) make an inventory of the sources of pollution of human or animal origin likely to be a source of contamination for the production areas;
(b) examine the quantities of organic pollutants which are released during the different periods of the year, according to the seasonal variations of both human and animal populations in the catchment area, rainfall readings, waste-water treatment, etc.;
(c) determine the characteristics of the circulation of pollutants by virtue of current patterns, bathymetry and the tidal regime in the production area; and
(d) establish a sampling programme of bivalve molluscs in the production area which is based on the examination of established data, and with a number of samples, a geographical distribution of the sampling points and a sampling frequency which must ensure that the results of the analysis are as representative as possible for the area considered.'

In line with the EURL Good Practice Guide Cefas is contracted to undertake reviews of sanitary surveys on behalf of the Food Standards Agency. Reviews are to be undertaken six yearly intervals after the original sanitary survey or sooner and where there are changes to the type and locations of the shellfisheries or significant changes in sources of pollution.

1.2. Liverpool Bay Review

This reviews information and makes recommendations for a new classification zone and sampling plan for sub-tidal clams as well as for that for re-classification of cockles based on their current stock distribution. This follows an application for classification of subtidal clam species north of Hoyle Bank in 2012

This review identifies changes to the information presented in the sanitary survey through a brief desk based study and to update the assessment and sampling plan if necessary, as well as providing new information relevant to new classification zones where necessary.

Specifically, the review will consider:

(a) changes to the shellfishery
(b) changes in microbiological monitoring results
(c) changes in sources of pollution impacting the production area or new evidence relating to the actual or potential impact of sources
(d) changes in land use in the area
(e) change in environmental conditions

Figure 1.1: Location of Liverpool Bay.

2. Shellfisheries

Currently, no cockle beds are classified in Liverpool Bay. The beds at Dove Point New Brighton and Leasowe are shown in Figure 2.1 are temporarily de-classified due to low levels of stock in the area.

Due to low stock densities, at present all cockle beds are subject to managed closures put in place by the North West Inshore Fisheries and Conservation Authority (NW-IFCA). The length of these closures is as yet unknown and will continue until stocks have reached a sufficient density to allow commercial exploitation (at least 20 m^{-2}). It will not be known when the beds will reopen until this year's spat fall has had a chance to become established, but it is unlikely to be before the beginning of 2014 at the earliest. The commercial harvesting of cockles is undertaken by hand in the intertidal region.

A classification for mussels existed in the area until 2010, but the area was declassified due to low stock numbers. Stocks for mussels are not expected to rise to viable levels for the foreseeable future.

Extensive clam beds are present in this area and intertidal razor clams are commonly harvested by hand. However, these beds are not commercially viable, with population densities of less than 10 m^{-2} (NW-IFCA, Pers. Comm.). An application for classification of subtidal clams [including *Spisula solida* (Thick trough shells), *Tapes decussates* (Palourdes), *Lutraria lutraria* (Common otter shell), *Ensis spp.* (Razor shells) and *Pharus legumen* (Bean solen)] north-west of the Wirral (Figure 2.1) was made in April 2012 and an interim RMP assessment was carried out by Cefas. No samples have been taken since this assessment to date and so the clam beds remain unclassified at present. The technique proposed by the applicant to be used to commercially harvest species of clams other than razor clams is by dredge. Dredging in this area is prohibited by North West IFCA on conservation and sustainability grounds. However a byelaw 1 derogation may be issued at some point in the future to allow dredging to take place as part of scientific studies on gear design and impacts, in which case a limited amount of commercial harvesting may be permitted to offset the cost of the study (NW-IFCA, pers. com.).

The applicant has requested that the razors be commercially harvested by an electrofishing technique. There are few areas classified for this species within England and Wales and first sale prices are from £2-4 per kg (Gray, 2008). Electrofishing in any form, within the marine environment, is banned at present under EC 850/98, Article 31 (EC, 1998). Electrofishing is the technique whereby electrodes are towed slowly across the seabed, this induces the razors to leave their burrows. Towed behind the electrode array is a dredge/collection box which subsequently collects razors from the surface of the substrate. This technique has been developed to minimise damage to both razors and to surrounding fauna and flora, a study undertaken by Woolmer and colleagues (2011) concluded that the technique does not appear to cause serious negative impacts to the benthic communities. Towed gear such as this will need to be operated on clean sandy areas only if and when approval is granted for this fishing technique within the proposed area. Currently the IFCA Committee requires further information on the fishing technique and its impact and is awaiting the results of Fisheries Science Partnership (FSP) project running between July 2013 and April 2014. This aims to assess the potential for the development of a sustainable razor clam (*Ensis*) fishery in the eastern Irish sea employing electro-fishing equipment, building on gear developments by BIM in Ireland. This project will in turn inform further scientific studies.

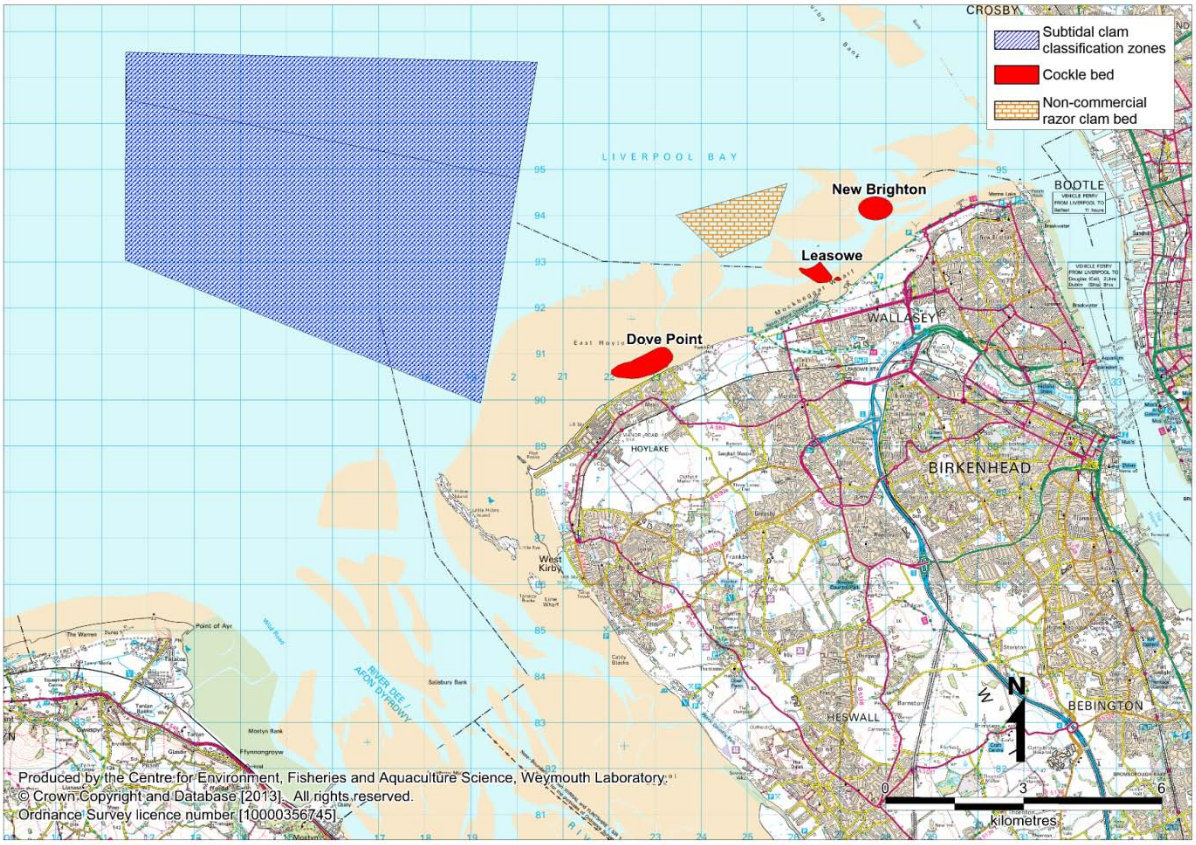

Figure 2.1: Location of shellfish beds and classification zone in Liverpool Bay

It should be noted that in addition to the area for which classification has been requested shown in Figure 2.1, the wider Liverpool Bay area may contain clam stocks that could also be exploited during scientific surveys or in the future as a commercial fishery.

3. Overall Assessment

Since the sanitary survey of Liverpool Bay was written in 2011, the shellfish beds which are exploited commercially have changed to the extent that no cockle or mussel beds are currently classified (September 2013). However, an application for classification of a sub-tidal clam bed has been made.

The overall population in the combined Mersey and Dee catchments has increased by approximately 0.12%. There have been some alterations to continuous discharges within the catchment which have likely increased the output of faecal contamination to the area via the Dee estuary. In addition, information on the number of intermittent discharges on the north Wirral coast has improved since the sanitary survey was written. As no spill data were available for these discharges, it was not possible to determine what effect they have had on the level of contamination to the area. Samples from the shoreline survey suggest that the levels of faecal contamination discharging directly from the north Wirral to the cockle beds is negligible, compared with the levels which are likely to have originated in the Mersey and Dee estuaries, and so monitoring should focus on these sources for cockles. Additionally, the long sea outfall for the North Wirral wastewater treatment works will likely have the most significant impact on the north-eastern end of the new clam zone.

No changes in agricultural practices have been reported, but numbers of over wintering migratory water birds have risen by approximately 6.5% since the sanitary survey. While this change may increase the overall level of contamination to shellfish in the area, due to the wide distribution of the birds it will not affect the positioning of the monitoring points.

No significant changes in rainfall patterns have occurred since the sanitary survey.

Similarly no significant changes in trends in levels of *E. coli* found in shellfish have occurred since the sanitary survey.

No major changes to sources of contamination have occurred since the sanitary survey that would require changes in monitoring points for shellfish hygiene at currently classified beds.

4. Sampling Plan

4.1. Recommendations

Clams

The following two zones are proposed for clams. Each zone has one Representative Monitoring Point (RMP) located to best capture peak levels of contamination within it, taking into account current stock distribution (Figure 4.2).

Newcome Knoll clam zone. This zone is sub tidal, it is located north west of the North Wirral Peninsular and north of the East Hoyle clam zone. This zone will be subjected to ebb flows from the south east, on spring tides tidal flows may originate from the Mersey estuary. The main source of contamination within this zone is likely to be from North Wirral outfall situated 1.6Km east of the zone, on an ebb tide. It is therefore recommended that the RMP be set as close as possible to (and within the ebb Plume of) the North Wirral outfall which lies on the eastern end of the zone (SJ 2010 9610) so would also be effective in capturing contamination from the Mersey estuary on spring ebb tides.

The species sampled should be the species for which classification is required, apart from in the case of razors, where any *Ensis* spp. can be sampled. A tolerance of 100m should be set around the RMPs to allow for repeated sampling, once suitable locations have been confirmed. Sampled stock should be of a market size and collected using the commercial harvesting technique. Sampling should be on a monthly basis for full classification. If classification is required more rapidly, 10 samples taken at least 1 week apart would be needed before a provisional classification can be awarded. Monthly sampling will be required thereafter to maintain this classification.

East Hoyle clam zone. This zone is sub tidal and is located north west of the North Wirral Peninsular and south of the Newcome Knoll clam zone. This zone will be subjected to ebb flows from the south, in particular the ebb plume from the Hilbre channel in the Dee estuary. Consequently the main source of contamination within this area is likely to be from the ebb plume originating from the Dee Channel
It is therefore recommended that the RMP be set as close as possible to (and within the ebb plume of) the Dee estuary (SJ 1790 9080).

The species sampled should be the species for which classification is required, apart from in the case of razors, where any *Ensis* spp. can be sampled. A tolerance of 100m should be set around the RMPs to allow for repeated sampling, once suitable locations have been confirmed. Sampled stock should be of a market size and collected using the commercial harvesting technique. In certain circumstances a sampling technique which differs from the commercial harvesting technique may be approved by the local authority on discussion with Cefas. Sampling should be on a monthly basis for full classification. If classification is required more rapidly, 10 samples taken at least 1 week apart would be needed before a provisional classification can be awarded. Monthly sampling will be required thereafter to maintain this classification.

Cockles

Both cockle zones described below are presently not commercially viable. The Leasowe and New Brighton cockle zone is temporarily declassified due to a lack of commercial activity, Hoylake cockle zone was also temporarily declassified recently to allow stocks to recover. The following recommendations apply to when the cockle beds become commercially viable and need to be reclassified.

As determined in the 2011 sanitary survey it is desirable that the entire intertidal area from Hoylake to New Brighton is classified for cockles to allow exploitation as new patches appear or are discovered without continual revision of the classification zones and sampling plans. This intertidal area was divided into two zones in 2011 this was to take into account the two largest sources of contamination to the intertidal area, the ebb plumes from the Dee estuary to the west and the Mersey estuary to the east (Figure 1.1).

<u>Hoylake cockle zone.</u> This zone is temporarily declassified because the bed is not commercially active and a reduced rate of monitoring has been agreed with the Local Authority. The RMP should remain in the same location, close to the western boundary to best capture contamination associated with the ebb plume from the Dee estuary (SJ 2205 9056). This zone extends from Hoylake to the breakwater at Parkfields. Sampled stock should be of a market size and collected using the commercial harvesting technique. If any party other than the LEA is taking the samples, the LEA should consult with the FSA to ensure that sample collection is adequately controlled and supervised. The location of the RMP may be moved at any time by NW IFCA or Mersey PHA on the basis of intelligence and stock surveys, but should always be at the closest possible point to the western boundary.

<u>Leasowe and New Brighton cockle zone</u>. This zone is not currently classified and a reduced rate of monitoring has been agreed with the Local Authority. If reclassification is required, the RMP should remain in the same location close to the eastern boundary, to best capture contamination associated with the ebb plume from the Mersey estuary (SJ 2953 9425). This zone extends from the eastern side of the breakwater at Parkfields to the second pier at New Brighton. Sampled stock should be of a market size and collected using the commercial harvesting technique. Since the 2011 recommendations the RMP has been relocated closer to shore, so as to follow the natural movements of the cockle beds. If any party other than the LEA is taking the samples, the LEA should consult with the FSA to ensure that sample collection is adequately controlled and supervised. The location of the RMP may be moved at any time by NW IFCA or Mersey PHA on the basis of intelligence and stock surveys, but should always be at the closest possible point to the eastern boundary.

4.2. General Information

Location Reference

Production Area	Liverpool Bay - Wirral
Cefas Main Site Reference	M058
Cefas Area Reference	Leasowe to New Brighton cockles, Hoylake cockles, Newcome Knoll clams, East Hoyle clams
Ordnance survey 1:25,000 map	OS Explorer 266 (Wirral & Chester)
Admiralty Chart	Admiralty Chart 1978 (Great Ormes Head to Liverpool)

Shellfishery

Species/culture	Cockles (*Cerastoderma edule*)	Wild
	Razors (*Pharus legumen* and *Ensis spp.*)	Wild
	Clams (*Lutraria lutraria*, Tapes *decussatus* or *Spisula solida*)	Wild
Seasonality of harvest	Closed season from 1st May to 31st August (cockles). Closed for the foreseeable future, will be revised in early 2014	

Local Enforcement Authority

Name	Mersey Port Health Authority Trident House 105, Derby Road Liverpool L20 8LZ
Environmental Health Officer	Glyn Cavell
Telephone number ☎	0151 233 2576
Fax number	0151 233 2580
E-mail	glyn.cavell@liverpool.gov.uk

Requirement for Review

The Guide to Good Practice for the Microbiological Monitoring of Bivalve Mollusc Harvesting Areas (EU Working Group on the Microbiological Monitoring of Bivalve Mollusc Harvesting Areas, 2010) indicates that sanitary assessments should be fully reviewed every six years, so this assessment is due for formal review in 2019. The assessment may require review in the interim should any significant changes in sources of contamination come to light, such as the upgrading or relocation of the major discharges to the Mersey estuary.

Table 4.1: Location and details of representative monitoring points (RMPs) and frequency of sampling for classification zones within the Liverpool Bay production area.

<table>
<tr><td>Classification zone</td><td colspan="2">Leasowe & New Brighton cockles</td><td colspan="2">Hoylake cockles</td><td colspan="2">East Hoyle clams</td><td colspan="2">Newcome Knoll clams</td></tr>
<tr><td>RMP</td><td colspan="2">B058R</td><td colspan="2">B058T</td><td colspan="2">TBA</td><td colspan="2">TBA</td></tr>
<tr><td>RMP name</td><td colspan="2">Harrison Drive East</td><td colspan="2">Hoylake</td><td colspan="2">East Hoyle</td><td colspan="2">Newcome Knoll</td></tr>
<tr><td>NGR</td><td colspan="2">SJ 2950 9439</td><td colspan="2">SJ 2205 9056</td><td colspan="2">SJ 1790 9080</td><td colspan="2">SJ 2010 9610</td></tr>
<tr><td>Latitude & Longitude (WGS84)</td><td colspan="2">53°24.46'N 3°03.74'W</td><td colspan="2">53°24.36'N 3°10.44'W</td><td colspan="2">53°24.46'N 3°14.19'W</td><td colspan="2">53°27.33'N 03°12.28'W</td></tr>
<tr><td>Species</td><td colspan="2">C. edule</td><td colspan="2">C. edule</td><td colspan="2">Any species as required</td><td colspan="2">Any species as required</td></tr>
<tr><td>Growing method</td><td colspan="2">Wild stocks</td><td colspan="2">Wild stocks</td><td colspan="2">Wild stocks</td><td colspan="2">Wild Stocks</td></tr>
<tr><td>Harvesting technique</td><td colspan="2">Hand (rake)</td><td colspan="2">Hand (rake)</td><td colspan="2">Dredge/electrofishing*</td><td colspan="2">Dredge/electrofishing*</td></tr>
<tr><td>Sampling method</td><td colspan="2">Hand (rake)</td><td colspan="2">Hand (rake)</td><td colspan="2">As per harvesting technique</td><td colspan="2">As per harvesting technique</td></tr>
<tr><td>Tolerance</td><td colspan="2">100m</td><td colspan="2">100m</td><td colspan="2">100m</td><td colspan="2">100m</td></tr>
<tr><td>Frequency</td><td>Monthly monitoring for 1 year towards full classification.</td><td>If classification need is more urgent, then 10 samples required not less than 1 week apart for preliminary classification</td><td colspan="2">Sampling to be undertaken quarterly.
If reclassification is required then sampling should be undertaken monthly</td><td>Monthly monitoring for 1 year towards full classification.</td><td>If classification need is more urgent, then 10 samples required not less than 1 week apart for preliminary classification.</td><td>Monthly monitoring for 1 year towards full classification.</td><td>If classification need is more urgent, then 10 samples required not less than 1 week apart for preliminary classification.</td></tr>
<tr><td>Comments</td><td>Temporarily declassified</td><td>Should the distribution of cockles within this zone change, this RMP may be relocated to the point closest to the eastern boundary where there are sufficient stocks for sampling.</td><td>Temporarily declassified</td><td>Should the distribution of cockles within this zone change, this RMP may be relocated to the point closest to the western boundary where there are sufficient stocks for sampling.</td><td colspan="2">New classification zone.</td><td colspan="2">New classification zone.</td></tr>
</table>

**Subject to a fishing technique being approved by Mersey PHA and NW IFCA*

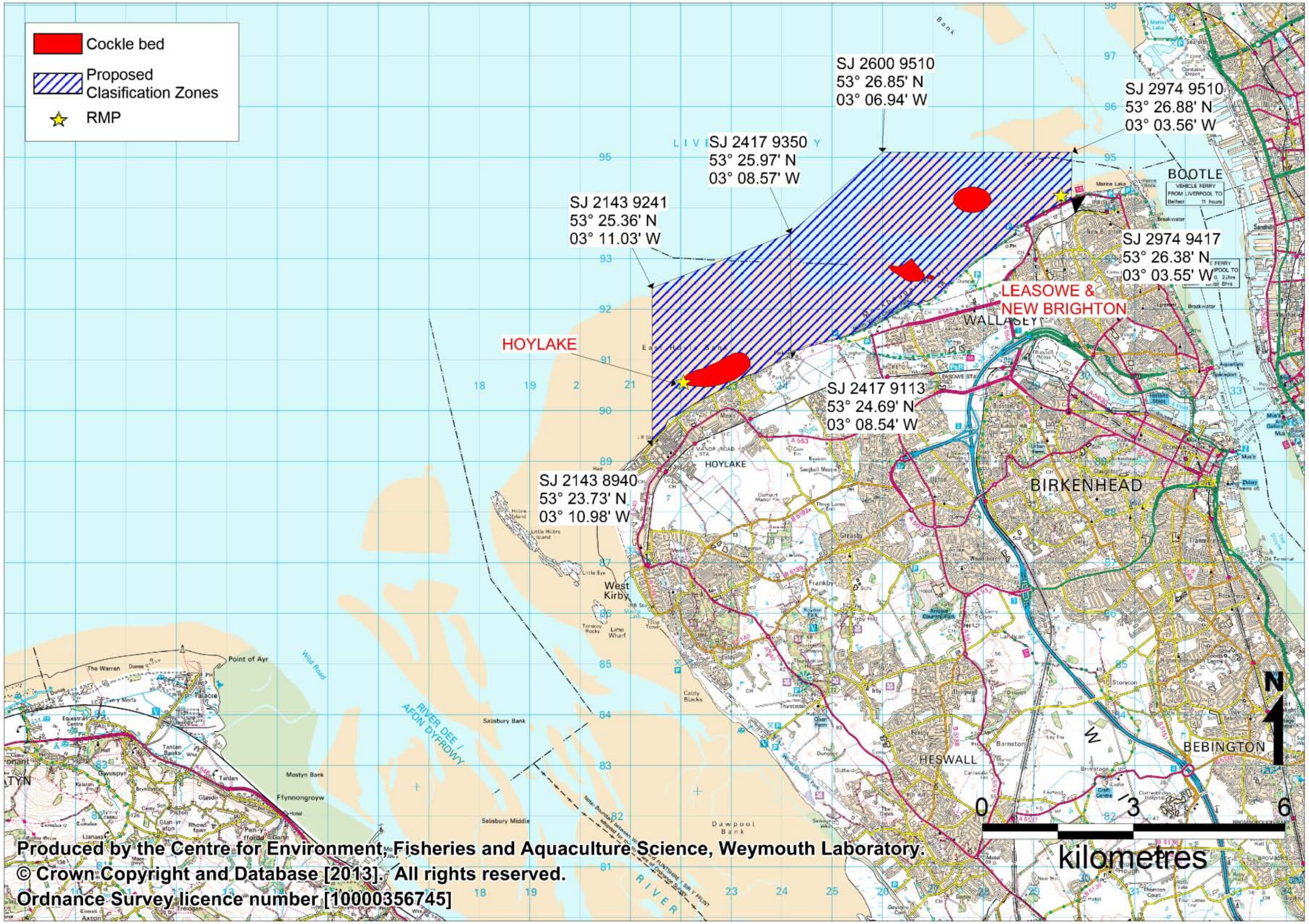

Figure 4.1: Recommended classification zone boundaries and RMP locations for cockles.

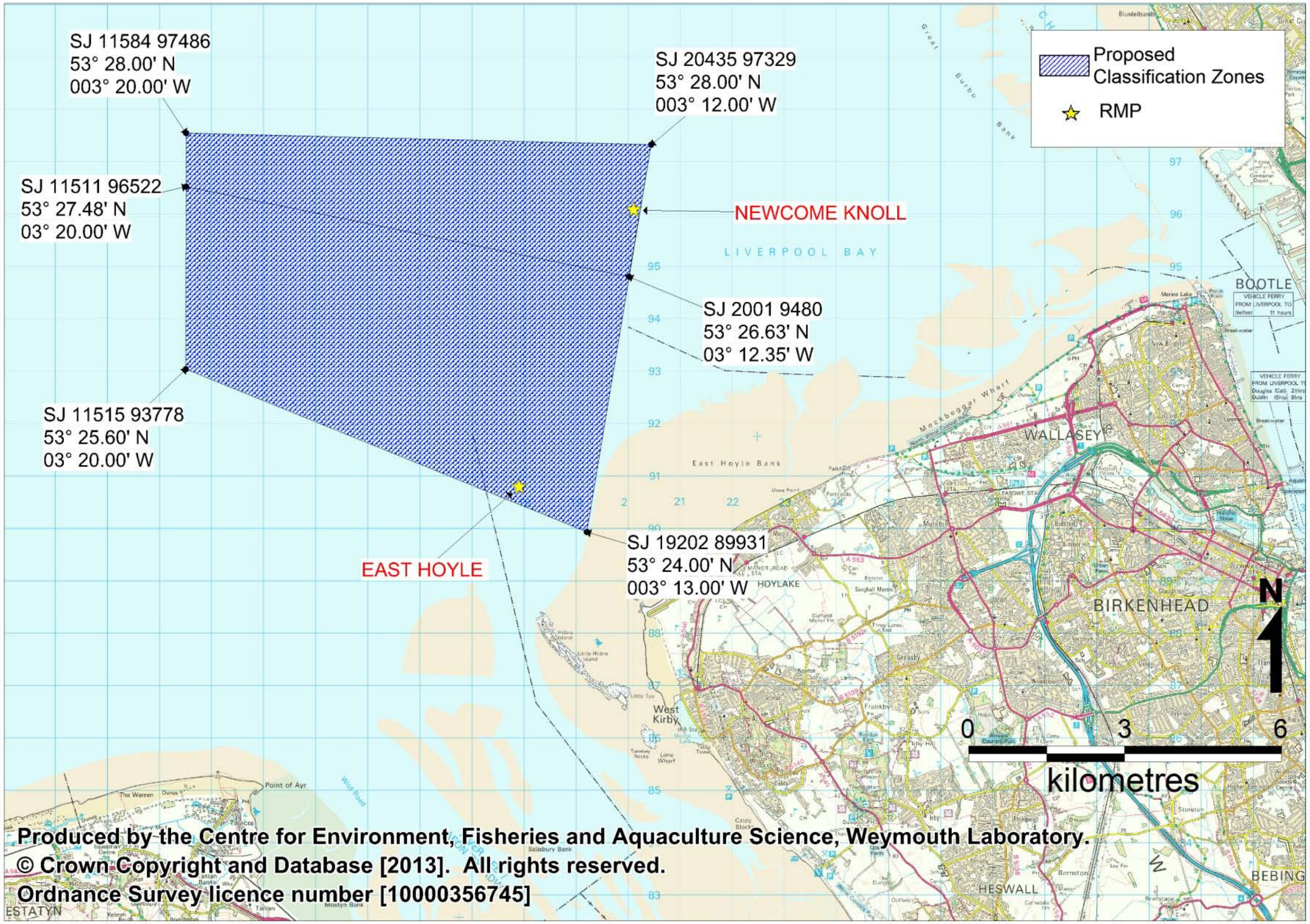

Figure 4.2: Recommended classification zone boundaries and RMP locations for clams

5. Pollution Sources

5.1. Population

The distribution of resident human population by super output area boundary totally or partially included within the river catchment areas for 2001 and 2011 are illustrated in Figure 5.1. Total resident population within both the Mersey and Dee catchments has increased by 8,000 persons (approximately 0.12%), to a total of 5,057,604 over ten years. The Mersey catchment is the more densely populated of these containing more than 4.5 million people. Similarly to 2001, the highest population densities remain in Greater Manchester and high densities are apparent in Liverpool, Chester and Wrexham.

Figure 5.1 suggests that there has been an increase in population density predominantly in and around the major conurbations, particularly around Greater Manchester within the Mersey catchment. An increase in population will increase overall sewage discharge into both estuaries, particularly into the Mersey estuary.

As concluded in the 2011 Sanitary Survey sewage inputs to the Mersey estuary are likely to be considerably higher than those to the Dee estuary. Overall volumes of sewage discharge to both estuaries maybe higher during the summer months as a result of increased numbers of visitors to the area. This is likely to be strongest for discharges serving areas such as the Wirral and the Dee estuary where many attractions are outdoors compared to the cities of Greater Manchester and Liverpool where the majority of attractions are more of a cultural nature.

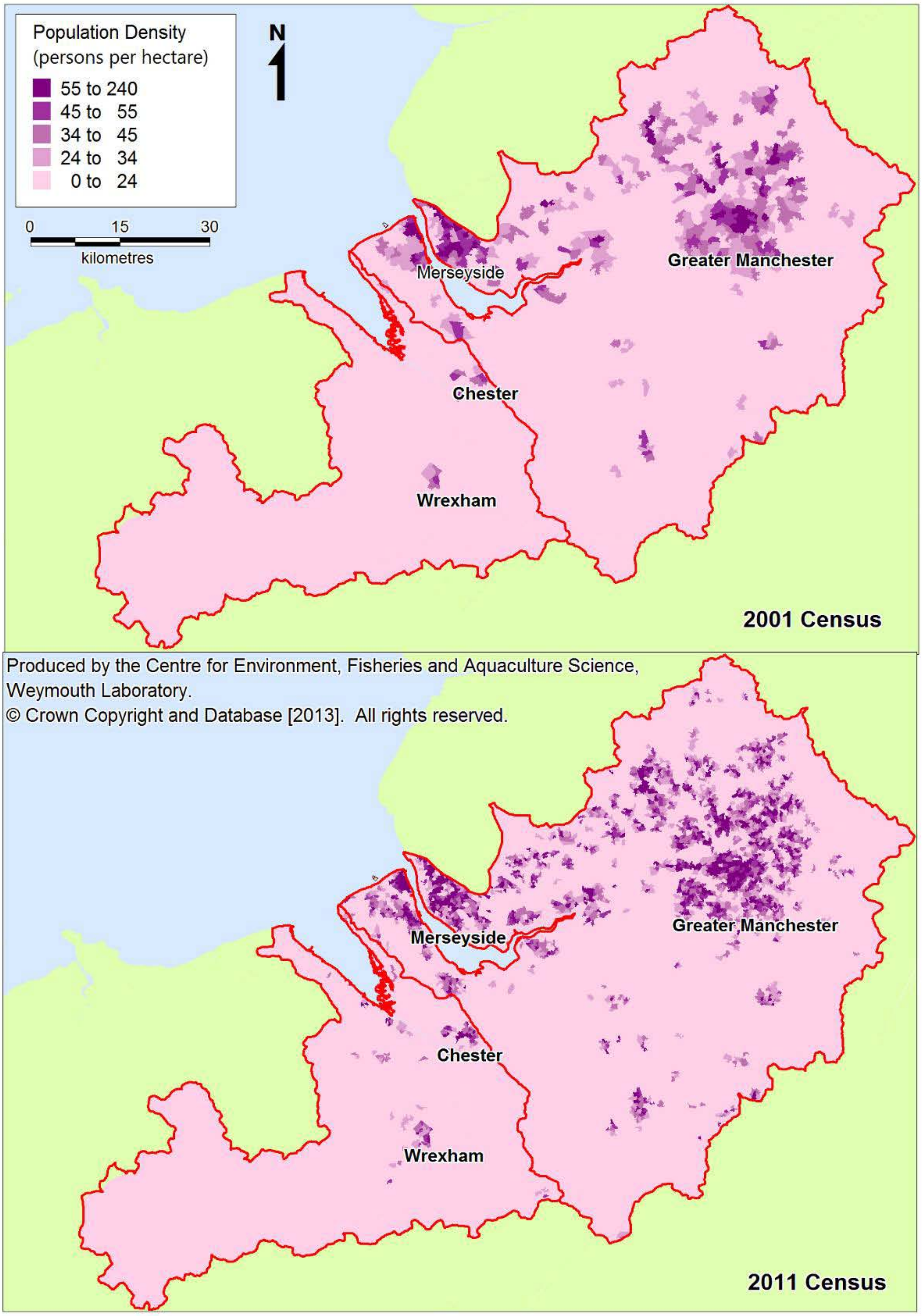

Figure 5.1: Human population density in the Dee and Mersey estuary catchments in 2001 and 2011.

Source: ONS, Super Output Area Boundaries (Middle layer). Crown copyright 2011. Crown copyright material is reproduced with the permission of the Controller of HMSO.

5.2. Sewage

Figure 5.2 shows the locations of the continuous sewage discharges in the area surrounding the Wirral and the Liverpool Bay shellfisheries based on the same criteria used in the sanitary survey. One of the current discharges, Woolton STW, was not active at the time of writing of the sanitary survey. Two discharges, Warrington South STW and Runcorn STW, which were active during the time of writing of the sanitary survey, are no longer active. Table 5.1 contrasts the continuous discharges that were identified as active during the sanitary survey and those identified as active now. The total volume of dry weather flow (DWF) of discharges into the Mersey (all secondary treated) has stayed approximately the same since the sanitary survey (a reduction of 0.001%). However in the Dee catchment, DWF volumes of secondary and tertiary treated effluent have increased by 1.3% and 5.3% respectively. Much of this increase has occurred at Flint STW, Connahs Quay STW and Queensferry STW, all in the upper reaches of the Dee estuary.

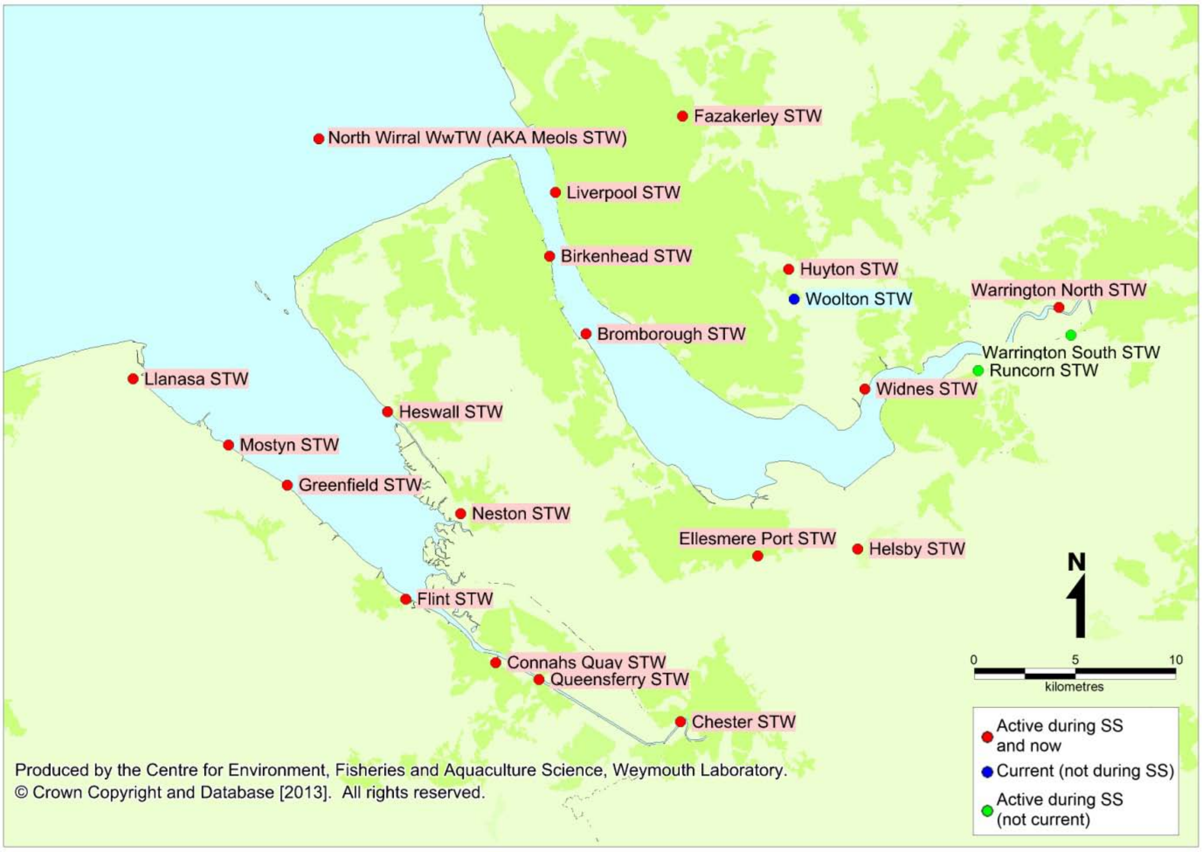

Figure 5.2: Continuous discharges identified as active in the 2011 survey and now (2013)
(With dry weather flows above 50 m³/day).

Table 5.1: Comparisons of continuous discharges identified before and since the sanitary survey

Site	NGR	Catchment	DWF (m³/day)		% change in DWF	Treatment type
			Before SS*	Since SS*		
Birkenhead STW	SJ3292089490	Mersey	55201.0	55200.0	<0.1	Secondary
Bromborough STW	SJ3471085640	Mersey	25099.2	25100.0	<0.1	Secondary
Chester STW	SJ39396645	Dee	31138.0	31138.0	0.0	Secondary
Connahs Quay STW	SJ30246938	Dee	3272.0	3898.3	19.1	Secondary
Ellesmere Port STW	SJ4320074650	Mersey	29497.0	29500.0	<0.1	Secondary
Fazakerley STW	SJ3949096420	Mersey	41999.0	42000.0	<0.1	Secondary
Flint STW	SJ25797252	Dee	3410.0	3902.7	14.4	Tertiary (UV)
Greenfield STW	SJ19947816	Dee	3891.0	3891.0	0.0	Secondary
Helsby STW	SJ4815075000	Dee	6652.8	6650.0	<0.1	Secondary
Heswall STW	SJ24908179	Dee	2562.0	2562.0	0.0	Tertiary (UV)
Huyton STW	SJ4473088840	Mersey	15664.3	15660.0	<0.1	Secondary
Liverpool STW	SJ3321092640	Mersey	234000.0	234000.0	0.0	Secondary
Llanasa STW	SJ12318342	Dee	8061.0	8061.0	0.0	Tertiary (UV)
Mostyn STW	SJ17038015	Dee	966.0	966.0	0.0	Secondary
Neston STW	SJ28527675	Dee	4074.0	4074.0	0.0	Tertiary (UV)
Queensferry STW	SJ32386855	Dee	10000.0	11067.9	10.7	Tertiary (UV)
Warrington North STW	SJ5811086960	Mersey	63002.9	63000.0	<0.1	Secondary
Widnes STW	SJ4851082920	Mersey	28002.2	28000.0	<0.1	Secondary

*Sanitary survey

There have also been changes to the numbers of intermittent discharges identified in the area.

Figure 5.3 shows the locations of the intermittent discharges in the north Wirral based on the same area used in the sanitary survey. Since the sanitary survey, eight intermittent discharges in the area have had their permits revoked, but 31 new discharges have identified as summarised in Table 5.2 to Table 5.4. This increases the total number of intermittent discharges to 55.

