Scottish Sanitary Survey Project

Sanitary Survey Report
Burwick: Shalders Ayre
SI 416 821 08
March 2009

Cefas

FOOD STANDARDS AGENCY SCOTLAND
Buidheann Inbhe-Bìdhe an Alba

Final Report Distribution – Burwick

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* Distribution of both draft and final reports to relevant agency personnel is undertaken by FSAS.

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1. General Description

Burwick is located on the southwest coast of Shetland. Burwick is a small exposed bay, roughly 0.5 km in width by 0.5 km in length. It is shallow and depths vary from 0-20 m, with the deepest region at the opening of the bay. Scalloway, the second largest settlement in Shetland with a population of approximately 1000, is located southeast of Burwick.

This sanitary survey was undertaken in response to an application for classification of the area for common mussels.

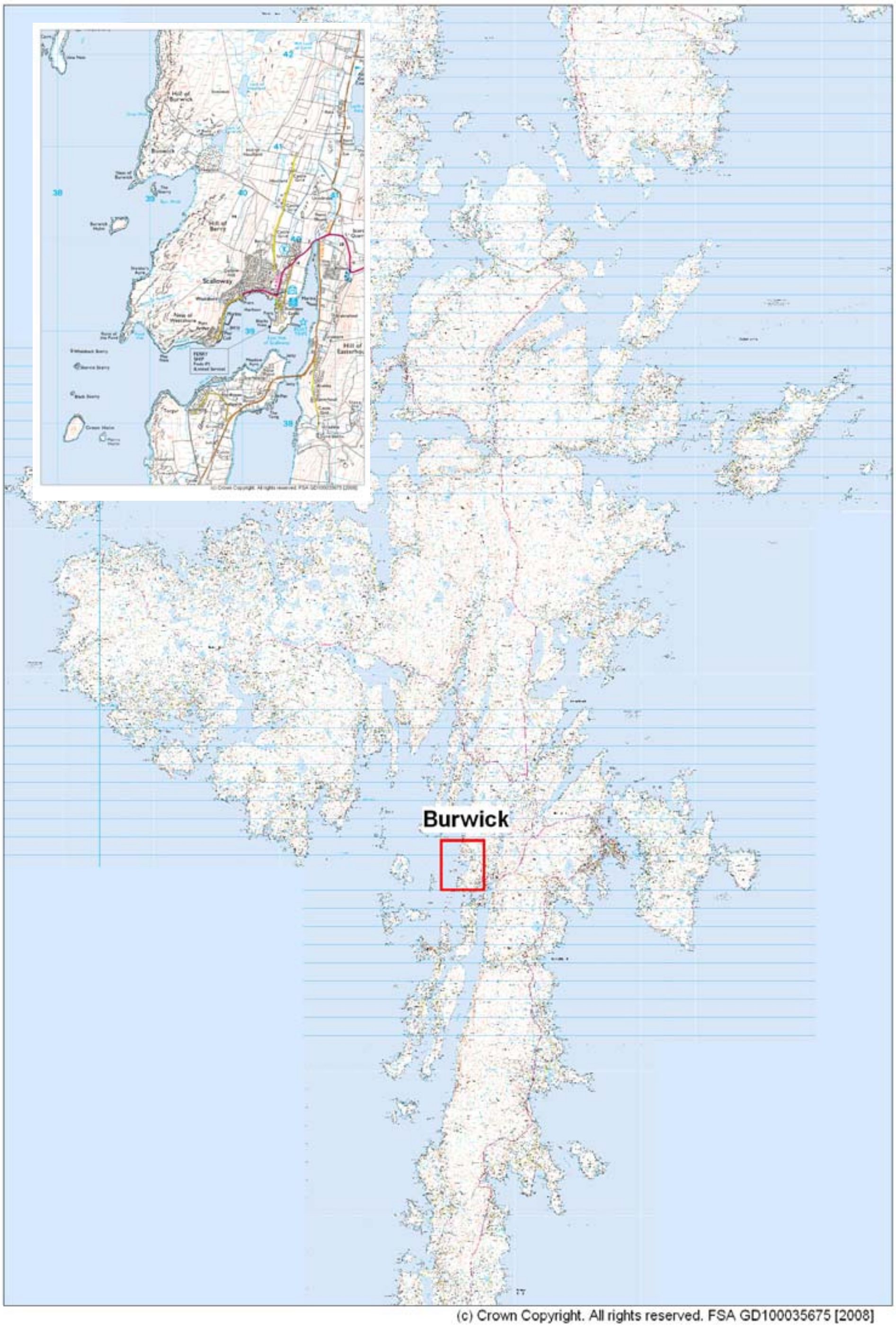

Figure 1.1 Location of Burwick

2. Fishery

The fishery at Burwick: Shalders Ayre (SI 416 821 08) consists of a single long line mussel (*Mytilus* sp.) farm.

There is currently no production area or RMP located in the Burwick area. At the time of survey, there were two single long lines with 10 metre droppers situated at one end of the seabed lease area. Long lines attached to floats are laid out in parallel lines anchored at either end. Vertical lines containing plastic pegs (droppers) are attached to the long lines. New lines are placed before or during spawning between May and early June and spat settle on to the droppers from the surrounding water. The spat are then left to grow for up to three years before reaching marketable size. However, there is no plan to harvest in the immediate future as the owner is considering sale of the lease.

An additional line was visited on the offshore side of Whaleback Skerry, just outside the entrance to Scalloway Harbour. This is not a classified site and was originally placed to attract Eider ducks from feeding on nearby mussel farms. The harvester, K. Pottinger, expressed interest in getting this line classified for harvest in autumn 2008, but as this opportunity has already passed, and no classification application has been made for this site, no sampling plan will be recommended in this report. Figure 2.1 shows the relative positions of the mussel farms and the seabed lease areas.

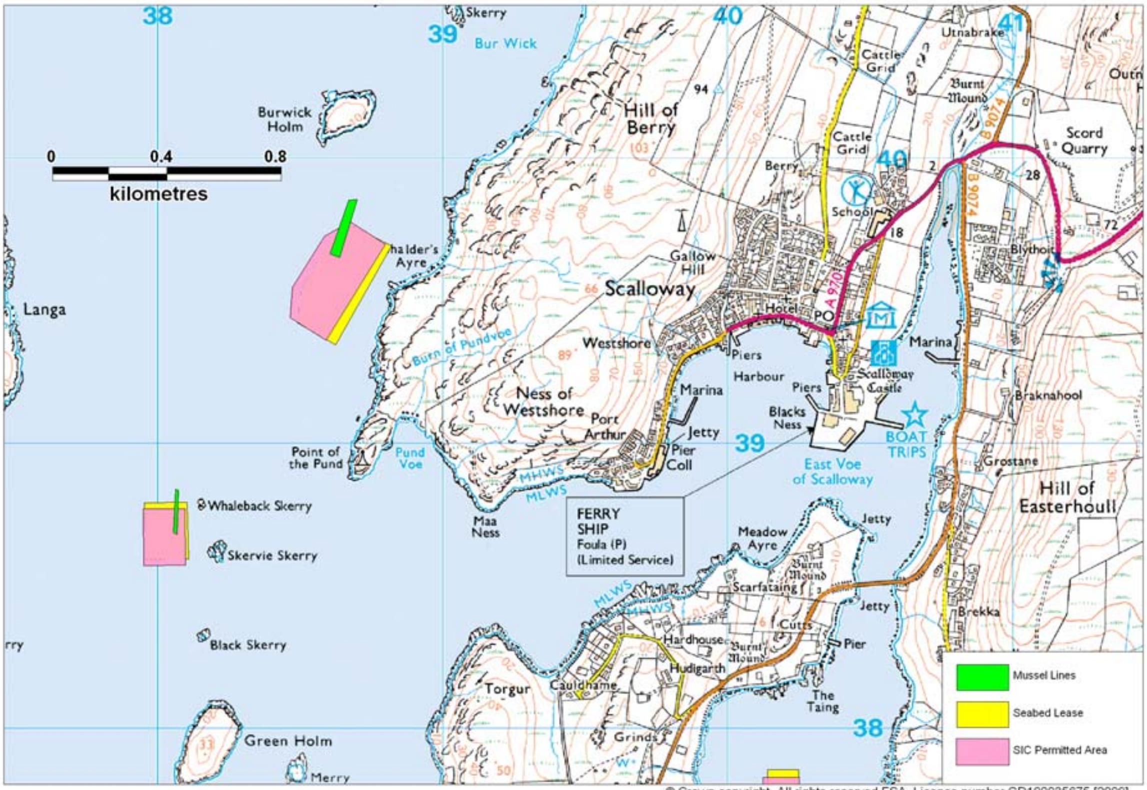

Figure 2.1 Burwick Fishery

3. Human Population

Figure 3.1 shows information obtained from the General Register Office for Scotland on the population within the census output in the vicinity of Burwick.

Figure 3.1 Human population surrounding Burwick

The population immediately bordering the shoreline at Burwick is small, with a population of 168 for the entire census area.

The large town of Scalloway lies southeast of Burwick and encompasses a further ten census output areas, with a combined population of 869. There are also a further three census output areas to the east of Scalloway with a population of 419 and one to the south with a population of 133.

Due to the size of the population at Scalloway, any associated faecal pollution from human sources is likely to be concentrated in this area.

4. Sewage Discharges

Scottish Water identified community septic tanks and sewage discharges for the area surrounding Burwick. These are detailed in Table 4.1.

Table 4.1 Discharges identified by Scottish Water

SEPA consent no.	NGR	Discharge Name	Discharge Type	Level of Treatment	Consented flow (DWF)	Consented Design pop
CAR/L/1004025	HU 3870 3930	Maa Ness Scalloway	Continuous	Septic tank, 6mm screening on overflow	Overflow operates at 35 l/s	1700
CAR/L/1002258	HU 399 393	Westshore P/S Scalloway	Intermittent	10mm screening	Overflow operates at 75 l/s	Not stated
CAR/L/1002261	HU 408 396	Scalloway Blydoit P/S EO	Intermittent	None	Not stated	Not stated
CAR/L/1002259	HU 403 393	Scalloway Burn Beach P/S EO/CSO	Intermittent	12mm screening	Overflow operates at 67 l/s	Not stated
CAR/L/1002262	HU 407 388	Scalloway Seachest P/S EO	Intermittent	None	Not stated	Not stated
CAR/L/1002260	HU 405 391	Scalloway Blackness P/S EO	Intermittent	None	Not stated	Not stated

No sanitary or microbiological data were available for these discharges. A number of discharge consents have been issued for this area by SEPA and these are listed in Table 4.2.

Table 4.2 SEPA discharge consents

Ref No.	NGR of discharge	Discharge Type	Discharges to	Consented flow (DWF) m^3/d	Consented/ design PE
CAR/L/1004025	HU 3870 3930	Sewage (Public)	North Channel, Scalloway	625 m^3/day	
CAR/L/1002261	HU 40768 39626	Sewage (Public) EO	East Voe of Scalloway	-	-
CAR/L/1002258	HU 39885 39313	Sewage (Public) EO	Scalloway Harbour	-	-
CAR/L/1002259	HU 40295 39345	Sewage (Public) EO	Scalloway Harbour	-	-
CAR/L/1002260	HU 40517 39054	Sewage (Public) EO	East Voe of Scalloway	-	-
CAR/L/1002262	HU 40649 38794	Sewage (Public) EO	East Voe of Scalloway	-	-
CAR/R/1016138	HU 3994 3774	Domestic	Land	-	5
CAR/R/1009165	HU 3970 3776	Domestic	Land	-	5

Sewage infrastructure recorded during the shoreline survey is listed in Table 4.3. All four observations noted in 2008 refer to various items associated with the Maa Ness discharge. The shoreline of Scalloway and Trondra were surveyed as part of a 2007 sanitary survey, so they were not walked again in 2008. Discharges observed in Scalloway harbour and on the northwest coast of Trondra in 2007 are also included in Table 4.3 for reference.

The positions of observed and reported discharges relative to the fishery can be seen in Figure 4.1.

Table 4.3 Discharges and septic tanks observed during shoreline survey

No.	Date	NGR	Description
1	01/05/2008	HU 38794 39249	Inspection cover
2	01/05/2008	HU 38775 39252	Outfall inspection hatch
3	01/05/2008	HU 38761 39260	Water sample 8. Outfall pipe above ground here
4	01/05/2008	HU 39129 38874	Brand new septic tank - smells
5	10/05/2007	HU 39500 38334	Septic overflow, pipe broken and leaking down shore
6	10/05/2007	HU 39617 38412	Pipe running underwater from house
7	10/05/2007	HU 39806 38404	Septic tank
8	10/05/2007	HU 39965 38563	Septic tank overflow pipe running under water
9	10/05/2007	HU 40010 38456	Septic tank cover
10	10/05/2007	HU 39856 39291	West Shore Pumping Station
11	10/05/2007	HU 40815 39529	Blydoit Pumping Station outfall

The most significant discharge to the Shalders Ayre site is the Maa Ness outfall, which continuously discharges septic tank treated wastewater from a population equivalent of 1700 into relatively shallow water (<10m on the bathymetry chart). A ‘boil’ was observed on the surface at the location of this discharge during the shoreline survey. The discharge is located approximately 360 m south of the Shalders Ayre site. The catchment area for this discharge includes the whole of Scalloway, as shown as a red shaded area in Figure 4.1. Kay et al (2008) found the mean level of *E. coli* in septic tank treated effluent to be $7.2x10^6$ cfu/100ml under dry conditions. Assuming a maximum dry weather flow of 625 m^3/day, the maximum estimated loading contributed by this discharge during dry weather would be 4. 5 x 10^{13} *E. coli* / day. This would probably be exceeded following high rainfall events.

The Scalloway system also includes five intermittent overflow discharges. It is uncertain how frequently these overflow or what the local impact on water quality is when they do. There is an emergency overflow at the Maa Ness septic tanks, which operates when the incoming flow exceeds 35 l/s, whereas the two CSOs do not overflow until incoming flow reaches 67 and 75 l/s. Therefore, the system will overflow at Maa Ness before it will start overflowing at either of these two pumping stations.

Outside of this catchment area, houses will probably have private septic tanks. Five of these were noted on the north coast of Trondra. Consents were provided by SEPA for a further two septic tanks that discharge to soakaway systems on land. These were not directly observed during a shoreline survey. The impact of these to the fishery at Shalders Ayre should be negligible due to their distance from the shellfish farm relative to the Maa Ness outfall.

Scalloway Harbour is an important port on the west coast of Shetland for fishing and survey boats. There are facilities for visiting boats in Scalloway Harbour but no sewage pumpout facilities. There are two marinas with berths for small boats, one in Scalloway Harbour and the other in the East Voe of Scalloway with space for approximately 200 boats. Therefore, contamination from boat traffic entering and leaving Scalloway Harbour may affect the fishery. Unless a particular boat or boats habitually discharges near the fishery, which is considered unlikely but possible, contamination from this source would be sporadic and unpredictable.

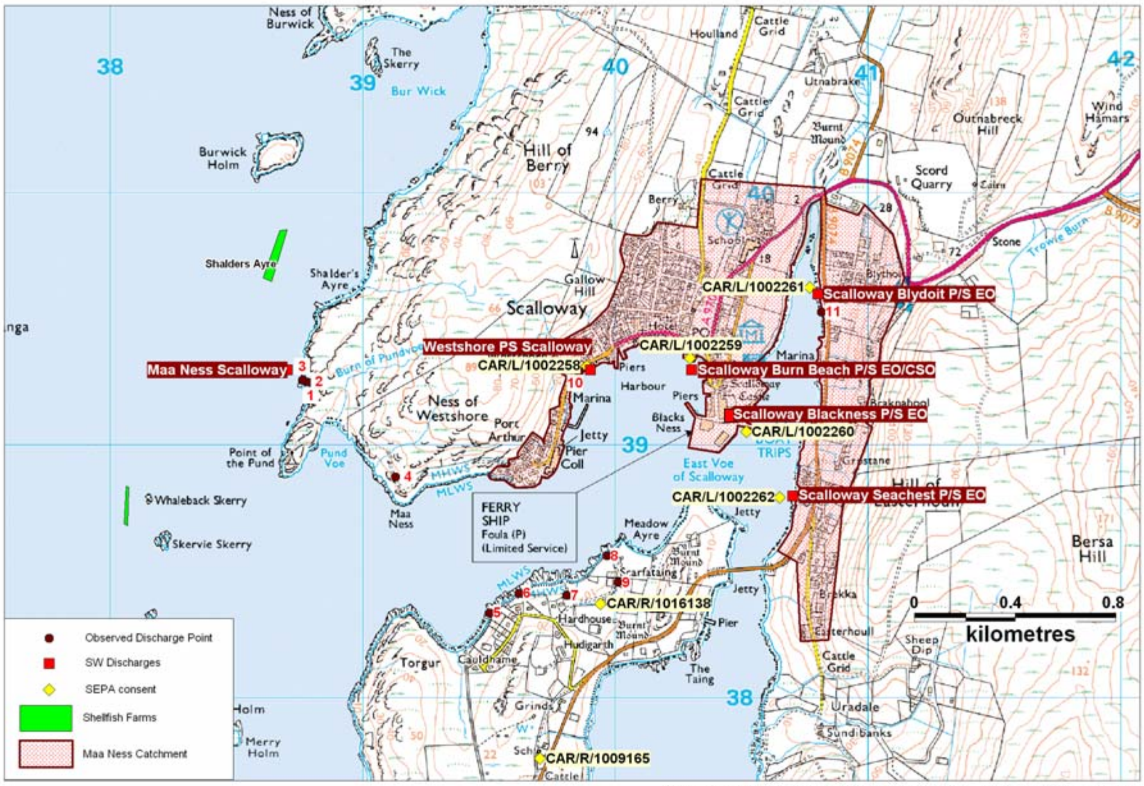

Figure 4.1 Sewage discharges at Burwick

5. Geology and Soils

Geology and soil types were assessed following the method described in Appendix 2. A map of the resulting soil drainage classes is shown in Figure 5.1. Areas shaded red indicate poorly draining soils while areas shaded blue indicate more freely draining soils.

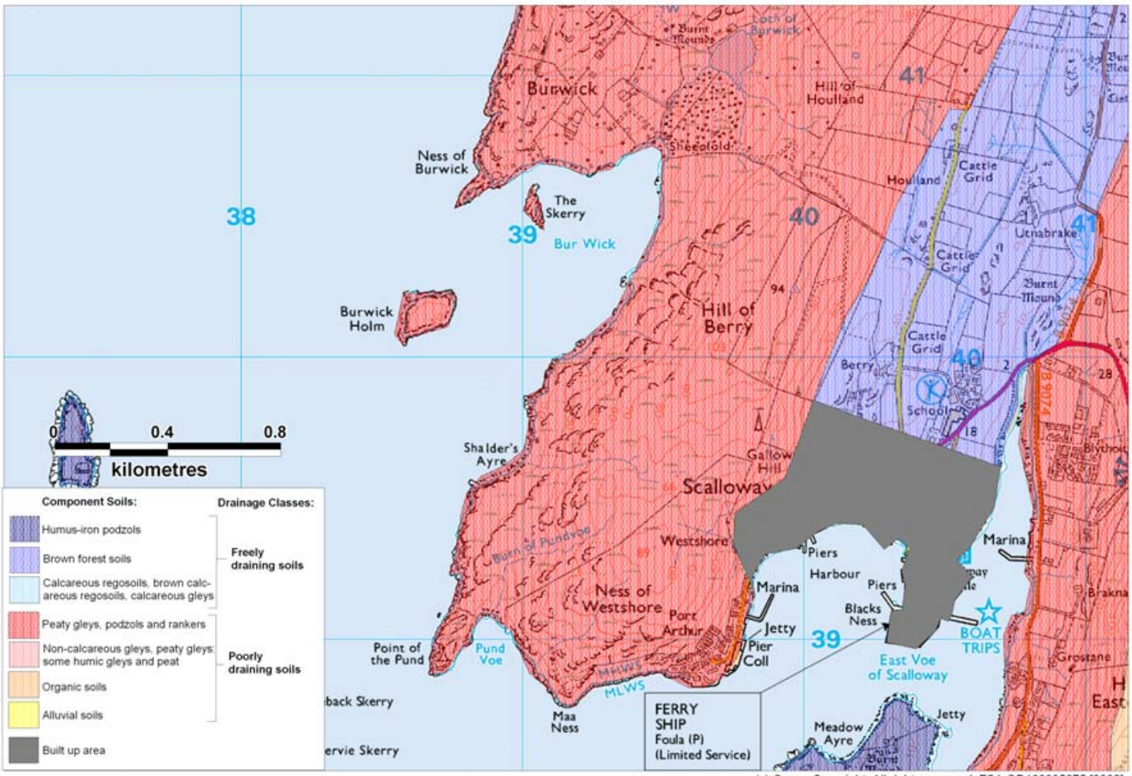

Figure 5.1 Component soils and drainage classes for Burwick.

There are three main types of component soil in this area. The most dominant is composed primarily of peaty gleys, podzols and rankers and is classed as poorly draining. This soil type covers the coastline directly adjacent to the Burwick production area and a strip further inland past Scalloway harbour.

In these poorly draining soils, surface run off is likely to be high, and the soil often waterlogged. In the built-up area indicated around the town of Scalloway, impermeable cover would lead to high levels of surface runoff.

The other two soil types are freely draining brown forest soils and humus-iron podzols found along a northeast to southwest strip running through Scalloway. This area is more likely to be used for arable agriculture and fields can be clearly seen on the underlying OS map.

Soil permeability is important for the proper function of septic tank soakaway systems and soakaways located in the red zones may be more likely to contribute to toward contaminated runoff.

Though the soils bordering the shellfish farm are poorly drained, the population in the area is sparse and so the impact of septic runoff likely to be low.

6. Land Cover

The Land Cover Map 2000 data for the area is shown in Figure 6.1 below:

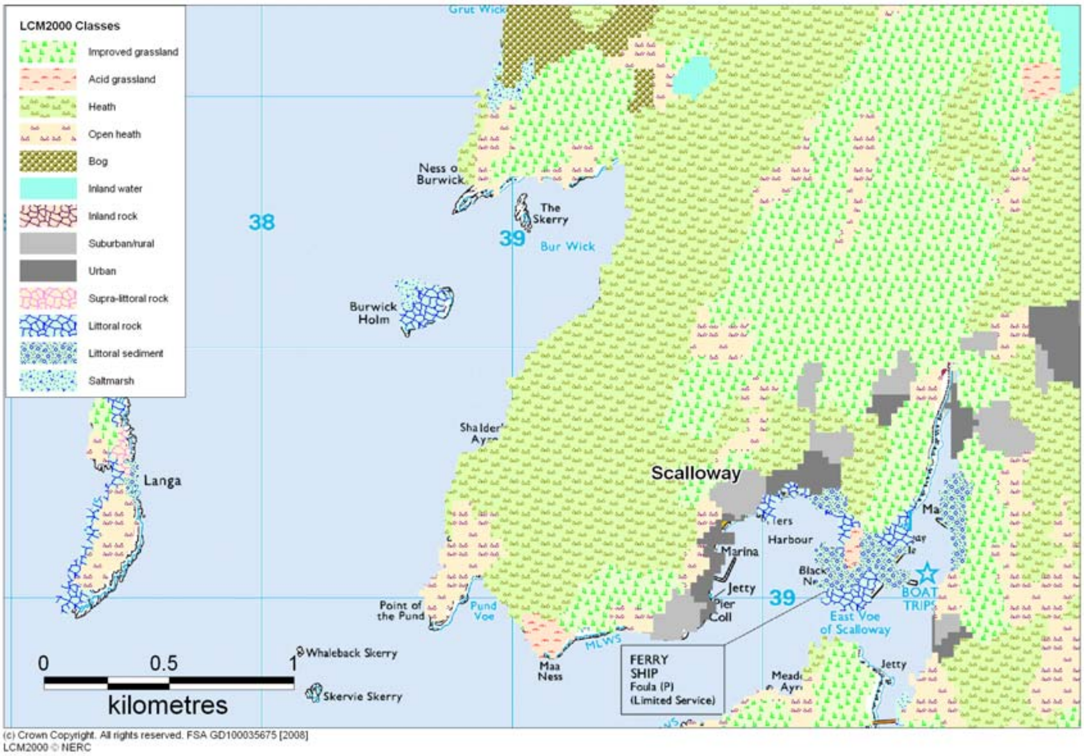

Figure 6.1 LCM2000 class land cover data for Burwick

The land cover surrounding Burwick is predominantly composed of heath and improved grassland with some patches of bog, open heath land, littoral rock and littoral sediment. Along the coastline of Burwick, heath is dominant until merging to improved grassland further inland. This was confirmed during the shoreline survey. The improved grassland cover roughly corresponds with the area of freely draining soils identified in Section 5. A small farm is located at the head of Bur Wick where it was noted during the shoreline survey that there was one arable field sown with Shetland oats. The town of Scalloway is developed area with some littoral rock and sediment along its coastline.

The faecal coliform contribution would be expected to be highest from developed areas (approx $1.2 – 2.8x10^9$ cfu km^{-2} hr^{-1}), with intermediate contributions from the improved grassland (approximately $8.3x10^8$ cfu km^{-2} hr^{-1}) and lowest from the other land cover types (approximately $2.5x10^8$ cfu km^{-2} hr^{-1}) (Kay *et al*. 2008). The contributions from all land cover types would be expected to increase significantly after marked rainfall events, this being expected to be highest, at more than 100-fold, for the improved grassland.

Surface runoff from the developed areas of Scalloway would be expected to contribute the most to contamination in the waters of Scalloway Harbour. Land cover and soil types immediately adjacent the fishery are associated lower contributions of faecal coliforms but higher surface runoff. Contributions of faecal contaminants from this area would be expected to be significantly higher after a prolonged period of dry weather as the primary source of contaminants will be animal faeces deposited on the ground.

7. Farm Animals

Agricultural census data was received from the Scottish Government Rural and Environment Research and Analysis Directorate (RERAD) for Tingwall parish. This parish covers a substantial portion of the main island of Shetland of which the survey area is a small proportion. Recorded livestock populations for the parish for 2007 and 2008 are listed in Table 7.1. RERAD withheld data for reasons of confidentiality where the small number of holdings reported would have made it possible to discern individual farm data.

Table 7.1 Livestock census data for Tingwall parish

	2007		2008	
	Holdings	Numbers	Holdings	Numbers
Total pigs	*	*	*	*
Total poultry	12	195	11	220
Total cattle	7	264	8	336
Total sheep	39	12046	38	13174
Horses and ponies	10	84	13	129

*Data withheld on confidentiality basis

Because these figures relate to the entire parish area of just over 65 km^2, they are of relatively little use in assessing the potential impact of livestock contamination at the fishery. However, in general they give an idea of the total numbers of livestock over the broader area. The most significant population of farm animals in the area is of sheep, with a rough average of 347 animals per holding. Cattle are present but not in substantial numbers given the size of the parish area. The only information specific to the area near the shellfishery was that obtained during the shoreline survey (see Appendix), which only relates to the time of the site visit on 30th April – 1st May 2008. The spatial distribution and numbers of animals observed and noted during the shoreline survey is illustrated in Figure 7.1.

The shoreline survey identified that sheep grazed widely around the Burwick coastline. Several ponies were also observed in the area (see figure 7.1). The most significant concentrations of livestock observed were sheep along the coastline north of the shellfish farm. The farm at Bur Wick is close to the fishery and 24 sheep were observed grazing near the farm. It is likely that this number represented only a portion of the sheep population present in the area. It is expected that sheep would graze across the entire headland here, so the impact would be assumed to be evenly spread along the entire shoreline adjacent to the mussel farm.