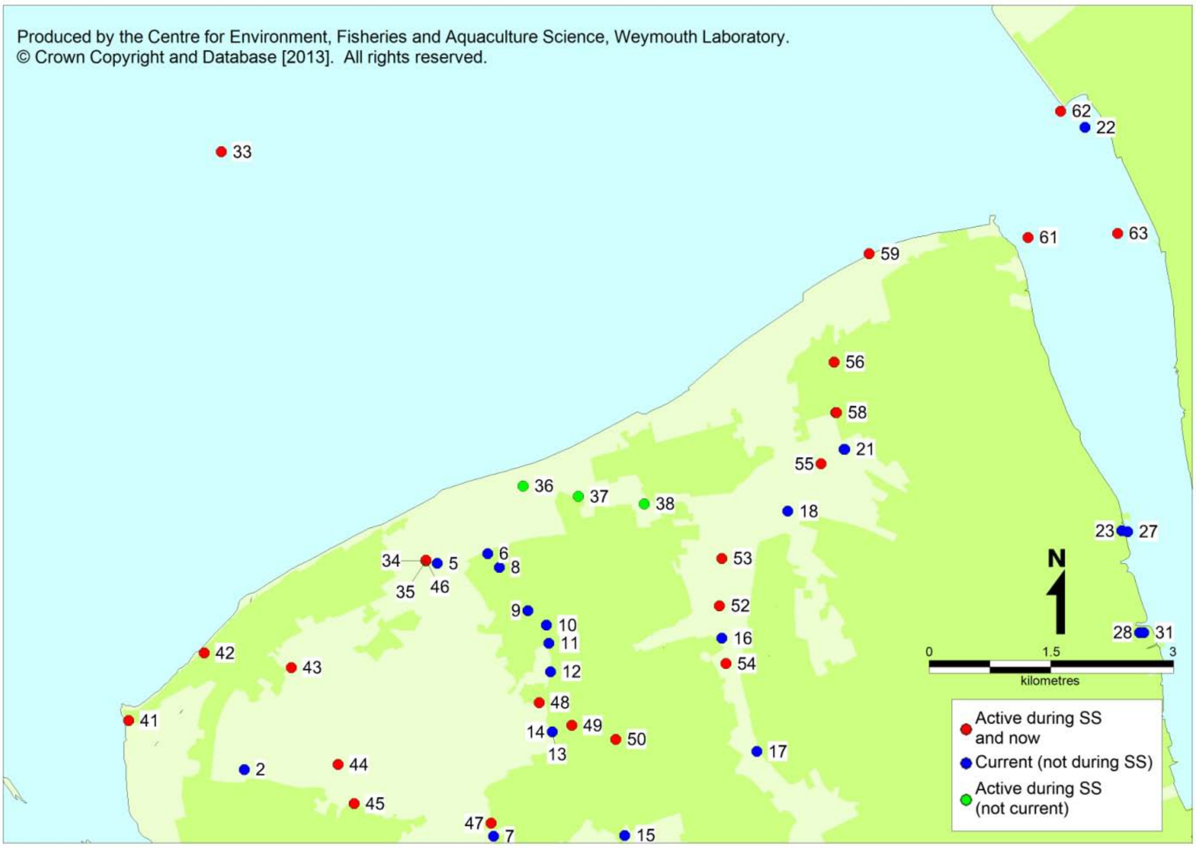

Figure 5.3: Intermittent discharges identified as active in the 2011 survey and now (2013)
(Numbers refer to discharges listed in Table 5.2 to Table 5.4)

Table 5.2:Current intermittent discharges not active at the time of the sanitary survey (July 2010).

No.	Discharge name	NGR	Receiving Water	Treatment
1	Greenbank Road PS (outlet 1)	SJ2178087720	River Birkett	Screening
2	Greenbank Road PS (outlet 2)	SJ2178087720	River Birkett	None
3	North Wirral WwTW (outlet 2)	SJ2415090250	River Birkett	Screening
4	North Wirral WwTW (outlet 3)	SJ2415090250	River Birkett	Screening
5	North Wirral WwTW (outlet 4)	SJ2415090250	River Birkett	Screening
6	Maryland Lane CSO	SJ2477090370	Arrowe Brook	Screening
7	Whitebeam Walk CSO	SJ2484086900	Greasby Brook	Screening
8	Wastdale Drive CSO	SJ2491090200	Arrowe Brooke	Screening
9	Garrick Avenue	SJ2526089670	Arrowe Brook	None
10	389 Hoylake Road CSO	SJ2549089490	Arrowe Brook	None
11	Acton Lane CSO	SJ2552089270	Arrowe Brook	None
12	Kingfisher Way CSO	SJ2554088920	Arrowe Brook	None
13	97 Wood Lane CSO	SJ2556088180	Arrowe Brook	None
14	Wood Lane/Glentree Close CSO	SJ2556188181	Arrowe Brook	None
15	Arrowe Rd/Arrowebrk Lane CSO	SJ2645086910	Arrowe Brook	Screening
16	Moreton Spur PS	SJ2764089330	River Fender	None
17	Noctorum Avenue	SJ2807087940	The River Fender	None

No.	Discharge name	NGR	Receiving Water	Treatment
18	Bidston Bypass/Station Approach CSO	SJ2845090890	River Birkett	None
19	Hillside Road CSO	SJ2914091650	Bidston Stream	Screening
20	Wallacre Rd/Beaufort Drv	SJ2914091650	Bidston Stream	None
21	Station Road CSO	SJ2915091650	Bidston Stream	Screening
22	Bootle North Outfall	SJ3210095600	River Mersey Estuary	Unspecified
23	Wallasey PS (outlet 3)	SJ3255090650	River Mersey Estuary	None
24	Wallasey PS (outlet 1)	SJ3262090640	River Mersey Estuary	None
25	Wallasey PS (outlet 2)	SJ3262090640	River Mersey Estuary	None
26	Wallasey PS (outlet 4)	SJ3262090640	River Mersey Estuary	None
27	Wallasey PS (outlet 5)	SJ3262090640	River Mersey Estuary	None
28	Birkenhead WwTW (outlet 3)	SJ3277089400	River Birkett	None
29	Birkenhead WwTW (outlet 4)	SJ3282089400	River Birkett	None
30	Birkenhead WwTW (outlet 5)	SJ3282089400	River Birkett	Screening
31	Birkenhead WwTW (outlet 6)	SJ3282089400	River Birkett	None

Table 5.3: Intermittent discharges active during the sanitary survey which have since been closed.

No.	Discharge_Site_Name	NGR	Receiving Water	Treatment
32	Meols WwTW (outlet 1)	SJ2150095300	River Birkett	Screening
33	Meols WwTW (outlet 2)	SJ2150095300	River Birkett	Screening
34	Meols WwTW (outlet 3)	SJ2401090280	River Birkett	Screening
35	Meols WwTW (outlet 4)	SJ2401090280	River Birkett	Screening
36	Eve-A-Lyn Farm Septic Tank	SJ2520091200	River Birkett	Biological Filtration
37	Pasture Rd/Silverburn Ave SS	SJ2588091070	River Birkett	None
38	20 Silverburn Ave SS	SJ2669090980	River Birkett	None
39	Moreton Spur PS	SJ2764089330	River Fender	None

Table 5.4: Intermittent discharges active both now and during the sanitary survey.

No.	Discharge_Site_Name	NGR	Receiving Water	Treatment
40	Stanley Rd/Hoylake (outlet 1)	SJ2036088320	The Irish Sea	None
41	Stanley Rd/Hoylake (outlet 2)	SJ2036088320	The Irish Sea	None
42	Kings Gap Hoylake	SJ2129089150	River Mersey	Unspecified
43	Harrington Avenue	SJ2236088970	Trib Carr Drain	Screening
44	Ennisdale Drive/Black Horse Hill	SJ2293087780	Newton Brook	None
45	Rear Of 65 Fulton Ave	SJ2313087300	Newton Brook	None
46	Carr Lane STW	SJ2401090290	River Birkett	None
47	Frankby Close	SJ2481087060	Greasby Brook	None
48	Saughall Massie Rd/Devonshire Upton	SJ2540088540	Arrowe Brook	None
49	81 Wood Lane CSO	SJ2580088260	Arrowe Brook	Screening
50	Greasby Road/Cortsway	SJ2634088090	River Fender	Unspecified
51	Briscoe Dr	SJ2761089730	River Fender	None
52	Rear Of 25 Wheatfield Close/Upton Road	SJ2761089730	River Fender	Screening
53	Hoylake Rd/Chapelhill Rd	SJ2764090310	River Fender	Screening
54	Upton Storm Tanks	SJ2769089020	River Fender	Screening
55	Bidston Moss Ps	SJ2886091470	Unnamed Watercourse	None
56	Stanley Ave/Green Lane CSO	SJ2902092720	Bidston Stream	None
57	Sandy Lane CSO/Leasowe Road	SJ2904092100	Bidston Stream	Screening
58	Beechwood Avenue CSO	SJ2905092100	Bidston Stream	None
59	Wallasey Detention Tank	SJ2945094050	River Mersey Estuary	None
60	New Brighton Pumping Station (outlet 1)	SJ3140094250	River Mersey Estuary	Screening
61	New Brighton Pumping Station (outlet 2)	SJ3140094250	River Mersey Estuary	None
62	Rimrose Brook Outfall	SJ3180095800	River Mersey Estuary	Unspecified
63	Strand Road Outfall	SJ3250094300	River Mersey Estuary	Unspecified

Due to the addition of a wider area for shellfish classification in Liverpool Bay, a larger area must be considered for sewage discharges. Figure 5.4, Figure 5.5 and Figure 5.6 show the locations and size (where relevant) of all continuous, intermittent and private discharges within the Dee and Mersey catchments respectively.

Details of all continuous discharges with DWFs greater than 2000 m³/day are shown in Table 5.5. Total volumes of approximately 10 m³, 540000 m³ and 65000 m³ of primary, secondary and tertiary treated sewage respectively are discharged daily to the Dee catchment; total volumes of approximately 0 m³, 1800000 m³ and 17000 m³ of primary, secondary and tertiary treated sewage respectively are discharged daily to the Mersey catchment. Using data by Kay and colleagues (2008), this equates to total estimated daily bacterial loadings of 1.8 x 10^{15} and 6.0 x 10^{15} faecal coliforms in the Dee and Mersey respectively, or an estimated combined total of 7.8 x 10^{15} faecal coliforms. However, many of the discharges, such as those around the Manchester area, occur in the upper catchments and so may not contribute such a high level of viable bacteria, as the discharges will take several days to arrive at the shellfisheries.

There are approximately 2,500 intermittent discharges in the Dee and Mersey catchments. The CSO at Heswall has been identified as a significant contribution to closures of the shellfish beds in the Dee estuary (Cefas, 2013). As a result, the storm tanks and CSO are currently being upgraded to limit the number of spill from this site to ten per year. This is due to be completed in summer 2013 (Dwr Cymru Welsh Water, Pers. Comm.). Spill data for intermittent discharges on the north Wirral were not available within the scope of this report.

In addition to the water company owned assets, there are 3,448 private discharges in the Dee and Mersey catchments. Details of those private discharges with DWFs above 50 m³/day are presented in Table 5.6. The total volume from those private discharges with reported DWFs is approximately 87,000 m³/day in the largely urban catchment of the Mersey, compared to only 47 m³/day in the largely rural Dee catchment.

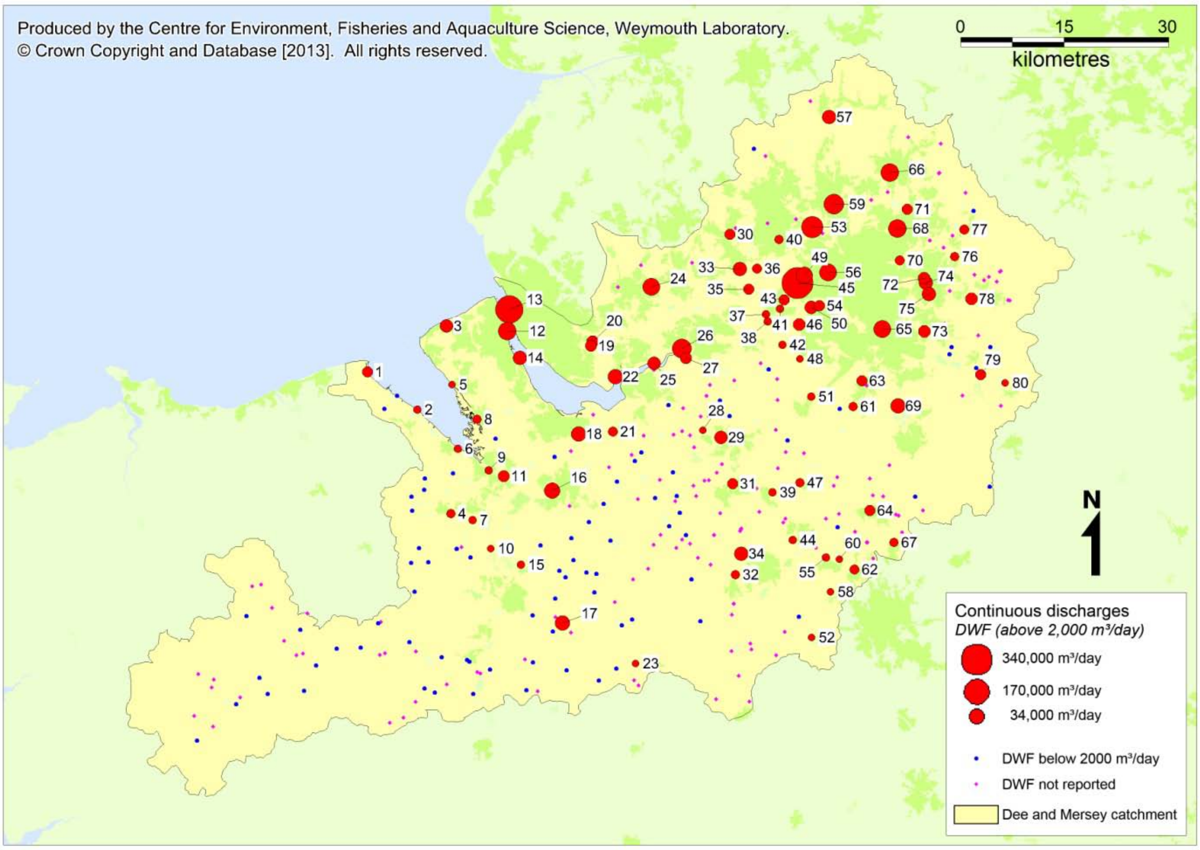

Figure 5.4: Current continuous discharges in the Dee and Mersey catchments. Numbers refer to discharges in Table 5.5

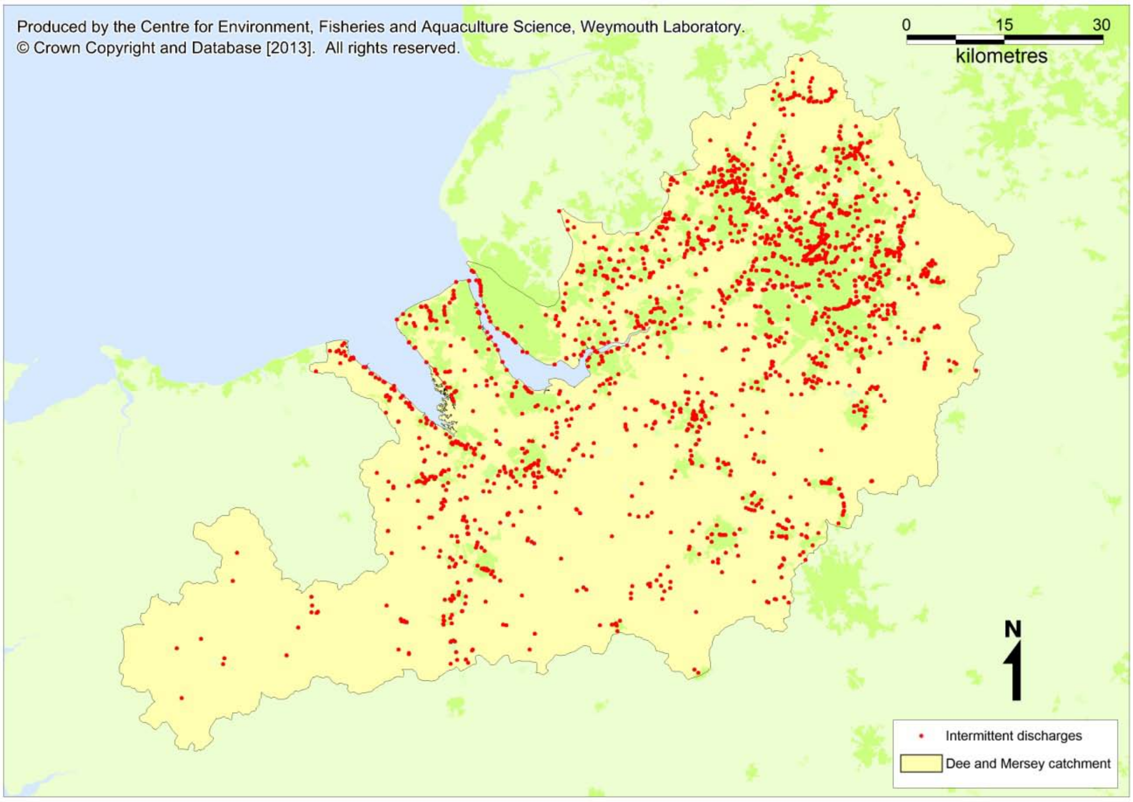

Figure 5.5: All current intermittent discharges in the Dee and Mersey catchments

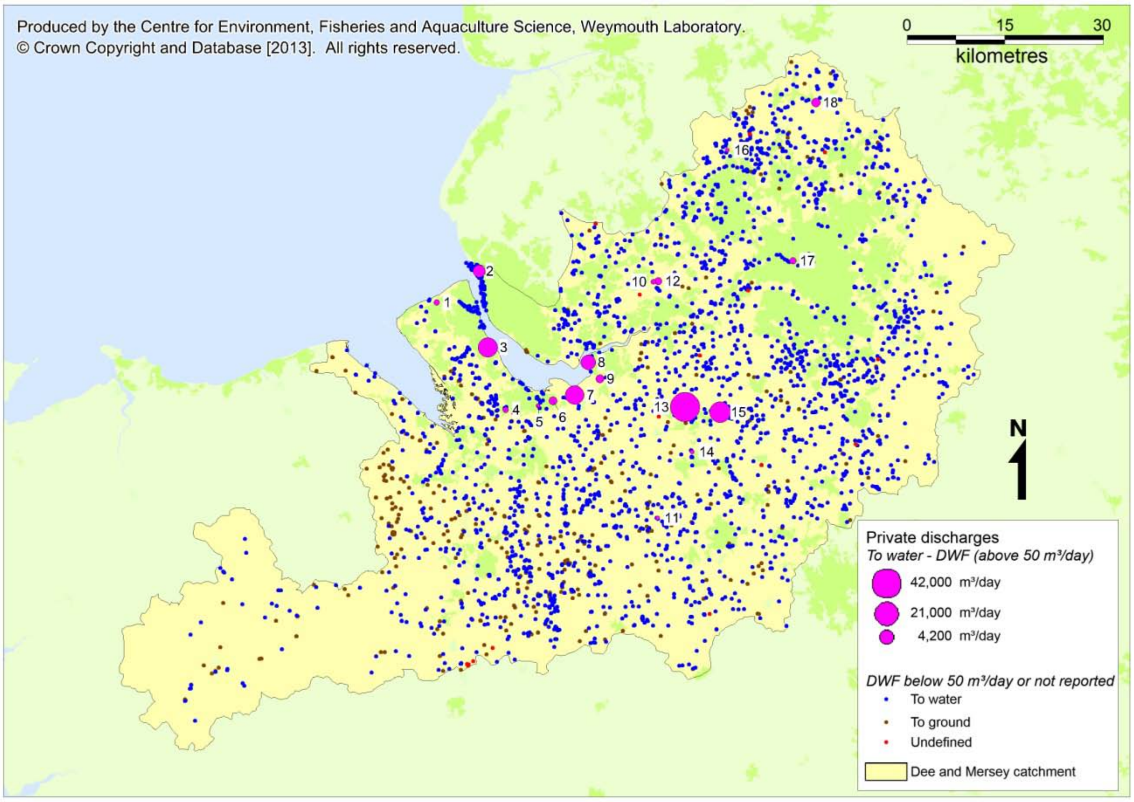

Figure 5.6: Current private discharges in the Dee and Mersey catchments. Numbers refer to discharges in Table 5.6.

Table 5.5: All continuous discharges in the Dee and Mersey catchments with a DWF above 2000 m³/day.

No.	Name	NGR	Catchment	Treatment level	DWF (m³/day)	Estimated bacterial load (Faecal coliforms/day)
1	Llanasa WwTW	SJ1271583618	Dee	Tertiary (UV)	8061	2.3×10^{10}
2	Greenfield WwTW	SJ1994078160	Dee	Secondary	3891	1.3×10^{13}
3	North Wirral WwTW	SJ2415090250	Mersey	Tertiary (UV)	16638	4.7×10^{10}
4	Mold STW	SJ2475063140	Dee	Secondary	4125	1.4×10^{13}
5	Heswall STW	SJ2490081791	Dee	Tertiary (UV)	2562	7.2×10^{9}
6	Flint WwTW	SJ2578872517	Dee	Tertiary (UV)	3902.7	1.1×10^{10}
7	Ty Gwyn WwTW	SJ2789062220	Dee	Secondary	4061	1.3×10^{13}
8	Neston WwTW	SJ2852476748	Dee	Tertiary (UV)	4074	1.1×10^{10}
9	Connahs Quay STW	SJ3024069380	Dee	Secondary	3898.3	1.3×10^{13}
10	Hope STW	SJ3054058070	Dee	Secondary	2237	7.4×10^{12}
11	Queensferry WwTW	SJ3237968522	Dee	Tertiary (UV)	11067.9	3.1×10^{10}
12	Birkenhead WwTW	SJ3292089490	Mersey	Secondary	55200	1.8×10^{14}
13	Liverpool WwTW	SJ3321092640	Mersey	Secondary	234000	7.7×10^{14}
14	Bromborough WwTW	SJ3471085640	Mersey	Secondary	25100	8.3×10^{13}
15	Gresford STW	SJ3488055780	Dee	Secondary	3590	1.2×10^{13}
16	Chester STW	SJ3939066450	Dee	Secondary	31138	1.0×10^{14}
17	Five Fords STW	SJ4090047320	Dee	Secondary	27720	9.1×10^{13}
18	Ellesmere Port WwTW	SJ4320074650	Mersey	Secondary	29500	9.7×10^{13}
19	Woolton STW	SJ4501087370	Mersey	Secondary	11710	3.9×10^{13}
20	Huyton STW	SJ4525087950	Mersey	Secondary (plus sand filtration)	15660	5.2×10^{13}
21	Helsby STW	SJ4815075000	Mersey	Secondary (plus sand filtration)	6650	2.2×10^{13}
22	Widnes WwTW	SJ4851082920	Mersey	Secondary	28000	9.2×10^{13}
23	Whitchurch STW	SJ5140641489	Dee	Secondary	2592	8.6×10^{12}
24	St Helens STW	SJ5373095890	Mersey	Secondary	47670	1.6×10^{14}
25	Runcorn STW	SJ5412084830	Mersey	Secondary	18500	6.1×10^{13}
26	Warrington North WwTW	SJ5811086960	Mersey	Secondary	63000	2.1×10^{14}
27	Warrington South STW	SJ5870085580	Mersey	Secondary	11000	3.6×10^{13}
28	Weaverham STW	SJ6115075180	Mersey	Secondary	2100	6.9×10^{12}
29	Northwich STW	SJ6374074160	Mersey	Secondary	19820	6.5×10^{13}
30	Westhoughton STW	SD6507003470	Mersey	Secondary	9100	3.0×10^{13}
31	Winsford STW	SJ6544067440	Mersey	Secondary	9470	3.1×10^{13}
32	Nantwich WwTW	SJ6586054330	Mersey	Secondary	5180	1.7×10^{13}
33	Leigh STW	SJ6650098460	Mersey	Secondary	22500	7.4×10^{13}
34	Crewe STW	SJ6669057370	Mersey	Secondary	23300	7.7×10^{13}
35	Glazebury STW	SJ6780095520	Mersey	Secondary	10000	3.3×10^{13}
36	Tyldesley STW	SJ6895098520	Mersey	Secondary (plus sand filtration)	6910	2.3×10^{13}
37	Irlam STW	SJ7025091910	Mersey	Secondary	3630	1.2×10^{13}
38	Partington STW	SJ7049090880	Mersey	Secondary	3050	1.0×10^{13}
39	Middlewich STW	SJ7122066220	Mersey	Secondary (plus sand filtration)	3500	1.2×10^{13}
40	Worsley STW	SD7215002720	Mersey	Secondary	4643	1.5×10^{13}

No.	Name	NGR	Catchment	Treatment level	DWF (m^3/day)	Estimated bacterial load (Faecal coliforms/day)
41	Northbank STW	SJ7227092730	Mersey	Secondary (plus sand filtration)	2870	9.5×10^{12}
42	Dunham Massey STW	SJ7262087540	Mersey	Secondary	3000	9.9×10^{12}
43	UrmstonSTW	SJ7287093990	Mersey	Secondary	9500	3.1×10^{13}
44	Sandbach STW	SJ7412059310	Mersey	Secondary	4000	1.3×10^{13}
45	Davyhulme STW	SJ7480196447	Mersey	Secondary	340000	1.1×10^{15}
46	Altrincham STW	SJ7504090440	Mersey	Secondary	13843	4.6×10^{13}
47	Holmes Chapel STW	SJ7515067590	Mersey	Secondary	4200	1.4×10^{13}
48	Bowden STW	SJ7517085470	Mersey	Secondary	2300	7.6×10^{12}
49	Eccles STW	SJ7580097570	Mersey	Secondary	38770	1.3×10^{14}
50	Sale STW	SJ7677092920	Mersey	Secondary	19261	6.4×10^{13}
51	Knutsford WwTW	SJ7678080040	Mersey	Tertiary (Biological)	4000	1.1×10^{10}
52	Madley WwTW	SJ7683045250	Mersey	Secondary	2770	9.1×10^{12}
53	Bolton STW	SD7695004520	Mersey	Tertiary (Chemical)	101000	2.8×10^{11}
54	Stretford STW	SJ7800693180	Mersey	Secondary	8170	2.7×10^{13}
55	Alsager STW	SJ7891056790	Mersey	Secondary (plus sand filtration)	3430	1.1×10^{13}
56	Salford STW	SJ7924097980	Mersey	Secondary	50000	1.7×10^{14}
57	Rossendale STW	SD7937020400	Mersey	Secondary	25000	8.3×10^{13}
58	Audley STW	SJ7956051850	Mersey	Secondary	2047	6.8×10^{12}
59	Bury STW	SD8004007810	Mersey	Secondary	82200	2.7×10^{14}
60	Lawton Gate STW	SJ8086056550	Mersey	Secondary	2050	6.8×10^{12}
61	Alderley Edge STW	SJ8283078580	Mersey	Secondary (plus sand filtration)	5310	1.8×10^{13}
62	Kidsgrove WwTW	SJ8303055080	Mersey	Secondary (plus sand filtration)	6500	2.1×10^{13}
63	Wilmslow STW	SJ8413082320	Mersey	Secondary	9000	3.0×10^{13}
64	Congleton STW	SJ8525063570	Mersey	Secondary	9800	3.2×10^{13}
65	Stockport STW	SJ8704089780	Mersey	Secondary	45731	1.5×10^{14}
66	Rochdale STW	SD8816012370	Mersey	Secondary	53024	1.7×10^{14}
67	Biddulph STW	SJ8871058970	Mersey	Secondary (plus sand filtration)	4700	1.6×10^{13}
68	Oldham STW	SD8925004310	Mersey	Secondary	56400	1.9×10^{14}
69	Macclesfield WwTW	SJ8934078690	Mersey	Secondary	28500	9.4×10^{13}
70	Failsworth WwTW	SJ8960099710	Mersey	Secondary	6180	2.0×10^{13}
71	Royton STW	SD9067007110	Mersey	Secondary	7800	2.6×10^{13}
72	Ashton-Under-Lyne STW	SJ9308097130	Mersey	Secondary	16040	5.3×10^{13}
73	Hazel Grove STW	SJ9312089440	Mersey	Secondary	14660	4.8×10^{13}
74	Dukinfield STW	SJ9332096490	Mersey	Secondary	24116	8.0×10^{13}
75	Hyde WwTW	SJ9379094840	Mersey	Secondary (plus sand filtration)	21828	7.2×10^{13}
76	Mossley STW	SD9750000260	Mersey	Secondary	4219.6	1.4×10^{13}
77	Saddleworth STW	SD9891004150	Mersey	Secondary	7000	2.3×10^{13}
78	Glossop STW	SJ9993094160	Mersey	Secondary	14800	4.9×10^{13}
79	Whaley Bridge STW	SK0125083220	Mersey	Secondary	7960	2.6×10^{13}
80	Chapel-En-Le-Frith WwTW	SK0481082020	Mersey	Secondary	2230	7.4×10^{12}

*Based on base flow average from a range of UK STWs (Kay *et al.*, 2008).

Table 5.6: Private discharges in the Dee and Mersey catchments with DWFs above 50 m³/day.

No.	Name	NGR	Type	Catchment	DWF (m³/day)
1	River Birkett	SJ 26400 91000	Miscellaneous foods	Mersey	200
2	Gladstone Dock	SJ 32900 95770	Sea transport	Mersey	2200
3	River Dibbin	SJ 34220 84120	Soap and toilet preparations	Mersey	11000
4	Trib. Rivacre Brook	SJ 36957 74531	Nuclear fuel production & waste processing	Mersey	180
5	Little Stanney Drain	SJ 41910 75180	Industrial estate	Mersey	80
6	Gale Brook	SJ 44200 75900	Chemicals (inorganic)	Mersey	546
7	Holpool Gutter	SJ 47500 76800	Spoil waste site	Mersey	10000
8	Runcorn & Weston Canal	SJ 49600 81800	Chemicals (inorganic)	Mersey	4000
9	Weston Canal	SJ 51360 79270	Chemicals (inorganic)	Mersey	600
10	Newton Brook	SJ 59530 94160	Coal extraction	Mersey	136
11	River Weaver	SJ 60200 58000	Sewage disposal work	Mersey	55
12	Hermitage Green Brook	SJ 60290 94240	Coal extraction	Mersey	458
13	River Weaver (Norwhich)	SJ 64400 75000	Chemicals (inorganic)	Mersey	42000
14	River Weaver	SJ 65510 68110	Chemicals (inorganic)	Mersey	75
15	Wade Brook	SJ 69744 74177	Chemicals (inorganic)	Mersey	14000
16	Eagley Brook	SD 70840 14340	Sewage disposal work	Mersey	50
17	Manchester Ship Canal	SJ 80900 97400	Sea Transport	Mersey	334.8
18	River Irwell	SD 84400 21600	Processing of Plastics	Mersey	773

5.3. Agriculture

Wirral Borough Council has indicated that livestock and agricultural distributions and numbers within the Wirral catchment, have not changed significantly since the 2011 sanitary survey (Pers. Comm.).

Environment agency, Defra and Welsh Government data detailed in the 2011 survey were recorded in 2009 and revealed that livestock numbers within the Dee catchment were slightly higher than in the Mersey catchment. Consequently higher concentrations of faecal indicators from livestock were expected in freshwater inputs into the Dee. In 2009 the number of grazing animals was almost double that of the human population in the Dee catchment. Conversely, in the Mersey catchment humans outnumber grazing animals by almost an order of magnitude. Seasonal and or rainfall related fluctuations in bacterial loadings of livestock origin are likely to be higher in the Dee estuary. Highest bacterial loadings are expected in summer months after high rainfall events when livestock numbers are highest and/or slurry has been spread.

5.4. Wildlife

Liverpool Bay hosts internationally important migratory and overwintering populations of wading birds and wildfowl on its extensive mudflats and saltmarsh. The Wetlands Birds Survey (WeBS, 2011) showed that numbers of waterbirds recorded in the Dee Estuary have increased 14.9% from 103,072 in 2009/2010 to 118,390 in 2010/2011. A decrease of 7.6% occurred in the Mersey Estuary, with 60,723 in 2009/2010 and 56,085 in 2010/2011 (Holt *et al.*, 2012). There has been an overall increase of approximately 10,000 waterbirds. However, it is unclear whether these are significant changes or due to natural fluctuation. There are no official data available to suggest that numbers of waders and wildfowl along the North Wirral foreshore have changed since the last survey. An average total count of 30,000 birds was observed over the five winters until 2008/2009 (Natural England, 2011). During the 2012 shoreline survey 200 birds were recorded foraging on the cockle beds at Dove Point. As concluded in the 2011 survey, due to their large numbers, birds are likely to be a significant source of contamination to shellfish beds, predominantly in the winter months when migratory birds are present. Contamination from the birds is deposited directly on to the shellfish beds, and so high levels of contamination may be found on the sediments here. Its spatial distribution is however likely to be irregular.

There is no evidence to suggest that seal numbers and their choice in haul-out sites have changed significantly since the sanitary survey. Numbers exceeding 500 seals have been recorded in the summer months on Hilbre Island. Numbers decline to around 50 in the autumn. Therefore, as previously concluded; contamination is likely to be heaviest in the immediate vicinity of the haul-out sites, which are located a sufficient distance from the shellfish beds to not significantly impact them. Potential impacts will peak in the summer months when numbers are largest and seals forage widely and will therefore be present throughout Liverpool Bay. Seals could represent a potential diffuse source of pollution to the shellfish beds but this is likely to be minor and spatially unpredictable and will consequently have no influence on the sampling plan.

Dog walking remains popular along the North Wirral shore. Dogs were observed on both the 2012 and 2013 shoreline surveys and in particular large amounts of dog faeces were observed during the 2013 shoreline survey. Dog walking is likely to be most common closest to the main access points and car parks, which are spread quite evenly along the shore.

5.5. Pollution sources recommendations

Data for a number of monitored storm overflows on the north-west Wirral coast with the potential to impact on the Liverpool Bay shellfish beds was not available from United Utilities for assessment within the time frame of this review. This should be addressed at the next review.

Identification of field level information on land receiving sewage sludge in the Mersey and Dee river catchments and coastal areas adjacent to Liverpool Bay would allow Cefas to evaluate the significance or otherwise of this potential source of pollution.

6. Hydrodynamics

Bathymetry in Liverpool Bay remains largely unchanged since the 2011 report however significant changes to sandbanks within the Mersey have taken place within the last 150 years; these are a natural and regular occurrence and it is likely to continue (Blott *et al.*, 2006). Notice to Mariners in relation to Admiralty chart number 1978 (UKHO, 2013) notes a small increase in the drying height of the sandbank north east of Hilbre Island in 2011, no other changes to the bathymetry are noted.

The hydrography within Liverpool Bay is largely affected by tidal driven processes interacting with shallow subtidal sandbanks and dredged channels. Therefore it is likely that slight changes to the tidal flows will have occurred since the survey in 2011.

Approximately 7 km north west of the North Wirral shore, lies the Burbo Bank Windfarm consisting of 25 turbines. An application for an extension of 40 km^2 to the west of the existing farm was made in March 2013 and is expected to be determined in 2014/15. It is assumed that there will be small localised changes to waves and tides and consequently effects to movements of sediments due to tide and wave will be negligible in the near shore zone (Dong Energy, 2012) where the shellfish are situated.

7. Rainfall

Rainfall data from the Chester weather station from 2005-2008 (pre sanitary survey data) and 2009-2012 (post sanitary survey data) were used to determine whether there have been any changes in rainfall patterns since the Liverpool Bay sanitary survey. Figure 7.1 shows the daily rainfall totals at the Chester weather station.

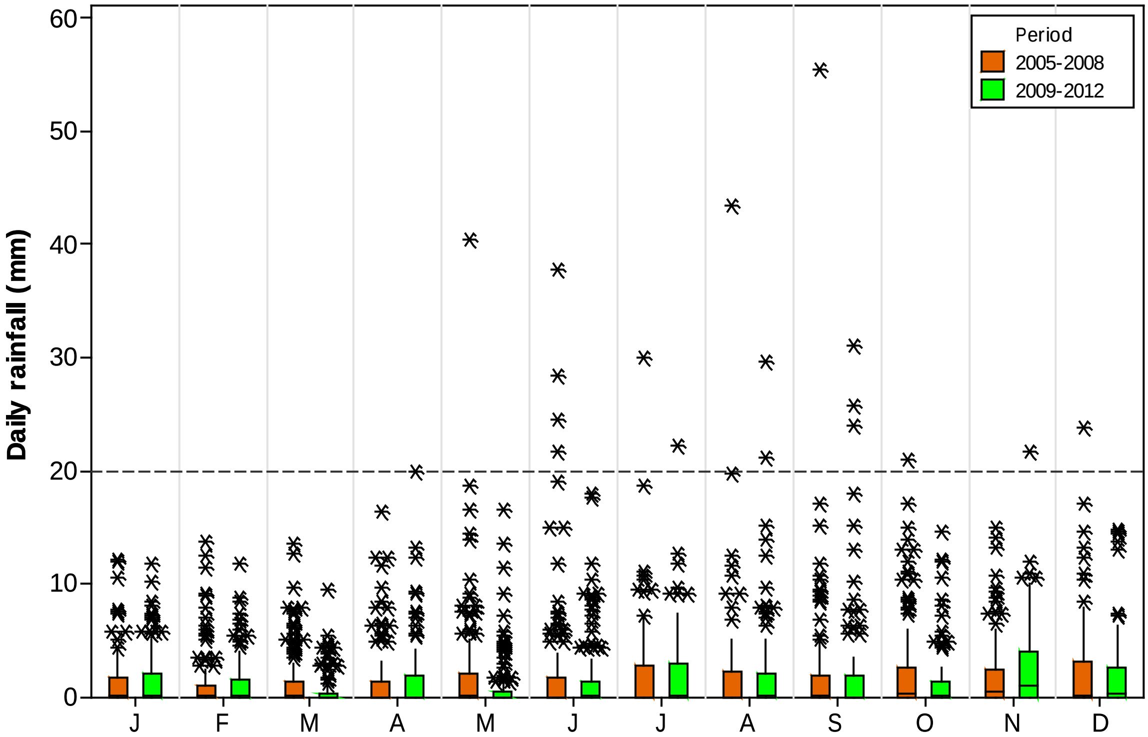

Figure 7.1: Daily rainfall totals by month at Chester weather station.

Two-sample t-tests revealed that there was no significant change ($p = 0.223$) in total monthly rainfall between the 2005-2008 and 2009-2012 periods. Additionally, similar tests showed no significant change ($p = 0.696$) in the proportion of days without any rainfall. Too few high rainfall events have occurred for robust comparisons to be made between periods. Table 7.1 summarises the rainfall at Chester for the two periods.

Table 7.1: Summary statistics for rainfall before and after sanitary survey

Period	Mean annual rainfall (mm)	% dry days	% days exceeding 20 mm	% days exceeding 10 mm
2005-2008	693.7	46.6	0.71	4.5
2009-2012	618.5	46.7	0.58	3.1

8. Microbiological Monitoring Results

Table 8.1 shows summary statistics for the shellfish hygiene data from the recommended monitoring points (RMPs) in Liverpool Bay. Due to the constant shifting of cockle beds in the area, there have been several RMPs that are no longer in use in Liverpool Bay (Figure 8.1).

No mussels have been sampled since the sanitary survey and none of the cockle RMPs included in analyses in the sanitary survey have been in use since the sanitary survey was written. This means that direct comparisons of *E. coli* levels before and after the survey were not possible. In order to carry out comparisons, a one-way ANOVA test was run including all data from 2006 onwards for all RMPs in Liverpool Bay which had more than 10 samples. This test revealed that there were no significant differences between any of the sites ($p = 0.341$). As there are no differences in sites that existed before and since the sanitary survey, this suggests that there has been no change in the level of *E. coli* taken up by bivalves in the area since the sanitary survey.