Numbers of sheep will be approximately double the year-round population during the period from May to September, following the birth of lambs in the spring. Therefore higher impacts from livestock are to be expected during this period.

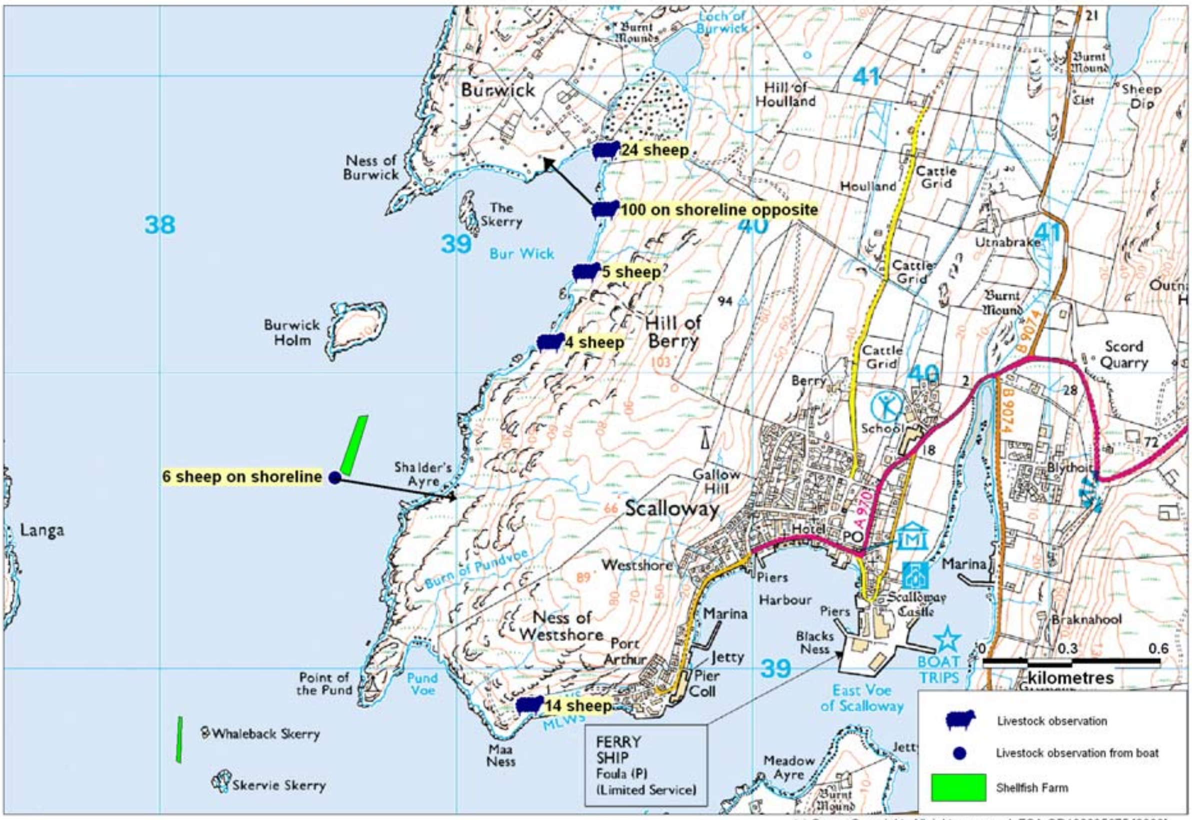

Figure 7.1 Livestock observations at Burwick

8. Wildlife

General information related to potential risks to water quality by wildlife can be found in Appendix 3. A number of the wildlife species present or likely to be present at Burwick: Shalders Ayre could potentially affect water quality in the loch and around the fishery.

Seals

No seals were seen during the shoreline survey. Information provided by the Sea Mammal Research Unit did not record any seal haulout sites in the vicinity of Burwick. However, seals are likely to present in and around the area due to fishing boat activity in Scalloway harbour.

Although there were no breeding or haulout sites identified in the vicinity, seals will forage widely for food so it is likely they will feed near the mussel farms at some point in time. The population is relatively small in relation to the size of the area concerned and is highly mobile therefore it is likely that any impact will be limited in time and area and unpredictable.

Whales and Dolphins

A variety of cetacean species are routinely observed near Shetland. It is highly likely that whales and dolphins will be found from time to time in the area, although the larger species are less likely to pass near the shore. As with seals, these are highly mobile animals and any impact from their presence is likely to be limited in duration and unpredictable.

Seabirds

A number of seabird species breed in Shetland. These were the subject of a detailed census carried out in sections during the late spring of 1999, 2000 and 2002. Total counts of all species recorded within 5km of the mussel lines are presented in Table 8.2. Where counts were of occupied sites/nests/territories, actual numbers of birds breeding in the area will be higher.

Table 8.2 Seabird counts within 5km of the site.

Common name	Species	Count	Method
Arctic Tern	*Sterna paradisaea*	926	Individuals on land/Occupied nests
Northern Fulmar	*Fulmarus glacialis*	823	Occupied sites
Herring Gull	*Larus argentatus*	564	Individuals on land/Occupied territory or nests
Common Gull	*Larus canus*	218	Individuals on land/Occupied territory or nests
Black Guillemot	*Cepphus grylle*	130	Individuals on land
Great Black-backed Gull	*Larus marinus*	109	Individuals on land/Occupied territory or nests
Lesser Black-backed Gull	*Larus fuscus*	44	Individuals on land
Black-headed Gull	*Larus ridibundus*	22	Individuals on land/Occupied territory or nests
European Storm Petrel	*Hydrobates pelagicus*	15	Occupied sites
Great Skua	*Stercorarius skua*	14	Occupied territory
European Shag	*Phalacrocorax aristotelis*	8	Occupied nests
Arctic skua	*Stercorarius parasiticus*	5	Occupied territory

Some large aggregations of breeding birds were found close to the sites. On the island of Langa, just offshore from Shalders Ayre, 180 arctic terns (individuals) were counted with a further 240 on Hildasay slightly further to the west. On the island of Green Holm, south of Whaleback Skerry, 156 northern fulmar occupied sites were counted.

Nesting occurs during the summer, following which many species disperse so any impacts from faecal waste at nesting sites will be largely limited to this period of time. However, gulls will be present in the area throughout the year and impacts from birds resting or swimming near the fishery will be likely to occur throughout the year.

Waterfowl (ducks and geese) are present in Shetland at various times of the year. Eider ducks feed on the mussel lines and are present, sometimes in large groups, throughout the year. Geese tend to pass through during migrations but do not linger in very large numbers as they do further south. No waterfowl were recorded during the shoreline survey, however the mussel lines at Whaleback Skerry were reported to have been put in place to attract the ducks from local mussel farms. Waterfowl impact on the fisheries at Burwick is likely to be mostly that of Eider ducks feeding on the mussel lines.

Other

There is a significant population of European Otters (*Lutra lutra*) present in Shetland, but no specific information was available on their presence in the Burwick area. However, given the total numbers present in Shetland and the foraging habits described in Appendix 3, it is highly unlikely that otter faeces will be a significant source of contamination to the fishery.

Summary

Species potentially impacting on Burwick include eiders, gulls, terns and seals. It would be expected that they could contribute a significant *E. coli* loading to the environment in the vicinity of the shellfishery. However, the impacts of these on will be unpredictable, and deposition of faeces by wildlife generally is likely to be widely distributed around the area and so will not be considered in the determination of the sampling plan.

9. Meteorological data

The nearest weather station is located at Lerwick, approximately 6.5 km to the east of the production areas, for which uninterrupted rainfall data is available for 2003-2007 inclusive. It is likely that the rainfall patterns at Lerwick are similar but not identical to those on Burwick and surrounding land due to their proximity, but it is not certain whether the local topography may result in differing wind patterns (Lerwick is on the east coast, Burwick is on the west coast). This section aims to describe the local rain and wind patterns and how they may affect the bacterial quality of shellfish within Burwick.

Rainfall

High rainfall and storm events are commonly associated with increased faecal contamination of coastal waters through surface water run-off from land where livestock or other animals are present, and through sewer and wastewater treatment plant overflows (e.g. Mallin et al, 2001; Lee & Morgan, 2003).

Figures 9.1 and 9.2 summarise the pattern of rainfall at Lerwick by year and by month respectively.

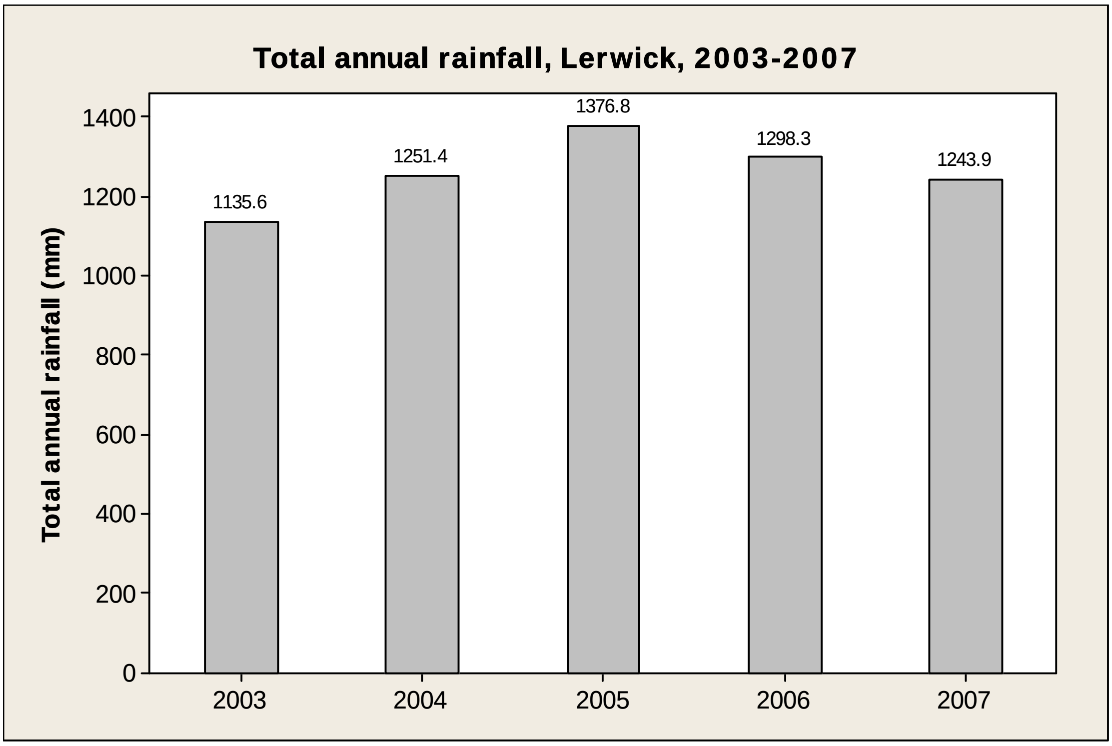

Figure 9.1 Bar chart of annual rainfall at Lerwick 2003-2007

Total annual rainfall at Lerwick did not vary significantly from year to year during this time period.

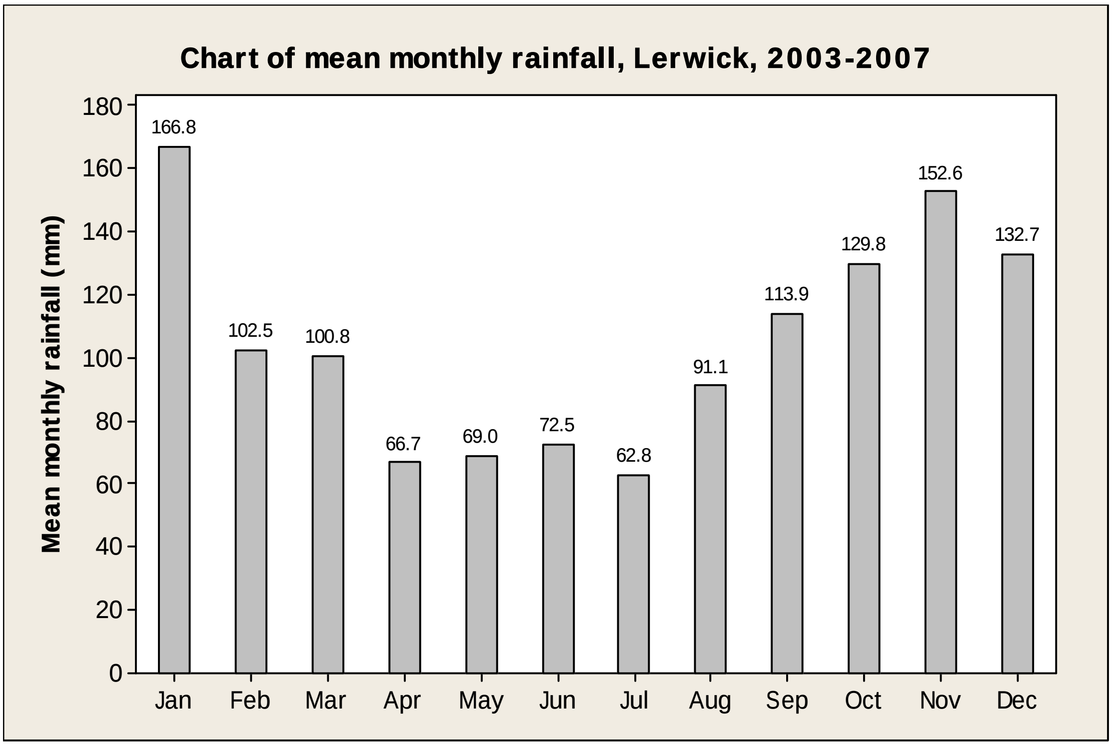

Figure 9.2 Bar chart of mean monthly rainfall at Lerwick 2003-2007

There is a clear seasonality to rainfall at Lerwick, with the wettest months (November and January) occurring during the winter and the driest during the late spring and summer (April to July, inclusive). For the period considered here (2003-2007), 12.9% of days experienced no rainfall and 44.6% of days experienced rainfall of 1mm or less.

A comparison of Lerwick rainfall data with Scotland average rainfall data for the period of 1970-2000 is presented in Table 9.3 (Data from Met office website © Crown copyright). This indicates that rainfall in Lerwick was lower than the average for the whole of Scotland for every month of the year, but there were fewer dry days in Lerwick during the autumn, winter and spring.

Table 9.1 Comparison of Lerwick mean monthly rainfall with Scottish average 1970-2000.

Month	Scotland rainfall (mm)	Lerwick rainfall (mm)	Scotland - days of rainfall >= 1mm	Lerwick - days of rainfall >= 1mm
Jan	170.5	135.4	18.6	21.3
Feb	123.4	107.8	14.8	17.8
Mar	138.5	122.3	17.3	19
Apr	86.2	74.2	13	14.4
May	79	53.6	12.2	10.1
Jun	85.1	58.6	12.7	11.3
Jul	92.1	58.5	13.3	11
Aug	107.4	78.3	14.1	12.5
Sep	139.7	115.3	15.9	17.4
Oct	162.6	131.9	17.7	19.4
Nov	165.9	152.4	17.9	21.5
Dec	169.6	150	18.2	22.2
Whole year	1520.1	1238.1	185.8	197.9

It can therefore be expected that levels of rainfall dependant faecal contamination entering the production area from these sources will be higher during the autumn and winter months. As there are few dry days, it is likely that a steady flow of contaminated runoff from pastures is to be expected throughout the wetter months. Faecal matter will tend to build up on pastures during the drier summer months when livestock levels are at their highest , leading to a flush of bacteria in surface runoff at the onset of wetter weather in autumn.

Wind

Wind data collected at the Lerwick weather station is summarised both annually and by season as presented in figures 9.3 to 9.7.

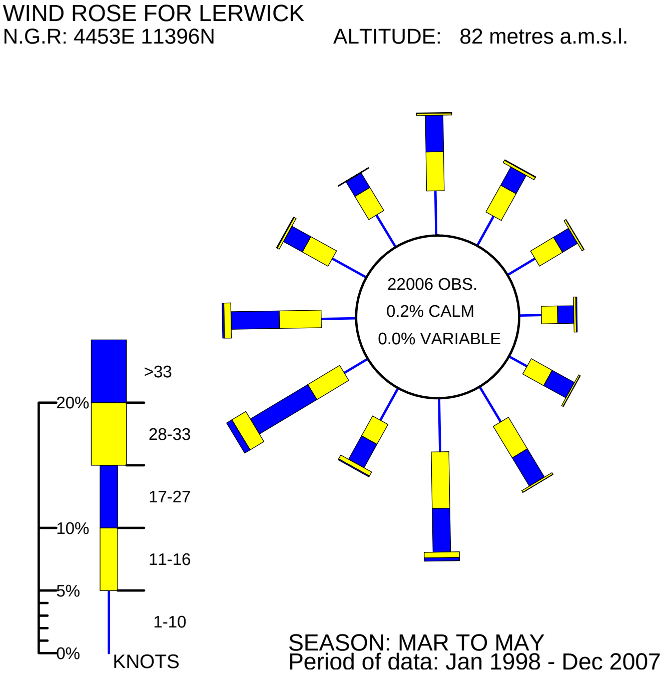

Figure 9.3 Wind rose for Lerwick (March to May)

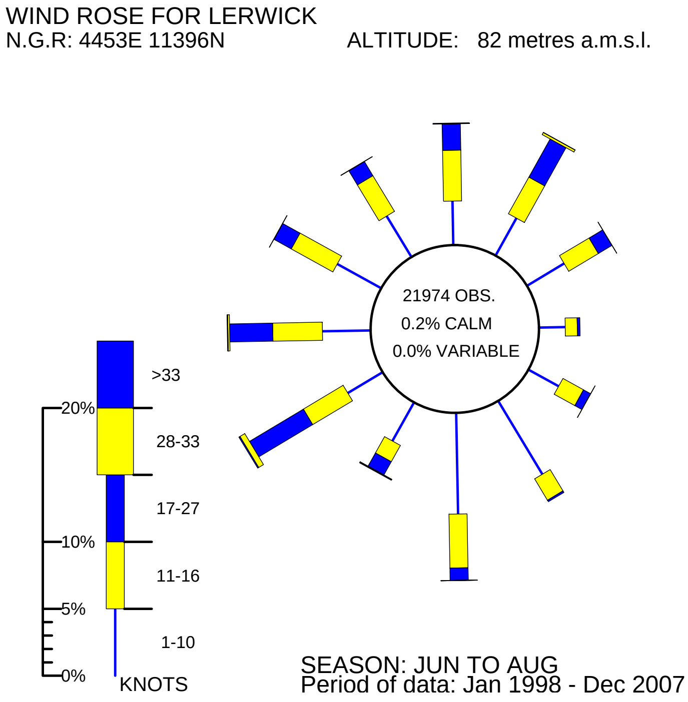

Figure 9.4 Wind rose for Lerwick (June to August)

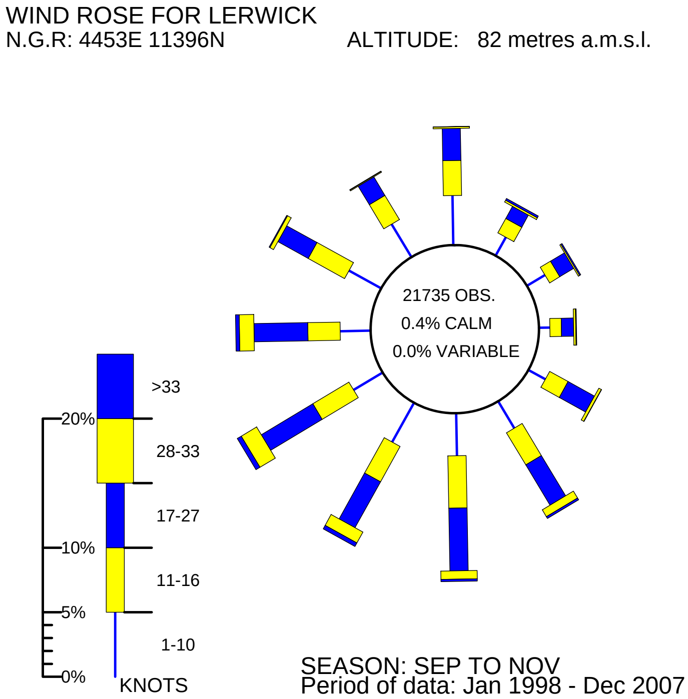

Figure 9.5 Wind rose for Lerwick (September to November)

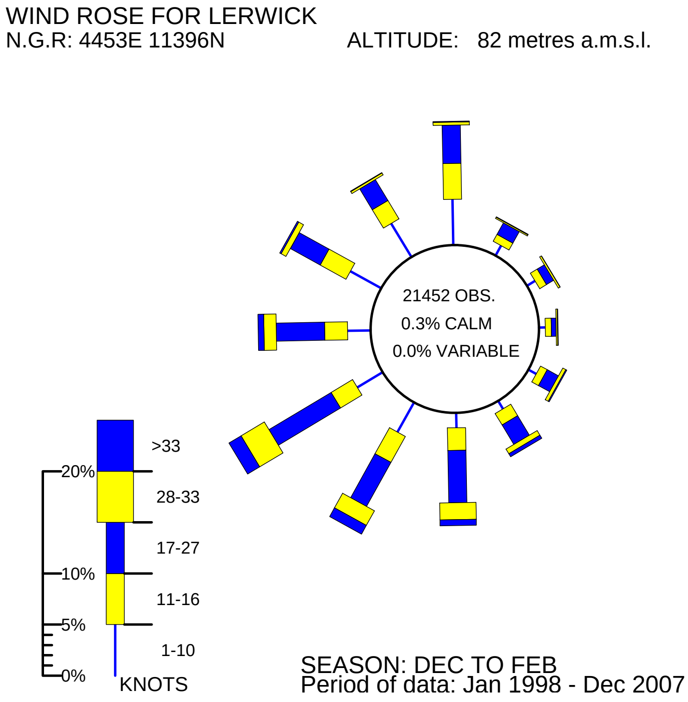

Figure 9.6 Wind rose for Lerwick (December to February)

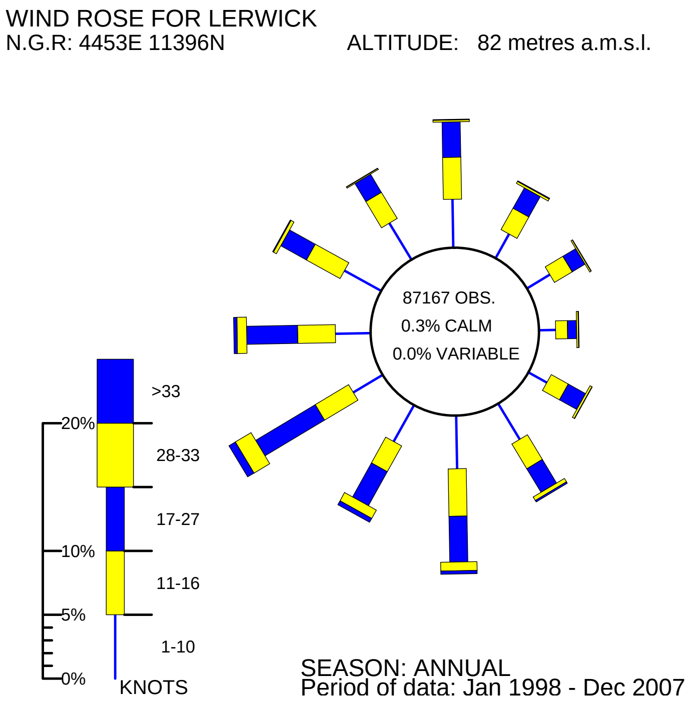

Figure 9.7 Wind rose for Lerwick (Annual)

Shetland is one of the more windy areas of Scotland with a much higher frequency of gales than the country as a whole. The wind roses show that the overall prevailing direction of the wind is from the south and west, and when it is blowing from this direction it is likely to be stronger than when blowing from other directions. Winds are generally lighter during the summer months and strongest in the winter.

Burwick is on the west coast of the mainland, so the site is relatively sheltered from winds from the east. A number of small low-lying islands lie to the west and south west of the area, providing some shelter from winds from this direction. The site is most exposed to winds from the northwest.

Wind effects are likely to cause significant changes in water circulation within the area as tidally influenced movements of water are relatively weak. 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) would drive a surface water current of about 1 knot or 0.5 m/s. These surface water currents create return currents, the path of which will depend on local bathymetry. Strong winds will increase the circulation of water and hence dilution of contamination from point sources within the area. In some instances however, wind-driven currents may transport contamination from the main point source in the area, the Maa Ness discharge, towards the mussel lines. A south east wind would carry contamination from this source towards the mussel lines at Shalders Ayre.

10. Current and historical classification status

Burwick has not yet been classified.

11. Historical *E. coli* data

No records of historical *E. coli* samples for this production area were found on the FSAS database of monitoring results to the end of 2007. Although there are other mussel production sites a few kilometres away, none of these sites are in the close proximity of a major sewage discharge, and so are likely to be primarily influenced by more minor sources of contamination. Therefore it would be inappropriate to use historical monitoring results from these sites as an indicator of potential results for Burwick: Shalders Ayre.

12. Designated Shellfish Growing Waters Data

Burwick: Shalders Ayre does not lie within a designated shellfish growing water.

13. Bathymetry and Hydrodynamics

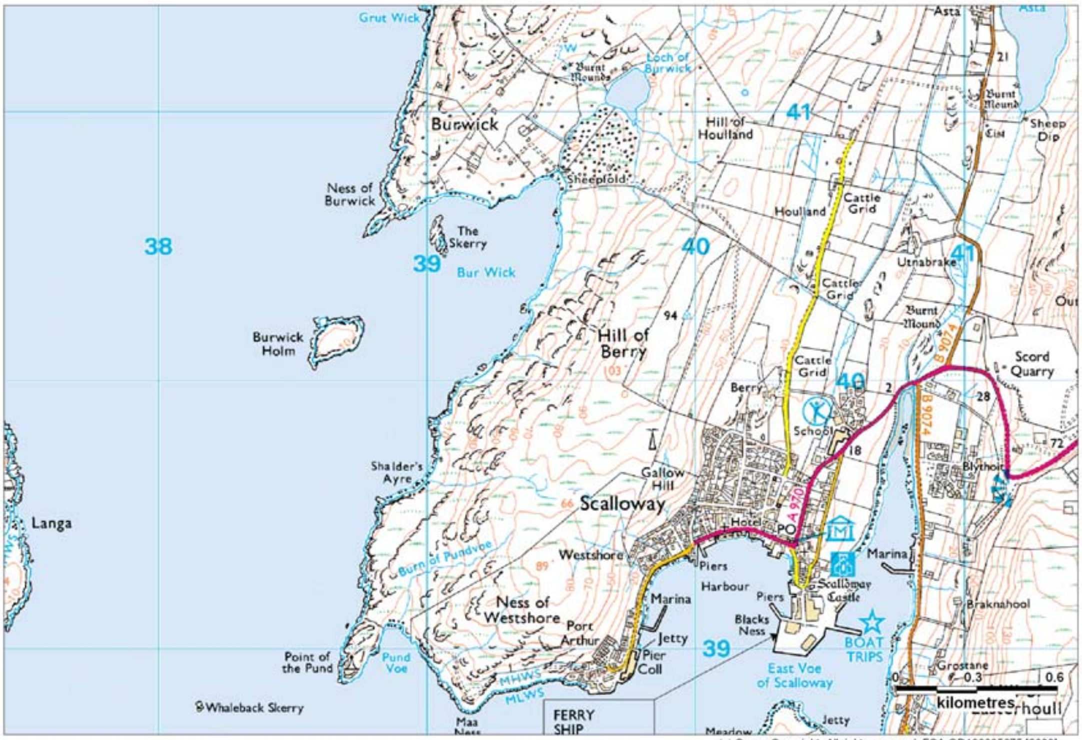

Figure 13.1 Burwick

Figure 13.2 Bathymetry of Burwick

The chart above shows that the area is shallow, at between 10 and 20 m depth at the Shalders Ayre site. To the north of the site is a shallow bay, in which a large amount of flotsam and jetsam was seen during the shoreline survey.