Table 8.1: Summary statistics for current and historical RMPs at Liverpool Bay

RMP	Species	No.	Date of first sample	Date of last sample	Geometric mean	Min.	Max.	% over 230	% over 4600
Hoylake (Sandhey Slipway)	Cockle	3	23/01/2006	27/11/2006	363.6	310	500	100.0	0.0
Hoylake	Cockle	11	16/01/2012	19/12/2012	464.0	40	9200	63.6	9.1
Leasowe North	Cockle	24	11/01/2010	13/12/2011	256.5	<20	24000	62.5	8.3
Leasowe South	Cockle	12	11/01/2010	25/01/2011	175.6	20	3500	41.7	0.0
North Wirral	Cockle	2	06/02/2010	22/02/2010	156.5	50	490	50.0	0.0
Harrison Drive East	Cockle	17	03/01/2011	19/12/2012	379.0	20	9000	76.5	5.9
Harrison Drive West	Cockle	10	03/01/2011	03/08/2011	526.2	170	2100	70.0	0.0
Leasowe Lighthouse	Mussel	46	23/01/2006	10/12/2010	349.6	<20	5400	65.2	2.2

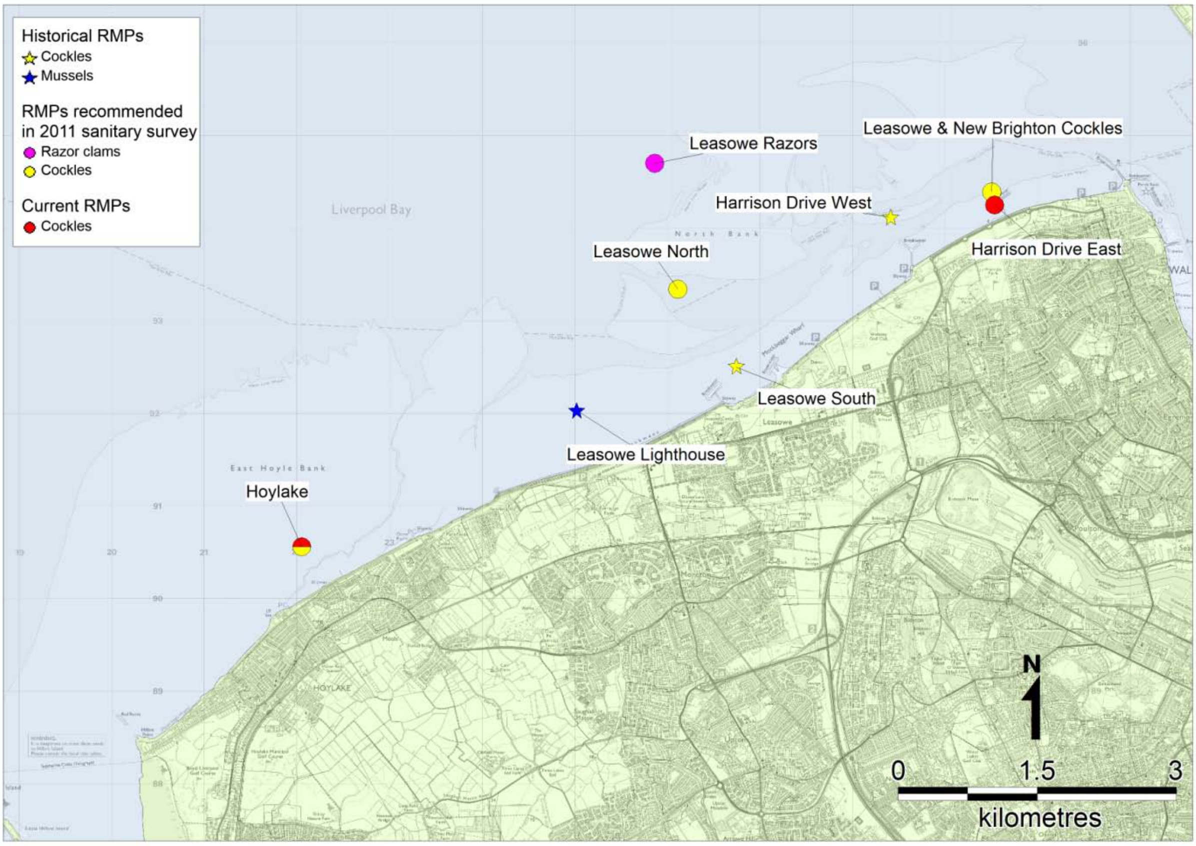

Figure 8.1: Current and historical RMPs in Liverpool Bay
(Current RMPs and those recommended by the sanitary survey have a 100 metre tolerance zone as shown by the extent of the points on the map.)

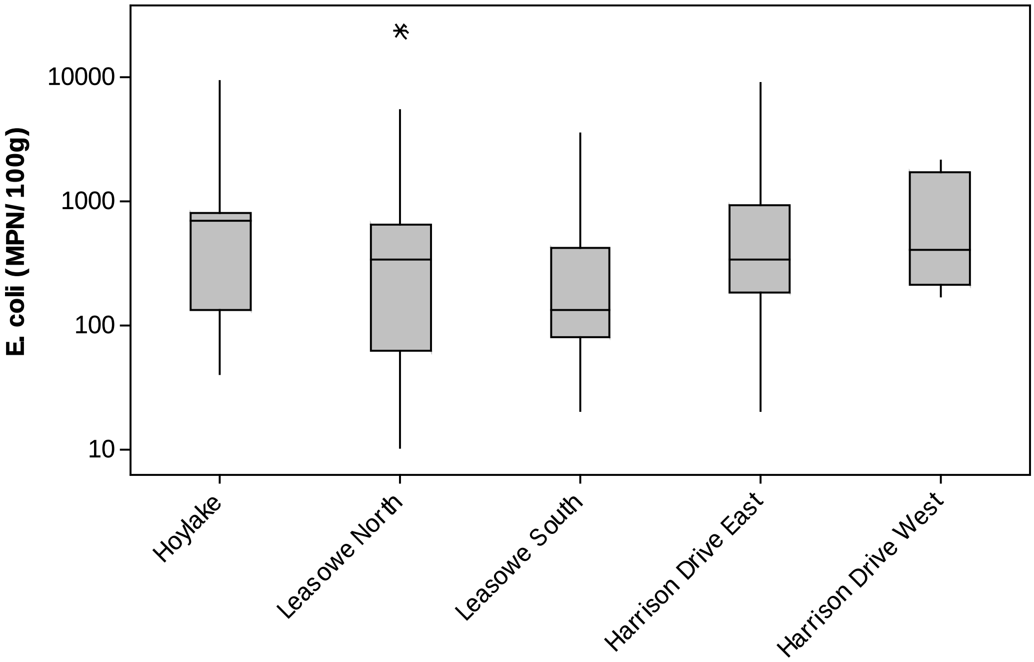

Figure 8.2: *E. coli* levels in cockles taken from RMPs in Liverpool Bay from 2006 to present.

9. References

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APPENDICES

APPENDIX I

Shoreline Survey

Date (time): 13 November 2012 and 6 March 2013

Applicant: Intershell

Cefas Officers: David Walker, Louise Rae

Local Enforcement Authority Officers:

Mark Davies (Wirral Borough Council, morning of 13/11/12 only)

Glyn Cavell (Mersey Port Health Authority, afternoon of 13/11/12 only)

Area surveyed: Wirral (northwest corner only)

Weather(wow.metoffice.gov.uk)**:**

13 November 2012 - Wind 258° 3.4 km/h, 14°C, Overcast

6 March 2013 – Wind 225° 6.1 km/h, 8.5 °C

Dry weather 48 hr before shoreline survey undertaken, 6 March 2013

Tidal predictions for Hilbre Island (Admiralty TotalTide):

Hilbre Island. Times GMT+0000. Predicted heights are in metres above chart datum.

13/11/2012			06/03/2013		
Low	04:18	1.36 m	Low	-	-
High	09:48	9.34 m	High	05:15	7.5 m
Low	16:37	1.33 m	Low	12:04	2.9 m
High	22:06	9.52 m	High	18:03	7.4 m

Objectives

The shoreline survey aims to locate potential sources of contamination previously unknown and document new information on the extent of the fishery and any changes in production. It also provides an opportunity to obtain sample of seawater and freshwater inputs to the area for bacteriological testing and confirm the location of previously identifies sources of potential contamination.

A full list of recorded observations is presented in Table I.1 and the locations of these observations are mapped in Figure I.2. Photographs referenced in are presented in Figure I.3 to Figure I.13

Water samples

Throughout the first survey on 13/11/2012, a total of nine water samples were taken. All of these were freshwater, most of which were from ground water pipes. However, the samples were received late by the laboratory and were not in an acceptable condition by the time they were received. An additional survey was undertaken on 06/03/2013 where a total of seven water samples were taken and measured for *E. coli* concentration as indicated in Table I.2. Most of the samples did not contain any *E. coli*, and those that did had relatively low levels. The outlet which had the highest *E. coli* loading (sample 1) contained 4,800 *E. coli*/100 ml and due to its low flow rate, had an *E. coli* loading of just 2.6×10^7 *E. coli* per day.

Description of Fishery

No direct observations of bivalves were made during the survey. Within the Dee estuary there are stocks of cockles (*Cerastoderma edule*) and mussels (*Mytilus spp.*). Along the north coast of the Wirral (Liverpool Bay), there are populations of cockles and razor clams (*Pharus legumen*). However the Wirral cockle beds are currently closed from 01/09/2012 until 30/04/2012[1] and the razor clam beds have not previously been classified.

Sources of contamination

Sewage discharges

According to the EA Permitting database[2], there are 3 sewer storm overflows along the shoreline survey route. Only one of these was observed (number 1 Figure I.2).

Freshwater inputs

Only one surface water source was observed. This ran through the salt marsh at West Kirby (point 7,Figure I.2). There were several groundwater outlets along the survey route. This is especially true of the north coast of the Wirral, where a large stretch (indicated in Figure I.2) had groundwater drainage pipes approximately every

[1] IFCA North Western, Notice of Closure WIRRAL COCKLE BEDS, August 2012

[2] EA Public Register Consented Discharges to Controlled Waters data, July 2012

60 metres. Along this stretch, part of the shoreline is protected by a concrete wall. Ground water was also observed seeping through this wall for much of its length (Figure I.1).

Figure I.1: Ground water seeping through sea defences along the north Wirral coast.

Wildlife

One moderately sized (~30 individuals) flock of birds was observed and one large flock (~200 individuals) at points along the survey route, however the numbers of birds present is likely to vary throughout the year due to migrations.

Several domestic dogs were seen throughout the area.

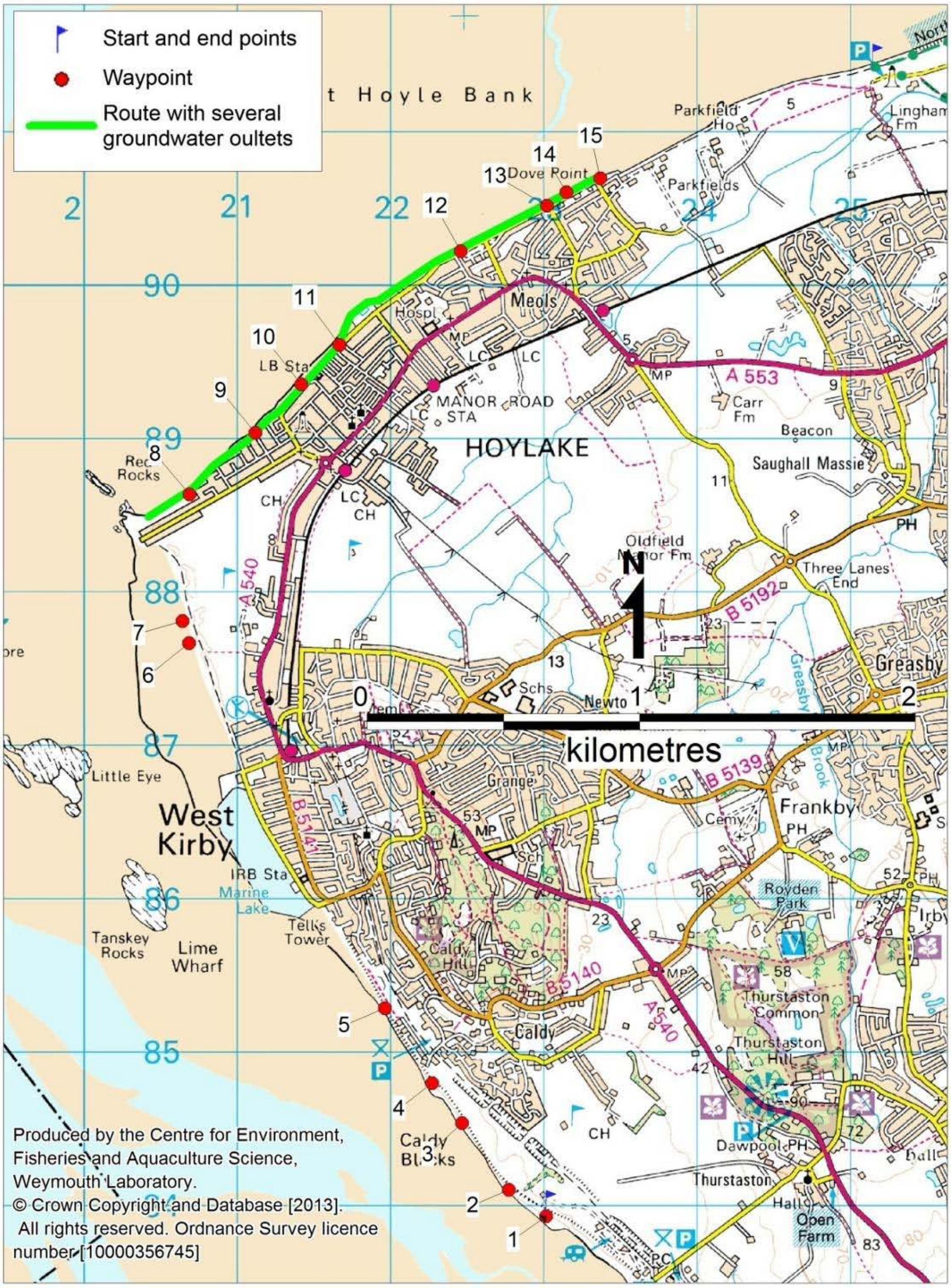

Figure I.2: Locations of shoreline observations for the north-western Wirral coast (see Table 1 for details)

Table I.1: Details of shoreline observations on 13/11/2012

No.	Date and time	NGR	Description	Image
1	13/11/2012 08:56	SJ 23013 83929	Probable sewerage over flow outlet from Long Hey road. Covered with boulders (193.2 m³/day)	Figure I.3
2	13/11/2012 09:05	SJ 22770 84102	Cotton buds	
3	13/11/2012 09:16	SJ 22466 84537	Groundwater from golf course	Figure I.4
4	13/11/2012 09:32	SJ 22269 84796	Groundwater from golf course (127.0 m³/day)	Figure I.5
5	13/11/2012 09:47	SJ 21961 85286	Dog walkers	
6	13/11/2012 10:42	SJ 20685 87665	Birds ~30, 50m 270°	Figure I.6
7	13/11/2012 10:49	SJ 20642 87810	Surface water in marsh (852.2 m³/day)	Figure I.7
8	13/11/2012 13:30	SJ 20688 88633	Groundwater pipes in wall (0.8 m³/day)	Figure I.8
9	13/11/2012 13:42	SJ 21116 89035	Groundwater pipe from garden	Figure I.9
10	13/11/2012 13:50	SJ 21417 89351	Groundwater pipes in wall (35.6 m³/day)	Figure I.10
11	13/11/2012 13:58	SJ 21666 89609	Groundwater pipes in wall	Figure I.11
12	13/11/2012 14:19	SJ 22456 90220	Groundwater pipes in wall (7.9 m³/day)	Figure I.12
13	13/11/2012 14:31	SJ 23018 90517	Large outlet pipe with grate (not flowing, sample taken from pool in front of grate)	Figure I.13
14	13/11/2012 14:39	SJ 23146 90603	Groundwater pipes in wall	
15	13/11/2012 14:42	SJ 23367 90695	Birds ~200, 50m 0°	

Table I.2: Details of samples taken on 06/03/2013

No.	No. from 13/11/2012	Date and time	Daily flow (m³/day)	*E. coli* per 100ml	*E. coli* per day
1	8	06/03/2013 14:57	0.5	4800	2.6×10^7
2	9	06/03/2013 14:46	1.3	0	0
3	10	06/03/2013 14:25		0	n/a
3	10	06/03/2013 14:30	27.5	0	0
4	12	06/03/2013 14:05	2.6	0	0
5	13	06/03/2013 13:45		25	n/a
6	14	06/03/2013 13:32		0	0

Conclusions

The results of microbiological analysis for samples collected on 06/03/2013 showed that the contribution of contamination from these sources to be very low under prevailing dry weather conditions. There are several ground water sources along the north coast of the Wirral. Considering the seepage of this ground water through the sea defences and the high frequency of outlet pipes, ground water in this area should be considered a diffuse source as opposed to a point source of contamination.

Figure I.3

Figure I.4

Figure I.5

Figure I.6

Figure I.7

Figure I.8

Figure I.9

Figure I.10


Figure I.11


Figure I.12

Figure I.13

APPENDIX II

Liverpool Bay Sanitary Survey Report 2011

EC Regulation 854/2004

CLASSIFICATION OF BIVALVE MOLLUSC PRODUCTION AREAS IN ENGLAND AND WALES

SANITARY SURVEY REPORT

Liverpool Bay

2011

Cover photo: Shellfish gathering at low tide on sandbanks off Leasowe.

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STATEMENT OF USE: This report provides information from a study of the information available relevant to perform a sanitary survey of bivalve mollusc classification zones in Liverpool Bay. Its primary purpose is to demonstrate compliance with the requirements for classification of bivalve mollusc production areas, determined in EC Regulation 854/2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption. The Centre for Environment, Fisheries & Aquaculture Science (Cefas) undertook this work on behalf of the Food Standards Agency (FSA).

CONSULTATION:

Consultee	Date of consultation	Date of response
Environment Agency	15/03/2011	16/11/2011
Local Enforcement Authority	15/03/2011	01/12/2011
Inshore Fisheries Conservation Authority	15/03/2011	01/04/2011

DISSEMINATION: Food Standards Agency, Mersey Port Health Authority, Environment Agency, North Western Sea Fisheries Committee.

RECOMMENDED BIBLIOGRAPHIC REFERENCE: Cefas, 2011. Sanitary survey of Liverpool Bay. 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 EC Regulation No. 854/2004.

CONTENTS

1. INTRODUCTION

1.1 LEGISLATIVE REQUIREMENT

Filter feeding, bivalve molluscan shellfish (e.g. mussels, clams, oysters) retain and accumulate a variety of microorganisms from their natural environments. Since filter feeding promotes retention and accumulation of these microorganisms, the microbiological safety of bivalves for human consumption depends heavily on the quality of the waters from which they are taken.

When consumed raw or lightly cooked, bivalves contaminated with pathogenic microorganisms may cause infectious diseases (e.g. Norovirus-associated gastroenteritis, Hepatitis A and Salmonellosis) in humans. Infectious disease outbreaks are more likely to occur in coastal areas, where bivalve mollusc production areas (BMPAs) are impacted by sources of microbiological contamination of human and/or animal origin.

In England and Wales, fish and shellfish constitute the fourth most reported food item causing infectious disease outbreaks in humans after poultry, red meat and desserts (Hughes *et al.*, 2007)

The risk of contamination of bivalve molluscs with pathogens is assessed through the microbiological monitoring of bivalves. This assessment results in the classification of BMPAs, which determines the level of treatment (e.g. purification, relaying, cooking) required before human consumption of bivalves (Lee and Younger, 2002).

Under EC Regulation 854/2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption, sanitary surveys of BMPAs and their associated hydrological catchments and coastal waters are required in order to establish the appropriate representative monitoring points (RMPs) for the monitoring programme.

The Centre for Environment, Fisheries & Aquaculture Science (Cefas) is performing sanitary surveys for new BMPAs in England and Wales, on behalf of the Food Standards Agency (FSA). The purposes of the sanitary surveys are to demonstrate compliance with the requirements stated in Annex II (Chapter II paragraph 6) of EC Regulation 854/2004, whereby 'if the competent authority decides in principle to classify a production or relay area it must:

(a) make an inventory of the sources of pollution of human or animal origin likely to be a source of contamination for the production area;

(b) examine the quantities of organic pollutants which are released during the different periods of the year, according to the seasonal variations of both human and animal populations in the catchment area, rainfall readings, waste-water treatment, etc.;

(c) determine the characteristics of the circulation of pollutants by virtue of current patterns, bathymetry and the tidal cycle in the production area; and

(d) establish a sampling programme of bivalve molluscs in the production area which is based on the examination of established data, and with a number of samples, a geographical distribution of the sampling points and a sampling frequency which must ensure that the results of the analysis are as representative as possible for the area considered.'

EC Regulation 854/2004 also specifies the use of *Escherichia coli* as an indicator of microbiological contamination in bivalves. This bacterium is present in animal and human faeces in large numbers and is therefore indicative of contamination of faecal origin.

In addition to better targeting the location of RMPs and frequency of sampling for microbiological monitoring, it is believed that the sanitary survey may serve to help to target future water quality improvements and improve analysis of their effects on the BMPA. Improved monitoring should lead to improved detection of pollution events and identification of the likely sources of pollution. Remedial action may then be possible either through funding of improvements in point sources of contamination or as a result of changes in land management practices.

This report documents the information relevant to undertake a sanitary survey for wild cockles (*Cerastoderma edule*), mussels (*Mytilus* spp.) and razors (*Ensis* spp.) harvested at Liverpool Bay together with new information obtained from a shoreline survey undertaken in the area.

1.2 Site Description

North Wirral Coast

The Wirral peninsula is a promontory of approximately 12 km in width that lies between the estuaries of two major rivers; the River Mersey to the east and the River (Welsh) Dee to the west. The Mersey estuary is heavily urbanised whereas the Dee has a more rural aspect. The north shoreline of the Wirral consists of intertidal sand and mud flats which extend about 2.5 km from MHWS to MLWS and support wild populations of cockles, mussels and razors (*Ensis* sp.). The shoreline is exposed to the open waters of Liverpool bay to the north-west and the tidal range here is large and sediments on this shore are mobile. There are extensive sea defences which include sea walls to prevent flooding and coastal erosion, and a number of breakwaters which are designed to stabilize the beaches by encouraging the deposition of sediment. The towns of Hoylake & Meols lie at the western end of this stretch of the coast, and the town of New Brighton lies at the eastern end. At the eastern end of Meols there is a holiday park. Between these settlements are Leasowe common and a golf course, to the south of which lies the town of Leasowe.

Figure 1.1 Features of the north Wirral coast.

Catchment

The river catchments draining to the area are shown in Figure 1.2.

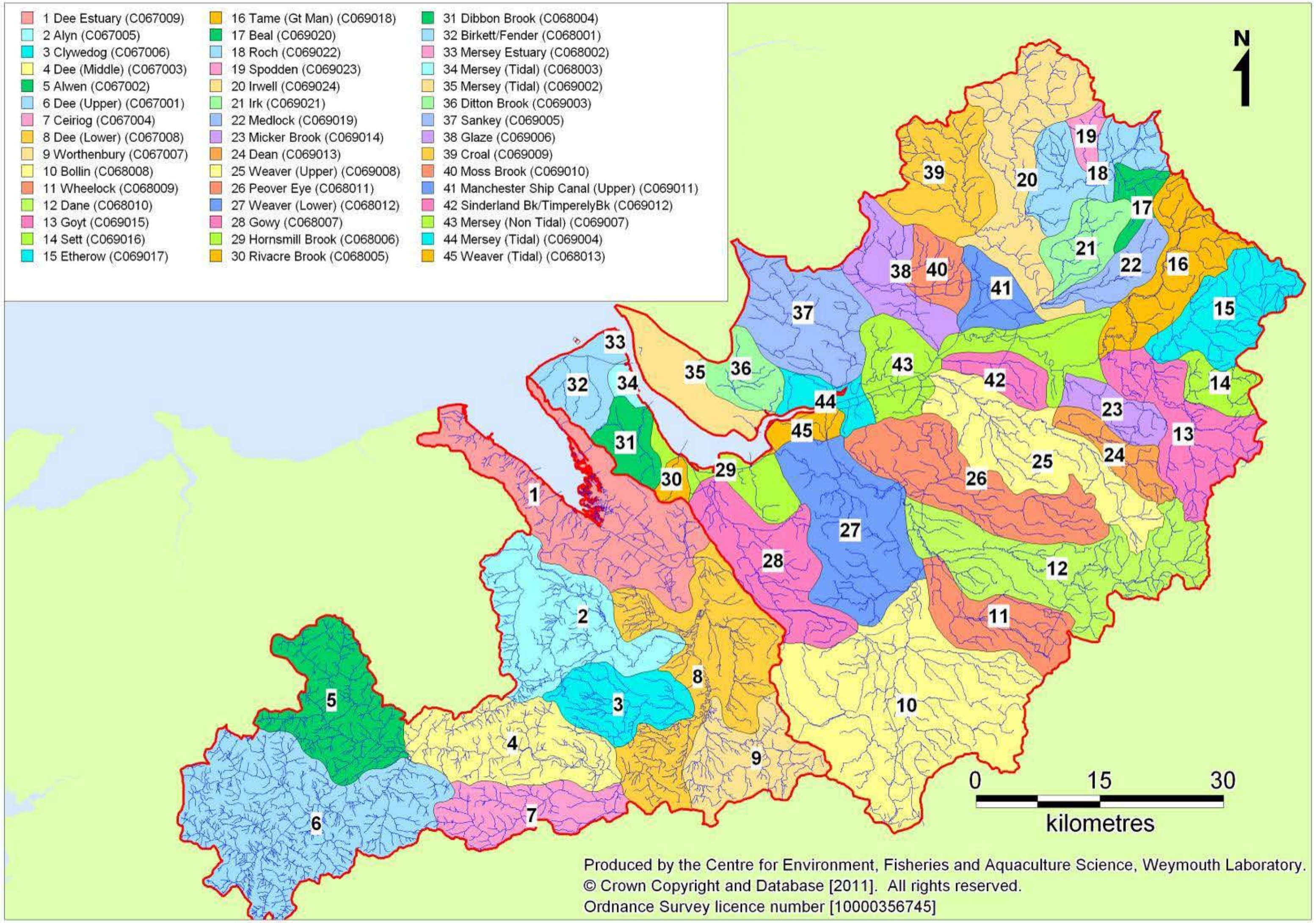


Figure 1.2 Location of catchments draining either side of the Wirral peninsula.

The Mersey estuary has a catchment area of about 4,305 km^2, and includes the major conurbations of Greater Manchester and Liverpool. As well as the River Mersey itself, there are a number of other smaller rivers such as the Weaver and the Gowy draining to the Mersey estuary. The Dee estuary has a catchment area of about 2,130 km^2, and whilst the conurbations of Chester and Wrexham lie within this area it is generally much more rural in character. There are no watercourses discharging directly to the north shore of the Wirral.

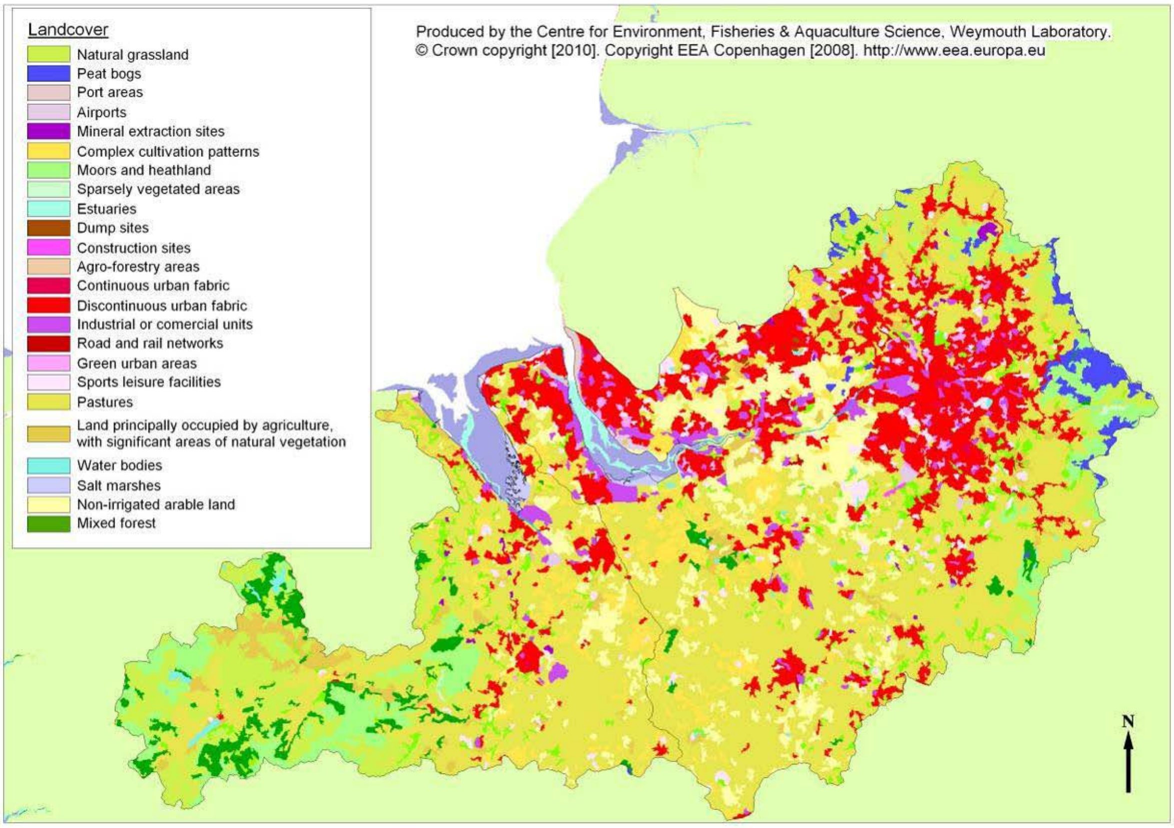


Figure 1.3 Land cover in the catchments draining either side of the Wirral peninsula.

Different land cover types will generate differing levels of contamination in surface runoff. Highest faecal coliform contributions arise from developed areas, with intermediate contributions from the improved pastures and lower contributions from the other land cover types (Kay *et al*. 2008a). The contributions from all land cover types would be expected to increase significantly after marked rainfall events, particularly for improved grassland which may increase up to 100 fold.

The Mersey estuary catchment area has diverse land cover types, with the northern half including the Wirral peninsula largely urban, and the southern half largely pastures. There are significant areas of docks and industry bordering the estuary. Most of the catchment is low lying, although it does rise to over 600 m elevation at its eastern extremity. Soil permeability is moderate to high throughout most of the area with the notable exception of the Weaver catchment the soils of which are mostly of very low permeability (NERC, 2010a). It must also be noted that although underlying soils may be highly permeable, high levels of runoff are expected from urban areas due to the extensive areas of hard standing.

There are significant areas of pasture throughout the Dee catchment. Urban and industrial areas are mainly located within the lower catchment, although these are much less extensive than those found within the Mersey catchment. There are large natural areas within the upper catchment (moors, grassland and forest). This relatively distinct division is also seen in soil types and elevations, with impermeable soils and a hilly landscape rising to over 800 m within the upper catchment, and more permeable soils and a low lying and flatter landscape in the lower catchment (NERC, 2010a).

2. SHELLFISHERIES

2.1 SPECIES, LOCATION AND EXTENT

This sanitary survey was prompted by an application for classification of a wild cockle (*Cerastoderma edule*) bed in the vicinity of Leasowe in June 2010 by the North Western Inshore Fisheries Conservation Authority (NW IFCA). A classification was subsequently awarded for the limited area in which the Leasowe bed is located in mid November 2010 on the basis of sampling results from a bacteriological survey. Classifications for further cockle beds at Dove Point and the western end of New Brighton were requested by Mersey Port Health Authority and the NW IFCA in late 2010 and early 2011. A larger area of the same shore is currently classified for the harvest of mussels. There are also extensive razor beds (*Ensis sp.*) towards MLWS at Leasowe, extending into the sub-littoral. The approximate extent of these beds is presented in Figure 2.1, based on information provided by the NW IFCA and Mersey PHA and observations made during the shoreline survey.

At the time of shoreline survey, the standing stock biomass of cockles within the Leasowe bed was estimated by NW IFCA to be in the region of 700 tonnes, almost exclusively originating from the 2009 spatfall. Growth of cockles here is rapid, particularly towards the outer (offshore) edge of the bed. At the time of shoreline survey densities were in the region of 15 kg/m^2 towards the centre of the bed. Also noted during the shoreline survey was the presence of a significant spatfall from 2010 in the inshore region of the bed.

The cockle bed at Dove Point is formed from the 2010 spatfall, and is less dense than the Leasowe bed. Stock here will be of a harvestable size by the opening day of the next season (September 2011). The presence of patches of cockles at a viable commercial density off New Brighton was discovered by harvesters working the Leasowe bed. There is believed to be a discrete patch off Harrison Drive, and sufficient stock for sampling as far east as the second New Brighton breakwater. Further east the substrate becomes less suitable for cockles. Again, a significant spatfall occurred throughout this area in 2010.

A large part of the north Wirral foreshore is currently classified for mussels. The approximate location of the mussel bed from past records held at Cefas is indicated on Figure 2.1. Since the time this information was gathered stock levels have deteriorated and remaining stock within the classification zone consists only of a small amount of mussels on the sea defences by Leasowe Lighthouse, which are of no commercial interest. It is believed unlikely that significant stocks will regenerate here in the foreseeable future (NW IFCA, personal communication), so continued classification of the area is not necessary for this species.

The razor beds cover a large area between off the Wirral from Mockbeggar Wharf through to the western end of the Wallasey Embankment, most of which is not uncovered by the tides. Razors may be found in depths of up to 40m in suitable conditions (Tebble, 1966), so potentially may extend throughout the majority of Liverpool Bay, to over 10km offshore. The exact location and extent of the razor beds below the low water mark are uncertain, but the hand gathering fishery is restricted to areas uncovered by the tides. The extent of the intertidal razor beds which are accessible to hand gatherers are shown on Figure 2.1 (NW IFCA, personal communication). During the shoreline survey around 15 individuals were seen gathering razors here (cover photograph). Whilst this is believed to largely be casual gathering for personal use is possible that some may be sold on.

There is interest in commercial exploitation of razors in the wider Liverpool Bay via a dredge fishery (NW IFCA, personal communication), and once surveys have established the extent of these stocks and whether there are commercial densities present it is likely that an application for hygiene classification will be submitted.

2.2 Growing Methods and Harvesting Techniques

All stocks here are wild, and are hand gathered from intertidal areas.

2.3 Seasonality of Harvest, Conservation Controls and Development Potential

The cockle fishery in this district operates a closed season running from 1st May to 31st August to protect settling spat. There is no closed season for mussels or razors. Statutory minimum landing sizes apply to cockles (20mm), mussels (45mm) and razors (100mm).

Gear limitations (hand gathering only) apply to the cockle fishery, limiting levels of exploitation, and preventing the use of techniques more destructive to the stocks and the habitat such as dredging.

The cockle bed off Leasowe lies between 1.5m and 3m above chart datum and so the beds will be fully accessible on about 30% of tides, and partially accessible on about 70% of tides, limiting the time windows in which the stock can be exploited to some extent. The Dove Point cockle bed is higher above chart datum so would be accessible for exploitation over larger windows. The beds at New Brighton are generally the least accessible of all.

Both cockles and mussels are a public fishery and anyone is allowed to take up to 5 kg of each species per calendar day. Greater (commercial) quantities can only be taken by Licenced operators. Permits are issued by the NW IFCA, allowing exploitation of cockle and mussel beds within the entire district. Around 450 permits are currently issued (NW IFCA, personal communication). Licenced fishing effort on the Leasowe cockle bed once classified was high due to the high stock density and ease of access, and most sizeable stock has now been taken from this bed. The razor fishery is not covered by the shellfish permit system, and casual gatherers may take any quantity provided it is for personal consumption only.

Cockle stocks are likely to fluctuate in their size and distribution within the area. Success of spatfalls may vary greatly between years, and storms, temperature extremes, diseases, predation and of course exploitation can all affect them,

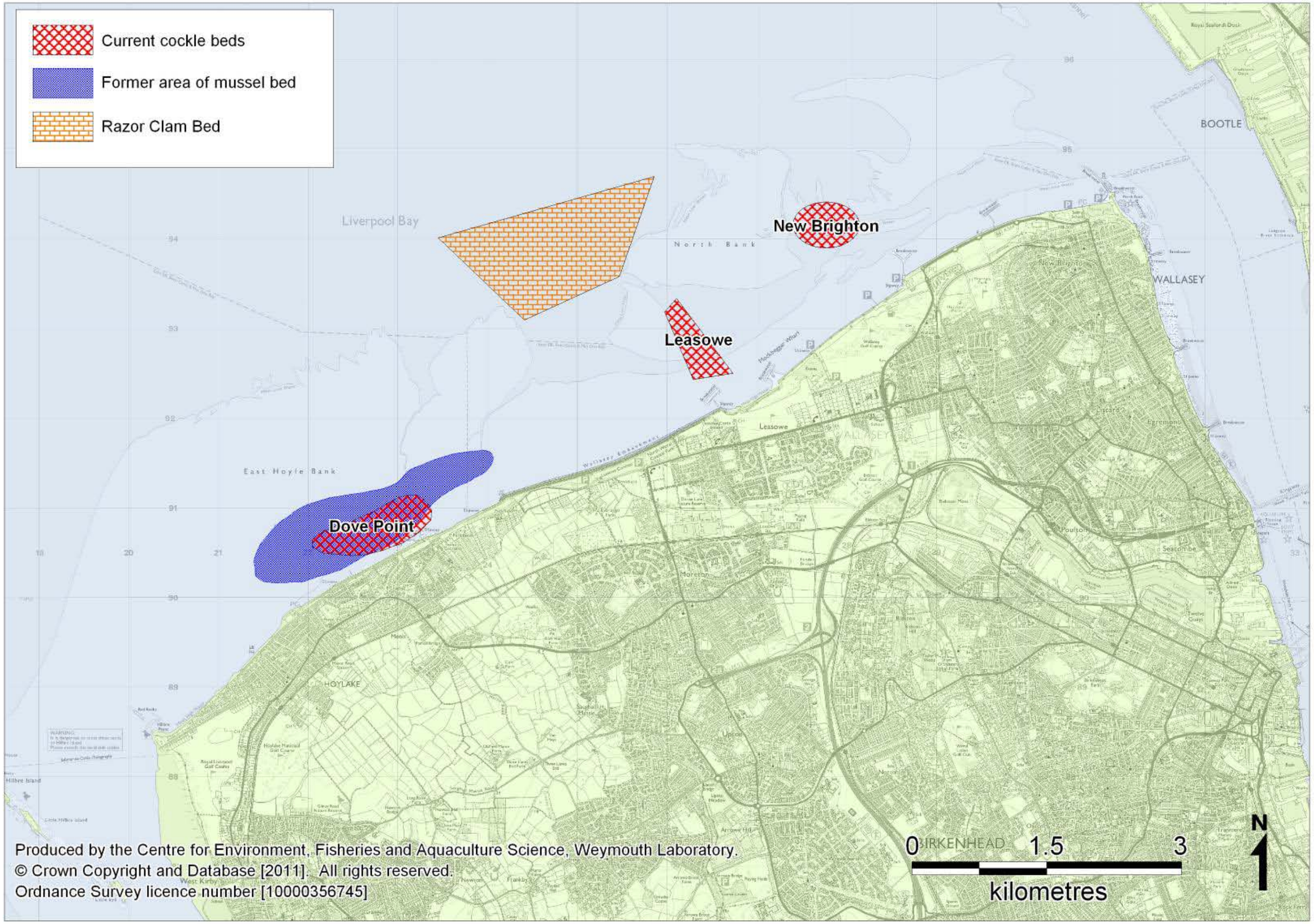


Figure 2.1 Approximate location of bivalve mollusc beds at Liverpool Bay-Wirral.

and mass mortalities may occur at times. The beds at Leasowe are thought to be relatively resilient to wave action as they lie in a small depression inshore of a raised sandbank and so are covered with a sufficient depth of water to offer them some protection from breaking waves by the time the tide has covered the sandbank. The applicant advised that cockle beds in the area are subject to significant bird predation during the winter months, more so towards the inshore limits of the bed which are exposed for a larger proportion of the tide. A study carried out in north Wales found that bird predation on cockle beds had a significant influence on population structure, and mainly occurred from mid to high shore levels (Sanchez-Salazar *et al*., 1987). The health / disease status of the cockle beds are not known.