Tidal Curve and Description

The two tidal curves below are for Scalloway. The tidal curves have been output from UKHO TotalTide. The first is for seven days beginning 00.00 GMT on 30/04/08 and the second is for seven days beginning 00.00 GMT on 07/05/08. This two-week period covers the date of the shoreline survey. Together they show the predicted tidal heights over high/low water for a full neap/spring tidal cycle.

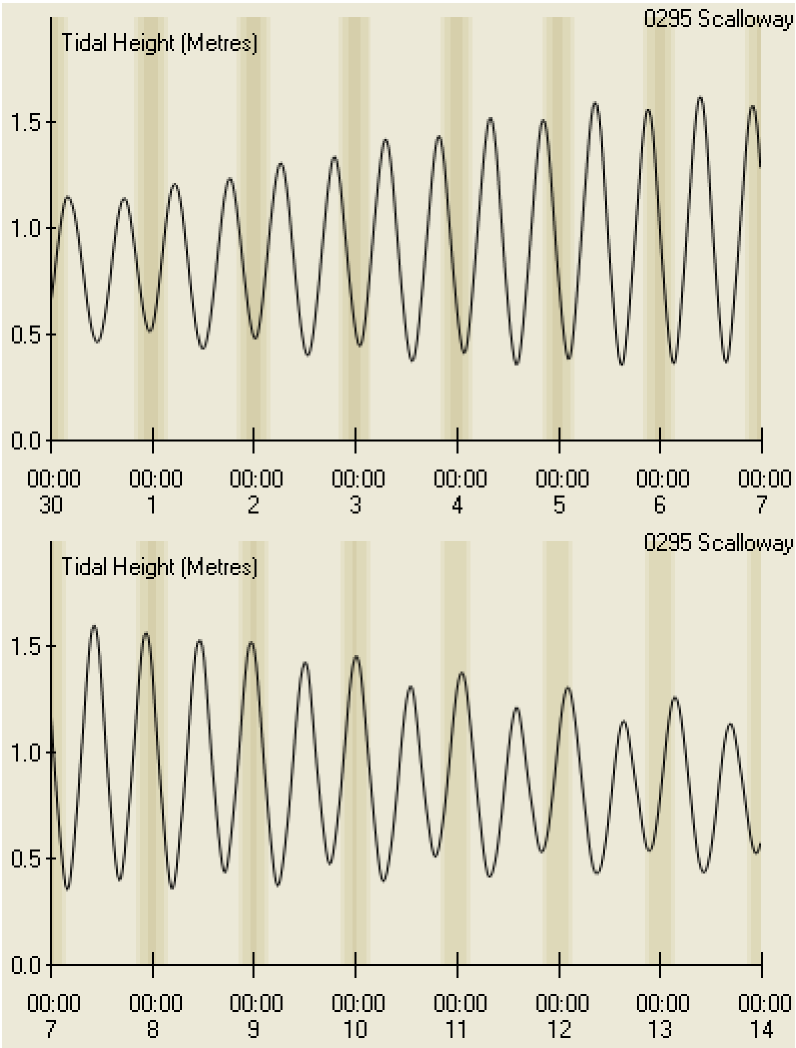

Figure 13.3 Tidal curves for Scalloway

The following is the summary description for Scalloway from TotalTide:

The tide type is Semi-Diurnal.

HAT	1.9 m
MHWS	1.6 m
MHWN	1.3 m
MLWN	0.6 m
MLWS	0.5 m

Predicted heights are in metres above chart datum. The tidal range at spring tide is therefore approximately 1.1 m and at neap tide 0.7 m, so tidal ranges here are relatively small.

Samples of water and shellfish were taken during the shoreline survey on 30/04/2008 between 1040 and 1110 BST. This correlated with an ebbing neap tide, as seen in the tidal curve in Figure 13.3. Contamination from the discharge would be expected to have been flowing away from the fishery on the tide at that time, so results would not have reflected worst case levels of contamination at that location.

Currents

Currents in coastal waters are predominantly driven by a combination of tide, wind and freshwater inputs. The tidal range here is small, the area is fairly exposed to winds, and there is little in the way of freshwater inputs. Therefore it might be expected that tidally driven currents are fairly weak, wind driven surface currents may significantly change the flow of water around the area depending on wind speed and direction, and that freshwater (density) driven currents are of negligible importance.

The best available source of information regarding the movement of water around the area was from a series of 5 studies carried out by the NAFC to assess movement of water around salmon farm sites. These were carried out on separate occasions, therefore under differing environmental conditions. The studies involved the deployment of a fixed current meter for periods of around 2 weeks, recording average speed and direction of the current at various depths at 10 minute intervals. Polar plots of total velocity and direction near the surface and near the bottom for each of the five locations are presented in Figures 13.4 and 13.5 respectively.

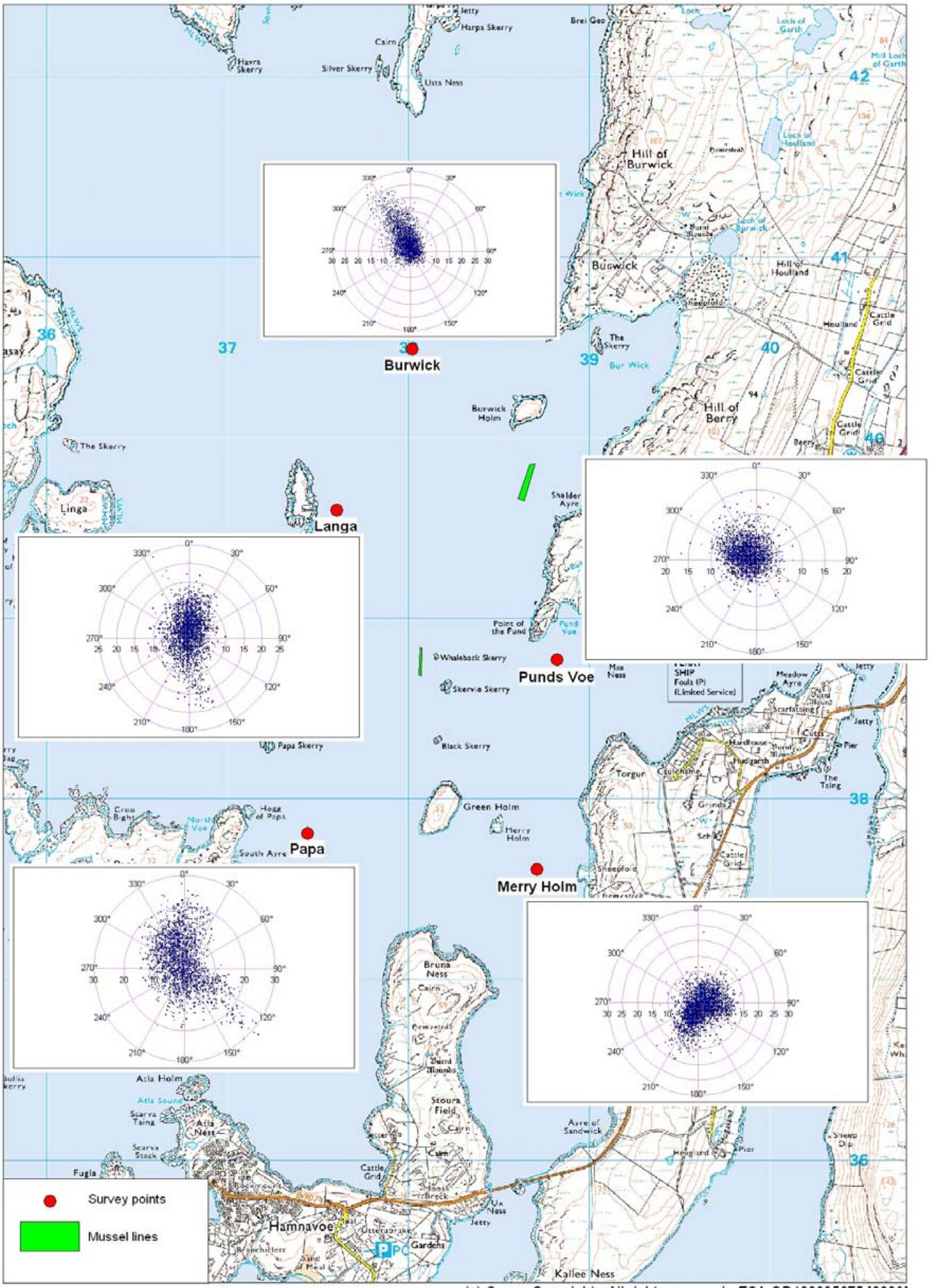

Figure 13.4 Polar plots of tidal direction and velocity readings near the surface for the five fish farm study sites.

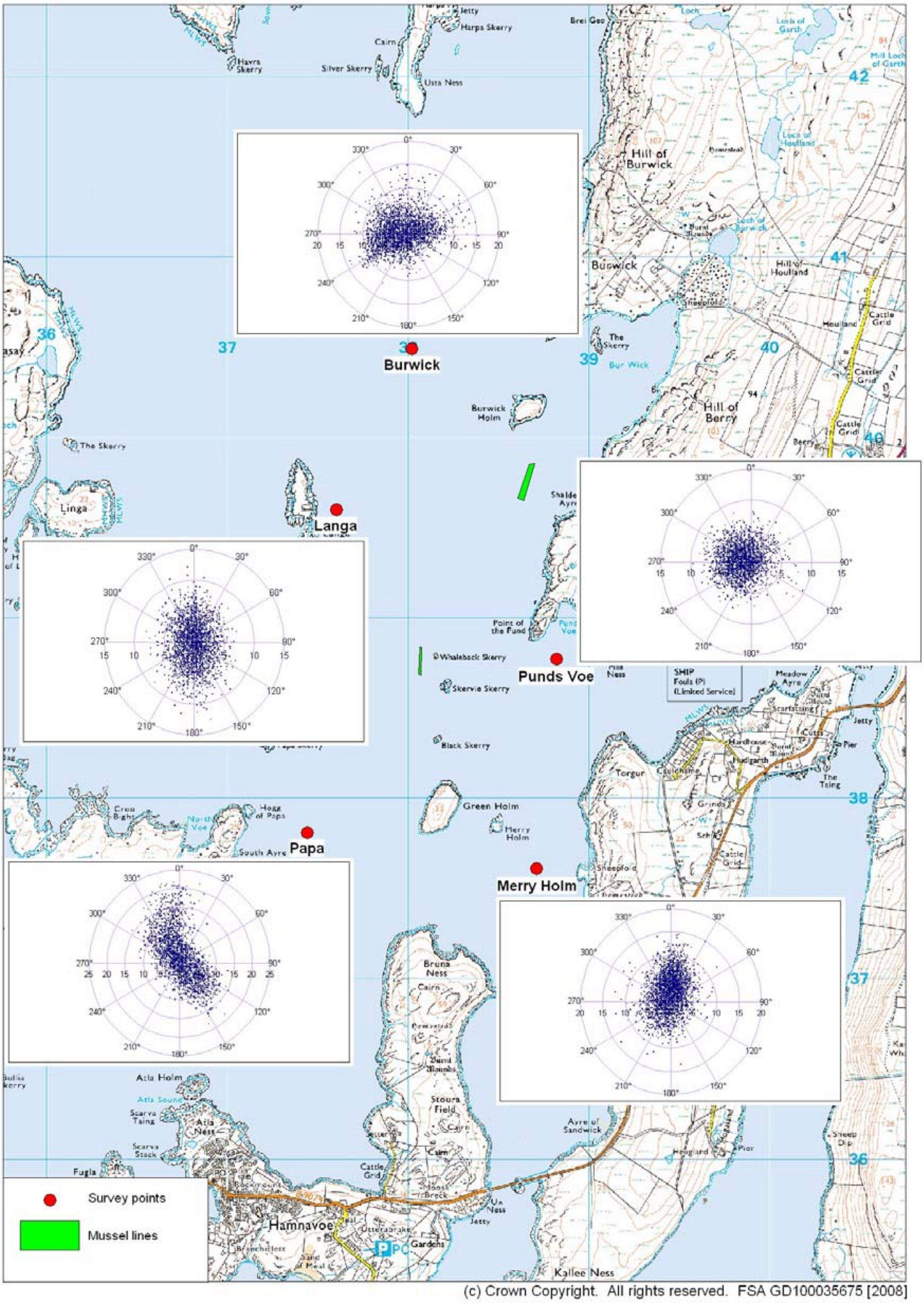

Figure 13.5 Polar plots of tidal direction and velocity readings near the bottom for the five fish farm study sites.

At Burwick, the mean current speed near the surface was 6.2 cm/s, and 5.2 cm/s at the bottom. The current flowed in a northwesterly direction at the surface for the majority of the time. Flows are quite evenly spread in terms of direction at the bottom, with slightly more records indicating a westerly flow. Wind was light to moderate, and consistently from the southeast during the survey period, and this would account for the flow directions recorded at the surface even though this site is relatively sheltered from winds from this direction.

At, Punds Voe, the mean current speed near the surface was 6.0 cm/s, and 3.6 cm/s at the bottom. Flows are quite evenly spread in terms of direction at both the surface and the bottom, although the current appeared to flow in a westerly direction for more of the time. Wind was light to moderate and fairly evenly spread in terms of direction during the survey period.

At Langa, the mean current speed near the surface was 3.2 cm/s, and 1.6 cm/s at the bottom. The plots indicate that although the flow directions were spread across all directions, flows were fastest along the north south axis. This bidirectional pattern was stronger near the surface. Wind was light to moderate and fairly evenly spread in terms of direction during the survey period.

At Papa, the mean current speed near the surface was 9.0 cm/s, and 6.8 cm/s at the bottom. The plots indicate bidirectional flows along the NNW SSE axis, with this pattern stronger near the bottom. Wind was light to moderate and fairly evenly spread in terms of direction during the survey period.

At Merry Holm, the mean current speed near the surface was 5.0 cm/s, and 4.8 cm/s at the bottom. Flows are fairly evenly spread in terms of direction at both the surface and the bottom, although the current flowed in a northerly direction for more of the time at the bottom. Wind was light to moderate and fairly evenly spread in terms of direction during the survey period.

Overall, current speeds are quite slow in the area, and were faster near the surface at all five sites. Most sites show a discernable tidal signal manifest as a preferred axis of flow direction. All of the sites showed significant scatter around any preferred transport direction indicating non-tidal, probably wind driven flows (despite relatively moderate winds during the deployment period). Patterns of speed and direction of flow varied markedly between sites, but were similar between the surface and the bottom at four of the five sites. At Burwick, major differences were seen between surface and bottom currents, however it may be that Burwick is deeper and therefore more likely to develop a two layer wind driven flow than the other, shallower sites.

The three sites nearest to the mussel lines Burwick (Burwick, Langa and Punds Voe) all experienced flows that were slow, and generally quite evenly spread in terms of direction at both the surface and the bottom. The exceptions to this were the surface currents at Burwick, which were affected by a persistent southeasterly wind during the survey period, and a bidirectional tendency along the north south axis at Langa, suggesting a stronger tidal signal here than at other stations. This implies that the movement of water at the Burwick mussel line is likely to be slow with wind probably a very important influence on the currents here. Although most important near the surface, wind can change bottom currents due to return flows and the scatter in bottom currents at most stations suggests that wind is influencing bottom currents.

Conclusions

The discharge at Maa Ness is into shallow water (<10m) and during the shoreline survey a ‘boil’ was visible on the surface here. The discharged effluent will be of lower salinity, and quite probably warmer than the receiving water, so it is likely it will tend to remain near the surface of the water, and will drift with the current, diffusing as it drifts. Given its proximity to the mussel lines at Burwick, the current analysis presented in section 13.2 indicates that contamination from the Maa Ness outfall is likely to be carried through the mussel lines by tidal currents at certain states of the tide, but only for a fairly small proportion of the time. A south or southwesterly wind will create surface water currents that will transport contamination from the outfall towards the mussel lines almost irrespective of tidal state. The presence of large amounts of rubbish washed up on the shore at Burwick seems to confirm that surface currents will tend to drive waste to the north or northeast here, where they are then concentrated in the bay. This is also anecdotally confirmed by the farmer at Burwick, who reported observing sewage plumes stretching northwards toward the bay and farm prior to installation of septic tank treatment at Maa Ness. Therefore, the mussels at Burwick will probably become much more contaminated during periods of S/SW wind than under other conditions. The discharge location is sheltered from E/SE by the adjacent land, so winds from a southeasterly direction may not change the circulation here as much as was observed at the Burwick fish farm site.

14. River Flow

There are no river gauging stations on rivers or burns along the Burwick and Scalloway coastline.

The following streams were measured and sampled during the shoreline survey. These represent the largest freshwater inputs into the Burwick area. No rain had fallen for two weeks prior to the survey apart from 7.2 mm two days before the measurements were taken. As a consequence some streams were too small to measure.

Table 14.1 Stream loadings for Burwick

No	Grid Ref	Description	Width (m)	Depth (m)	Flow (m/s)	Flow in m^3/day	*E.coli* (cfu/ 100ml)	Loading (*E.coli* per day)
1	HU 39484 40768	Stream	1.0	0.08	0.02	4838	170	8.23×10^9
2	HU 39503 40683	Stream	0.24	0.06	0.17	212	<1	$<2.12 \times 10^6$
3	HU 39442 40338	Stream	*	*	*	*	<1	*
4	HU 39202 39999	Stream	*	*	*	*	<1	*
5	HU 39002 39612	Stream	0.045	0.027	0.118	12.4	<1	$<1.24 \times 10^5$

*Streams were too small to measure

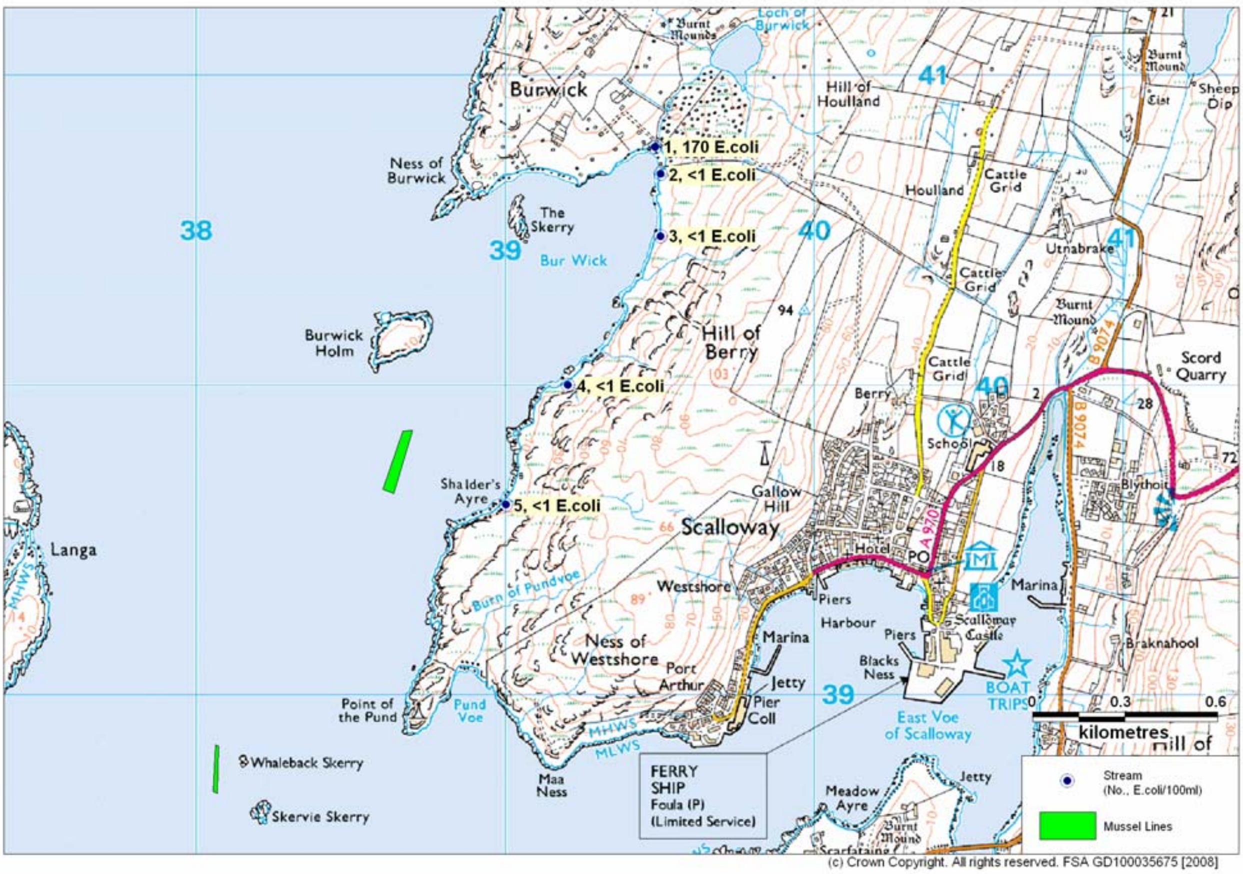

Figure 14.1 Significant streams and concentrations

In addition to the five streams above, several other were also observed however they were too small to sample, and so were deemed to be of little significance at the time of survey.

Despite draining areas of pasture where sheep were present, *E. coli* levels were very low (<1 cfu/100ml) in all the smaller streams sampled. Moderate levels of *E. coli* were found in the largest stream (stream 1), which drains a larger area of pasture and discharges to the head of the Burwick Bay, approximately 1.2 km away from the mussel lines at Burwick.

The total loading contributed by these streams is 8.23×10^9 *E. coli* per day, which is several orders of magnitude lower than the estimated maximum loading contributed by the Maa Ness outfall, so streams draining the area were of relatively little significance at the time of shoreline survey. Following heavy rain, the loadings contributed by these streams may increase significantly. However, even if they increased 100 fold, their total contribution would still be between 1 and 2 orders of magnitude less than the maximum dry weather discharge at Maa Ness.

15. Shoreline Survey Overview

The sanitary survey at Burwick was carried out in response to an application to harvest mussels from the production area.

The shoreline survey was conducted on the 30th April to 1st May 2008 following a prolonged period of dry weather.

At the time of the survey, there were two single longlines with 10 metre droppers situated at one end of the seabed lease area, which had been stripped by ducks in places. There was no plan to harvest in the immediate future as the owner is considering sale of the lease. An additional line was visited on the offshore side of Whaleback Skerry, just outside the entrance to Scalloway Harbour. This is not a classified site and was originally placed to attract Eider ducks from feeding on nearby mussel farms. There was a large amount of stock on the line and the harvester expressed interest in getting this line classified for harvest in autumn 2008.

The town of Scalloway lies to the east of the site and is the second largest settlement in Shetland. The southeast corner of the Burwick lease area lies within 100 metres of the outfall from the Maa Ness septic tank outfall which is designed to serve Scalloway's population of 1700. The discharge could be observed as an area of distinct 'boiling' currents offshore from an observed discharge pipe. Little in the way of tourist facilities appeared to be available in the area, with few B&Bs located in Scalloway, so it is not expected that the population increases greatly during the summer months.

The shore adjacent to the Burwick site is mainly pasture, with 147 sheep seen here at the time of survey, with a further 6 on Burwick Holm, and two sheep and 8 ponies on the north shore of Trondra. A number of small streams, ground seeps and drains were observed along the shoreline that would provide a means for carrying waste to the sea. Many of these streams had very little water flow on the day due to the lack of rain during the previous fortnight. A number of seabirds were observed nesting on a rock east of the mussel lines at Whaleback Skerry. Other than that, no large aggregations of wild animals or birds were observed during the shoreline survey.

Scalloway Harbour is an important port on the west coast of Shetland for fishing and survey boats. In addition to the port, there are two marinas with berths for small boats, one in Scalloway Harbour and the other in the East Voe of Scalloway with space for approximately 200 boats. There are no pumpout facilities in Scalloway.

Seawater samples collected from the surface at the mussel lines at Burwick and Whaleback Skerry all had low levels of *E. coli* (maximum of 2 cfu/100ml). A water sample collected from the area of turbulent water at the Maa Ness discharge had an *E. coli* concentration of 1100 cfu/100 ml.

Four mussel samples taken from the Burwick site all showed similar levels of contamination. The two samples collected from the southeastern corner of the mussel lines gave results of 490 and 130 *E. coli* mpn/100g. This corner was situated closest to the septic tank outfall at Maa Ness. At the northern end of the line where it was possible to take a sample from more than one depth on the same dropper, similar concentrations of *E. coli* were found at the 10 m depth (230 mpn/100g) and at 5 m depth (170 mpn/100g). The two mussel samples collected from Whaleback Skerry had lower levels of contamination than those collected from Burwick (20 and 50 *E. coli* mpn/100g).

E. coli levels were very low (<1 cfu/100ml) in all the smaller streams sampled. Moderate levels of *E. coli* were found in the largest stream (170 cfu/100 ml), which drains a larger area of pasture and discharges to the head of the Burwick Bay, approximately 1.2 km away from the mussel lines at Burwick.