It is anticipated by the applicant that commercially exploitable patches of cockles may appear anywhere from Leasowe to the second New Brighton breakwater. Their distribution is likely to change annually in steps based on the extent of the preceding spatfall. Therefore, at the start of each new season in September the size and location of the exploitable beds are likely to be significantly different from the start of the previous season. The Dove Point cockle bed has re-established in an area previously supporting cockle beds but subsequently denuded. It is likely that the extent of this cockle bed will also change significantly each season. Indeed, further patches may appear anywhere along the entire North Wirral coast where conditions are suitable.

Mussels on sandy substrates, such as that of the north Wirral foreshore, anchor to any hard surfaces (generally each other) to form areas of slightly raised beds, the locations of which are relatively stable over time, although they are subject to erosion by fishing, predators, or storms, and replenishment by spatfalls. Dare *et al* (2004) concluded in a study of mussel stocks in the Wash, that the dependence of spatfall on the presence of adult stocks as a settlement surface means that once the beds became depleted (as has occurred on the north Wirral foreshore) it was difficult for them to re-establish.

Razor stocks are believed to be maintained to some extent by the inshore movement or displacement of inaccessible stocks from below the low water mark. Access to the razor stocks is limited to low water on spring tides.

2.4 HYGIENE CLASSIFICATION

Table 1.2 Historical classifications of bivalve molluscs at Liverpool Bay – Wirral.

Bed name	Bed ID	Species	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
North Wirral (Meols and Hoylake)	B058F	Cockles			B	B	B	B	B	B	B	B	B	B	B	B-LT	B [1&4]	DC	n/c		
All other beds (except Crosby)		Cockles	B	B																	
Moreton & Leasowe	B058D	Mussels				C[1]	B[1]	B[1]	B	B	B	B	B	B	B	B-LT[4]	B-LT	B-LT	B-LT	B-LT	B-LT
Leasowe cockles	B058P	Cockles																			B[1]

** - seasonal classification applies.*
1 - Classification was provisional due to insufficient sample results, either in number or period of time covered.
4 – Area classified at higher level due to results close to the tolerance limit. A downgrade may be possible if further failures are returned.
LT - Long-Term classification system applies. N.B. Long-Term (LT) classification system was introduced in England and Wales alongside the annual classification system, and applies to class B areas only. New class B areas will initially be given annual classification until they meet criteria for a long-term classification.

Table 1.3 summarises the post-harvest treatment required before bivalve molluscs can be sold for human consumption.

Table 1.3 Criteria for classification of bivalve mollusc production areas.

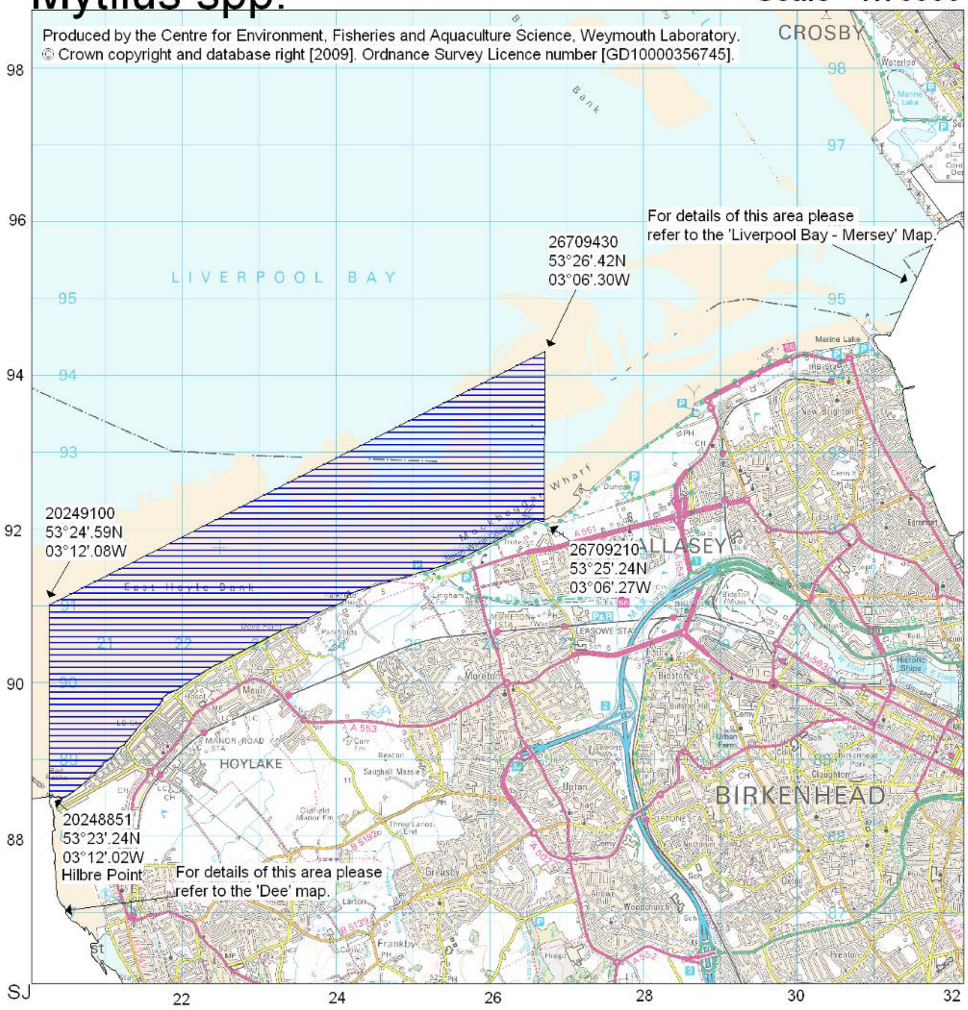
Class	Microbiological standard[1]	Post-harvest treatment required
A[2]	Live bivalve molluscs from these areas must not exceed 230 Most Probable Number (MPN) of *E. coli* $100g^{-1}$ Fluid and Intravalvular Liquid (FIL)	None
B[3]	Live bivalve molluscs from these areas must not exceed the limits of a five-tube, three dilution MPN test of 4,600 *E. coli* $100g^{-1}$ FIL in more than 10% of samples. No sample may exceed an upper limit of 46,000 *E. coli* $100g^{-1}$ FIL	Purification, relaying or cooking by an approved method
C[4]	Live bivalve molluscs from these areas must not exceed the limits of a five-tube, three dilution Most Probable Number (MPN) test of 46,000 *E. coli* $100g^{-1}$ FIL	Relaying for, at least, two months in an approved relaying area or cooking by an approved method
Prohibited[6]	>46,000 *E. coli* $100g^{-1}$ FIL[5]	Harvesting not permitted

[1] The reference method is given as ISO 16649-3.
[2] By cross-reference from EC Regulation 854/2004, via EC Regulation 853/2004, to EC Regulation 2073/2005.
[3] From EC Regulation 1021/2008.
[4] From EC Regulation 854/2004.
[5] This level is not specifically given in the Regulation but does not comply with classes A, B or C. The competent authority has the power to prohibit any production and harvesting of bivalve molluscs in areas considered unsuitable for health reasons.
[6] Areas which are not classified and therefore commercial harvesting of LBMs cannot take place. This also includes areas which are unfit for commercial harvesting for health reasons e.g. areas consistently returning prohibited level results in routine monitoring and these are included in the FSA list of designated prohibited beds

Current classification zone boundaries for the two currently classified beds on the north Wirral shore are shown in Figure 2.2. Harvesting is prohibited for health reasons in the outer Mersey estuary following three consistently high results in cockles, one of which exceeded 46,000 *E.coli* from initial monitoring in 1993. There are several classified areas within the Dee estuary for cockles and mussels, with most parts classified either B or C, but there is one area which is designated as prohibited from commercial harvesting (again, for health reasons).

Liverpool Bay - N. Wirral - Mytilus spp.

Scale - 1:75000



Classification Zones: Class A, Class B, Class C, Prohibited, LT Class B

Classification of Bivalve Mollusc Production Areas: Effective from 1 September 2009

The areas delineated above are those classified as bivalve mollusc production areas under EU Regulation 854/2004.

Further details on the classified species and the areas may be obtained from the responsible Food Authority. Enquiries regarding the maps should be directed to: Shellfish Microbiology, CEFAS Weymouth Laboratory, Barrack Road, The Nothe, Weymouth, Dorset DT4 8UB.
(Tel: 01305 206600 Fax: 01305 206601)

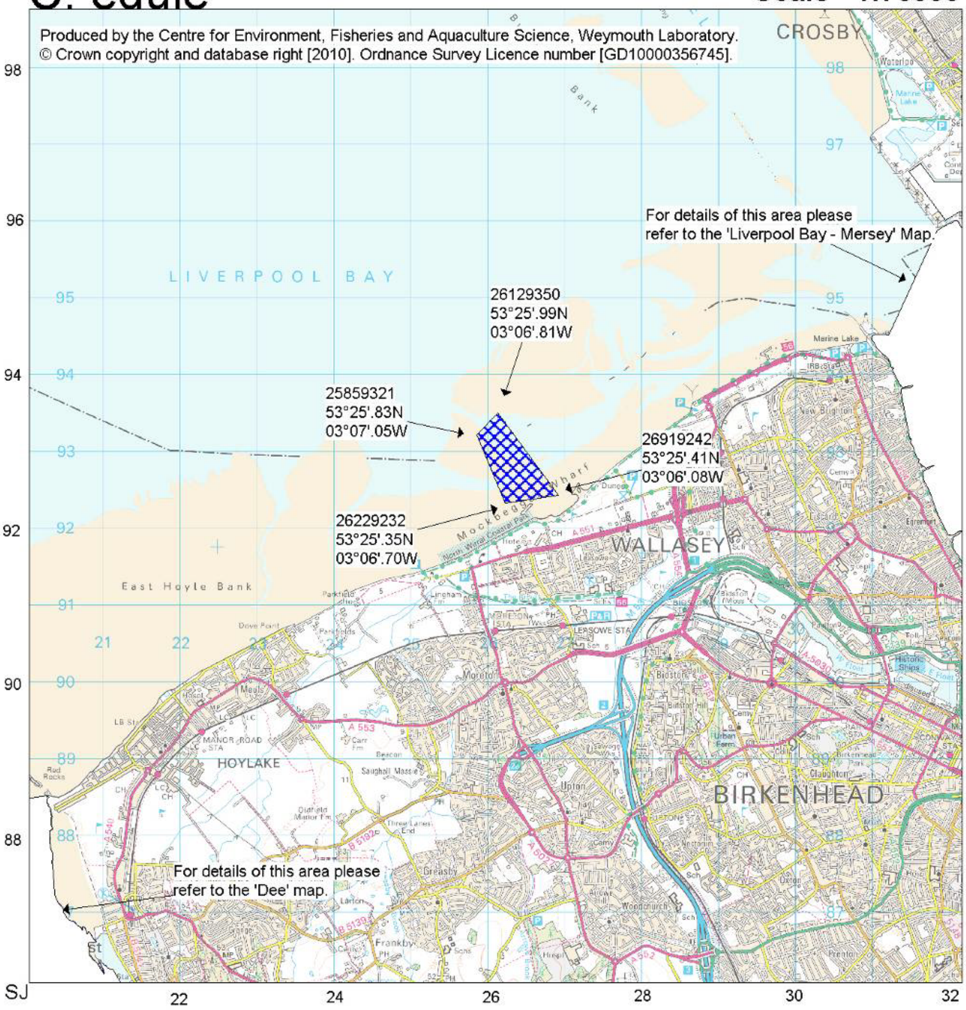
N.B. Lat/Longs quoted are WGS84

Food Authority: Mersey Port Health Authority

Figure 2.2 Classification zones and current classification status for mussels at Liverpool Bay-Wirral.

Liverpool Bay - N. Wirral - C. edule

Scale - 1:75000



Classification Zones:	Class A	Class B	Class C	Prohibited
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N.B. Lat/Longs quoted are WGS84
Separate map available for Mytilus spp. at Liverpoll Bay - N. Wirral

Food Authority: Mersey Port Health Authority

Figure 2.2 Classification zones and current classification status for cockles at Liverpool Bay-Wirral.

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, summarised from supporting information in the previous sections and the Appendices. Its main purpose is to inform the sampling plan for the microbiological monitoring and classification of the bivalve mollusc production area (BMPA) in this geographical area.

SHELLFISHERIES

Cockle beds are known to exist at Leasowe, Dove Point and New Brighton. Further as yet undiscovered patches may exist, and in the future, expoitable patches may appear anywhere along the North Wirral shore where suitable conditions exist. The environment supports rapid growth, with the currently exploitable stock at Leasowe originating almost entirely from the 2009 spatfall. Evidence of a significant 2010 spatfall was noted at Leasowe during the shoreline survey. Therefore, the location of commercially viable beds is likely to change on an annual basis dependent the previous spatfall. The NW IFCA are likely to be able to advise on the extent of the beds through stock surveys and observations of areas being exploited.

There are several approaches which may be taken to defining the location of the production area boundaries and the RMP for these mobile shellfish beds. These include;

1. classifying a larger zone which covers the wider area into which the bed may expand with a fixed RMP to which stock may be transplanted for sampling, or
2. resetting the RMP(s) and classification zone boundaries during each closed season on the basis of the actual location of the beds, or
3. classifying the wider area and sampling moveable RMP(s) (within one or more identified zones) situated where stock is present at the location within this area likely to be most heavily contaminated.

The first option, whilst being highly protective of public health is likely to suffer from practical issues associated with transplanting and recovering stock from the RMP. The second option allows the RMP to be located in the most contaminated part of the actual beds, but would require annual input from NW IFCA and Cefas and would restrict the harvestable area to known patches, so any newly discovered patches would fall outside classified areas. The third option would allow monitoring in the most appropriate location(s) where stocks are present to be sampled, would not require periodic revision to boundaries, but requires the RMP to be resited periodically as new patches appear and disappear, which may complicate the interpretation of results for the purposes of classification. It also relies on up to date information on where stocks are present, which would be based on ongoing intelligence gathering by Mersey PHA and NW IFCA on where exploitation is occurring, and periodic stock surveys undertaken by NW IFCA.

On balance, the third option is believed to be most appropriate, as it allows the entire area to be classified giving the flexibility to exploit new patches as they are discovered, and allows the RMP to be situated at the point considered most vulnerable to contamination where stocks are present. If upon repositioning of the RMP levels of contamination are detected which breach classification thresholds, the competent authority will be automatically alerted as soon as the result is generated and so will be able to pursue an appropriate course of action. Currently, there are sufficient stocks for sampling purposes off both Breakwaters at New Brighton.

The NW IFCA advise that there are no commercial quantities of mussels on the north Wirral foreshore at present, and they are unlikely to re-establish in the foreseeable future. Therefore the continued classification of the area for this species is not necessary, and they will not be considered further in this assessment. Should a significant mussel spatfall occur and commercial interest is rekindled, there should be sufficient time for reclassification of the area before the stock attains a harvestable size.

Also on the north Wirral coast there are significant areas of razor beds, mainly located below MLWS. These are exploited down to the low water mark, mainly by casual gatherers, although it is possible that some are sold on. Therefore, recommendations for classification monitoring of these species will be made in this report, which can then be applied should formal commercial interest be expressed or if Mersey PHA otherwise decide it is appropriate to classify this species in the future.

POLLUTION SOURCES

FRESHWATER INPUTS

Whilst there are no watercourses discharging to the north shore of the Wirral peninsula, two major catchments drain to either end of this shoreline, and these are the two main hydrological connections between terrestrial sources of contamination and the shellfishery. The Mersey estuary to the east receives runoff from a heavily urbanised catchment area of about 4,305 km^2 via two large rivers (the Mersey and the Weaver) and a number of other small to medium sized watercourses. The Dee estuary to the west has a more rural catchment with an area of about 2,130 km^2, almost all of which is drained by the River Dee On average, freshwater inputs to the Mersey estuary are nearly double those to the Dee estuary. River discharges are generally higher during the winter, but high flow events have been recorded in most months of the year. Discharge from the River Dee is more variable than for the Mersey and Weaver. Contamination from sources in the upper catchments of these large rivers is likely to be of little importance to the North Wirral shore as transit times to the estuaries are likely to be in the order of several days, so significant die-off of indicator bacteria is expected.

Given the larger area of the Mersey estuary catchment and its more extensive urbanised areas, which will tend to produce more heavily contaminated runoff than rural areas, greater overall *E. coli* loadings may be expected from land runoff from this catchment than the Dee. This is likely to result in higher loadings of faecal indicator bacteria entering the Mersey estuary compared to the Dee estuary. Therefore, higher levels of contamination from land runoff may generally be expected within shellfish most influenced by the outflow from the Mersey estuary. Although lower levels of contamination are expected within the influence of the Dee estuary, levels of contamination within this body of water are nevertheless expected to be considerably higher than in the open waters of Liverpool Bay.

HUMAN POPULATION

The catchment of the Mersey estuary is densely populated, with a total resident human population of approximately 4.5 million in 2001. A large proportion reside in the metropolis of Greater Manchester, but large conurbations also line the shores of the outer Mersey estuary at Liverpool and Birkenhead. The resident population within the Dee estuary catchment was considerably lower at approximately 0.5 million in 2001, and population densities on the shores of the Dee estuary were relatively low. Therefore, sewage inputs to the Mersey estuary and the rivers discharging to it are likely to be considerably higher than those to the Dee estuary.

Visitors to the area will increase the amount of sewage discharged, so overall volumes may be higher during the summer months. This seasonality is likely to be less acute for the large discharges serving the cities of Greater Manchester and Liverpool, which attract a high proportion of visitors to the region but where attractions are more of a cultural nature. It is likely to be strongest for discharges serving areas such as the Wirral and the Dee estuary where many attractions are outdoors.

SEWAGE DISCHARGES

The Mersey estuary receives about 10 times the (dry weather) bacterial loading from continuous sewage discharges than the Dee estuary receives (estimated at 1.8×10^{15} and ~1.3×10^{14} faecal coliforms/day respectively). Therefore it is expected that the Mersey estuary is significantly more contaminated that the Dee. In addition, there is a UV treated discharge to Liverpool Bay from the Meols STW which produces an estimated loading of ~2.6×10^{11} faecal coliforms/day. Although it lies closer to some of the shellfish beds compared to two of the much larger secondary treated discharges to the Mersey, impacts from this discharge are thought to be of less significance compared to those within the outer Mersey as it generates a much lower bacterial loading. Testing results indicate that the bacteriological quality of the final effluent from this STW does fluctuate significantly, with the 95 percentile falling about an order of magnitude higher than the geometric level of faecal coliforms in the effluent, so increased impacts from this discharge will arise from time to time.

In addition to these continuous sewage discharges, there are a large number of intermittent discharges within the area, again mainly to the Mersey and to a lesser extent the Dee. Four are located along the north Wirral shore, three discharging to the shoreline, and one at the same location as the main Meols STW outfall. Aside from the New Brighton overflow discharge, which spills very infrequently if at all, data on storm overflows was unavailable at the time of writing, so it is difficult to assess their impacts. Rainfall in the area is higher on average in October and November, and the majority of high rainfall events occur between May and October, so overflow spills may be more likely to occur at these times. Sanitary related debris was observed during the shoreline survey between Meols and New Brighton suggesting spills of untreated sewage occur in the area, but it did not appear to be of recent origin so may have come from farther afield. Overall, more and larger sources of sewage lie to the east of the north Wirral shoreline, so if these do result in spatial variation in levels of contamination across this stretch, the eastern end will be more heavily impacted. The Meols STW discharge is likely to be of most significance at the razor bed off Leasowe.

AGRICULTURE

Livestock numbers are fairly similar within the Dee and Mersey estuary catchments, but densities are higher in the Dee catchment, so higher concentrations of faecal indicators may be expected in freshwater inputs to the Dee estuary on this basis. Based on numbers a similar overall bacterial loading from livestock may be expected between the two however. In the Mersey estuary catchment, humans outnumber livestock and outnumber grazing animals by almost an order of magnitude. Within the Dee catchment, grazing livestock numbers are almost double that of the human population. Therefore, a higher proportion of faecal indicator bacteria within the Dee estuary are likely to be of livestock origin, so any seasonal or rainfall related fluctuations in bacterial loading from livestock will be more noticeable here. Seasonal patterns of variation in livestock inputs may be expected within both these catchments, with highest bacterial loadings expected from pastures following high rainfall events in the summer when stock numbers are highest, or in localised areas where slurry has been spread before heavy rain. In terms of the sampling plan, agricultural influences are expected to be of more significance in areas impacted by ebb flows from the Dee, but are believed to be minor in relation to sewage discharges from Merseyside.

BOATS

The Port of Liverpool handles very large volumes of commercial shipping, and a much smaller deepwater port is located at Mostyn in the Dee estuary. Commercial shipping is no longer allowed to discharge wastewater overboard in coastal waters, and does not venture near the shellfish beds so is not expected to be a significant contaminating influence.

Smaller vessels such as yachts, pleasure craft and fishing vessels are more likely to make overboard discharges, particularly those in overnight occupation with on board toilets. Areas of moorings are present off West Kirby, Meols and in the mouth of the Mersey. The moorings at Meols are at approximately the same location as the cockle bed at Dove Point, so highest potential for contamination from overboard discharges may be expected here. However, as these the numbers of boats here in overnight occupation are likely to be small, impacts from these on the shellfish beds are likely to be minor if any, with the possible exception of Dove Point. The spatial profile of impacts here will depend on exactly which boat if any makes overboard discharges, and this is not possible to predict. It is probable that there are more occupied small vessels in the area during the summer months. Small craft may discharge closer to the cockle beds while *en route*, but the timing, location and frequency of such occurrences, aside from a probable seasonal fluctuation, is difficult to predict. Therefore it is concluded that boats and shipping have no material influence on the sampling plan.

WILDLIFE

The North Wirral coast, and neighbouring Dee and Mersey estuary support large overwintering populations of waterbirds. Previous studies have found significant concentrations of microbial contaminants including faecal coliforms in intertidal sediments in similar UK environments supporting large seabird communities. About 3,000 birds, mainly waders, are believed to forage on the cockle bed at Leasowe during the autumn and winter, and other cockle beds are also likely to represent a food source to these birds. At other times of the year, gulls and waders do forage in the area, but in much smaller numbers. Therefore, birds are likely to be a significant contaminating influence on the shellfish beds during the winter months in particular. Contamination from these is deposited directly on the shellfish beds, so high levels of contamination may be found on the sediment here, but its spatial distribution is likely to be somewhat patchy, although not in a predictable way. There is some evidence to suggest that these birds tend to forage more towards the inshore areas, so an RMP on the inshore edge of the beds may be more effective at capturing contamination from this source.

There is a grey seal colony at Hilbre Island at the mouth of the Dee estuary where numbers can exceed 500 during the summer. They are likely to forage widely throughout Liverpool Bay, and so potentially represent a minor diffuse source of pollution to the beds but any impacts will be unpredictable spatially and so will have no influence on the sampling plan. No other wildlife species of potential significance were identified.

DOMESTIC ANIMALS

Observations made during the shoreline survey indicate that the North Wirral shoreline is heavily used by dog walkers, with horse riders also using the area to a lesser extent. These animals constitute a diffuse but patchy source of contamination direct to the shore. Although the intensity of dog walking activities may be greatest near access points and car parks, these are spread quite evenly along the shore so it is not anticipated that any particular stretch is more heavily affected than any other. It is however likely that the inshore areas of the beds are most affected by contamination from these sources. Whilst residents are likely to engage in these activities year round, a slight increase in impacts due to visitors to the area may be expected during summer months.

Summary of Pollution Sources

An overview of sources of pollution likely to affect the levels of microbiological contamination to the shellfish beds is shown in Table 3.1 and Figure 3.1. Contamination from continuous sewage discharges to the Mersey are likely to be of most significance and fairly predictable spatially so will be the primary consideration for the sampling plan. Land runoff from the Mersey catchment will follow a similar spatial profile. Contamination originating from the Dee estuary is likely to be a significant influence towards the western end of the shoreline. Without information on spills, the impacts of intermittent discharges are difficult to assess aside from noting their location and potential to cause significant localised hotspots of contamination at times. Diffuse inputs from birds and dogs, whilst they may be a significant contaminating influence and may be of increasing significance closer to the shore are considered a diffuse input so will be of lesser relevance to the sampling plan.

Table 3.1 Qualitative assessment of changes in pollution load at Leasowe.

Pollution source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Continuous sewage discharges	High	High	High	High	High	High	High	High	High	High	High	High
Waterbirds	High	High	High	Moderate	Moderate	Moderate	Moderate	Moderate	High	High	High	High
Land runoff	Moderate	Moderate	Moderate	Moderate	High	High	High	High	High	High	High	Moderate
Rainfall-dependent discharges	Moderate	Moderate	Moderate	Moderate	High	High	High	High	High	High	High	Moderate
Domestic animals	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

Red - high risk; orange - moderate risk.

Hydrodynamics

The hydrodynamic regime in the area is dominated by tidally driven processes interacting with shallow sub-tidal sandbanks and dredged channels, as well as the presence of major estuaries. The incoming tide conveys relatively clean water from the Irish Sea. It flows into Liverpool Bay from the west, and is then channelled in a southerly direction into the Dee and Mersey estuaries through their main channels, with the opposite occurring on ebb tides. At the eastern end of the north Wirral coast water draining from the Mersey estuary flows out through the gap between Rock Lighthouse and the start of the western training wall in a westerly direction. Therefore, the north eastern extremities of the shellfish beds at Leasowe and New Brighton are likely to come into most contact with the more contaminated water ebbing from the Mersey estuary, and RMPs situated on these parts of the beds will best capture contamination originating from here. Sources of contamination on the west shore of the outer Mersey estuary (e.g. Birkenhead STW and any contamination carried by The Birket) are likely to be of greater impact at Leasowe and New Brighton than those to the east shore as the water ebbing towards the cockle beds will originate from the western side of the channel. Contamination from sources further inside the estuary is likely to be more mixed both vertically and horizontally by the time it reaches the estuary mouth. Spills from the Wallasey Detention Tank intermittent sewage discharge will also be carried towards the New Brighton and Leasowe beds on the ebbing tide following a parallel route but to the south of the westerly flowing element of the Mersey plume and so will impact more extensively.

Contamination from the discharge from the Meols STW would be carried towards the shellfish beds at Leasowe and New Brighton on a flooding tide, spreading as it travels and arriving first along their northern edge. Therefore, an RMP on the northern edge of these beds would best capture contamination from this source. This discharge generates an estimated bacterial loading of about 3 orders of magnitude less than either of the two major discharges to the outer Mersey estuary. Tidal flows are not expected to carry contamination from this discharge directly towards the cockle bed at Dove Point.

Water ebbing from the Dee estuary via the eastern channel generally remains within this channel, and does not come into much contact with the intertidal area except at its western edge. Therefore, sources of contamination within the Dee estuary are generally expected to be of little or no impact on the shellfish beds at Leasowe and New Brighton, but are likely to impact most towards the western end of the Dove Point bed. This will also apply to spills from the intermittent sewage discharge at Hoylake.

Stratification is likely to occur within the Dee and Mersey estuaries, particularly at times of high freshwater input. It is also possible that the plumes from sewage discharges may have a tendency to rise to the surface. The less dense lower salinity surface water is likely to spread out horizontally and move in a net seaward direction just outside the estuary mouths. This means that the ebb flows from the Mersey estuary through the relatively shallow gap between Rock Lighthouse and the start of the western training wall may be of potentially more contaminated lower salinity water from the top of the water column.

Strong winds are likely to modify tidal flows, pushing a surface current in their direction. Exact effects are dependent on the wind speed and direction and the state of the tide at the time and so a great range of scenarios may arise. The prevailing westerly winds would tend to increase the importance of contamination from the Dee estuary on the Dove Point bed. A strong northerly wind combined with an ebb tide may push water which has ebbed from the Mersey through the gap between Rock Lighthouse and the start of the western training wall towards the north Wirral coast and so this water may come into more extensive contact with the shellfish beds at Leasowe and New Brighton under these conditions. Onshore winds will create wave action which may resuspend any contamination held within the sediments of the intertidal zone, such as that deposited by birds and dogs.

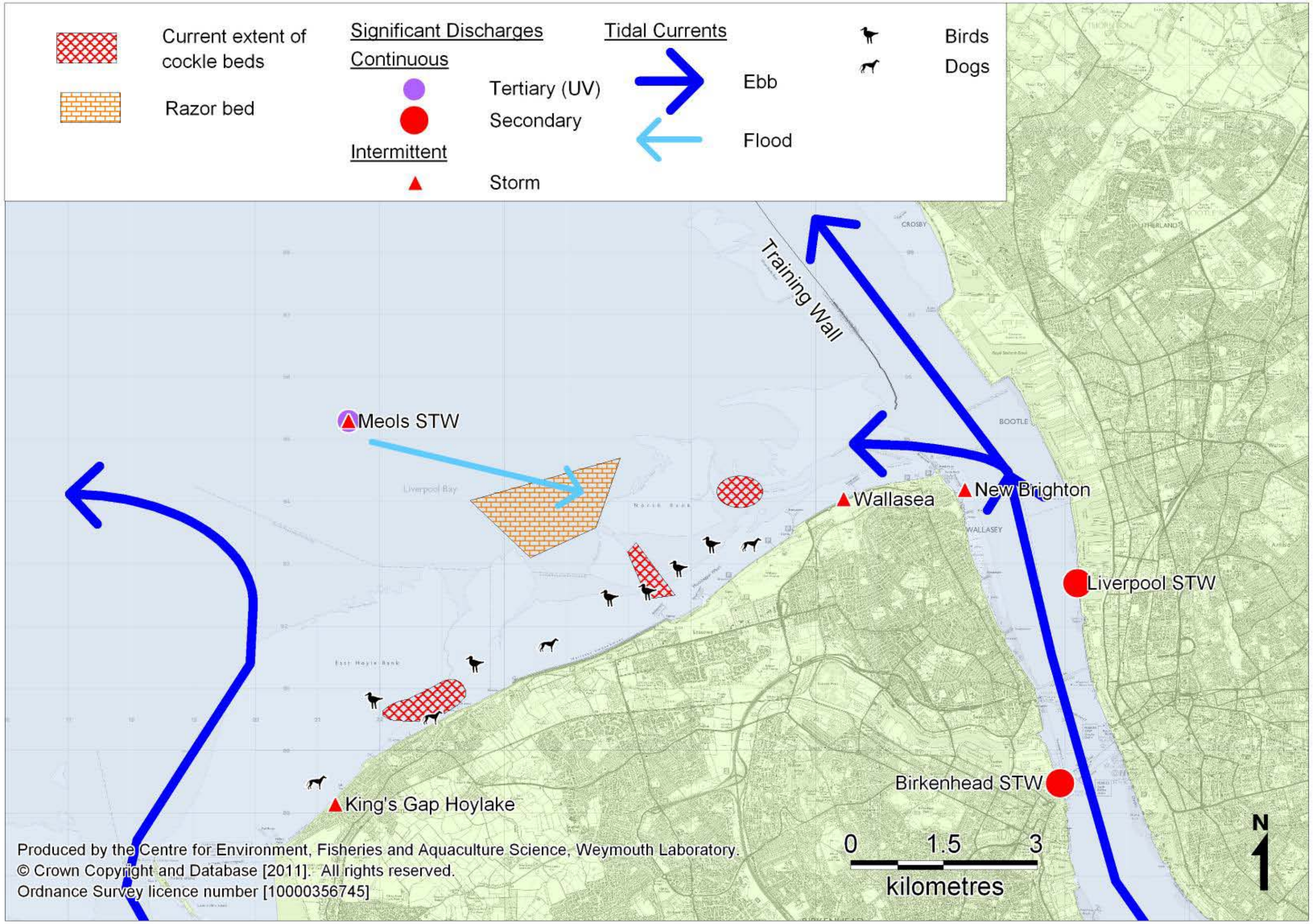

Figure 3.1 Significant sources of microbiological pollution to the north Wirral foreshore.

SUMMARY OF EXISTING MICROBIOLOGICAL DATA

There are four bathing waters sites in the area, three of them on the North Wirral coast (from east to west, New Brighton, Moreton, and Meols) and one just inside the mouth of the Dee estuary (West Kirby). On average results since 2000 were highest at New Brighton and lowest at Moreton. The difference in levels of contamination between Moreton and New Brighton has decreased in recent years, but results remain higher at New Brighton. In 2010 their respective geometric mean faecal coliform results were 28 and 9 cfu/100ml respectively, with maximum results of 308 and 44 cfu/100ml. This would suggest that the New Brighton cockle bed is subject to higher levels of contamination than the Leasowe cockle bed. A distinct deterioration in water quality was seen in samples taken at New Brighton just after the tide started to ebb which implies that water ebbing from the Mersey estuary is more contaminated than water carried in on the flood tide from the open waters of Liverpool Bay. A similar deterioration was seen at Meols, where the Dove Point bed is located, but not at West Kirby within the mouth of the Dee estuary. Of the three sites on the north Wirral shore, correlations between tidal state on the spring/neap tidal cycle were found at two (Meols and New Brighton) and in both cases results were generally slightly higher as the tide size increased from neaps to springs, possibly suggesting that contamination deposited in the intertidal zone between the high water mark for neap and spring tides may be of importance. Positive correlations with recent rainfall were only observed at West Kirby and to a lesser extent at Meols suggesting that rainfall dependent sources are of more importance within the Dee estuary and that the influence of the Dee estuary extends as far as the Dove Point cockle bed.

In general, similar patterns in levels of contamination described for the bathing waters results were observed in shellfish hygiene flesh monitoring results, although it must be noted that a large proportion of the samples considered in this report were taken over a decade ago. A geographical analysis tentatively indicated higher levels of contamination towards the eastern end of the north Wirral shore. For cockles, results were generally higher during the summer during the 1990s and in the autumn post 2000. Seasonal variation in mussels at Meols (mainly sampled post 2000) was less marked, although a higher proportion of results exceeded 230 *E. coli* MPN/100g during the winter. Of the two RMPs for which results were compared with recent rainfall, positive correlations were found at the RMP near the western end of the north Wirral shore, but none was found at the RMP located at roughly the centre of this stretch of coast.

No significant difference was found between the North Wirral East and North Wirral West shellfish growing waters for either water or shellfish sampling results. A strong seasonal pattern was found for water samples taken from North Wirral West, with results for the autumn and winter significantly higher than those for the spring. No significant seasonal pattern was found at North Wirral East. Again, this leads to the conclusion that the shellfish beds at Leasowe and New Brighton are mainly under the influence of the Mersey, whereas the Dove Point bed will be mainly under the influence of the Dee. A source apportionment study undertaken on one seawater sample taken in July

2008 off the western end of New Brighton identified the presence of human, avian and canine mitochondrial DNA, which is in agreement with the above assessment of likely impacting sources. Relative contributions could not be determined, and only one sample was analysed however.

Cockle samples taken from the four corners of the Leasowe cockle bed during the shoreline survey contained very variable levels of *E. coli* (from 170 to 24,000 MPN/100g), suggesting that a localised, patchy source (i.e. bird droppings) may be of significance. The highest result arose at the north eastern corner and the lowest result at the south western corner, perhaps suggesting that contamination from the Mersey impacts more heavily to the north and east of the beds, although it is unlikely that such a strong gradient in levels of contamination across the bed is attributable to a source lying over 4km away. Water samples taken on an ebbing tide from the mouths of the Dee and Mersey estuaries during the shoreline survey had markedly different levels of *E. coli* (10 and 340 cfu/100ml respectively) tentatively suggesting that the Mersey estuary is considerably more contaminated than the Dee estuary. Bacteriological survey results showed highest peak result at the north east corner of the bed compared to the south east corner, but very little difference in mean result between the two.

In summary, the more robust observations of relevance to the assessment arising from analyses of bacteriological sampling results include:

- Levels of contamination are generally highest towards the eastern end of the north Wirral foreshore, suggesting the plume from the Mersey is likely to be a significant source to the shellfish beds at Leasowe and New Brighton, impacting most heavily towards the eastern end of this stretch.
- A marked deterioration of water quality was apparent after the tide started ebbing at New Brighton indicating that water ebbing from the Mersey is more contaminated than water flooding into the Mersey.
- Significant increases in levels of contamination following rainfall tended to only arise at the western end of the north Wirral foreshore and in the Dee estuary, suggesting that the Dove Point bed is in a location much more under the influence of the Dee than the Mersey.
- One seawater sample to which source apportionment techniques were applied identified humans, birds and dogs as contamination sources.
- Whilst the geometric mean result from the two bacteriological survey points at the Leasowe cockle bed were very similar, the highest peak result arose at the north east corner of the bed.

4. RECOMMENDATIONS

4.1 For cockles, it is desirable for the entire intertidal area from Hoylake to New Brighton to be classified to allow exploitation as new patches appear or are discovered without continual revision of the classification zones and sampling plans.

4.2 An analysis of sources, water circulation patterns and sampling results suggests that the western and eastern ends of this shore are subject to differing contaminating influences and as such should be classified and monitored separately. An appropriate dividing line would be one running out from the breakwater at Parkfields, at the eastern end of Meols. The Leasowe to New Brighton zone should not extend past the second New Brighton breakwater due to the contaminating influence of the Mersey.

4.3 For the Leasowe to New Brighton cockle zone, it is recommended that a representative monitoring point (RMP) be set at the closest point to the eastern boundary of this zone where stocks are present (currently SJ 2950 9439) to best capture contamination associated with the ebb plume from the Mersey estuary, which, on balance, is likely to be the most significant and consistent contaminating influence on the eastern end of the north Wirral foreshore. SJ 2950 9439 is within 250m of the eastern boundary so should be indicative of peak levels of contamination within this zone. The location of the RMP may be moved at any time by NW IFCA or Mersey PHA on the basis of intelligence and stock surveys, but should always be at the closest possible point to the eastern boundary. A record of the exact locations sampled on each occasion should be held and communicated back to Cefas and FSA.

4.4 A small part of the Leasowe to New Brighton zone, where the Leasowe bed is located, is currently classified, on the basis of results obtained from the north east corner of this bed (B058P). It is proposed that this zone be extended as far as the most westerly of the New Brighton breakwaters. This would extend the classification zone towards the influence of the ebb plume from the Mersey, so the current classification may not adequately reflect the peak levels of contamination in the larger area. Therefore, before a classification can be awarded for this extended zone, a period of parallel monitoring of 6 samples taken no less than 1 week apart from B058P and SJ 2950 9439.

4.5 For the Hoylake cockle zone, it is recommended that a representative monitoring point (RMP) be set at the closest point to the western boundary of this zone where stocks are present (currently SJ 2205 9056), to best capture contamination associated with the ebb plume from the Dee estuary. The location of this may be moved at any time by NW IFCA or Mersey PHA on the basis of intelligence and stock surveys, but should always be at the closest possible point to the western boundary. A record of the exact locations sampled on each occasion should be held. 10 samples will need to be taken from here, not less than 1 week apart by the end of August 2011 so that a provisional classification can be awarded here by the start of the 2011 season.

4.6 Razor clams are gathered from the lower shore off Leasowe. Should there be commercial interest, or Mersey PHA otherwise decide this species requires classification in the future then this species should be classified within the zone shown in Figure 5.2 on the basis of the *E. coli* results of samples taken from the north eastern corner of this bed (SJ 2586 9470). This RMP should be effective at capturing contamination originating from the Mersey estuary and from the Meols STW discharge.

4.7 It is recommended that classification monitoring for mussels at B058D (Leasowe Lighthouse) be stopped as NW IFCA advise there is not an active commercial fishery here at present, nor is there likely to be in the near future.

4.8 When available, data on storm sewage overflows should be reviewed and the sampling plan amended as necessary.

5. SAMPLING PLAN

GENERAL INFORMATION

Location Reference

Production Area	Liverpool Bay - Wirral
Cefas Main Site Reference	M058
Cefas Area Reference	Leasowe to New Brighton cockles, Hoylake cockles, Leasowe razors
Ordnance survey 1:25,000 map	OS Explorer 266 (Wirral & Chester)
Admiralty Chart	Imray Chart C52 (Cardigan Bay to Liverpool)

Shellfishery

Species/culture	Cockles (*Cerastoderma edule*) Razors (*Ensis* spp.)	Wild Wild
Seasonality of harvest	Closed season from 1st May to 31st August (cockles)	

Local Enforcement Authority

Name	Mersey Port Health Authority Trident House 105, Derby Road Liverpool L20 8LZ
Environmental Health Officer	Glyn Cavell
Telephone number ☎	0151 233 2576
Fax number	0151 233 2580
E-mail	glyn.cavell@liverpool.gov.uk

REQUIREMENT FOR REVIEW

The location of the cockle beds are likely to change significantly each season, and new patches may be discovered at any time which may necessitate the location of their respective RMPs. This can be undertaken on an *ad hoc* basis by Mersey PHA and NW IFCA, and the exact location sampled should be recorded the location of the new RMPS should be communicated to Cefas and FSA. The Guide to Good Practice for the Microbiological Monitoring of Bivalve Mollusc Harvesting Areas (EU Working Group on the Microbiological Monitoring of Bivalve Mollusc Harvesting Areas, 2010) indicates that sanitary assessments should be fully reviewed every 6 years, so this assessment is due a formal review in 2017. The assessment may require review in the interim should any significant changes in sources of contamination come to light, such as the upgrading or relocation of the major discharges to the Mersey estuary.

Table 5.1 Number and location of representative monitoring points (RMPs) and frequency of sampling for classification zones within the Liverpool Bay production area.

Classification zone	RMP	RMP name	NGR	Latitude & Longitude (WGS84)	Species	Growing method	Harvesting technique	Sampling method	Tolerance	Frequency	Comments
Leasowe & New Brighton cockles	B058R	Harrison Drive East	SJ 2953 9425	53°26.42N 3°03.74W	*C. edule*	Wild stocks	Hand (rake)	Hand (rake)	100m	Not less than weekly for the first 6 samples. Monthly thereafter.	To be monitored in parallel with B058P (Leasowe North, SJ 2611 9334) for 6 samplings, after which it will replace B058P, and a classification will be awarded for the entire zone. Should the distribution of cockles within this zone change, this RMP may be relocated to the point closest to the eastern boundary where there are sufficient stocks for sampling.
Hoylake cockles	B058T	Hoylake	SJ 2205 9056	53°24.36N 3°10.44W	*C. edule*	Wild stocks	Hand (rake)	Hand (rake)	100m	10 samples required not less than 1 week apart for provisional classification. Monthly thereafter.	New classification zone. Should the distribution of cockles within this zone change, this RMP may be relocated to the point closest to the western boundary where there are sufficient stocks for sampling.

Classification zone	RMP	RMP name	NGR	Latitude & Longitude (WGS84)	Species	Growing method	Harvesting technique	Sampling method	Tolerance	Frequency	Comments
Leasowe razors	TBA	Leasowe Razors	SJ 2586 9470	53°26.63N 3°7.06W	*Ensis* spp.	Wild stocks	Hand	Hand (salting)	100m	Monthly monitoring for 1 year towards full classification. If classification is more urgent, then 10 samples required not less than 1 week apart for preliminary classification.	New classification zone. To be sampled for classification if deemed appropriate by Mersey PHA.
~~Leasowe Lighthouse~~	~~B058D~~	~~Leasowe Lighthouse~~	~~SJ 2500 9200~~	~~53°25.17N 3°7.80W~~	~~*Mytilus* spp.~~	~~Wild stocks~~	It is recommended that monitoring is ceased at this current RMP as there are no commercial scale mussel stocks within this classification zone.				

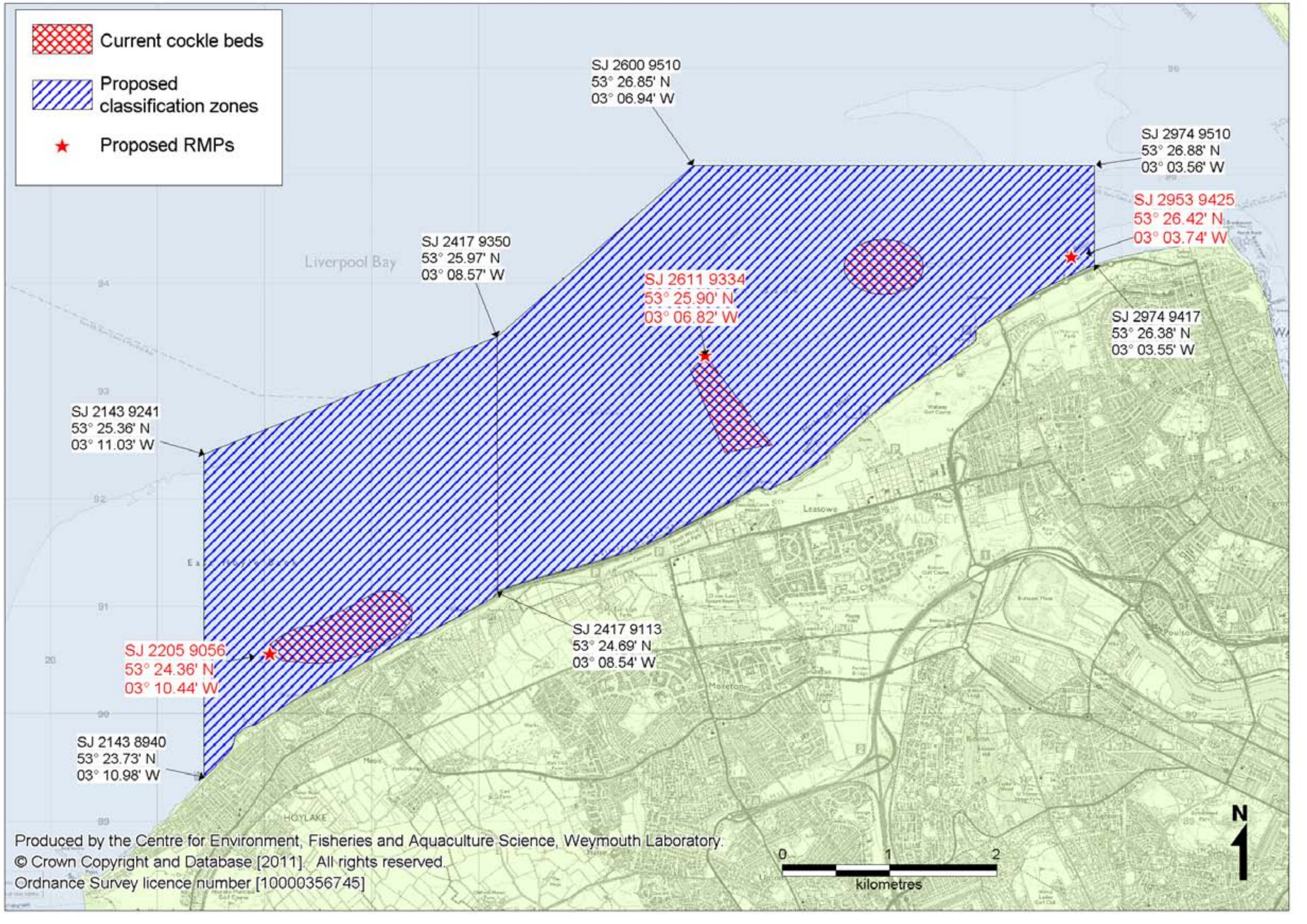

Figure 5.1 Recommended classification zone boundaries and RMP locations for cockles.

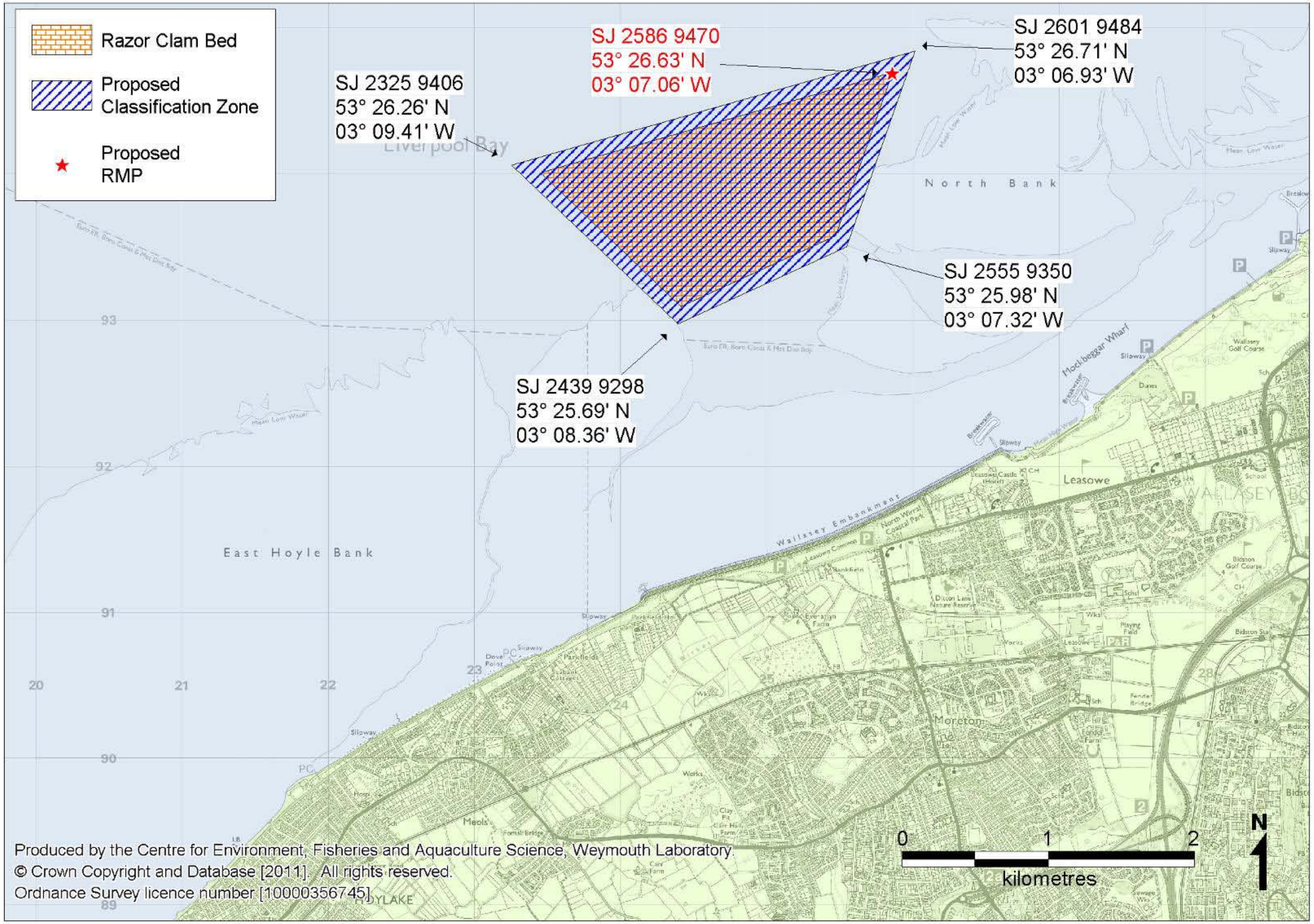

Figure 5.2 Recommended classification zone boundaries and RMP locations for razors.

APPENDICES

APPENDIX I
HUMAN POPULATION

The distribution of resident human population by Super Output Area Boundary totally or partially included within the river catchment areas is shown in Figure I.1. Total resident human population in the Mersey estuary catchment was approximately 4.5 million in 2001. A large proportion reside in the metropolis of Greater Manchester. High population densities are also present on the shores of the outer Mersey estuary at Liverpool. The resident population within the Dee estuary catchment was considerably lower at approximately 0.5 million in 2001. Highest population densities are apparent at Chester and Wrexham, and population densities on the shores of the Dee estuary were relatively low. Therefore, sewage inputs to the Mersey estuary and the rivers discharging to it are likely to be considerably higher than those to the Dee estuary.

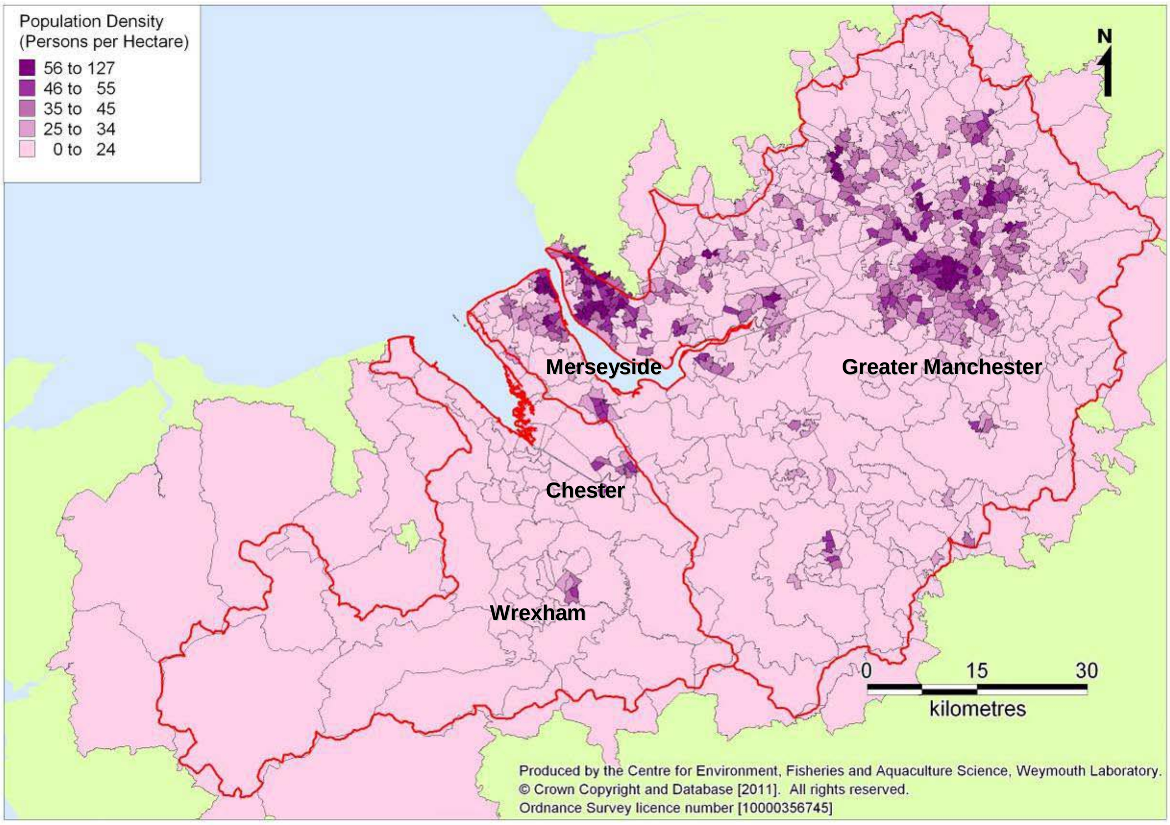

Figure I.1 Human population density in the Dee and Mersey estuary catchments. *Source: ONS, Super Output Area Boundaries (Middle layer). Crown copyright 2004. Crown copyright material is reproduced with the permission of the Controller of HMSO.*

Merseyside has an international airport and many tourist attractions such as museums, architectural features and events. In 2006, there were 61.6m visitors to Merseyside, who generated £1,209m for the local economy (Mersey Partnership, 2008). In 2007, hotel room occupancy statistics for Merseyside indicate highest occupancy in September (79%) and lowest occupancy in January (59%), so some seasonal variation in visitor numbers is apparent, but it is not particularly strong. Greater Manchester has a similar array of mainly cultural attractions, and drew 108.5 million visitor days in 2006, with a similar lack of strong seasonality to hotel room occupancy rates (Marketing Manchester, 2010). An exodus of residents from these cities during the summer holiday season may occur to some extent.

Significant numbers of tourists also visit the Dee estuary catchment area. Attractions include the city of Chester which receives about 1.5 million vistors a year (Cheshire County Council, 2004), other towns such as Langollen, and to some extent the Dee estuary itself, where there is likely to be a tourist driven increase in population during the summer months. On the Wirral peninsula, Birkenhead is a Victorian seaside resort and attractions on the Wirral generally have an outdoor theme, so significant seasonality in visitor numbers may be expected here. The north Wirral coast is a summer tourist attraction in itself, with the seaside towns of New Brighton and Hoylake at either end, a large holiday park hosting about 300 static caravans, some attractive natural outdoor areas and a golf course.

Visitors to the area will increase the amount of sewage discharged, so overall volumes will be higher during the summer months. This seasonality is likely to be less acute for the large discharges serving the cities of Greater Manchester and Liverpool, which attract a high proportion of visitors to the region, and is likely to be strongest for discharges serving areas such as the Wirral and the Dee estuary where many attractions are outdoors.

APPENDIX II
HYDROMETRIC DATA: RAINFALL

North Wales and North West England form one of the wetter regions of England and Wales, but rainfall varies considerable across the region. Areas with higher elevations tend to receive higher rainfalls, and the main conurbations are relatively low lying so rainfall is lower in these areas. For example Manchester receives an average of only 860 mm of rain per year, whereas Snowdonia, near the source of the Dee receives over 3000 mm (Met Office, 2010). Figure II.1 presents boxplots of daily rainfall totals by month from rainfall gauging stations on the Wirral peninsula and in the upper catchment of the Mersey, and at Chester in the Lower Dee catchment.

At Moreton rainfall is highest on average in October and November and lowest in March. High rainfall events where over 20mm of rain fell in a day were rare (0.7% of records) and the majority of these occurred from May to October. 46% of records were dry days. At Higher Swineshaw rainfall was on average almost twice that recorded at Moreton. Again rainfall was highest on average in October and November and lowest on average in March. High rainfall events where over 20mm of rain fell in a day were more frequent (2.6% of records) and more evenly spread throughout the year. Dry days were less frequent (37% of records). The seasonal pattern at Chester was similar to that observed at Moreton, although there were slightly fewer dry days (44% of records) and slightly more high rainfall events (1.0% of records).

Rainfall may lead to the discharge of raw or partially treated sewage from combined sewer overflows (CSO) and other intermittent discharges as well as runoff from faecally contaminated land (Younger *et al.*, 2003). Representative monitoring points located in parts of shellfish beds closest to rainfall dependent discharges and freshwater inputs will reflect the combined effect of rainfall on the contribution of individual pollution sources. Rainfall records from the Moreton weather station, which is most representative of conditions in the vicinity of the shellfish bed indicate average rainfall is highest in October and November, but peak rainfall events, although infrequent, tend to occur any time from May to October.

Relationships between levels of *E. coli* and faecal coliforms in shellfish and water samples and recent rainfall are investigated in detail in Appendices XI and XII.

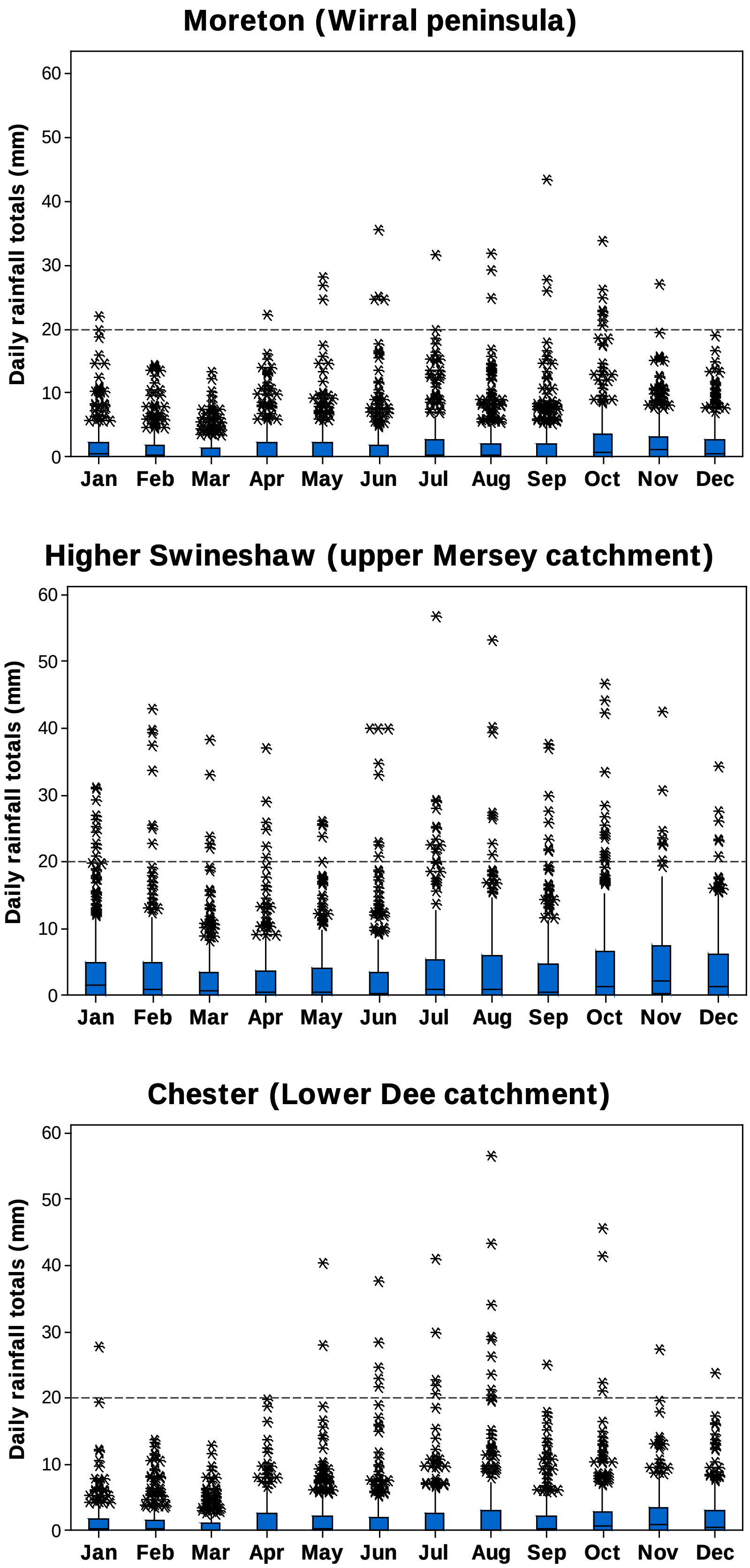

Figure II.1 Box and whisker plots of daily rainfall totals recorded at Moreton (on the Wirral), Higher Swineshaw (upper Mersey catchment for the period January 2000 to April 2010), and Chester (Dee catchment) from 2000-2008 (no data for August and September 2006). *Data from the Environment Agency.*

APPENDIX III
HYDROMETRIC DATA: FRESHWATER INPUTS

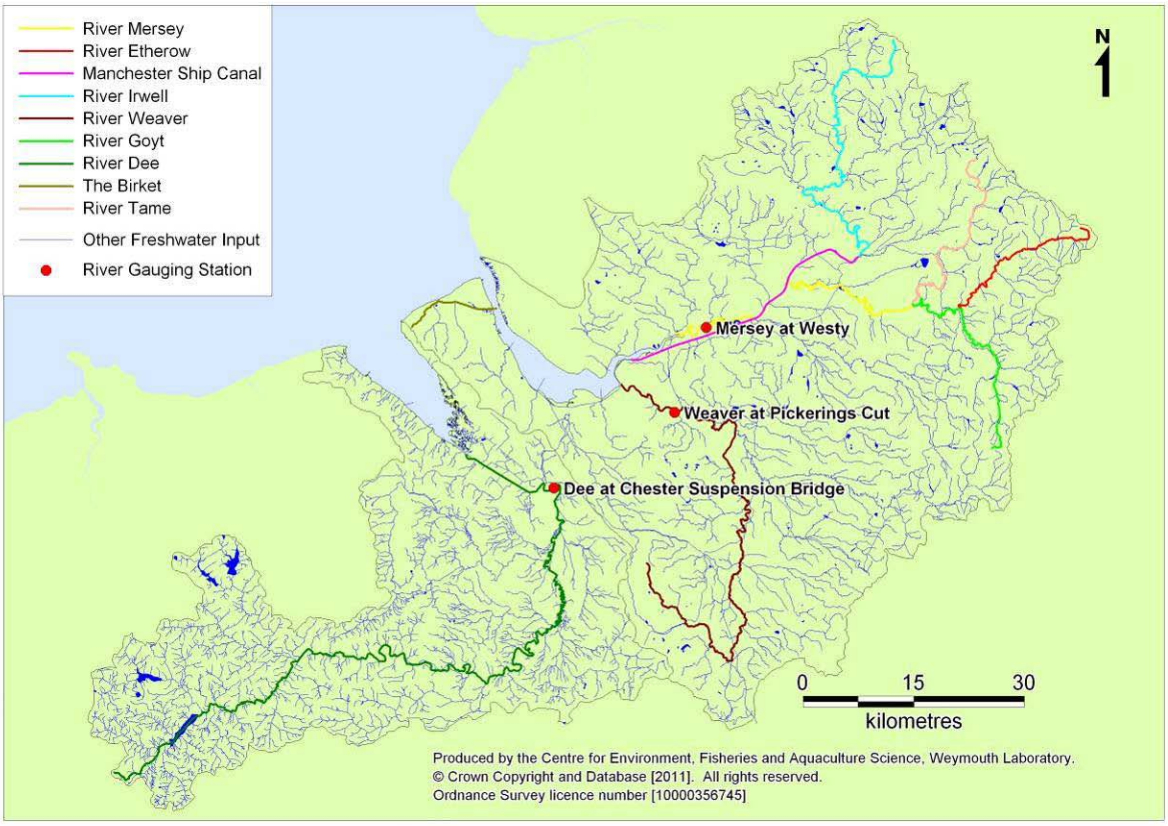

Figure III.1 Freshwater inputs to the Mersey and Dee estuaries.

There are no significant streams or rivers discharging to the north Wirral shore. The land adjacent to this shore is drained by The Birket, which discharges to the Mersey estuary about 4.5 km upstream from its mouth. The Mersey estuary receives freshwater inputs from the River Mersey, the River Weaver and numerous other smaller watercourses. The only major river draining to the Dee estuary is the River Dee, although there are numerous small streams draining to the west and to a lesser extent the east shore of the estuary. Table III.1 presents some statistics from the lowest gauging stations located on the three main freshwater inputs. Figure III.1 presents boxplots of mean daily flow records for these three rivers by month. It must be noted that due to data availability, the temporal coverage varies between the stations, and for all stations there are some small gaps in the records for various reasons.

Table III.1 Summary discharge statistics for major rivers discharging to the Dee and Mersey estuaries (from NERC 2010b).

River	Station	Catchment area (km^2)	Mean Daily Flow ($m^3 s^{-1}$)	Flow exceeded 95% of the time ($m^3 s^{-1}$)	Flow exceeded 10% of the time ($m^3 s^{-1}$)
Mersey	Westy	2030	37.5	7.947	81.79
Weaver	Pickerings Cut	1307	17.4	2.527	39.00
Dee	Chester weir	1817	29.7	3.739	80.45

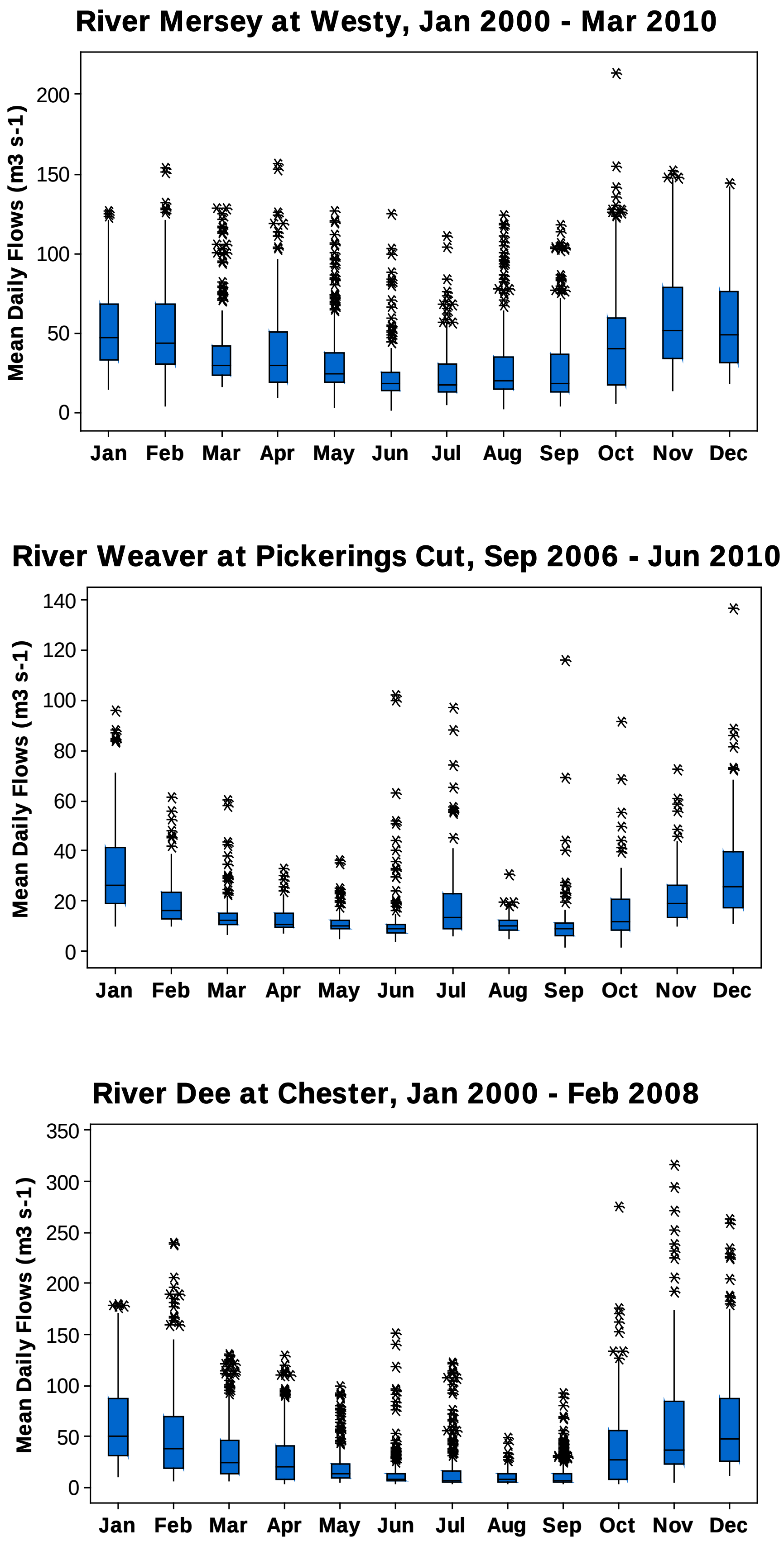

Figure III.2 Boxplots of mean daily flow records from the three major rivers discharging to the Dee and Mersey estuaries (Data from the Environment Agency)

Table III.1 indicates suggests that the Mersey estuary receives almost twice the volume of runoff on average than the Dee estuary, but that freshwater input to the Dee estuary is slightly more variable presumably due in part to the higher proportion of upland areas within its catchment.

A strong seasonal pattern which is fairly consistent between the rivers is apparent, with highest flows on average during winter months and lower flows on average during the spring and summer. High flow events are more evenly distributed through the year for the Mersey than the Weaver, where none was recorded during April, May and August. The high flows apparent in July for the Weaver were largely due to a high flow event during July 2007 strongly influencing the boxplot as data for July was only available for a total of three years at this station. This nevertheless highlights the potential for high flow events during the summer. The seasonal variation in flows was most marked for the Dee, where highest flows were recorded in the autumn and winter. The seasonal trends appear stronger and slightly different to rainfall patterns described Appendix II. The seasonal pattern of flows is not entirely dependent on rainfall as during the colder months there is less evaporation, less transpiration, and soils are more likely to be waterlogged so higher proportion of rainfall will run off. Increased levels of runoff are likely to result in an increased bacterial loading carried into coastal waters. They will also decrease residence time in rivers and estuaries and so contamination from more distant sources may have an increased impact during high flow events.

An Environment Agency initiative collated and analysed the results of dye tracer studies in England (Guymer, 2002), and found that solute travel velocities in a selection of watercourses averaged about 24km d^{-1} and ranged from 1.7 to 91 km d^{-1}. Therefore hydraulic transit times from sources in the upper areas of larger catchments are in the order of days, so bacteriological contamination originating from here is likely to suffer significant die off before reaching the estuaries.

APPENDIX IV
HYDROGRAPHIC DATA: BATHYMETRY

The cockle beds are located within an extensive intertidal area of sand and mud which extends about 2.5 km from MHWS. Below MLWS the seabed continues to slope very gradually, with gently undulating sandbanks sculpted by the tides. The bathymetry of these sandbanks has changed significantly over the last 150 years (Blott *et al*., 2006) and this evolution is likely to continue gradually. Source data for the part of Admiralty Chart presented in Figure IV.1 was mainly gathered during the 1980s and 1990s, although some areas in the offshore part in the north western corner were based on surveys undertaken as long ago as 1964. Therefore, bathymetry may be slightly different now, but important features discussed below are unlikely to have changed much.

The Mersey estuary and its approach lie to the east of the shellfisheries. The mouth of the Mersey estuary is known as The Narrows, and is about 1 km wide with a fairly even depth of about 20-25m. Inshore of The Narrows, the estuary widens and shallows. The approach to the Mersey is via the Crosby Channel, a ~25m depth dredged channel which is bounded throughout most of its length by the training walls. These are constructed of limestone blocks and help maintain the depth of the channel by preventing the ingress and buildup of sediments. The Crosby Channel extends in a NNW direction parallel to the coast for about 13 km, after which it bends round to the west then opens out. There is a gap of about 1 km between the Rock Lighthouse on the northeast point of the Wirral and the start of the western training wall. Two small channels emanate in a WNW direction from this gap and other bathymetric features just off the north Wirral coast such as the Brazil Bank and the East Hoyle Spit are also aligned in this direction suggesting that main tidal flows here are along this axis.

The Dee estuary lies to the west of the north Wirral coast. The mouth of this estuary is considerably wider (8.5km) than that of the Mersey, and has a much more complex bathymetric profile. The main channel has split in two branches here, which are both scoured to a depth of over 15m by a rocky outcrop on the eastern side (Hilbre Island) and by the point of Ayre on the western side. A large intertidal sand bank (the West Hoyle Bank) lies between them. The two channels have divergent paths where the West Hoyle Bank widens at the estuary mouth with the western channel heading in a westerly direction, and the eastern channel heading in a north easterly direction before bending round to a north westerly direction further offshore, more in alignment with the orientation of most channels and sandbanks in the area.

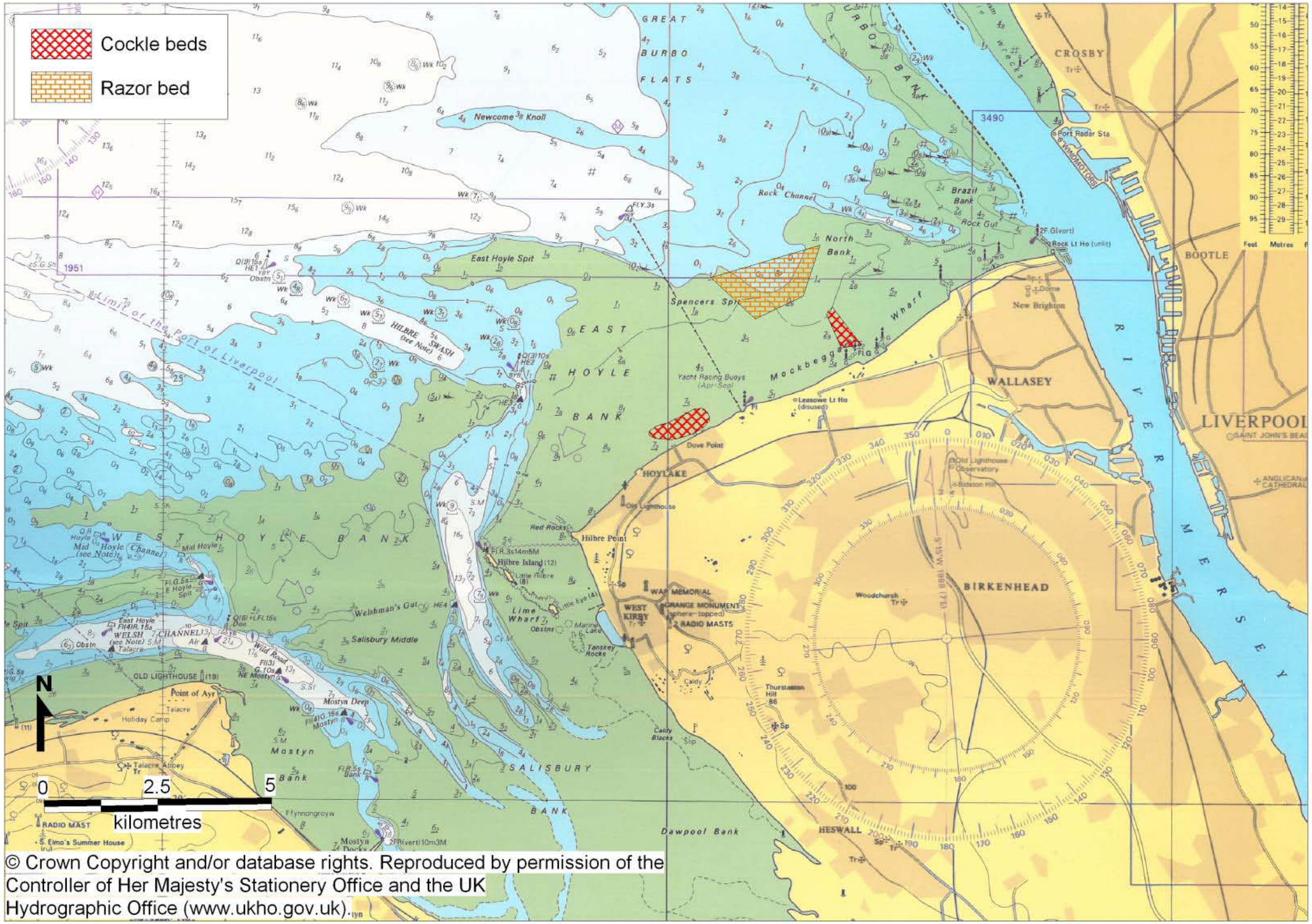

***Figure IV.1 Bathymetry chart of the inner reaches of Liverpool Bay*.**

APPENDIX V
HYDRODYNAMIC DATA: TIDES AND CURRENTS

Currents in coastal waters are predominantly driven by a combination of tide, wind and freshwater inputs. The Irish Sea is open to both the north and the south, with tides arriving almost simultaneously from these two directions, meeting around the Isle of Man, then flowing east into Liverpool Bay. After high water, the tide reverses to flow west out of Liverpool Bay. Liverpool Bay has a large tidal amplitude and semi-diurnal tides (i.e. two tidal cycles per day).