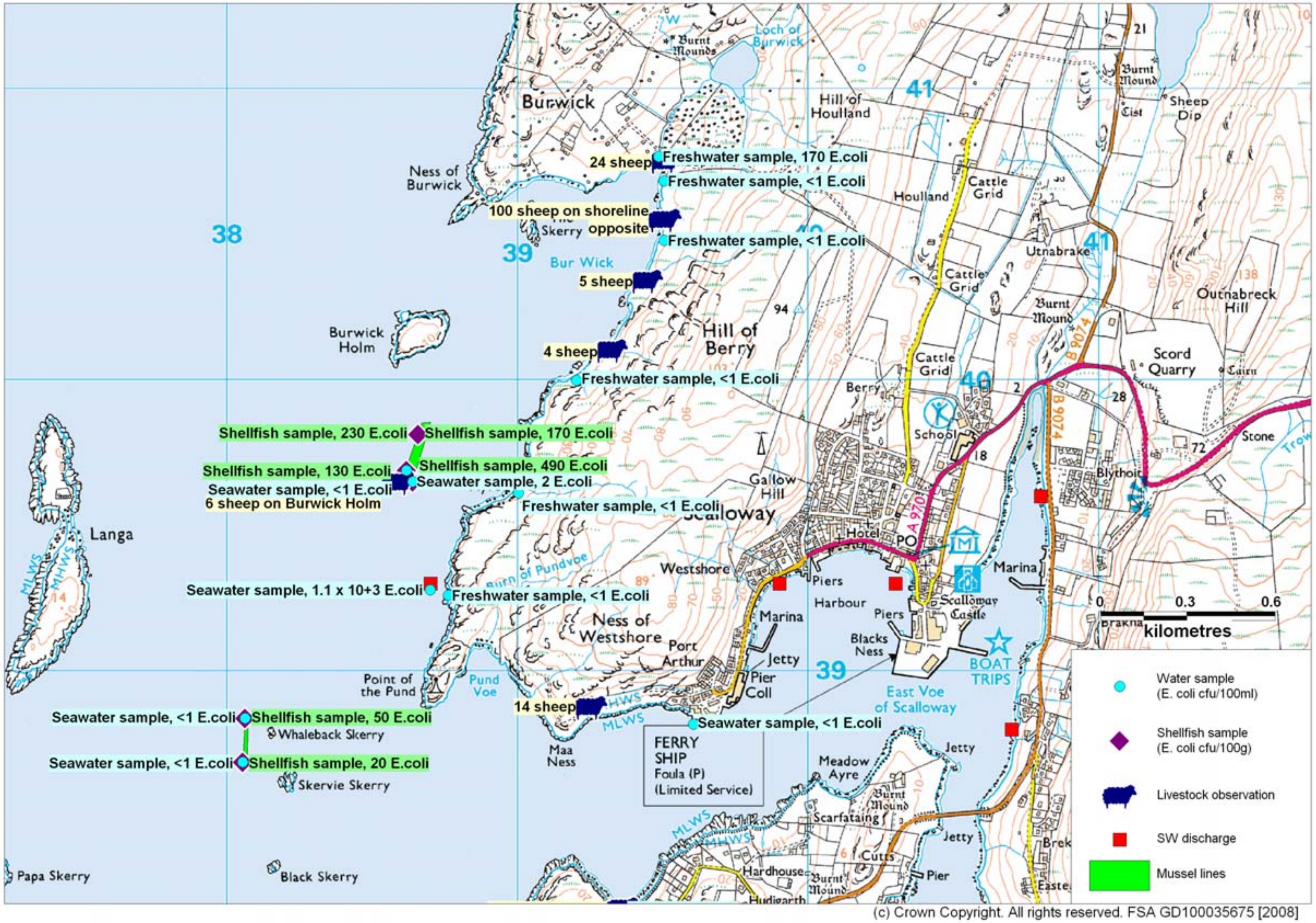

Figure 15.1 Summary of shoreline survey findings

16. Overall Assessment

Human sewage impacts

The most important discharge for Burwick at Maa Ness, 89 m from the Crown Estates lease boundaries, and 358 m from the current location of the mussel lines. This continuously discharges septic tank treated wastewater from a population equivalent of 1700 into relatively shallow water (<10m on the bathymetry chart). The catchment area includes the whole of Scalloway and the maximum estimated loading contributed by this discharge during dry weather is 4.5×10^{13} *E. coli* / day. There is also an emergency overflow here.

The Scalloway system includes a further four intermittent overflow discharges around Scalloway Harbour and the East Voe of Scalloway. It is uncertain how frequently these overflow, and the local impact on water quality when they do.

Outside of the Scalloway catchment area, houses will have private septic tanks. Five of these were noted on the north coast of Trondra, and SEPA lists consents for a further two not seen on the shore. The impact of these will be negligible relative to the Maa Ness outfall.

Scalloway is an important port in the area, used by fishing boats, survey boats and pleasure craft. Some inputs from boat traffic entering and leaving the harbour may therefore be expected.

This suggests that RMP should be located at the southern extremity of the fishery, to place it as close to the Maa Ness discharge as possible.

Agricultural impacts

The land adjacent to Burwick is rough grassland which is grazed sheep. The only source of detailed information on livestock numbers and distribution was the shoreline survey, which only applies to the day of survey. This recorded a total of 147 sheep here, mainly near a farm to the north of the site in Burwick bay. A further 6 sheep were recorded on Burwick Holm, and 8 ponies and two sheep were noted on the north shore of Trondra.

Overall numbers of livestock will be higher during the summer and autumn months following the birth of lambs in spring. Contamination of livestock origin will mainly be carried to the site via the streams draining the area. The most important of these by far at the time of survey was the stream discharging to the head of Burwick bay, to the north of the site.

In conclusion, the location of livestock (as observed on the shoreline survey) and the major stream draining the pastures in the area suggest a secondary significant source of contamination to the north of the existing mussel farm

Wildlife impacts

Species potentially impacting on Burwick include eiders, gulls, terns and seals. However, the impacts of these on the fishery will be unpredictable, and deposition of faeces by wildlife is likely to be widely distributed around the area and so will not be considered in the determination of sampling plans.

Seasonal variation

Little in the way of tourist facilities appeared to be available in the area, with few B&Bs located in Scalloway, so it is not expected that the population, and hence the size of the Maa Ness discharge increases greatly during the summer months.

Livestock numbers will be higher in the summer, so contamination from livestock sources may be higher during the summer.

Weather is wetter and windier during the winter months, so higher levels of rainfall dependent contamination, such as runoff from pasture and discharges from sewer overflows, may be expected during these times.

There is no historic *E. coli* monitoring data from Burwick, so no analysis of the seasonality in levels of contamination could be carried out for this site.

In conclusion, there is no firm information upon which the seasonality of results can be properly assessed.

Rivers and streams

Freshwater input to the area is relatively low, consisting of only one significant stream contributing a loading of 8.23×10^9 *E. coli* per day at the time of the shoreline survey. This almost four orders of magnitude lower that the estimated maximum dry weather loading contributed by the Maa Ness discharge, although the contribution from the stream might be expected to increase significantly, perhaps by up to two orders of magnitude, following heavy rainfall. The stream discharges 1.2 km north of the northern end of the mussel lines at Burwick and so is over three times further away from the mussel lines than the Maa Ness discharge.

There were also a number of very small streams draining the pasture on the shoreline adjacent to the Burwick mussel lines. The contribution from these was very low at the time of shoreline survey, and although it would likely increase following heavy rainfall, would still be insignificant relative to the larger stream and the Maa Ness discharge.

In conclusion, diffuse inputs from livestock will be carried into the area principally by a stream 1.2 km north of the mussel lines. Although this will provide a contribution to the levels of contamination in the area, the overall loading from these sources will be lower than that contributed by the Maa Ness outfall, even following heavy rainfall.

Meteorology, hydrology, and movement of contaminants

Currents in the area will be driven by a combination of tide, wind and freshwater inputs. Tidal range is relatively small here, the site is fairly exposed, and freshwater inputs are low. Therefore, fairly weak tidally driven currents might be expected, with surface currents potentially very variable depending on wind speed and direction. Freshwater (density) driven currents are likely to be of negligible significance.

A series of five hydrographic surveys were carried out in the area to assess whether current speeds and directions were suitable for deploying fish farm cages. Results indicated that current speeds are likely to be quite slow at Burwick, and in a range of directions, possibly with a vague bidirectional tendency along the north south axis as water moves along the coastline driven by tides. Wind will probably be a very important influence on surface currents here, but will not usually cause major changes to the currents lower down in the water column. The effluent from Maa Ness will be of lower salinity, and quite probably warmer than the receiving water, so it is likely it will tend to remain near the surface of the water, and will drift with the current, spreading as it does. Given its proximity to the mussel line at Burwick, contamination from the Maa Ness outfall is likely to be carried through the mussel lines by tidal currents at certain states of the tide, but only for a fairly small proportion of the time. A south or south easterly wind will create surface water currents which will transport contamination from the outfall towards the mussel lines almost irrespective of tidal state but it must be noted that the discharge location is sheltered from the S/SE by the adjacent land so this effect may not be so marked here as it was at the Burwick fish farm site. Therefore, the mussels at Burwick will probably become much more contaminated during periods of S/SE wind than under other conditions.

No historical *E. coli* monitoring data was available, so relationship between *E. coli* results and environmental variables could not be investigated. The weather is wetter and windier during the autumn and winter months, and the prevailing wind direction is from the southwest.

Temporal and geographical patterns of sampling results

Given that the site has no monitoring history, there is little information available under this heading with which to inform the sampling plan apart from sampling results from the shoreline survey, which must be treated with caution as they are specific to the conditions on the day.

Seawater samples collected from the surface at the mussel lines at Burwick and Whaleback Skerry all had low levels of *E. coli* (maximum of 2 cfu/100ml). A water sample collected from the area of turbulent water at the Maa Ness discharge had an *E. coli* concentration of 1100 cfu/100ml. This suggests that although the water quality was significantly affected in the immediate vicinity of the discharge, any plume from here was not compromising water quality at the surface at the Burwick mussel lines at the time of sampling.

Four mussel samples taken from the Burwick site all showed similar levels of contamination. The two samples collected from a range of depths at the southeastern corner of the mussel lines gave results of 490 and 130 *E. coli* mpn/100g. At the northern end of the line where it was possible to take a sample from more than one depth on the same rope, similar concentrations of *E. coli* were found at the 10 metre depth (230 mpn/100g) and at 5 metre depth (170 mpn/100g).

The two mussel samples collected from Whaleback Skerry had lower levels of contamination than those collected from Burwick (20 and 50 *E. coli* mpn/100g).

Mussels collected in areas impacted by human sewage are likely to contain human viruses at least seasonally, and for some viruses, year round (Le Guyader et al., 2000). *E. coli* concentrations in shellfish are poor predictors of risk from viruses and in this case, they may understate the public health risk posed by shellfish produced in this area.

It is highly likely that shellfish grown further south in the established lease area, and thus closer to the sewage outfall, would be more heavily contaminated with both indicator bacteria and human pathogens. In the absence of further testing, it is not possible to establish whether a RMP established at the southern end of the current lines would reflect contamination closer to the outfall.

17. Recommendations

A major concern at Burwick is the proximity of the Maa Ness discharge, which is located 89 m from the Crown Estates lease boundaries, and 358 m from the current location of the mussel lines, which currently straddle the northern border of the lease.

The EU guide to good practice in the microbiological monitoring of bivalve mollusc harvesting areas recommends the consideration of exclusion zones around sewage discharges, but gives no indication of how to determine the size of exclusion. The US FDA NSSP *Guide for the Control of Molluscan Shellfish* specifically recommends that prohibited areas should be established around significant sewer outfalls, their size determined by:

(i) The volume flow rate, location of discharge, performance of the wastewater treatment plant and the bacteriological or viral quality of the effluent;

(ii) The decay rate of the contaminants of public health significance in the wastewater discharged;

(iii) The wastewater's dispersion and dilution, and the time of waste transport to the area where shellstock may be harvested; and

(iv) The location of the shellfish resources, classification of adjacent waters and identifiable landmarks or boundaries.

Clearly, it is appropriate to establish an exclusion zone around the Maa Ness outfall, but determining the size of this with the available information is problematic. The EU good practice guide recommends an exclusion zone of 300m around marinas. Water samples taken during the course of the shoreline survey show that levels of *E. coli* were high in the immediate vicinity of the discharge, but had dropped to 2 cfu/100ml at the southern end of the lines, 358 m away from the discharge. An exclusion zone with a radius of 300 m around the discharge is therefore recommended. It is recognised that this impinges significantly on the seabed lease area, but not on the current extent of the shellfishery.

Recommended production area boundaries are the area bounded by lines drawn between HU 3901 3986 and HU 3879 3959 and between HU 3879 3959 and HU 3846 3969 and between HU 3846 3969 and HU 3858 4004 and between HU 3858 4004 and HU 3901 3986.

The RMP should be situated as close as possible to the discharge, and close to the surface as it is likely contamination from the discharge will float on top of the more dense seawater. Therefore, it is recommended that the RMP be set at HU 3863 3966. Only stock of a harvestable size should be sampled. Sampling depth should be < 1 m. A sampling tolerance of 20 m is recommended to allow for movement of the mussel lines.

As this is a new production area, and there are likely to be seasonal fluctuations in *E. coli* results, the sampling frequency should be monthly.

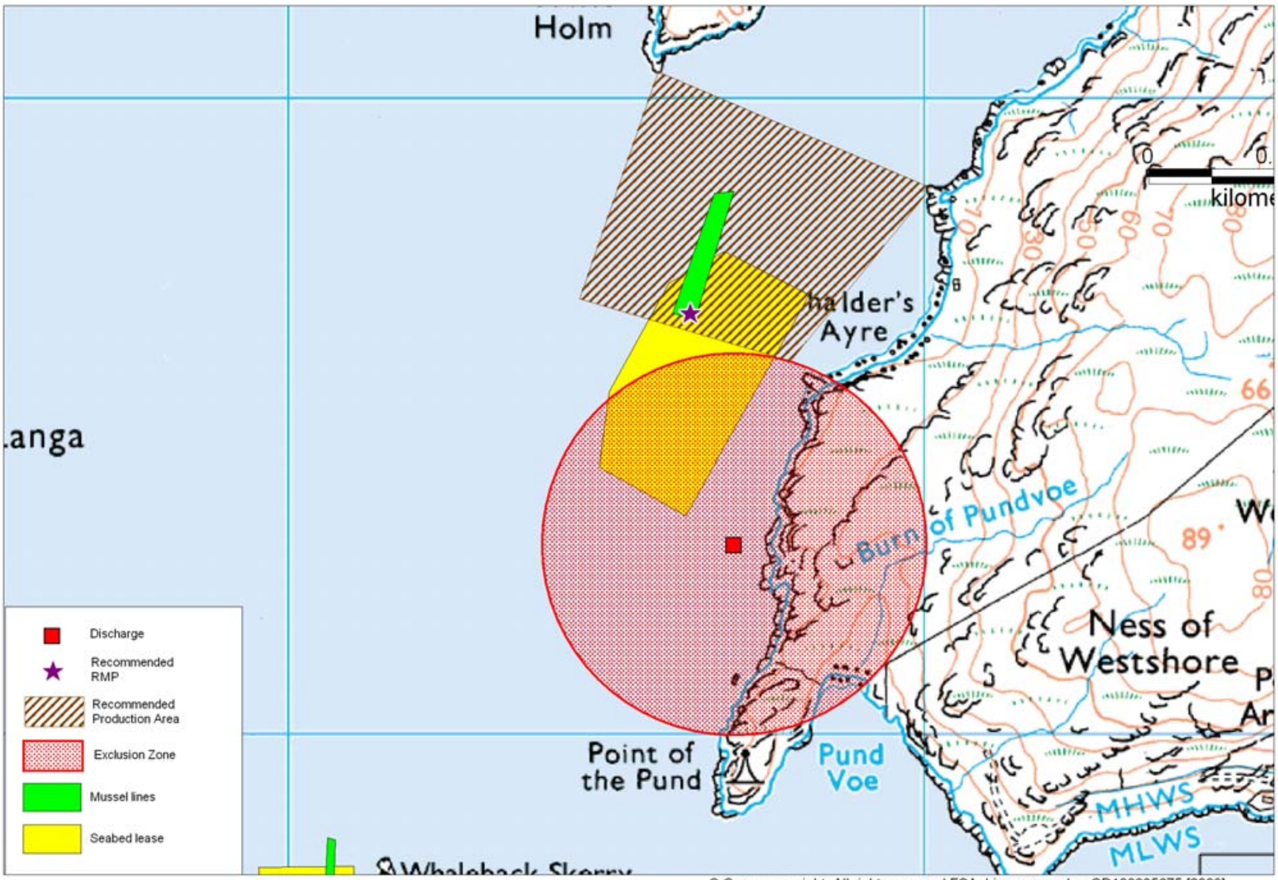

Figure 17.1 Recommended production area boundaries and sampling points

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6. **Hydrographic Methods**
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Sampling Plan for Burwick