Table V.1 Tide levels and ranges at within Liverpool Bay.

	Height (m) above Chart Datum				Range (m)	
Port	MHWS	MHWN	MLWN	MLWS	Springs	Neaps
Hilbre Island	9.2	7.3	2.9	0.8	8.4	4.4
Gladstone Dock	9.0	7.2	3.1	1.3	7.7	4.1

Data from the UK Hydrographic Office.

The hydrodynamic regime in the area is dominated by tidally driven processes interacting with shallow subtidal sandbanks and dredged channels, as well as the presence of major estuaries. Figures V.1 and V.2 present peak flood and ebb flows on spring tides, as derived by a 3D model. Model results were in good agreement with field observations and tidal diamonds. The figures were produced by ABP Marine Environmental Research (2002) as supporting information for the Environmental Statement required for the Burbo Bank offshore wind farm.

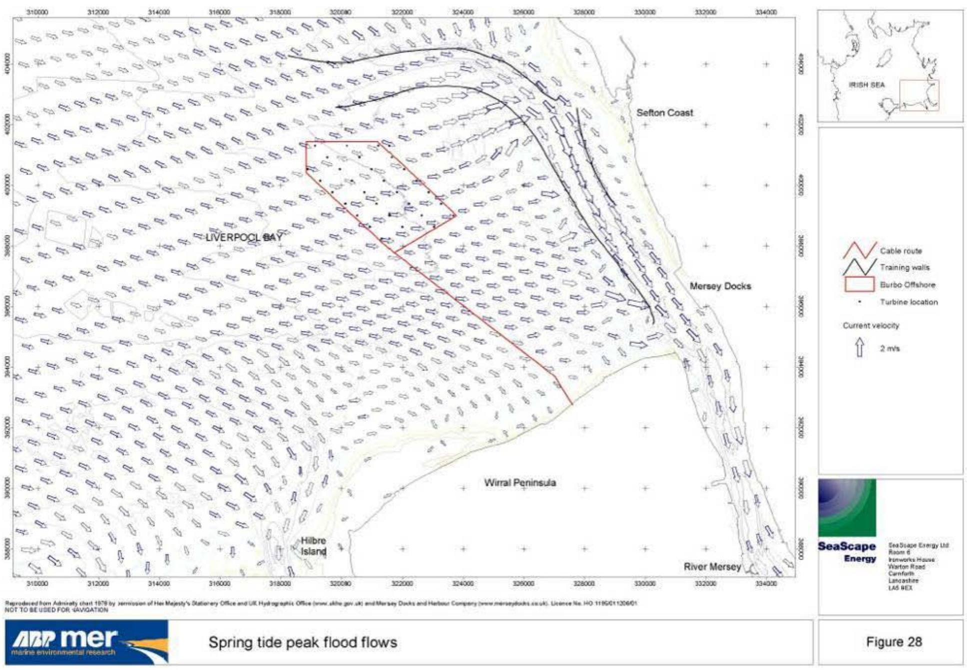

Figure V.1 Modelled peak spring tide flood flows within Liverpool Bay.
Produced by ABP Marine Environmental Research, 2002.

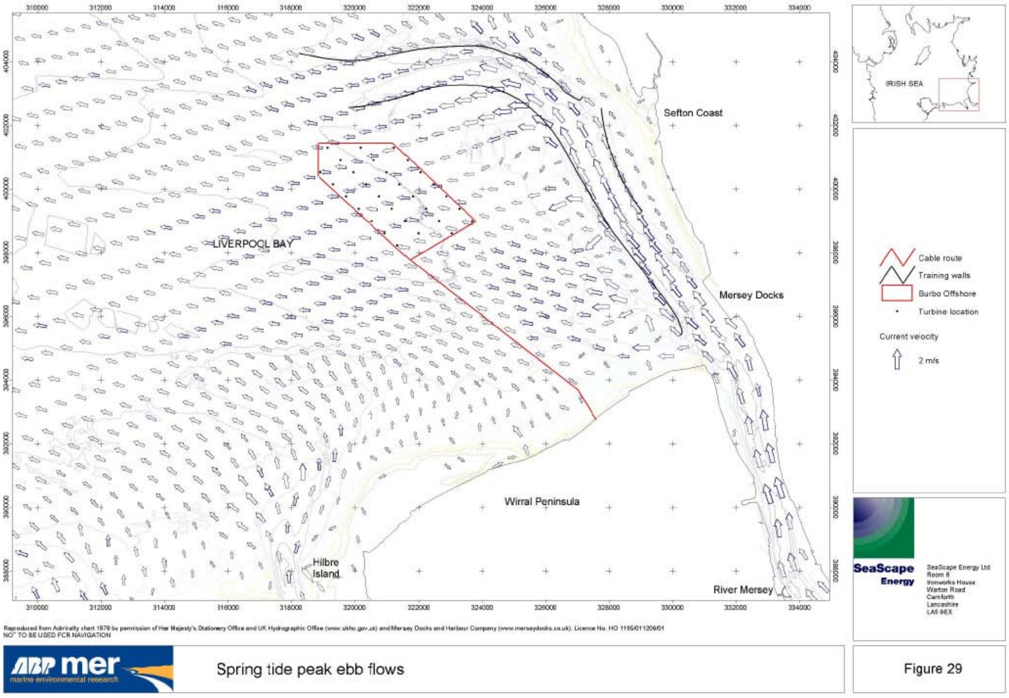

Figure V.1 Modelled peak spring tide ebb flows within Liverpool Bay
Produced by ABP Marine Environmental Research, 2002.

On neap tides flows are about 50% of that experienced on spring tides. Vertical differences in flows are found through water column, with near bed flows markedly slower, varying slightly in direction (ABP Marine Environmental Research, 2002).

The incoming tide conveys relatively clean water from the open Irish Sea. It flows into Liverpool Bay from the west, and is then channelled in a southerly direction into the Dee and Mersey estuaries through their main channels. Strongest flows of 1-2m s^{-1} are seen in the Crosby Channel and in The Narrows. Flows are much weaker closer to the north Wirral coast, apart from at its eastern extremity, where there are stronger flows through the small channels leading into the shipping channel at the southern end of the western training wall.

Of greater importance to the shellfisheries is the pattern of flows on the ebb tide, which will carry contamination out of the Dee and Mersey estuaries. Peak ebb flows are generally in the exact opposite direction to peak flood flows, but slightly weaker as the ebb lasts for about an hour longer than the flood. Slow northerly flows on ebb tide from the central Wirral shore indicate that here ebb flows consist of water which has come in from the open water of Liverpool Bay on the flood tide slowly draining away. Towards the eastern end of the north Wirral coast it is apparent that water draining from the Mersey estuary flows out through the gap between Rock Lighthouse and the start of the western training wall in a westerly direction. Therefore, the north eastern extremities of the razor and cockle beds at Leasowe are likely to come into most contact with the more contaminated water ebbing from the Mersey estuary. Sources of contamination on the west shore of the Mersey estuary are likely to be of greater impact on these beds than those on the east shore as the water ebbing towards the cockle beds will originate from the western side of the channel. Contamination from sources further inside the estuary is likely to be more mixed both vertically and horizontally by the time it reaches the estuary mouth.

The speed of flows through The Narrows indicates that any contamination released into this stretch would be carried out of the estuary on an ebbing tide within an hour or two of release. The flushing time from the head to the mouth of the estuary has been estimated at 32 days (NRA, 1995) suggesting sources of contamination to the upper estuary are of much less significance.

Water ebbing from the Dee estuary via the eastern channel by Hilbre Island generally remains within this channel, and does not come into much contact with the intertidal area on the north Wirral coast apart from at the western edge of the East Hoyle Bank and over the East Hoyle Spit. Therefore, sources of contamination within the Dee estuary are likely to be of little impact to the shellfish beds at Leasowe. Figure V.1 indicates that tidal flows at the Dove Point cockle bed are weaker, so more local sources are likely to be of greater importance here. Ebb flows will be mainly comprised of water carried in from the wider Liverpool Bay during the flood tide, with some exposure to water ebbing from the Dee estuary, particularly at its western end. This bed is not directly exposed to the ebb flows from the Mersey, and so it is concluded that a very different profile of contaminating sources are likely to impact on this bed compared to the two beds at Leasowe.

Superimposed on tidally driven currents are the effects of freshwater inputs and wind. There are significant freshwater inputs to both the Dee and Mersey estuaries, and these are likely to modify the circulation of water within these estuaries at times (both may be described as partially mixed systems). There is likely to be some limited stratification at their mouths, the degree of this being dependent on recent levels of freshwater discharge and the degree of tidally induced mixing. The less dense lower salinity surface water is likely to spread out horizontally and move in a net seaward direction just outside the estuary mouth. This means that the ebb flows from the Mersey estuary through the relatively shallow gap between Rock Lighthouse and the start of the western training wall (towards the north eastern corner of the cockle bed) may be of potentially more contaminated less saline water from the top of the water column.

Although density effects do have some effect on residual currents in the wider Liverpool Bay area as they are persistent, they do not cause major modification of (instantaneous) tidal flows off the north Wirral coast as they are small in relation to them (Shoreline Management Partnership, 1998). Periodically, salinity driven stratification may occur in Liverpool Bay (Sharples & Simpson, 1995) and under these conditions levels of contamination may be higher in the less saline water at the surface but this is of little relevance to the sampling plan as cockles and razors live within the seabed.

Strong winds will modify surface currents in Liverpool Bay. Winds typically drive surface water at about 3% of the wind speed (Brown, 1991) so a gale force wind (34 knots or 17.2 m s^{-1}) would drive a surface water current of about 1 knot or 0.5 m s^{-1}. The north Wirral coast is most exposed to winds from the north and west. Exact effects are dependent on the wind speed and direction and the state of the tide at the time and so a great range of scenarios may arise. The prevailing wind direction will tend to enhance the importance of the Dee estuary as a source of contamination at the Dove Point cockle bed. A strong northerly wind combined with an ebb tide is likely to push water which has ebbed from the Mersey through the gap between Rock Lighthouse and the start of the western training wall towards the north Wirral coast and so this water may come into greater contact with the shellfish beds at Leasowe under these conditions. As well as driving surface currents, onshore winds will create wave action. This may resuspend any contamination held within the sediments of the intertidal zone, temporarily increasing levels of contamination within the water column until it is carried away by the tides.

APPENDIX VI
METEOROLOGICAL DATA: WIND

The strongest winds are associated with the passage of deep depressions and the frequency and strength of these depressions is greatest in the winter (Met Office, 2010). As Atlantic depressions pass England and Wales, the wind typically starts to blow from the south or southwest, but later comes from the west or northwest as the depression moves away.

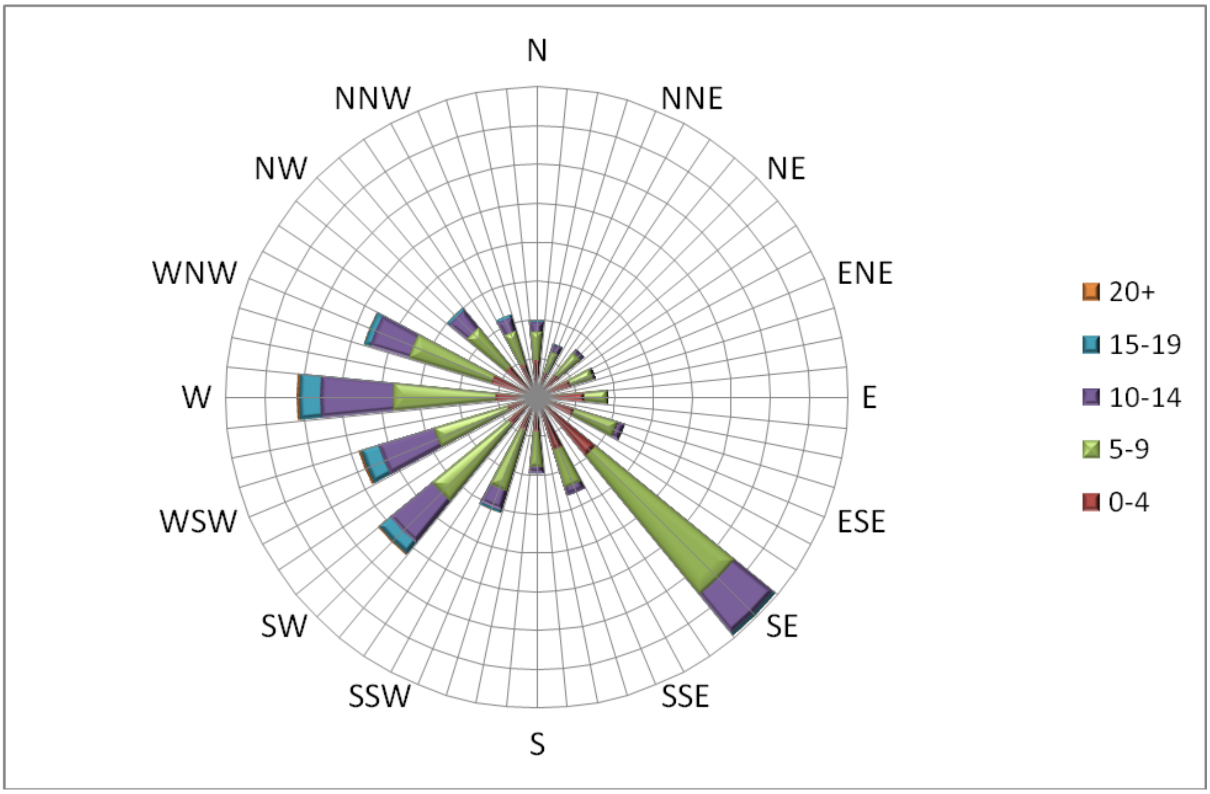

Figure VI.1 Wind speed and direction at Hilbre Island for the period 2005-2009.
Data provided by the Proudman Oceanographic Laboratory Coastal Observatory Project.

The prevailing wind direction is from the west, although at this station there is a high occurrence of mainly light winds from a narrow band in the south east. It is uncertain how this effect arises but it may be a consequence of the instruments location in relation to topographic features. Winds typically drive surface water at about 3% of the wind speed (Brown, 1991) so a gale force wind (34 knots or 17.2m s^{-1}) would drive a surface water current of about 1 knot or 0.5m s^{-1}. Therefore strong winds will significantly alter the pattern of flows within Liverpool Bay at times, in a manner dependent on wind direction, as well as increasing the vertical mixing of the water column.

The north Wirral coast is exposed to winds from the north and west, and winds from this direction travels across up to 200 km of open water before reaching the shore. Wave heights at the mouth of the Mersey estuary average 0.8 m and can exceed 3 m at times (Blott *et al*, 2006) so significant wave action is a feature of this stretch of coast. Wave action may resuspend any organic matter settled in the substrate as well as dislodging shellfish from the beds.

APPENDIX VII
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: SEWAGE DISCHARGES

Figure VII.1 presents a map showing the locations and sizes of major continuous sewage discharges to the area. Table VII.2 shows further details of these discharges.

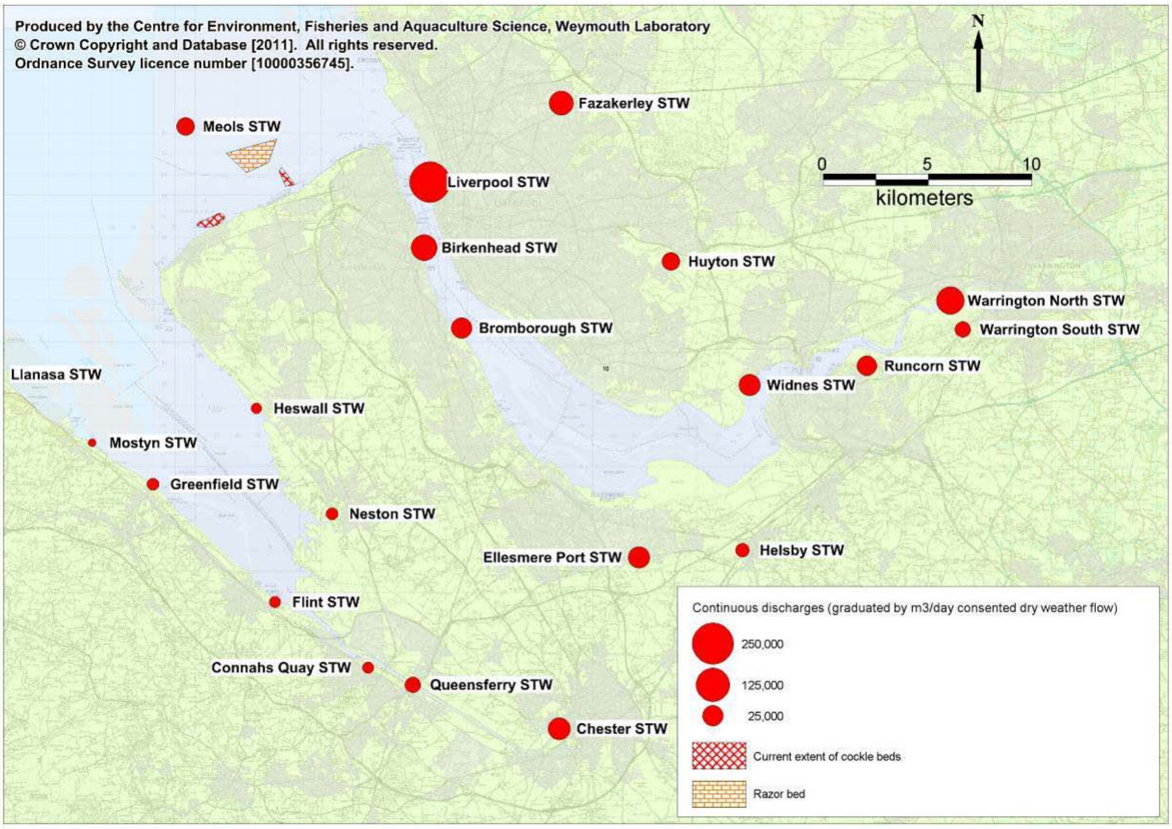

Figure VII.1. Locations and size of major continuous water company sewage discharges

In total, these discharges amount to a maximum total daily consented dry weather flow of ~548,000m^3 of secondary treated effluent to the Mersey estuary and tributaries, and ~67,000m^3 of a mixture of secondary and UV treated effluent to the Dee estuary and tributaries. Rough estimates of the bacterial loading generated by these discharges indicate that the Mersey estuary receives about 10 times that which the Dee estuary receives (~1.8x10^{15} and ~1.3x10^{14} faecal coliforms/day respectively).

In addition, there is a UV treated discharge to Liverpool Bay from the Meols STW with a consented dry weather flow of ~17,000m^3/day. The anticipated bacterial loading from this continuous discharge is relatively minor in relation to the large secondary treated discharges to the Mersey estuary, for example its anticipated loading is about three orders of magnitude lower than that of Birkenhead STW. It is however closer to the shellfish beds than any of the Merseyside discharges, and it must be noted however that UV disinfection is less effective at removing viruses than bacteria. STWs with disinfection systems are required to show a 25,000fold reduction in bacterial loading across

Table VII.1 Details of major continuous water company sewage discharges to the area

Name	Location	DWF (m^3/day)	Treatment level	Estimated bacterial loading (faecal coliforms/day)*	Receiving water	Fluvial distance from shellfish bed (km)** Leasowe cockles	Dove Point	Leasowe razors
Meols STW	SJ 2410 9030	16,641	Tertiary (UV)	2.6×10^{11}	Liverpool Bay	4.9	4.4	2.3
Liverpool STW	SJ 3321 9264	233,997	Secondary	7.7×10^{14}	Mersey Estuary	7.7	11.4	8.1
Birkenhead STW	SJ 3292 8949	55,201	Secondary	1.8×10^{14}	The Birket	10.1	12.8	10.5
Bromborough STW	SJ 3471 8564	25,099	Secondary	8.3×10^{13}	Mersey Estuary	15	17.7	15.4
Mostyn STW	SJ 1703 8015	966	Secondary	3.2×10^{12}	Dee Estuary	16.6	11.8	15.3
Llanasa STW	SJ 1231 8342	8,061	Tertiary (UV)	8.9×10^{10}	Dee Estuary	16.8	12.0	15.5
Heswall STW	SJ 2490 8179	2,562	Tertiary (UV)	3.3×10^{10}	Dee Estuary	17	12.2	15.7
Greenfield STW	SJ 1994 7816	3,891	Secondary	1.3×10^{13}	Dee Estuary	18.3	13.5	17.0
Fazakerley STW	SJ 3949 9642	41,999	Secondary	1.4×10^{14}	River Alt	21.4	24.1	21.8
Neston STW	SJ 2852 7675	4,074	Tertiary (UV)	1.3×10^{12}	Dee Estuary	24.1	19.3	22.8
Flint STW	SJ 2579 7252	3,410	Tertiary (UV)	7.5×10^{11}	Dee Estuary	25.1	20.3	23.8
Ellesmere Port STW	SJ 4320 7465	29,497	Secondary	9.7×10^{13}	Thornton Brook	29	31.7	29.4
Connahs Quay STW	SJ 3024 6938	3,272	Secondary	1.1×10^{13}	Tidal River Dee	30.5	25.7	29.2
Widnes STW	SJ 4851 8292	28,002	Secondary	9.2×10^{13}	Mersey Estuary	30.7	33.4	31.1
Queensferry STW	SJ 3238 6855	10,000	Tertiary (UV)	1.8×10^{12}	Tidal River Dee	32.6	27.8	31.3
Helsby STW	SJ 4815 7500	6,653	Secondary	2.2×10^{13}	Hornsmill Beck	33.2	35.9	33.6
Runcorn STW	SJ 5412 8383	21,600	Secondary	7.1×10^{13}	Manchester Ship Canal	37.2	39.9	37.6
Huyton STW	SJ 4473 8884	15,664	Secondary	5.2×10^{13}	Netherley Brook	40.5	43.2	40.9
Chester STW	SJ 3939 6645	31,138	Secondary	1.0×10^{14}	Tidal River Dee	40.8	43.5	41.2
Warrington South STW	SJ 5870 8558	10,403	Secondary	3.4×10^{13}	Manchester Ship Canal	42.2	44.9	42.6
Warrington North STW	SJ 5811 8696	63,003	Secondary	2.1×10^{14}	Tidal River Mersey	42.4	45.1	42.8

*Based on geometric mean result from samples of final effluent for the UV treated discharges(Table VII.2) or base flow averages from a range of UK STWs (Table VII.3). These estimates are intended for comparative purposes only, and bacterial loadings generated by each STW are likely to fluctuate significantly.

**Shortest path via water. This does not take into account water circulation patterns.

the entire works to be consented as such, whereas they are only required to demonstrate a 10fold reduction in viral loading (Environment Agency, 2001). Table VII.2 does indicate that whilst it tends to be the most consistently effective UV plant in the area, the bacteriological quality of effluent from Meols STW does vary significantly.

Table VII.2 Summary statistics of faecal coliform data for final effluents post UV-disinfection monitoring.

		Faecal coliforms (cfu/100ml)				
Name	Period	Number of samples	Geometric mean	Minimum	Maximum	95%ile
Meols STW	2007–2010	85	1,600	20	160,000	18,600
Llanasa STW	2004–2006	79	1,100	<10	162,000	62,000
Heswall STW	2002–2006	124	1,300	10	>100,000	>100,000
Neston STW	2005–2006	53	31,000	1,500	>100,000	>100,000
Flint STW	2005–2006	47	22,000	100	280,000	200,000
Queensferry STW	2005–2006	45	18,000	120	>100,000	195,800

Table VII.3 Summary of reference faecal coliform levels (cfu/100ml) for different sewage treatment levels under different flow conditions.

	Flow			
Treatment Level	Base-flow		High-flow	
	n	Geometric mean	n	Geometric mean
Primary (12)	127	$1.0x10^7$	14	$4.6x10^6$
Secondary (67)	864	$3.3x10^5$	184	$5.0x10^5$
Tertiary (UV) (8)	108	$2.8x10^2$	6	$3.6x10^2$

Data from Kay et al. (2008b).
n - number of samples.
Figures in brackets indicate the number of STWs sampled.

In addition to the continuous sewage discharges, there are a large number of intermittent discharges within the area. Of these, four discharge along the north Wirral shore, and large numbers discharge to the Mersey and to a lesser extent the Dee estuary and tributaries thereof. A more local map showing the location of intermittent discharges in the area is presented in Figure VII.2 where the four to the north Wirral shore annotated, details of which are shown in Table VII.4. None is located within 1.5km of any of the shellfish beds.

Table VII.4 Details of intermittent discharges to the north Wirral shore

Name	Location	Type
Kings Gap Hoylake	SJ 2129 8915	Storm
Meols STW	SJ 2150 9530	Storm & Emergency
Wallasey Detention Tank	SJ 2945 9405	Storm
New Brighton	SJ 3140 9420	Storm

The New Brighton overflow was upgraded in 2008 to a design criteria of 1 spill per summer, and did not spill between May and October 2011. Information on spills from the other three outfalls was not available at the time of writing.

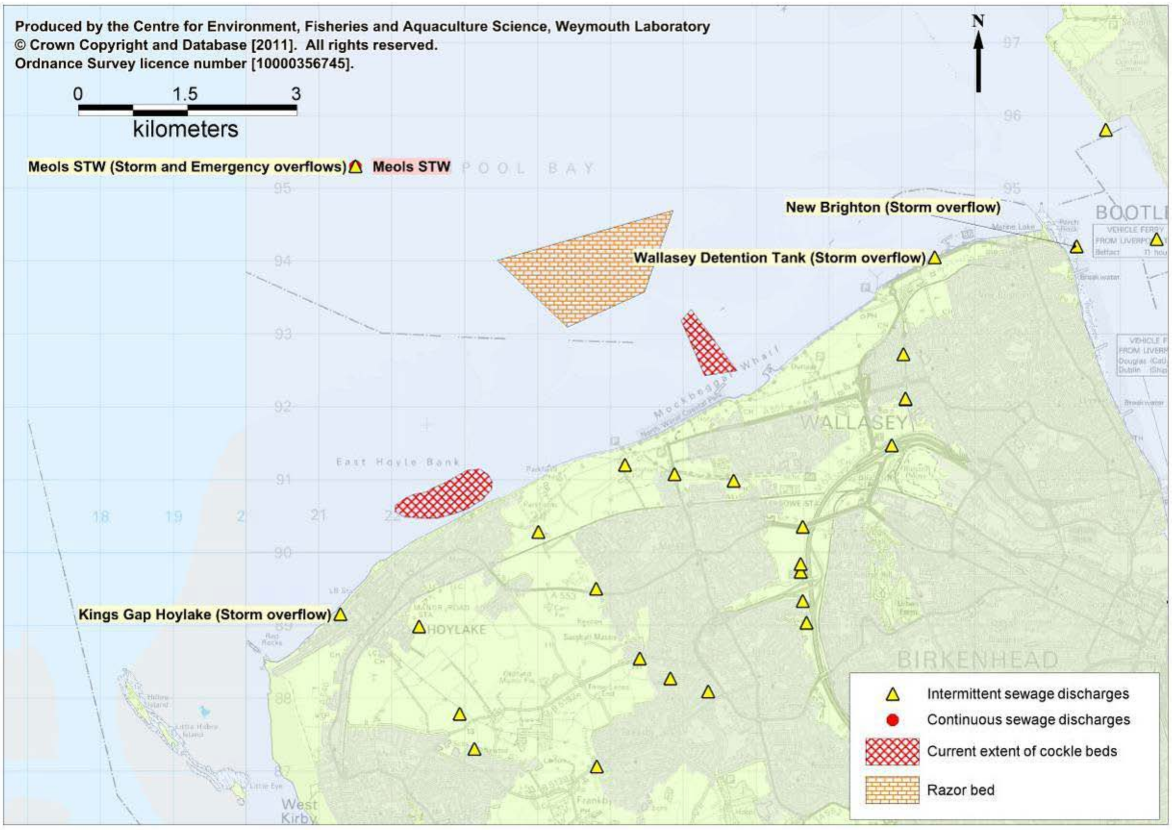

Figure VII.2. Locations of intermittent water company sewage discharges to the north Wirral shore

Significant reductions to the amount of bacterial contamination entering the area have been achieved in the last 20 years or so through ongoing improvements to sewer networks and treatment works. For example, treatment levels at Liverpool STW, Birkenhead STW, Bromborough STW and Meols STW were upgraded to secondary between 1999 and 2001, and later in 2005 Meols STW was upgraded to tertiary (UV) treatment. Historically, large volumes of sewage sludge were dumped in Liverpool Bay but this practice ceased in 1998.

In summary, there are major continuous sewage inputs to the Dee and Mersey estuaries, with the sewage loading to the Mersey about an order of magnitude higher that that to the Dee. In addition to this there is a major sewage discharge to Liverpool bay (Meols STW), but this has a higher level of treatment (UV) and discharges a considerably smaller volume than either of the two major continuous discharges to the outer Mersey estuary (Liverpool and Birkenhead STWs). Greater impacts at Leasowe are therefore expected from sources in the Mersey, although the Meols discharge is also likely to be of significance, particularly towards the outer part of the razor bed. When circumstances lead to a spill from the Meols STW storm or emergency discharges the importance of this discharge may increase significantly.

APPENDIX VIII
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: AGRICULTURE

Figure VIII.1 presents thematic maps of livestock densities for river subcatchment areas draining to the Dee and Mersey estuaries. This data was provided by Defra and the Welsh Assembly Government and is based on 2009 census data. Geographic assignment of animal counts in this dataset is based on the allocation of a single point to each farm, whereas in reality an individual farm may span two or more of the subcatchment areas. Nevertheless, Figure VII.1 should give a broad overview of the distributions of livestock within the Mersey and Dee estuary catchment areas, and Table VII.1 presents summary statistics by main catchment.

Table VIII.1 Summary statistics from 2009 livestock census by main catchment

	Mersey		Dee	
	Number	Density (animals/km^2)	Number	Density (animals/km^2)
Cattle	265,155	62	140,158	66
Sheep	369,729	86	657,382	309
Poultry	3,041,731	707	2,897,510	1,360
Pigs	55,029	13	5,971	3

Table VIII.1 indicates that there are higher overall numbers and densities of grazing livestock within the Dee catchment. Sheep are present in highest densities in the upper reaches of both these catchments, and so their main concentrations are some distance from the estuaries. Cattle are found at highest densities in the southern half of the Mersey estuary catchment, and in the lower catchment of the Dee, and so their main concentrations are closer to the estuaries and so may be of more influence. Numbers of pigs were low in both catchments relative to cattle and sheep. Poultry were present throughout the area, apart from in the more urbanised areas and the upper reaches of the Dee catchment. A major anomaly in poultry numbers in one of the lower Dee subcatchments (the Clywedog) is noted, with reported numbers being much higher than actual numbers due to the head office of a large poultry firm being located here. The concentration of faecal coliforms excreted in the faeces of animal and human and corresponding loads per day are summarised in Table VIII.1.

Table VIII.1 Levels of faecal coliforms and corresponding loads excreted in the faeces of warm-blooded animals.

Farm Animal	Faecal coliforms (No. g^{-1} wet weight)	Excretion rate (g day^{-1} wet weight)	Faecal coliform load (No. day^{-1})
Chicken	1,300,000	182	2.3×10^8
Pig	3,300,000	2,700	8.9×10^8
Human	13,000,000	150	1.9×10^9
Cow	230,000	23,600	5.4×10^9
Sheep	16,000,000	1,130	1.8×10^{10}

Data from Geldreich (1978) and Ashbolt et al. (2001).

There is likely to be seasonality in levels of contamination originating from livestock. Numbers of sheep and cattle will increase significantly in the spring,

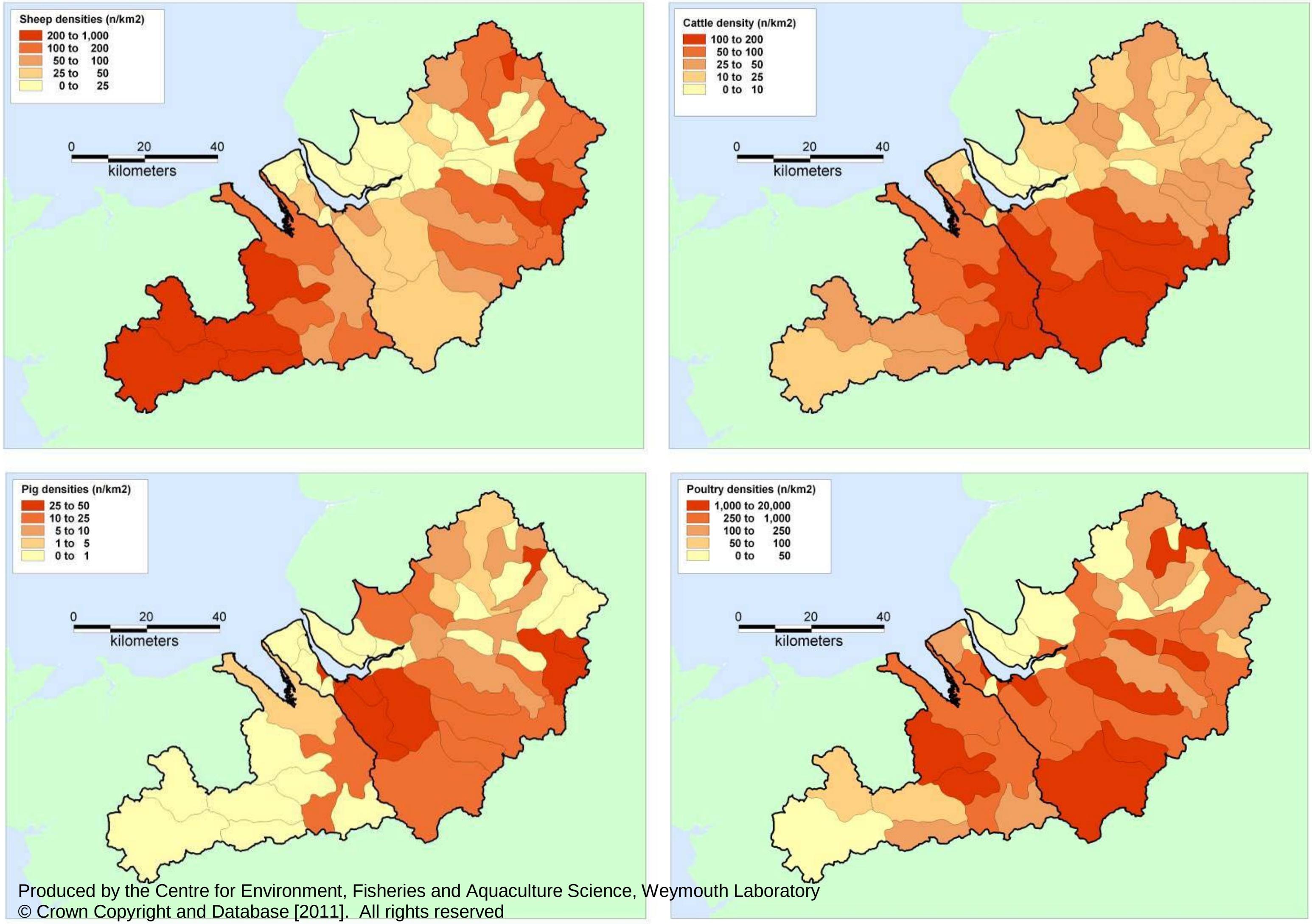

Figure VIII.1 Estimated densities of livestock by subcatchment (Data provided by DEFRA and WAG).

with the birth of lambs and calves, and decrease in the autumn when animals are sent to market. During winter cattle may be transferred from pastures to indoor sheds, and at these times slurry will be collected and stored for later application to fields. Timing of these applications is uncertain, although farms without large storage capacities are likely to spread during the winter and spring. Therefore peak levels of contamination from sheep and cattle may arise following high rainfall events in the summer, particularly if these have been preceded by a dry period which would allow a build up of faecal material on pastures, or if wet weather occurs following slurry application which is more likely in winter or spring. Manure/slurry from pig and poultry operations are typically spread on nearby farm land (Defra, 2009), and this may occur at any time of the year.

Overall, livestock numbers are fairly similar within the Dee and Mersey estuary catchments, but densities are higher in the Dee catchment, so higher concentrations of faecal indicators may be expected in freshwater inputs to the Dee estuary on this basis. A similar seasonal variation in livestock inputs may be expected within both these catchments, with highest bacterial loadings expected from pastures following high rainfall events in the summer when stock numbers are highest, or in localised areas where slurry has been spread before heavy rain.

APPENDIX IX
SOURCES AND VARIATION AND MICROBIOLOGICAL POLLUTION: BOATS

The main centre for shipping in the area is the Port of Liverpool, which is the largest port on the north west coast and handles about 15,000 shipping movements and 40 million tonnes of cargo annually (Peel Ports, 2010). Traffic is mainly commercial containerships, although a few cruise liners also use the port. Most docks are on the east shore of the Mersey, although there are also significant areas of docks on the Wirral side of the estuary. The only safe approach to the Mersey estuary for larger vessels is via the Crosby channel, which is about 4.5 km from the cockle beds at its closest point. Sewage disposal services are available from the Mersey Docks and Harbour Company. The Manchester ship canal handles much more limited shipping traffic from Eastham Lock entrance, 8 miles up the Mersey estuary, to Salford Quays, 36 miles further east. The much smaller Port of Mostyn lies on the west side of the outer Dee estuary and also handles some commercial shipping. As the discharge of sewage to the sea by merchant shipping is not permitted within 3 nautical miles of land[1] no impacts on the shellfish bed from sewage discharged by commercial shipping traffic are anticipated.

Smaller vessels such as yachts, pleasure craft and fishing vessels are not covered by the specific sewage disposal regulations for commercial shipping and so offer a greater potential for contaminating shellfish in inshore waters. It may be speculated that live aboard yachts and other small craft which are occupied overnight are most likely to make overboard discharges. Three areas of moorings hosting smaller craft were identified during the shoreline survey; one at West Kirby (48 yachts on drying moorings, a small proportion of which may have been occupied), one at Meols (29 yachts and fishing boats on drying moorings), and one at the mouth of the Mersey (16 yachts on moorings). There are 350 yacht berths at Liverpool Marina, located in central Liverpool on the east shore of the Mersey, but no pumpout facilties.

[1] The Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008.

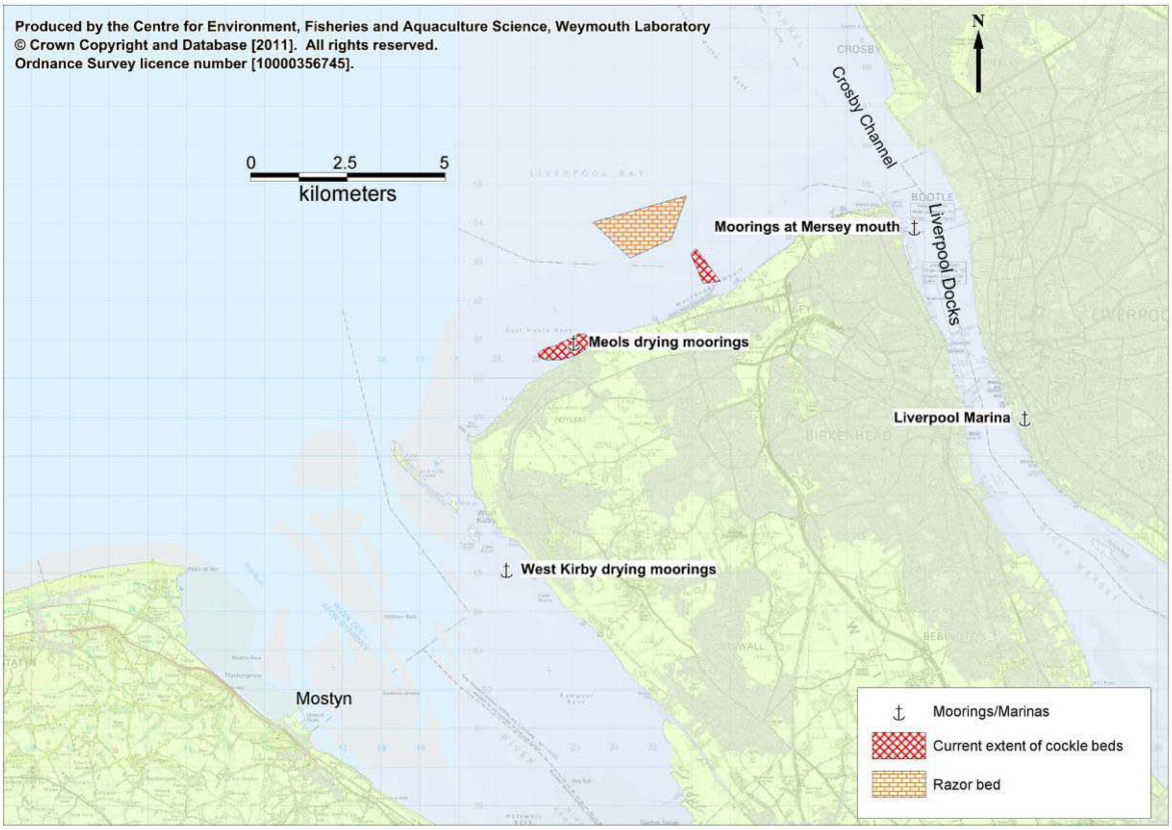

Figure IX.1 Summary of shipping and boating activity in the area.

It is concluded that only the smaller vessels are likely to discharge in the vicinity of the fishery. It is likely that there are more occupied small craft in the area during the summer months. Moorings where yachts in overnight occupation may be present are located at Meols, West Kirby and the mouth of the Mersey. The magnitude of these potential inputs is likely to be relatively small, but some of the moorings at Meols lie on top of the Dove Point cockle bed, so the potential for contamination of this bed by overboard discharges is higher than at Leasowe. These moorings cover a large area and any geographic patterns in impacts within this bed will depend on which boats, if any, make overboard discharges and this information is not available. Small craft may discharge closer to the Leasowe beds while *en route*, but the timing, location and frequency of such occurrences, aside from a probable seasonal fluctuation, is difficult to predict.

APPENDIX X
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: WILDLIFE

The North Wirral foreshore and the Mersey and Dee estuaries feature large areas of intertidal sand and mud flats, which support internationally important populations of migrant and overwintering wildfowl and waders. The Dee and to a lesser extent the Mersey estuaries also have significant areas of saltmarsh habitat also used by wildfowl and waders. Table X.1 presents bird counts for by species for the month of peak numbers from the Wetland Bird Survey (WEBS) for the Dee and Mersey estuaries at the most recent count (Holt *et al*, 2009). Bird counts are only reported for these estuaries where they are present in numbers of national importance, and this threshold varies by species. Only those species for which peak counts were 500 or above are presented.

Table X.1 Peak WEBS counts of wildfowl and waders, 2007/8

	Dee		Mersey	
Species	Count	Month	Count	Month
Dunlin	12,094	Feb	41,270	Nov
Oystercatcher	20,922	Dec	-	-
Shelduck	9,425	Sep	10,644	Jul
Lapwing	9,526	Jan	7,154	Feb
Redshank	12,994	Sep	2,069	Oct
Knot	11,212	Jan	-	-
Shelduck	9,425	Sep	-	-
Curlew	5,346	Sep	982	Feb
Black Tailed Godwit	5,278	Nov	339	Jul
Canada goose	2,536	Sep	2,706	Jul
Pintail	4,334	Nov	-	-
Teal	2,144	Nov	2,072	Jan
Wigeon	2,461	Nov	-	-
Herring gull	1,360	Apr	-	-
Sandwich Tern	1,334	Jul	-	-
Cormorant	1,133	Nov	-	-
Grey Plover	762	Jan	-	-
Sanderling	762	Feb	-	-
Common Tern	579	Aug	-	-
Ringed Plover	551	Aug	-	-

The north Wirral foreshore is not subject to WEBS counts but is designated as an SSSI under the Wildlife and Countryside Act due to its importance as a feeding and roosting site for migrating and wintering flocks of waders, wildfowl, terns and gulls. Whilst it does not support the diversity or numbers of these species recorded in the Dee and Mersey estuary, Natural England indicate the area supports large wintering populations of knot (20000+), dunlin (10000+) and bar tailed godwit (2000+), redshank (1000+), turnstone (500+), oystercatcher (500+) and some other species in smaller numbers (English Nature, 1986). This information was last updated in 1986, so numbers may have changed significantly since this time.

The applicant advised that around 3000 waterbirds reside in the area feeding on the cockle beds at Leasowe during the autumn and winter, and that they tend to forage more on the inshore parts of the bed. During the shoreline survey about 100 birds were noted foraging on the cockle beds, and there appeared to be more bird footprints and droppings towards the shore although they were present throughout the area. At high tide, they are likely to rest on breakwaters and other structures such as the two breakwaters at Mockbeggar Wharf, so there may be increased concentrations of droppings around these features. The cockle beds at Dove Point are also likely to represent a food source for overwintering waterbirds, and are also higher up the intertidal zone, so it is likely that a similar pattern of bird presence occurs at this bed.

Studies in the UK have found significant concentrations of microbiological contaminants (thermophilic campylobacters, salmonellae, faecal coliforms and faecal streptococci) from intertidal sediment samples supporting large communities of birds (Obiri-Danso and Jones, 2000). Therefore, it is likely that a proportion of the *E. coli* found within shellfish samples is likely to be of avian origin, and this will be much more significant during the autumn and winter months. As this contamination is via direct deposition it may be quite patchy, so some shellfish may contain quite high levels of *E. coli* whereas others a short distance away may be unaffected. However, as they tend to forage more towards the inshore parts of the bed it is likely that on average the more inshore areas are subject to higher levels of contamination from this source.

There is a population of grey seals which haul out on Haul out on the east side of the West Hoyle sand bank, just to the west to the Hilbre islands, about 2 km off the east shore of the outer Dee estuary (Cheshire Region Biodiversity Partnership, 2010). They use this site to haul out, feed and moult, but not to breed, so breeding adults will leave the area during the autumn. During the summer, numbers can exceed 500, but drop to about 50 during the autumn. In spatial terms, contamination is likely to be heaviest in the immediate vicinity of their haulout site. Any contamination deposited here is unlikely to impact significantly on the shellfish beds on the North Wirral coast due to the distance between the two. On a wider scale they are likely to forage throughout Liverpool Bay, and so potentially represent a diffuse source of pollution to the beds. Given the large area they are likely to forage over impacts are likely to be minor, and unpredictable in spatial terms, but will peak during the summer, and be at its lowest during the autumn.

No other wildlife species which have a potentially significant influence on levels of contamination within shellfish on the North Wirral shore have been identified.

APPENDIX XI
MICROBIOLOGICAL DATA: WATER

BATHING WATERS

There are four bathing waters sites within 10 km of the fishery, designated under the Directive 76/160/EEC (Council of the European Communities, 1975): West Kirby, Meols, Moreton and New Brighton (Figure XI.1). Three of these lie on the north coast of the Wirral, and one (West Kirby) is located on the Wirral coast just within the mouth of the Dee estuary.

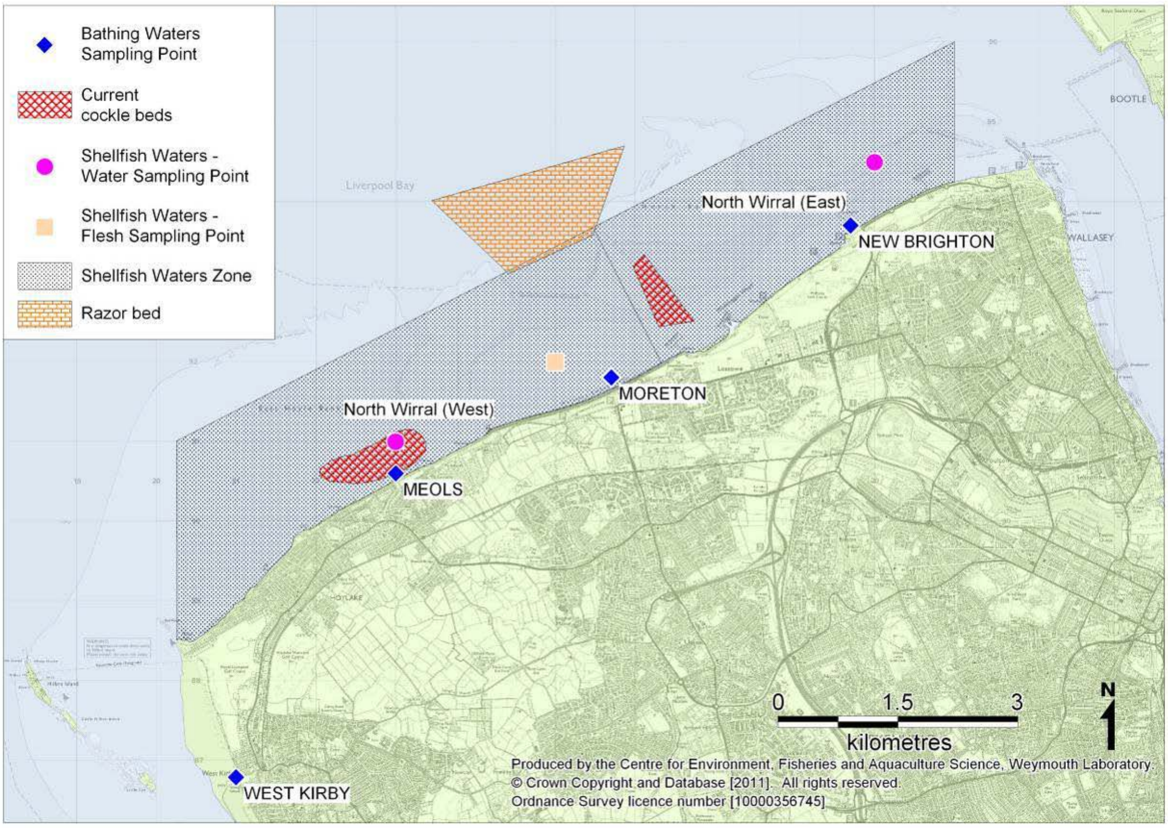

Figure XI.1 Location of designated bathing waters, shellfish growing waters and associated monitoring points on the north Wirral coast.

Around 20 samples were taken from each of these sites during each bathing season, which runs from the 15th May to the 30th September. Faecal coliforms (confirmed) were enumerated in all these samples. Figure XI.2 presents box plots of all results from 2000 to 2009 by bathing water (from west to east).

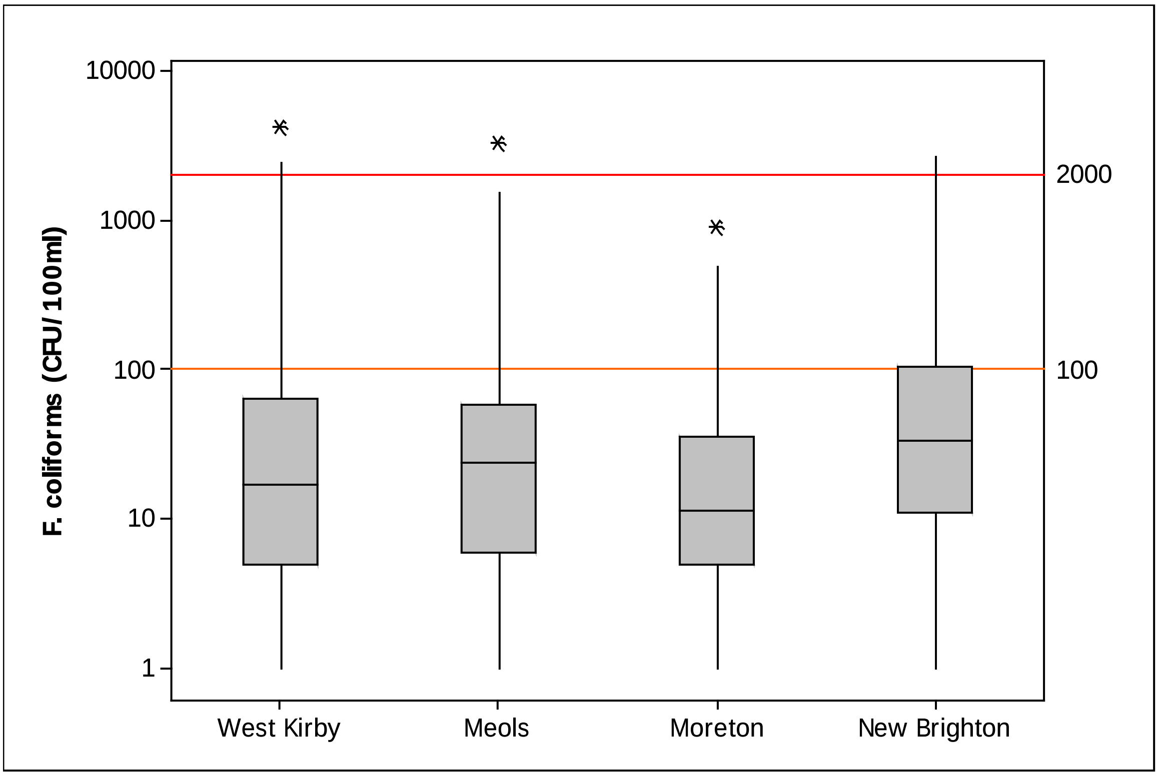

Figure XI.2 Box-and-whisker plots of all faecal coliforms results by site (2000-2009)

In terms of geometric mean results, the sites were ranked as New Brighton>Meols>West Kirby>Moreton. Results from New Brighton were significantly higher than those for Moreton and West Kirby, and results for Meols were significantly higher than those for Moreton (One-way ANOVA, p=0.000, Tukey's comparison).

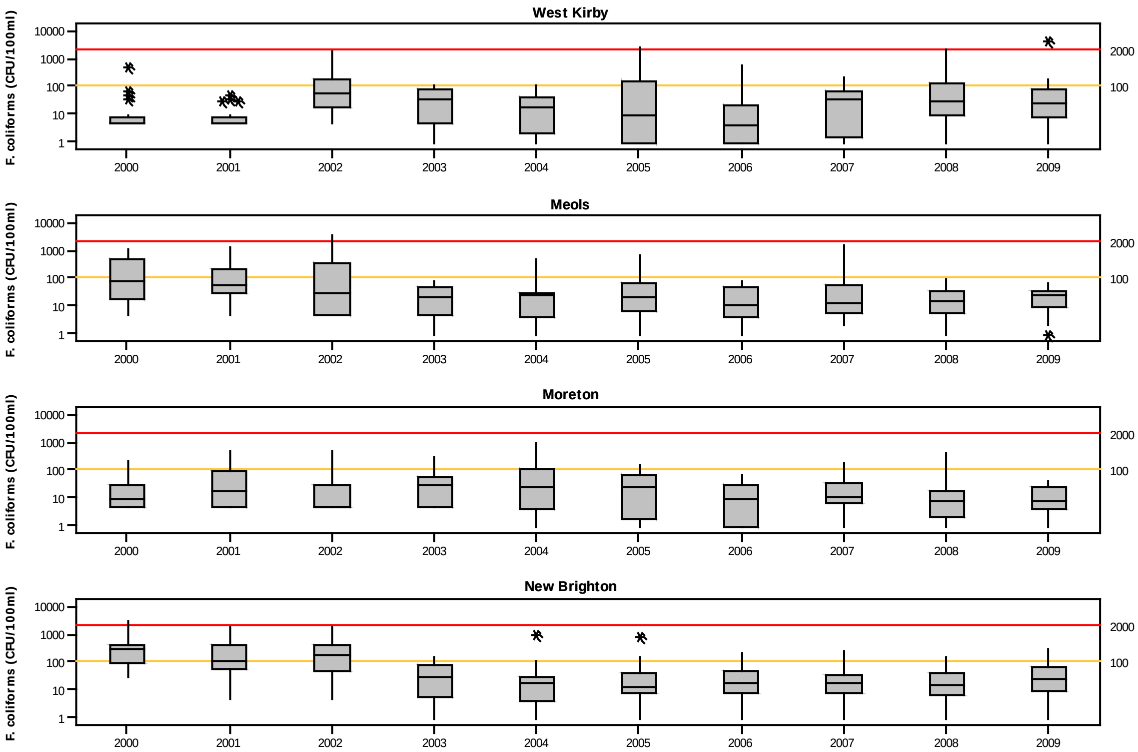

Figure XI.3 Box-and-whisker plots of levels of faecal coliforms in designated bathing waters by year, 2000-2009

Marked improvements in water quality appear to have occurred at Meols and New Brighton between 2002 and 2004, but not at the other 2 sites.

Figure XI.4 presents polar plots of log_{10} faecal coliforms (cfu/100ml) against tidal state on the high low cycle for each monitoring point. High water at Liverpool (Alfred Dock) is at 0° and low water is at 180°. Results of 100 faecal coliforms/100ml or less are plotted in green, those between 100 and 2000 are plotted in yellow, and those exceeding 2000 are plotted in red. Circular linear correlations were carried out on these results, and correlation coefficients (r) and p values are presented for each chart.

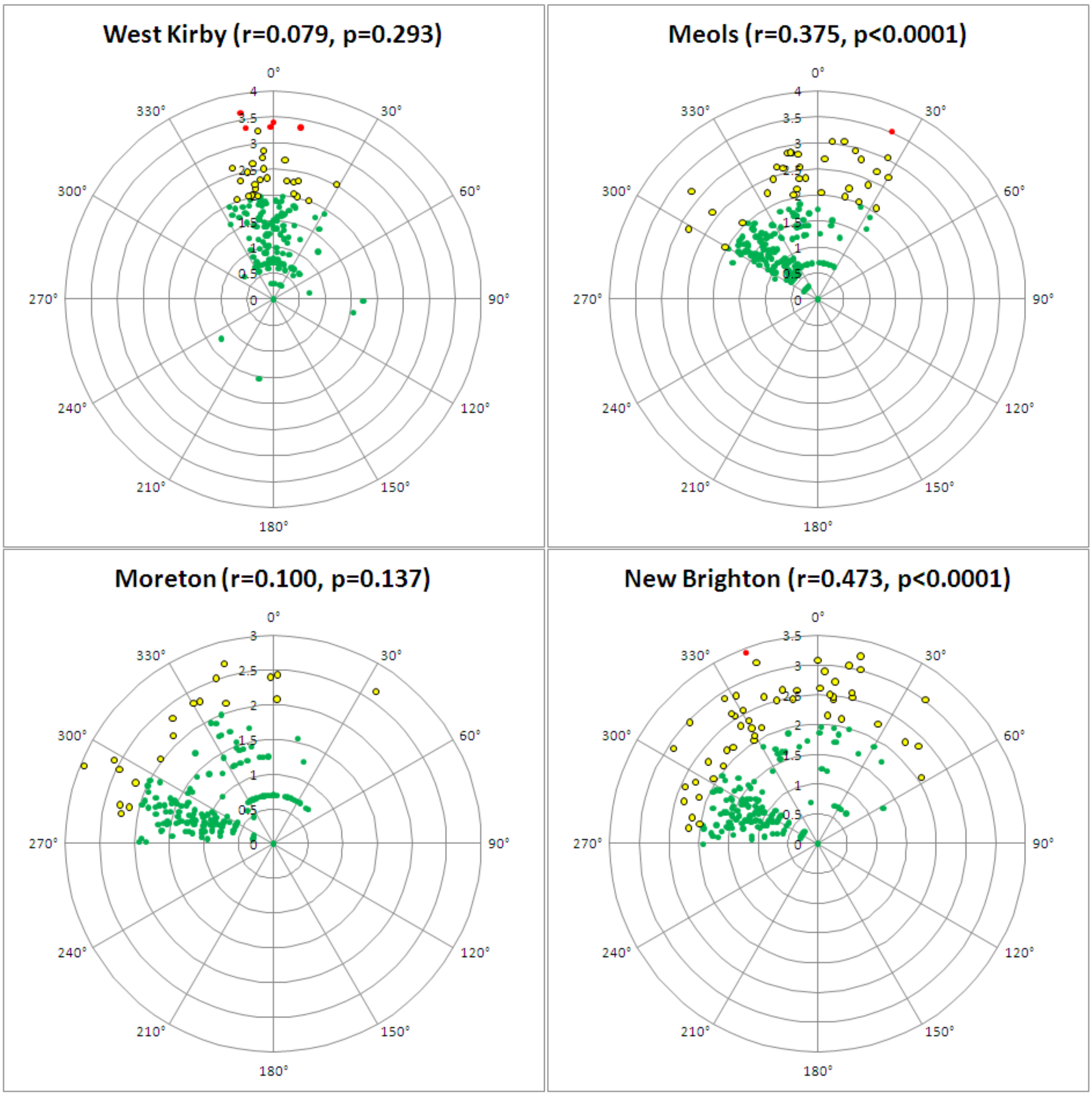

Figure XI.4. Polar plots of $\log_{10}$ faecal coliform results (cfu/100ml) against tidal state on the high low cycle for the four bathing waters monitoring points (2000-2009)

Highly significant correlations between tidal state and levels of contamination were found at Meols and New Brighton. For both these monitoring points a distinct increase in contamination can be seen as the tide starts to ebb.

Figure XI.5 presents polar plots of $\log_{10}$ faecal coliforms (cfu/100ml) against tidal state on the spring neap cycle for each monitoring point. Full/new moons occur at 0º, and half moons occur at 180º. The largest (spring) tides occur about 2 days after the full/new moon, or at about 45º, then decrease to the smallest (neap tides) at about 225º, then increase back to spring tides.

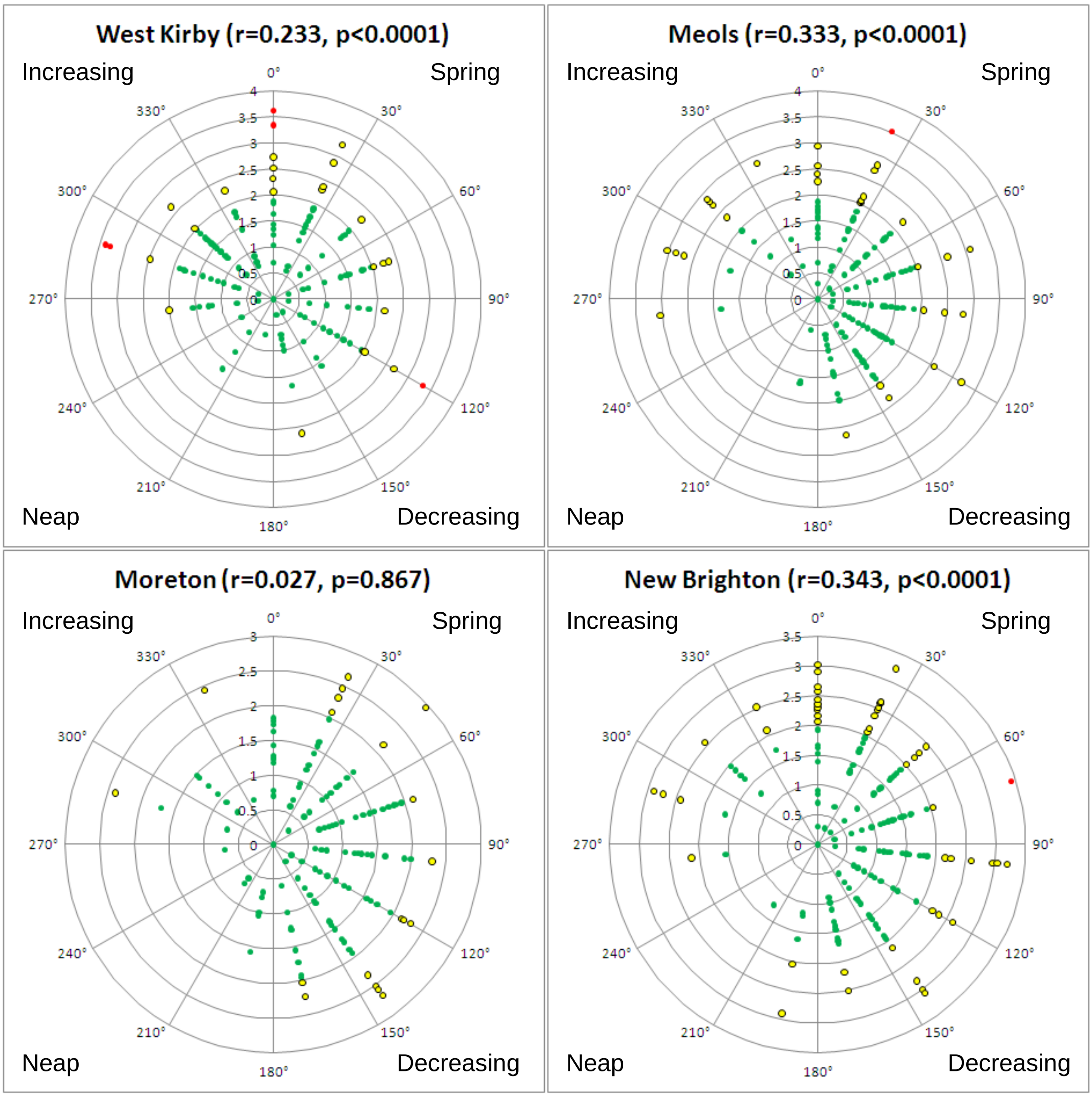

Figure XI.5. Polar plots of $\log_{10}$ faecal coliform results (cfu/100ml) against the spring neap tidal cycle for the four bathing waters monitoring points (2000-2009)

At West Kirby, few samples were taken during neap tides. A correlation was found between the spring/neap tidal cycle and levels of contamination, which were highest on average just before the largest spring tides, and lowest during neap tides.

For Meols, Moreton and New Brighton few samples were taken during neap tides and those increasing in size towards springs. No correlation was found between the spring/neap tidal cycle and levels of contamination at Moreton. Correlations between these two variables were found at Meols and New Brighton. In both cases, results were higher on average as the tide size increased from neaps to springs.

To investigate the effects of rainfall on levels of contamination at the bathing waters sites Spearman's rank correlations were carried out between rainfall recorded at the Moreton weather station (Appendix II for details) over various periods running up to sample collection. These are presented in Table XI.2, and statistically significant correlations ($p<0.05$) are highlighted in yellow.

Table XI.2 Spearman's Rank correlations between rainfall recorded at Moreton and Bathing Waters sample results from sites on the North Wirral (2000-2009)

		West Kirby	Meols	Moreton	New Brighton
	No.	197	201	201	201
24 hour periods prior to sampling	Day of sampling	0.160	0.038	0.129	0.027
	1 day	0.211	0.187	0.080	0.133
	2 days	0.149	0.009	0.049	0.068
	3 days	0.199	-0.094	0.069	0.009
	4 days	0.034	-0.121	-0.020	-0.122
	5 days	0.005	-0.054	-0.072	0.021
	6 days	0.189	0.058	-0.002	0.068
	7 days	0.056	-0.093	-0.095	-0.106
Total prior to sampling over	2 days	0.239	0.153	0.106	0.102
	3 days	0.221	0.123	0.133	0.096
	4 days	0.239	0.083	0.128	0.119
	5 days	0.231	0.042	0.107	0.073
	6 days	0.187	0.034	0.085	0.089
	7 days	0.233	0.055	0.103	0.113

Table XI.2 indicates that levels of contamination at West Kirby are influenced by rainfall in the week preceding sampling. Significant but fairly weak correlations were also found between results at Meols and rainfall on the day before sampling and the total over 2 days prior to sampling. No correlations between recent rainfall and levels of contamination were found at either Moreton or New Brighton. This suggests that rainfall dependent sources are of importance in the Dee estuary, but their importance decreases towards the eastern end of the North Wirral coast.

SHELLFISH WATERS

The intertidal area on the north shore of the Wirral has been designated under Directive 2006/113/EC as a Shellfish Water since 1999 (European Communities, 2006). It is split into two areas; North Wirral East and North Wirral West (Figure XI.1). Table XI.2 presents summary statistics for all bacteriological monitoring results from these sites.

Table XI.2 Summary statistics for levels of faecal coliforms in surface waters and shellfish flesh at the designated Shellfish Waters on the north Wirral coast.

	Shellfish Water			
	North Wirral West	North Wirral East	North Wirral West	North Wirral East
NGR sampled	SJ 230 910	SJ 290 945	SJ 230 910	SJ 290 945
Matrix	Seawater	Seawater	Mussel	Mussel
No. samples	48	49	9	9
Minimum	<2	<2	<10	<10
Maximum	279	4,000	240	250
Geometric mean	14.7	11.5	18.3	21.7
Date of first sample	25 April 2001	25 April 2001	26 January 2000	26 January 2000
Date of last sample	13 May 2010	13 May 2010	12 October 2000	12 October 2000

Data from the Environment Agency. Results are in cfu/100ml (water samples) or MPN/100g (shellfish samples)

No significant difference was found between the results from the two shellfish waters for either seawater samples (T-test, t=-0.68, p=0.50) or shellfish samples (Paired T-test, t=-0.33, p=0.752).

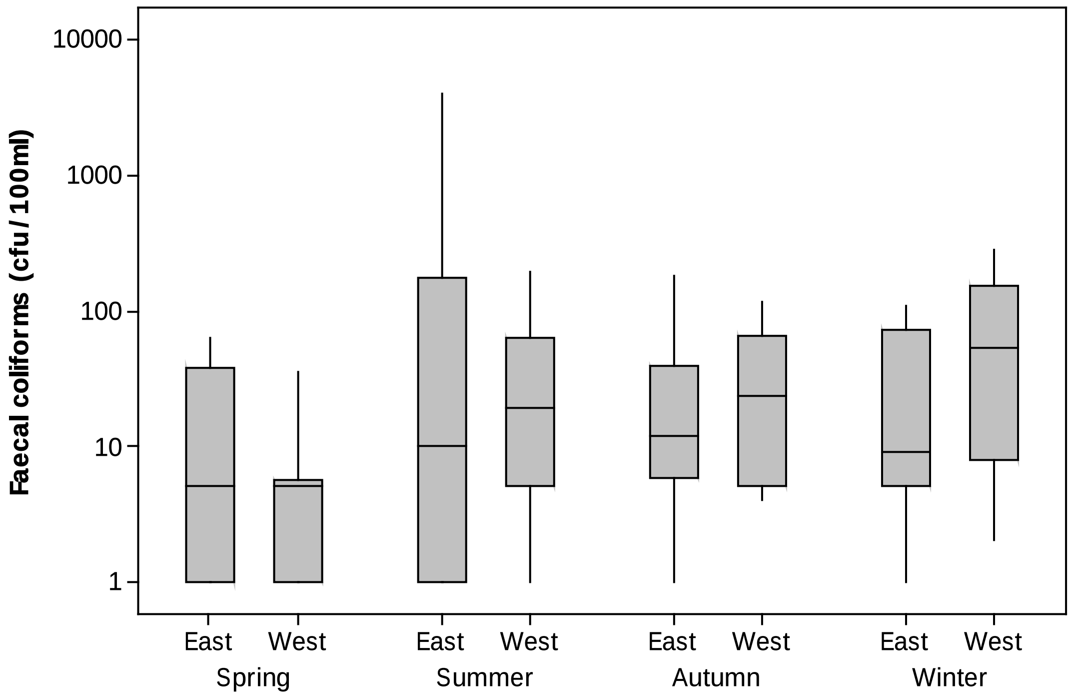

Figure XI.5. Box plot of seawater faecal coliform results (cfu/100ml) by shellfish water and by season.

Significant differences in mean result by season were found at North Wirral West, with results for the autumn and winter significantly higher than those for the spring (One-way ANOVA, p=0.002, Tukeys' post ANOVA comparison). Results for North Wirral West were highest on average in the summer, and lowest in the spring, but this pattern was not statistically significant (One-way ANOVA, p=0.626).

APPENDIX XII
MICROBIOLOGICAL DATA: SHELLFISH FLESH

Sample results for a total of 11 bed/species combinations were listed on the Cefas Shellfish Hygiene database. Of these, 6 were located on the north coast of The Wirral (Figure XII.1), one was located in the Mersey estuary upstream of the docks at Liverpool, and 5 were located on the coast of Liverpool Bay between the towns of Crosby and Formby.

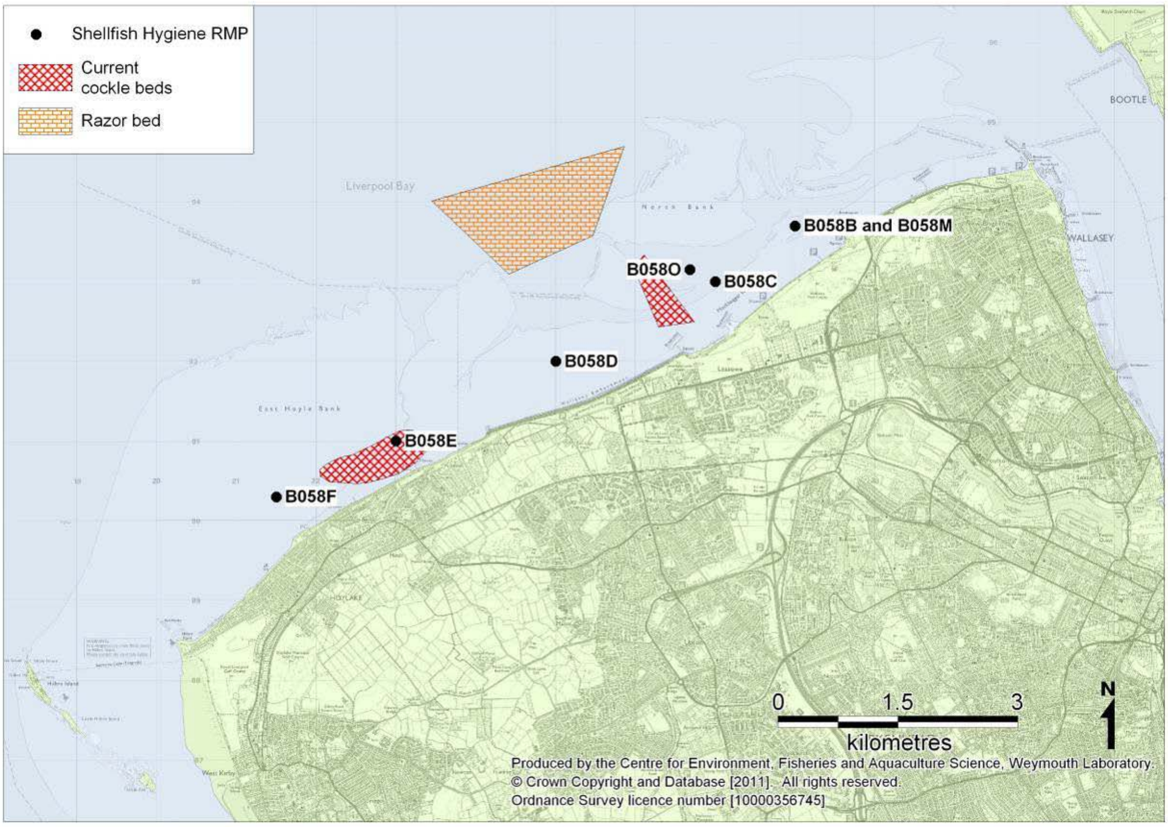

Figure XII.1 Location of historic Liverpool Bay RMPs located on the North Wirral coast

Those beds located on the Crosby to Formby Coast, and within the Mersey estuary have not been sampled since 1999 at the latest, and lie 5 km or more from the shoreline considered in this report, so results from these beds are not presented as they are of little relevance to the present situation on the north shore of The Wirral. Table XII.1 shows summary statistics for levels of *E. coli* in bivalves from all RMPs on the north Wirral coast for the period January 1992 – June 2010.

Table XII.1 Summary statistics for* E. coli *levels at representative monitoring points (RMPs) on the North Wirral coast.

RMP	Bed name	Species	n	Date of first sample	Date of last sample	% samples >230	% samples >4600	MPN *E. coli* 100g^{-1} FIL Minimum	Maximum	Median	Geometric mean
B058B	Wallasey Harrison Drive	*C. edule*	72	27 January 1992	28 September 1999	72%	13%	<20	17000	600	703
B058C	Leasowe	*C. edule*	29	27 January 1992	13 October 1999	69%	7%	<20	7000	430	350
B058D	Leasowe Lighthouse	*M. edulis*	131	07 February 1995	05 May 2010	60%	5%	<20	18000	310	337
B058E	Meols Dove Point	*C. edule*	61	13 January 1992	22 October 2001	61%	11%	40	17000	500	545
B058F	Hoylake (Sandhey Slipway)	*C. edule*	74	13 January 1992	27 November 2006	46%	4%	<20	54000	220	272
B058M	Wallasey Harrison Drive	*M. edulis*	2	13 September 1995	03 March 1998	100%	50%	500	9100	4800	2133
B058N	Leasowe Lighthouse	*C. edule*	17	13 January 1992	15 December 1992	65%	0%	70	3500	700	477
B058O	North Wirral	*C. edule*	1	22 February 2010	22 February 2010	100%	0%	-	-	490	-

FIL - flesh and intravalvular liquid.
RMP - representative monitoring point.
n - number of samples.

GEOGRAPHICAL VARIATION IN LEVELS OF CONTAMINATION

Six locations on the north Wirral coast were sampled for cockles, but 77% of these samples were taken in the 1990s, and none is currently sampled. Although these results may not be an accurate reflection of current levels of contamination in shellfish given the improvements in wastewater treatment in the area since this time, this is the only dataset available with comprehensive geographical coverage along the north Wirral foreshore. A box and whisker plot of these results by site is presented in Figure XII.2 (the single result for B058O is not included).

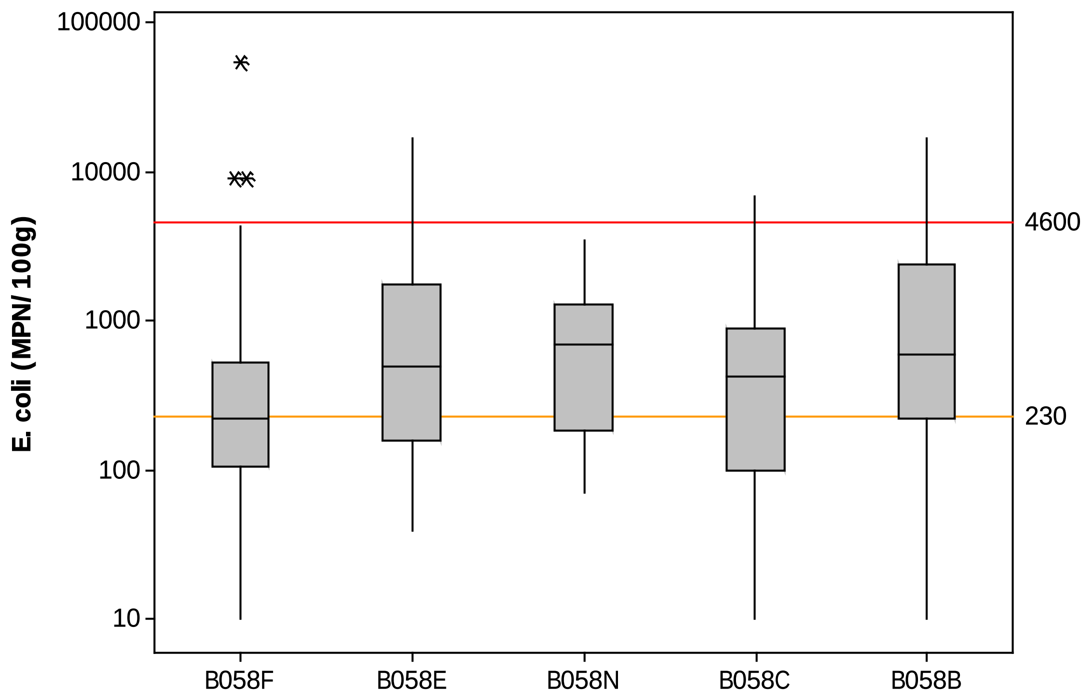

Figure XII.2 Box-and-whisker plots of levels of* E. coli *in cockles from the five representative monitoring points sampled more than once (from west to east).

Geometric mean results for cockle sites rank as B058B>B058E>B058N>B058C>B058F, tentatively suggesting levels of contamination are higher towards the eastern end of this stretch of shoreline. Site B058E lies in the path of a creek through which the ebbing tide drains which may cause a localised hotspot of contamination, and therefore potentially explain why the results from this site do not align with this possible gradient in levels of contamination. The bed exhibiting the lowest results was the only one extensively sampled after 2000, so the lower results at this bed may be a consequence of temporal rather than spatial variation in levels of contamination. Also of note, the maximum recorded result arose at this location, but this occurred in 2005, and none of the other beds was sampled on this date. On 12 occasions in 1992, cockle samples were taken from five of the sampling locations on the same day and hence under the same environmental conditions allowing a more robust comparison. Geometric mean result for these occasions only rank as B058B> B058C> B058N> B058E> B058F, i.e. increasing from west to east, although the differences in levels of contamination for these samples by location were not statistically significant (2-way ANOVA, p=0.065).

Taken together, these cockle results tentatively suggest the more important sources of contamination lie to the east of the beds, aside from perhaps a localised hotspot in the vicinity of B058E which is located within a small creek through which the tide drains away. However, these conclusions were mainly drawn from data from the early 1990s and so are unlikely to be an accurate reflection of the current situation as significant improvements have been made to sewage infrastructure since this time.

Only two locations were sampled for mussels, one of these on only two occasions, so it was not possible to investigate geographical differences in levels of contamination for this species.

TEMPORAL CHANGES IN LEVELS OF CONTAMINATION

Figure XII.3 presents boxplots of *E. coli* results by year for all by bed/species combinations sampled during more than one year.

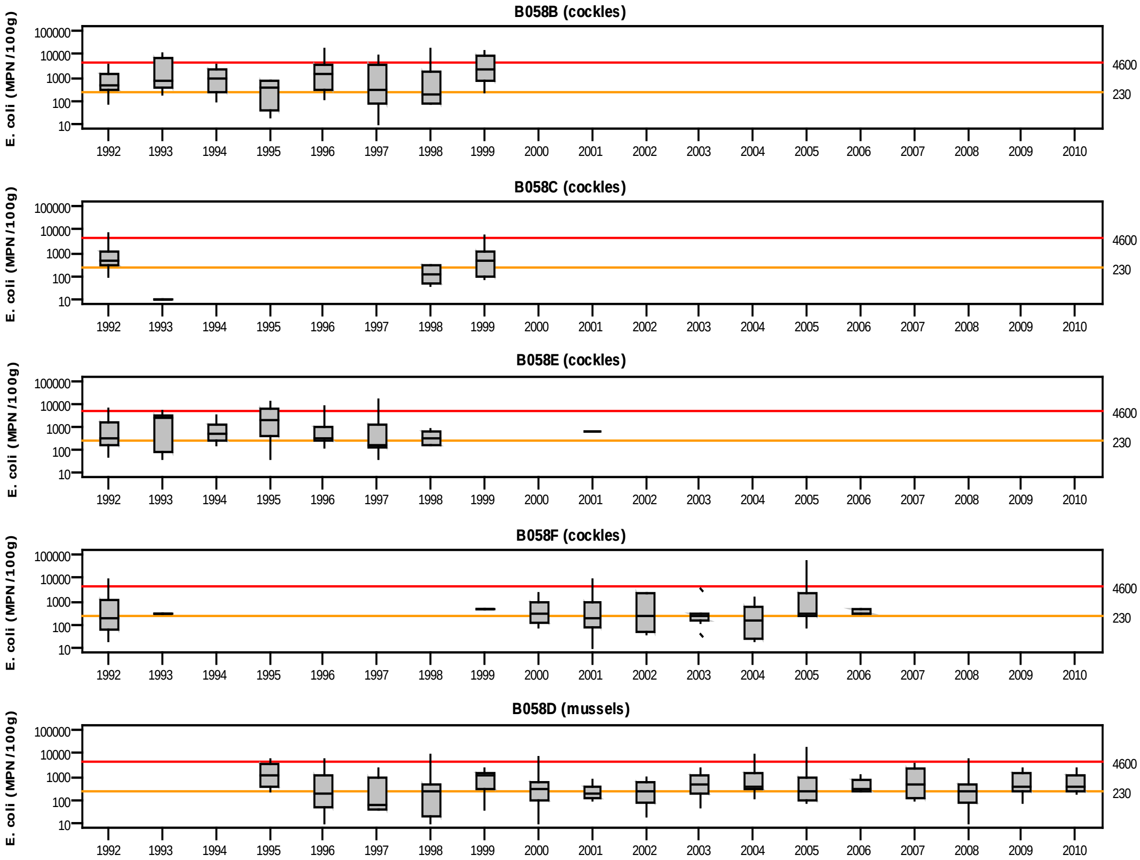

Figure XII.3 Boxplots of* E. coli *results by year for each bed species combinations sampled for more than one year

The most comprehensive monitoring history was for the mussel bed B058D, which was sampled 131 times from 1995 to the time of writing. Results for this bed appear to have improved from 1995 to 1997, deteriorated in 1998 and 1999, and while they have continued to fluctuate somewhat between years since 2000, they have generally been more consistent. Differing and inconsistent patterns between the years are apparent for the cockle beds.

SEASONAL VARIATION

Season influences not only weather patterns and water temperature, but patterns of human occupation, and the distribution of livestock and wildlife. All of these can affect levels of microbial contamination, and cause seasonal patterns in results.

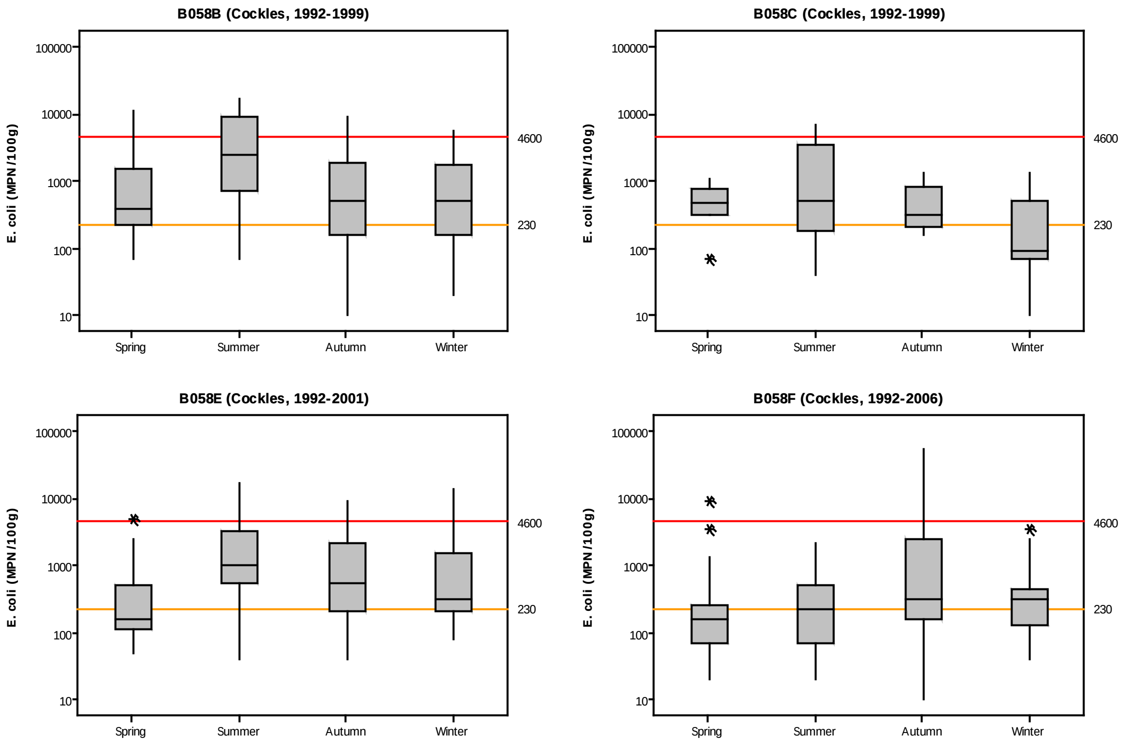

Figure XII.4 Boxplots of* E. coli *results by season for cockle beds sampled on more than 20 occasions

The general pattern in cockles was for higher results during the summer months, and lower results during the winter and spring. The seasonal pattern of results was only statistically significant for B058B, where results for the summer were sigificantly higher than those for the other seasons (One-way ANOVA with Tukey's comparison, p=0.009 for B058B, p=0.094 for B058C, p=0.077 for B058E, p=0.183 for B058F). Bed B058F was most intensively and most recently sampled, and results here were highest on average and most variable during the autumn months.

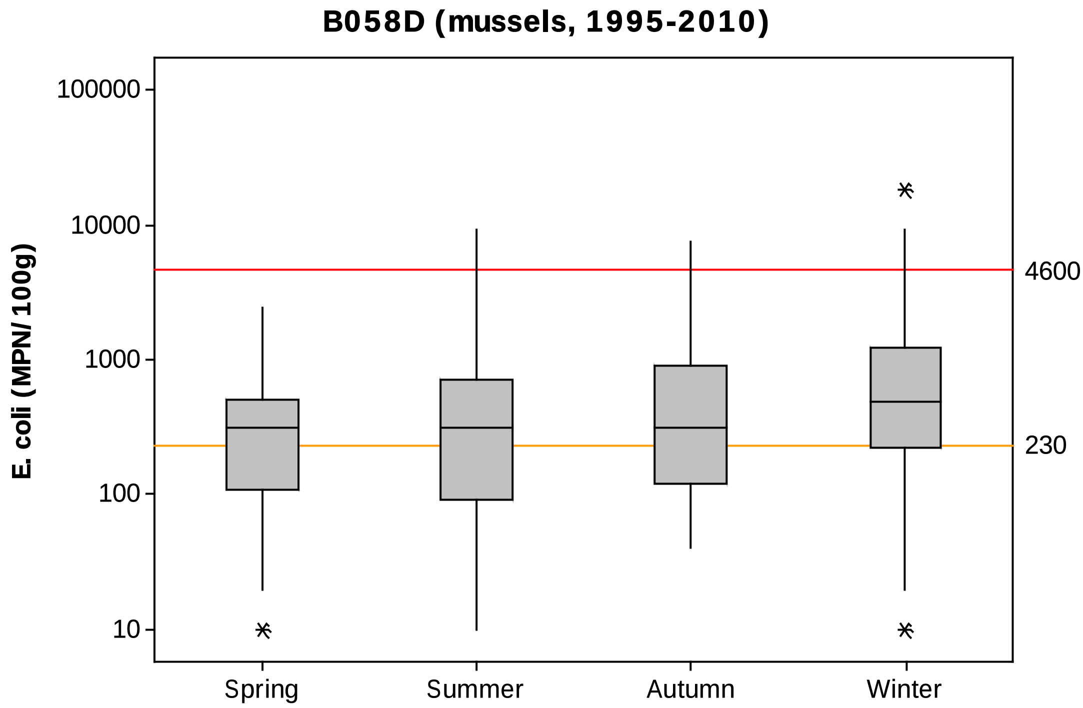

Figure XII.5 Boxplots of* E. coli *results by season for mussel bed B058D

For mussels from B058D, results were lowest on average during the spring, and highest on average during the winter, and a higher proportion of the results were over 230 *E. coli* MPN/100g arose during the winter. A comparison of geometric mean result by season revealed no significant difference (One way ANOVA, p=0.053).

In summary, seasonal variations were observed in both species. For both species, results were generally lowest in the spring. For cockles, results were generally highest during the summer in the 1990s, and in the autumn months after 2000. For mussels, which were mainly sampled post 2000, results were generally highest during the winter. Factors potentially responsible for the difference in these seasonal patterns between the two species may include the different periods through which they were sampled and any changes in relative importance of different sources, biological differences between them, and the location of the monitoring points.

INFLUENCE OF RAINFALL

To investigate the effects of rainfall on levels of contamination within shellfish samples Spearman's rank correlations were carried out with rainfall recorded at the Moreton weather station (Appendix II for details) over various periods running up to sample collection. These are presented in Table XII.2, and statistically significant correlations (p<0.05) are highlighted in yellow. Rainfall data was only available from 2000 onwards so this investigation was limited to samples from B058D and B058F only.

Table XI.2 Spearman's Rank correlations between rainfall recorded at Moreton and shellfish hygiene results from the North Wirral (2000 onwards)

		B058D (mussels)	B058F (cockles)
	No.	93	54
24 hour periods prior to sampling	Day of sampling	-0.006	0.454
	1 day	0.127	0.422
	2 days	0.046	0.391
	3 days	0.069	0.240
	4 days	0.152	0.327
	5 days	0.107	0.089
	6 days	0.142	0.069
	7 days	0.063	-0.185
Total prior to sampling over	2 days	0.070	0.550
	3 days	0.040	0.597
	4 days	0.058	0.571
	5 days	0.115	0.610
	6 days	0.097	0.552
	7 days	0.084	0.534

Strong correlations between *E. coli* results and rainfall in the 4 individual days and totals over the 7 days preceding sampling were found for cockles from B058F. No correlations were found between recent rainfall and levels in *E. coli* in mussels from B058D.

INFLUENCE OF TIDE

As sampling was targeted towards low water to permit access to the shellfish beds it was not appropriate to investigate the influence of the high/low tidal cycle on levels of *E. coli* in shellfish.

Figure XI.8 presents polar plots of $\log_{10}$ *E. coli* (MPN100g) against tidal state on the spring neap cycle for each monitoring point. Full/new moons occur at 0º, and half moons occur at 180º. The largest (spring) tides occur about 2 days after the full/new moon, or at about 45º, then decrease to the smallest (neap tides) at about 225º, then increase back to spring tides. Results of 230 *E. coli* MPN/100g or less are plotted in green, those from 231 to 4600 are plotted in yellow, and those exceeding 4600 are plotted in red. Circular linear correlations were carried out on these results, and correlation coefficients (r) and p values are presented for each chart. These analyses were only carried out for samples take from 2000 onwards.

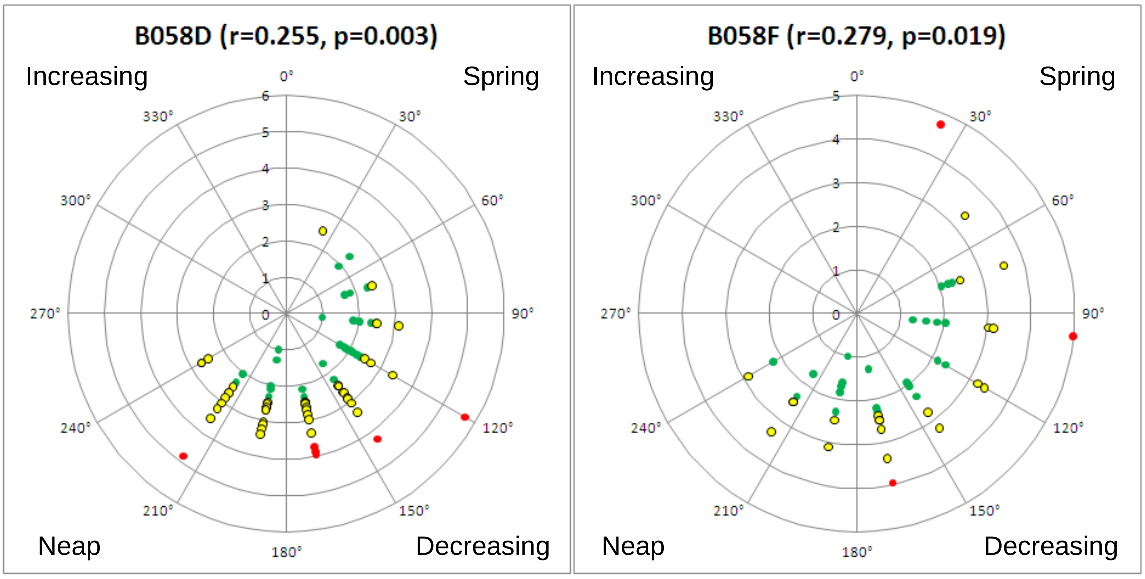

Figure XII.8 Polar plots of log_{10} faecal coliform results (cfu/100ml) against the spring neap tidal cycle for the four bathing waters monitoring points

Sampling was targeted towards the periods when tide size decreased from springs to neaps. Significant but weak correlations were found for both RMPs, but the patterns in levels of contamination in relation to tidal state differed. For mussels from B058D results increased on average as the tide size decreased, whereas the opposite pattern was observed for cockles from B058F. This may tentatively suggest that B058D is more influenced by contaminating sources close to it whereas B058F is influenced by more distant sources.

APPENDIX XIII
MICROBIOLOGICAL DATA: BACTERIOLOGICAL SURVEYS

INVESTIGATIONS UNDERTAKEN BY THE ENVIRONMENT AGENCY

Of particular relevance to this report, microbial source tracking was undertaken on a shellfish water sample taken in July 2008. Although this was only undertaken on one water sample, and the relative contributions of the identified sources could not be quantified, the presence of human, avian and canine mitochondrial DNA was identified. The water sample contained high levels of faecal coliforms (4000 cfu/100ml).

BACTERIOLOGICAL SURVEY RECOMMENDED BY CEFAS

On receipt and acceptance of the application for classification of shellfish beds by the North Western Sea Fisheries Committee on the 23rd June 2010 it became clear that the applicant wished to progress the classification of the cockle bed at Leasowe for the opening of the season on 1st September 2010.

After undertaking an initial desk-based study and a shoreline survey, the location of two potential representative monitoring points were identified. It was recommended that these points should be sampled at least 10 times for cockles at regular intervals not closer than weekly and not more than monthly and tested for the statutory indicator of contamination (*E. coli*). Two of the cockle samples taken during the shoreline survey were taken from these points and so were included in the bacteriological survey. It was agreed between the competent authority (the FSA) and the LEA that, unless the ongoing sanitary survey assessment identifies otherwise, the results of the bacteriological survey will form part of the preliminary monitoring towards classification for these beds. The points identified were at the north eastern and south eastern extremities of the present area covered by the cockle bed. Results of these samples to date are presented in Table XIII.1.

Table XIII.1 Bacteriological survey results

Date	*E. coli* (MPN/100g) SJ 2611 9334 (NE extremity)	 SJ 2674 9250 (SE extremity)
13/07/2010	24000	3500
11/08/2010	130	460
25/08/2010	330	490
13/09/2010	110	70
27/09/2010	330	130
12/10/2010	130	110
26/10/2010	50	130
01/11/2010	<20	20
08/11/2010	50	110
15/11/2010	50	50
Geometric mean	151	160

Bacteriological survey results indicate that there is little consistent difference in levels of contamination between the inshore and offshore ends of the cockle bed at Leasowe. As the highest result arose at the north eastern corner of the bed, this tentatively supports the location of the RMP here.

APPENDIX XIII
SHORELINE SURVEY

Date (time): 12th July 2010 1300-1730, 13th July 2010 0630-0930
Applicant: Chris Woods (North Western Sea Fisheries Committee)
Cefas Officers: Carlos Campos & Alastair Cook
Local Enforcement Authority Officer: Selwyn Willams (Mersey PHA)

Area surveyed: selected parts of the north Wirral shoreline between West Kirby and New Brighton (Figure XIII.2).

Objectives: (a) confirm the existence of pollution sources identified during the desk study likely to constitute sources of microbiological contamination for the mussel beds; (b) identify any additional pollution sources in the area; (c) confirm the extent and location of the shellfish beds and shellfish gathering activities on the north Wirral shoreline.; (d) submit cockle samples for *E. coli* testing which may potentially be used in determining classification.

The predicted times and heights of high and low waters and tidal curve on the day of the survey are given in Figure XIII.1 and Table XIII.1.

***Table XIII.1 Predicted high and low water times and heights for Liverpool on 12-13th July 2010**.*

	Time-BST (height)
Low Water	12/7/2010 06:49 (1.0m)
High Water	12/7/2010 12:27 (9.2m)
Low Water	12/7/2010 19:01 (1.1m)
High Water	13/7/2010 00:44 (9.6m)
Low Water	13/7/2010 07:39 (0.6m)
High Water	13/7/2010 13:15 (9.4m)
Low Water	13/7/2010 19:48 (0.9m)

Predicted heights are in metres above Chart Datum.

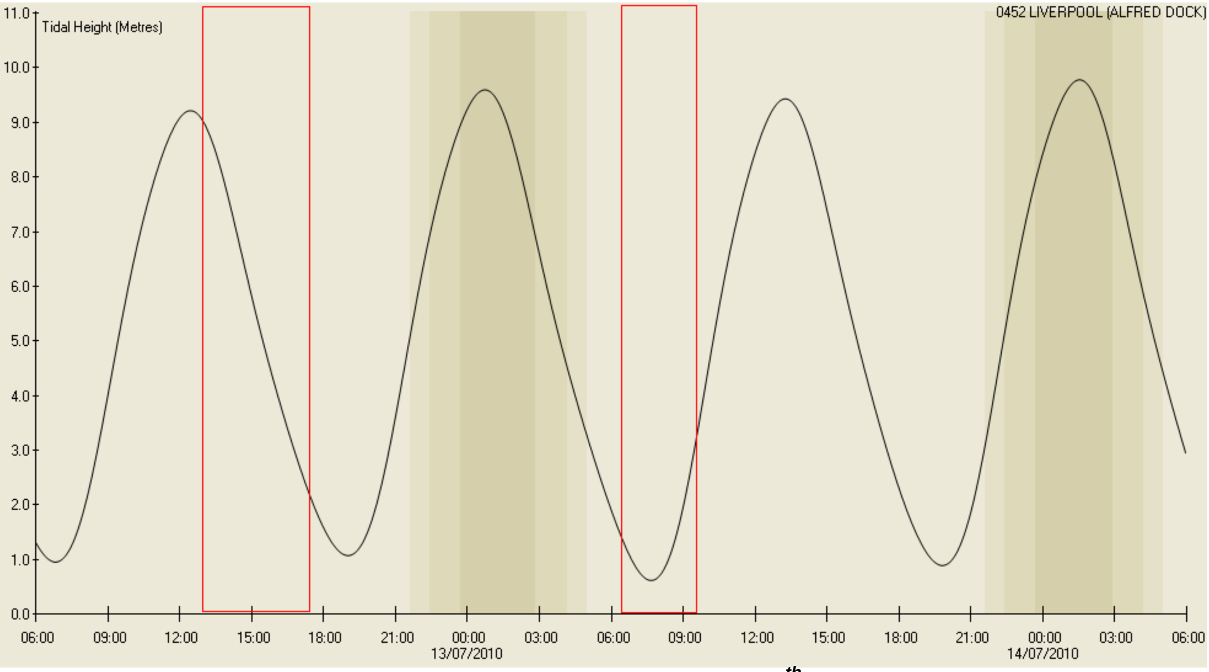

Figure XIII.1 Tidal curve at Liverpool on 12-13th July 2010.
Predicted heights are in metres above Chart Datum Republished with permission from Admiralty Total Tide (United Kingdom Hydrographic Office) by permission of Her Majesty's Stationery Office and the UK Hydrographic Office.
© Crown copyright.

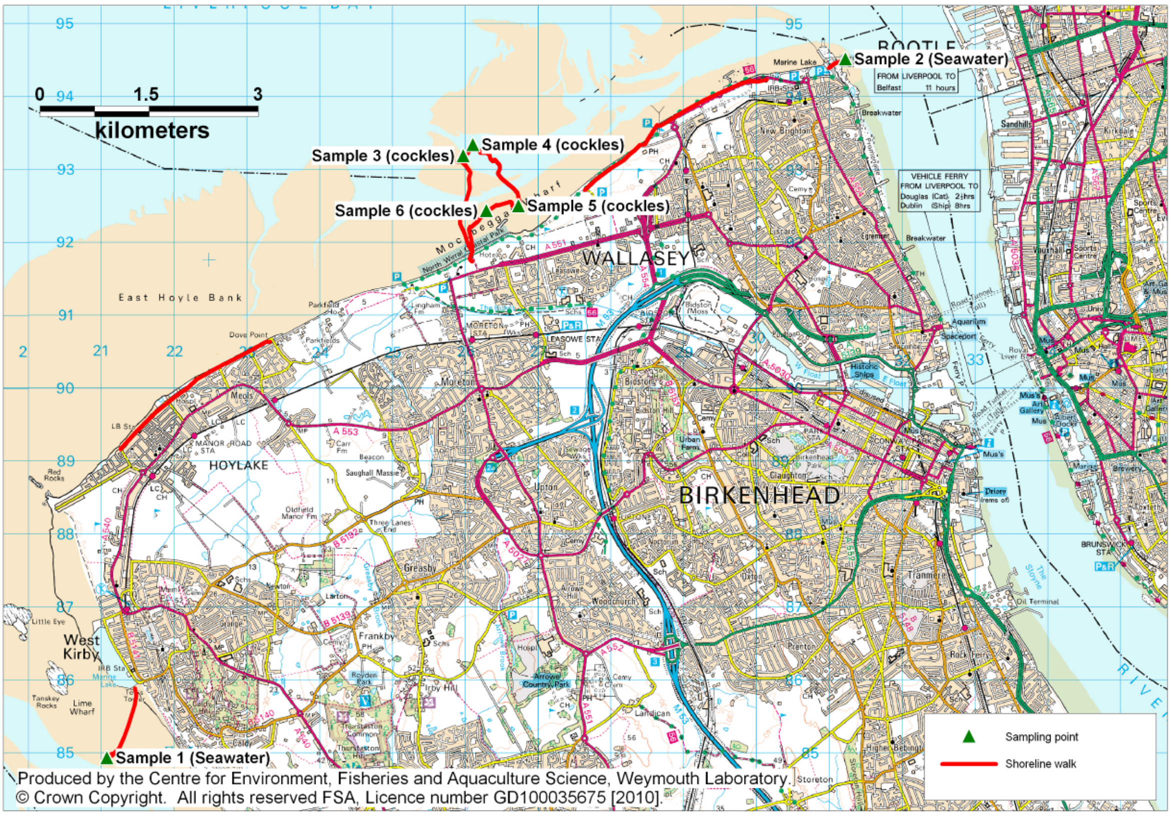

Figure XIII.2 Location of sites sampled at Liverpool Bay on 12-13th July 2010.

Table XIII.2 summarises the observations made during the survey.

Table XIII.2 Results and observations made during the shoreline survey.

Production area	Liverpool Bay – Wirral (M058)
Classification zones and ID/species	Moreton & Leasowe (B058D) (mussels) Leasowe (To be assigned) (cockles)
Area of **b**eds	Moreton & Leasowe (mussels) – classified area = 13.4 km^2, approximate area of mussel beds = 1.6 km^2 Leasowe (cockles) – approximate area of bed = 0.3 km^2, potential extent of exploitable bed in 2 or 3 years = 8.2 km^2
SWD Flesh Points	North Wirral East (None assigned) North Wirral West (SJ 2300 9100)
SWD Water Points	North Wirral East (SJ 2900 9450) North Wirral West (SJ 2300 9100)
BWD Sampling point(s)	West Kirby (SJ 20996 86794) Meols (SJ 23001 90600) Moreton (SJ 25700 91803) New Brighton (SJ 28700 93705)
Applicant's details	Christopher Woods 18 Windermere Close Little Neston Neston CH64 9XY Tel: 0151 336 6771
Map/Chart references	Imray Chart C52 (Cardigan Bay to Liverpool) OS Explorer 266 (Wirral & Chester)

Recorded air temperature	13.3°C (13:00, 12/7/2010)
Recorded wind	Max 13.3 km/h, NE (13:00, 12/7/2010)
Precipitation	None throughout survey
Streams/springs	No streams were found discharging to the North Wirral shoreline.
River flows (gauged)	None
Significant sewage discharges (Cefas database)	Kings Gap Hoylake Storm Overflow (not observed) Meols WWTW (pumping station observed, offshore discharge point not observed) (Figure XIII.3a) Wallasey Detention Tank Storm overflow (not observed)
Other potential discharges	A large (circa 1m diameter) concrete pipe protruding a short distance from the sea wall adjacent to the Meols WWTW pumping station, presumed to be disused. Two cast iron pipes below sea wall at Hoylake (SJ 23259 90641), not flowing at time of survey, purpose uncertain, possibly disused or a surface water drain (Figure XIII.3b).
Boats/port	48 yachts on drying moorings at West Kirby (around SJ 21326 85235) 29 yachts and fishing boats on drying moorings just off Meols (around SJ 23130 90562) (Figure XIII.4a). 16 yachts on moorings near the mouth of the Mersey (about 500 m upstream of SJ 31225 94514) (Figure XIII.4b). Mersey Docks line large parts of the outer Mersey estuary (Figure XIII.4b).
Dogs	The whole north shore of the Wirral is popular with dog walkers. Specifically, dogs were recorded on the beach at SJ 27385 92506, SJ 23259 90641, SJ 31225 94514.
Other animals	Seabirds (mainly gulls, also some waders) were recorded on the shore at SJ 28328 93253 (12), SJ 28650 93617 (25), SJ 26188 93268 (30), SJ 26696 92703 (70-100). Bird droppings were frequent on intertidal sands (Figure XIII.5). 3 horses were recorded on the promenade at New Brighton (SJ 23130 90562) and droppings were seen on the seawall between Leasowe and New Brighton (SJ 28015 93027)
Sewage related debris	Cotton buds recorded in the tideline around New Brighton at SJ 28328 93253 and SJ 28697 93615 (Figure XIII.6). These may have been there for some time, and were not accompanied by more degradable types of sewage related debris.
Samples taken	See Table XIII.2.
Bivalve harvesting activity	At the time of survey about 15 private individuals were observed harvesting razors off Leasowe. Extensive disturbances to the sand at the cockle bed at Leasowe suggested recent illegal cockle gathering (Figure XIII.7a).

Capacity of harvesting area	The biomass of cockles at Leasowe was in the region of 700 tonnes of harvestable stock at the time of survey. This lies within a relatively small area at very high densities, and originates almost exclusively from the 2009 spatfall (Figure XIII.7b). Large numbers of lentil sized specimens were observed towards the inshore part of this bed indicating a strong 2010 spatfall (Figure XIII.7c). It is likely that this bed will expand in size over the next few years in an easterly direction. The North Western Sea Fisheries Committee advised that the exploitable beds may extend as far as the most western of the breakwaters at New Brighton within a few years. The applicant indicated that stocks on the mussel beds are currently too low for commercial scale exploitation. Extensive razor beds lie mainly below the low water mark along the whole north Wirral shore, although the location and density of these beds is uncertain. Large numbers of empty razor shells were seen between Leasowe and New Brighton (Figure XIII.7d).
Water appearance	Slightly turbid.
Water temperature/salinity	Salinity was 32.96ppt and sea surface temperature was 16.57°C at 07:59 on the 13th June at the Cefas Liverpool Bay Smart Buoy (located about 20km NW of the cockle bed in 22m of water).
Human population	Population centres by the shore at Hoylake/Meols and New Brighton.
Topography	The north Wirral coastline is low lying. Sea defences consisting of sea walls and a number of breakwaters protect it from erosion and encourage the build up of sediment. The land immediately adjacent to the shoreline is slightly elevated from that further south, so the watercourse draining the north of the Wirral peninsula (The Birket) flows eastwards and discharges into the Mersey at the docks at Seacombe. Therefore there is little or no direct hydrological connection between the Wirral and its north shore, and runoff from this area mixes with that from the entire Mersey catchment.
Land Use	The urban centres of Hoylake/Meols and New Brighton lie at the eastern and western ends of the north Wirral coast. At the eastern end of Hoylake there are some holiday chalets and camping sites, and to the south of these there are some areas of pasture. In between Hoylake and New Brighton lie the North Wirral Coastal Park, Leasowe Common, and a golf course. The towns of Moreton and Leasowe are located to the south of these.
Other comments/observations	The North Western Sea Fisheries Committee advised that the cockle beds at Leasowe are likely to be targeted by unlicenced gatherers due to the high densities present and the number of access points to the shore along this stretch of coast, and should this occur it is possible that stocks may be rapidly depleted. Therefore, classification is desirable by the opening of the cockle season on the 1st September to allow licenced operators to exploit the area before stocks are depleted.

Figure XIII.3 Observed discharges. A – Meols WWTW pumping station. B – Cast iron pipes from sea wall at Meols.

Figure XIII.4 Moorings at Meols (A), and the mouth of the Mersey (B).

Figure XIII.5 Bird droppings on intertidal sand at Leasowe.

Figure XIII.6 Cotton bud in tideline at New Brighton.

Figure XIII.7 Disturbances to the sand at Leasowe cockle bed (A), harvestable cockles at Leasowe (B), recently settled spat at Leasowe (C), empty razor shells between Leasowe and New Brighton (D).

Table XIII.2 Results of samples collected during the shoreline survey.

Sample ID	Matrix	Site sampled	Collection time	Easting	Northing	*E. coli* result
1	Seawater	Outer Dee	12-JUL-10 3:48:51PM	321080	384925	10 cfu/100ml
2	Seawater	Outer Mersey	12-JUL-10 5:30:07PM	331225	394514	340 cfu/100ml
3	Cockle	Leasowe	13-JUL-10 7:24:57AM	325973	393184	1100 MPN/100g
4	Cockle	Leasowe	13-JUL-10 7:43:01AM	326108	393336	24000 MPN/100g
5	Cockle	Leasowe	13-JUL-10 8:20:22AM	326736	392498	3500 MPN/100g
6	Cockle	Leasowe	13-JUL-10 8:42:07AM	326292	392432	170 MPN/100g

Please refer to Figure XIII.2 for locations where these samples were collected.

CONCLUSIONS

The following conclusions can be drawn from the shoreline survey:

1. Significant local sources of human contamination direct to the north Wirral coastline include the Meols WWTW discharge, the Kings Gap Hoylake Storm Overflow and the Wallasey Detention Tank Storm overflow. It is possible that overboard discharges are made from the 29 yachts and fishing boats on drying moorings just off Meols. Although some sewage related debris was found between Leasowe and New Brighton, it did not appear to have been recently deposited so may not have been of particularly local origin.
2. Waders and other seabirds are likely to be a significant source of diffuse contamination to the shellfish beds via direct deposition whilst they are foraging. At Leasowe large numbers of these birds (~3000) are reported congregate during the autumn and winter and tend to forage more towards the inshore part of the bed.
3. The north Wirral shore is very popular with dog walkers along its entire length, and horse riders also use the area. These are likely to constitute further diffuse sources of contamination to the shellfish beds.
4. On a wider scale, contamination from multiple sources within the Mersey and Dee catchments are carried towards the shellfish beds from their estuaries. Water samples taken from the mouths of these two estuaries during the ebb tide showed higher levels of contamination within the Mersey estuary (340 *E. coli* cfu/100ml compared to 10 *E. coli* cfu/100ml at the mouth of the Dee). The extent and spatial profile of impacts from these sources will depend on local hydrography.
5. The cockle bed at Leasowe supports a very high density of exploitable stock in a discrete area, originating almost exclusively from the 2009 spatfall. Indications of a strong 2010 spatfall were seen, and it is believed likely that this bed will expand eastwards towards New Brighton over the next few years.
6. Levels of *E. coli* within cockle samples taken from the four approximate corners of the Leasowe bed varied from 170 at the south western corner to 24000 MPN /100g at the north eastern corner. The most likely explanation for this high variability may be patchy contamination from bird droppings.
7. The classified mussel bed at Moreton and Leasowe does not currently support commercially exploitable densities, is not fished at present, and so does not require continued classification in the meantime.
8. The razor beds are regularly exploited by private individuals. Although it is possible some of these are sold on, no request for classification of these species has been made.

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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
NW IFCA	North Western Inshore Fisheries Conservation Authority
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”.

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