PRODUC-TION AREA	SITE NAME	SIN	SP.	TYPE OF FISH-ERY	NGR OF RMP	EAST	NORTH	TOLER-ANCE (M)	DEPTH (M)	METHOD OF SAMPLING	FREQ OF SAMPLING	LOCAL AUTHORITY	AUTHORISED SAMPLER(S)	LOCAL AUTHORITY LIAISON OFFICER
Burwick	Shalders Ayre	SI 416	Common mussels	Long lines	HU 3863 3966	43863	113966	20 m	<1m	Hand	Monthly	Shetland Islands	Sean Williamson George Williamson Kathryn Winter Marion Slater	Dawn Manson

Comparative Table of Boundaries and RMPs – Burwick: Shalders Ayre

Production Area	Species	SIN	Existing Boundary	Existing RMP	New Boundary	New RMP	Comments
Burwick: Shalders Ayre	Common mussels	SI 416 821 08	Not yet a classified production area	NA	Area bounded by lines drawn between HU 3901 3986 and HU 3879 3959 and between HU 3879 3959 and HU 3846 3969 and between HU 3846 3969 and HU 3858 4004 and between HU 3858 4004 and HU 3901 3986	HU 3863 3966	New production area and RMP

Geology and Soils Information

Component soils and their associations were identified using uncoloured soil maps (scale 1:50,000) obtained from the Macaulay Institute. The relevant soils associations and component soils were then investigated to establish basic characteristics. From the maps seven main soil types were identified: 1) humus-iron podzols, 2) brown forest soils, 3) calcareous regosols, brown calcareous regosols, calcareous gleys, 4) peaty gleys, podzols, rankers, 5) non-calcareous gleys, peaty gleys: some humic gleys, peat, 6) organic soils and 7) alluvial soils.

Humus-iron podzols are generally infertile and physically limiting soils for productive use. In terms of drainage, depending on the related soil association they generally have a low surface % runoff, of between 14.5 – 48.4%, indicating that they are generally freely draining.

Brown forest soils are characteristically well drained with their occurrence being restricted to warmer drier climates, and under natural conditions they often form beneath broadleaf woodland. With a very low surface % runoff of between 2 – 29.2%, brown forest soils can be categorised as freely draining (Macaulay Institute, 2007).

Calcareous regosols, brown regosols and calcareous gleys are all characteristically freely draining soils containing free calcium carbonate within their profiles. These soil types have a very low surface % runoff at 14.5%.

Peaty gleys, peaty podzols and peaty rankers contribute to a large percentage of the soil composition of Scotland. They are all characteristically acidic, nutrient deficient and poorly draining. They have a very high surface % runoff of between 48.4 – 60%.

Non-calcareous gleys, peaty gleys and humic gleys are generally developed under conditions of intermittent or permanent water logging. In Scotland, non-calcareous gleys within the Arkaig association are most common and have an average surface % runoff of 48.4%, indicating that they are generally poorly draining.

Organic soils often referred to as peat deposits and are composed of greater than 60% organic matter. Organic soils have a surface % runoff of 25.3% and although low, due to their water logged nature, results in them being poorly draining.

Alluvial soils are confined to principal river valleys and stream channels, with a wide soil textural range and variable drainage. However, the alluvial soils encountered within this region have an average surface % runoff of 44.3%, so it is likely that in this case they would be poorly draining.

These component soils were classed broadly into two groups based on whether they are freely or poorly draining. Drainage classes were created based on information obtained from the both the Macaulay Institute website and personal communication with Dr. Alan Lilly. GIS map layers were created for each class with poorly draining classes shaded red, pink or orange and freely draining classes coloured blue or grey. These maps were then used to assess the spatial variation in soil permeability across a survey area and it’s potential impact on runoff.

Glossary of Soil Terminology

Calcareous: Containing free calcium carbonate.

Gley: A sticky, bluish-grey subsurface layer of clay developed under intermittent or permanent water logging.

Podzol: Infertile, non-productive soils. Formed in cool, humid climates, generally freely draining.

Rankers: Soils developed over noncalcareous material, usually rock, also called 'topsoil'.

Regosol: coarse-textured, unconsolidated soil lacking distinct horizons. In Scotland, it is formed from either quartzose or shelly sands.

General Information on Wildlife Impacts

Seals

Two species of pinniped (seals, sea lions, walruses) are commonly found around the coasts of Scotland: These are the European harbour, or common, seal (*Phoca vitulina vitulina*) and the grey seal (*Halichoerus grypus*). Shetland hosts significant populations of both species.

Common seal surveys are conducted every 5 years and an estimate of minimum numbers is available through Scottish Natural Heritage. The Shetland-wide count in 2006 was 3021 harbour seals, though this was anticipated to be an underestimation of the total population (Sea Mammal Research Unit 2007).

According to the Scottish Executive, in 2001 there were approximately 119,000 grey seals in Scottish waters, the majority of which were found in breeding colonies in Orkney and the Outer Hebrides, although there are some breeding colonies in other areas including Shetland. Minimum pup production in Shetland was estimated as 943 in 2004. Adult numbers are estimated to be 3.5 times the pup population (Callan Duck, Sea Mammal Research Unit, personal communication).

Adult grey seals weigh 150-220 kg and adult common seals 50-170kg. They are estimated to consume between 4 and 8% of their body weight per day in fish, squid, molluscs and crustaceans. No estimates of the volume of seal faeces passed per day were available, though it is reasonable to assume that what is ingested and not assimilated in the gut must also pass. Assuming 6% of a median body weight for harbour seals of 110kg, that would equate to 6.6kg consumed per day and probably very nearly that defecated.

The concentration of *E. coli* and other faecal indicator bacteria contained in seal faeces has been reported as being similar to that found in raw sewage, with counts showing up to 1.21×10^4 CFU (colony forming units) *E. coli* per gram dry weight of faeces (Lisle *et al* 2004).

Both bacterial and viral pathogens affecting humans and livestock have been found in wild and captive seals. *Salmonella* and *Campylobacter* spp., some of which were antibiotic-resistant, were isolated from juvenile Northern elephant seals (*Mirounga angustirostris*) with *Salmonella* found in 36.9% of animals stranded on the California coast (Stoddard et al 2005). *Salmonella* and *Campylobacter* are both enteric pathogens that can cause acute illness in humans and it is postulated that the elephant seals were picking up resistant bacteria from exposure to human sewage waste.

One of the *Salmonella* species isolated from the elephant seals, *Salmonella typhimurium*, is carried by a number of animal species and has been isolated from cattle, pigs, sheep, poultry, ducks, geese and game birds in England and Wales. Serovar DT104, also associated with a wide variety of animal species, can cause severe disease in humans and is multi-drug resistant (Poppe et al 1998).

Whales and Dolphins

A variety of cetacean species are routinely observed near Shetland. During 2001-2002, there were confirmed sightings of the following species (Shetland Sea Mammal Group 2003):

Table 8.1 Cetacean sightings near Shetland by species.

Common name	Scientific name	No. sighted*
Minke whale	*Balaenoptera acutorostrata*	28
Humpback whale	*Megaptera novaeangliae*	1
Sperm whale	*Physeter macrocephalus*	3
Killer whale	*Orcinus orca*	183
Long finned pilot whale	*Globicephala melas*	14
White-beaked dolphin	*Lagenorhynchus albirostris*	399
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	136
Striped dolphin	*Stenella coeruleoalba*	1
Risso's dolphin	*Grampus griseus*	145
Common dolphin	*Delphinus delphis*	6
Harbour porpoise	*Phocoena phocoena*	>500

*Numbers sighted are based on rough estimates based on reports received from various observers and whale watch groups.

Little is known about the volume or bacterial composition of cetacean faeces. As mammals, it can be safely assumed that their guts will contain an unknown concentration of normal commensal bacteria, including *Escherichia coli*. It is highly likely that cetaceans will be found from time to time in the area, although the larger species may not visit this area as it is fairly shallow. The impact of their presence is, as with pinnipeds, likely to be fleeting and unpredictable.

Birds

Seabird populations were surveyed all over Britain as part of the SeaBird 2000 census. These counts are investigated using GIS to give the numbers observed within a 5km radius of the production area. This gives a rough idea of how many birds may be present either on nests or feeding near the shellfish farm or bed.

Further information is gathered where available related to shorebird surveys at local bird reserves when present. Surveys of overwintering geese are queried to see whether significant populations may be resident in the area for part of the year. In many areas, at least some geese may be present year round. The most common species of goose observed during shoreline surveys has been the Greylag goose. Geese can be found grazing on grassy areas adjacent to the shoreline during the day and leave substantial faecal deposits. Geese and ducks can deposit large amounts of faeces in the water, on docks and on the shoreline.

A study conducted on both gulls and geese in the northeast United States found that Canada geese (*Branta canadiensis*) contributed approximately 1.28×10^5 faecal coliforms per faecal deposit and ring-billedgulls (*Larus delawarensis*) approximately 1.77×10^8 FC per faecal deposit to a local reservoir (Alderisio and DeLuca, 1999). An earlier study found that geese averaged from 5.23 to 18.79 defecations per hour while feeding, though it did not specify how many hours per day they observed to feed (Bedard and Gauthier, 1986).

Waterfowl can be a significant source of pathogens as well as indicator organisms. Gulls frequently feed in human waste bins and it is likely that they carry some human pathogens and birds are known to carry *Salmonella*.

Deer

No significant populations of deer are found on Shetland.

Other

The European Otter (*Lutra lutra*) is present around Scotland with some areas hosting populations of international significance. Coastal otters tend to be more active during the day, feeding on bottom-dwelling fish and crustaceans among the seaweed found on rocky inshore areas. An otter will occupy a home range extending along 4-5km of coastline, though these ranges may sometimes overlap (Scottish Natural Heritage). Otters primarily forage within the 10 m depth contour and feed on a variety of fish, crustaceans and shellfish (Paul Harvey, Shetland Sea Mammal Group, personal communication).

Otters leave faeces (also known as spraint) along the shoreline or along streams which is subject to run into the water either due to rainfall or on the incoming tide. No information was found at the time of this report on the bacteriological content of otter faeces. However, given the total numbers present in Shetland and the foraging habits described above it is highly unlikely that otter faeces will be a significant source of contamination to the fishery.

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Tables of Typical Faecal Bacteria Concentrations

Summary of faecal coliform concentrations (cfu 100ml-1) for different treatment levels and individual types of sewage-related effluents under different flow conditions: geometric means (GMs), 95% confidence intervals (Cis), and results of t-tests comparing base- and high-flow GMs for each group and type.

Indicator organism	Base-flow conditions				High-flow conditions			
Treatment levels and specific types: Faecal coliforms	n^c	Geometric mean	Lower 95% CI	Upper 95% CI	n^c	Geometric mean	Lower 95% CI	Upper 95% CI
Untreated	252	$1.7 \times 10^{7*}$ (+)	1.4×10^7	2.0×10^7	282	$2.8 \times 10^{6*}$ (-)	2.3×10^6	3.2×10^6
Crude sewage discharges	252	$1.7 \times 10^{7*}$ (+)	1.4×10^7	2.0×10^7	79	$3.5 \times 10^{6*}$ (-)	2.6×10^6	4.7×10^6
Storm sewage overflows					203	2.5×10^6	2.0×10^6	2.9×10^6
Primary	127	$1.0 \times 10^{7*}$ (+)	8.4×10^6	1.3×10^7	14	4.6×10^6 (-)	2.1×10^6	1.0×10^7
Primary settled sewage	60	1.8×10^7	1.4×10^7	2.1×10^7	8	5.7×10^6		
Stored settled sewage	25	5.6×10^6	3.2×10^6	9.7×10^6	1	8.0×10^5		
Settled septic tank	42	7.2×10^6	4.4×10^6	1.1×10^7	5	4.8×10^6		
Secondary	864	$3.3 \times 10^{5*}$ (-)	2.9×10^5	3.7×10^5	184	$5.0 \times 10^{5*}$ (+)	3.7×10^5	6.8×10^5
Trickling filter	477	4.3×10^5	3.6×10^5	5.0×10^5	76	5.5×10^5	3.8×10^5	8.0×10^5
Activated sludge	261	$2.8 \times 10^{5*}$ (-)	2.2×10^5	3.5×10^5	93	$5.1 \times 10^{5*}$ (+)	3.1×10^5	8.5×10^5
Oxidation ditch	35	2.0×10^5	1.1×10^5	3.7×10^5	5	5.6×10^5		
Trickling/sand filter	11	2.1×10^5	9.0×10^4	6.0×10^5	8	1.3×10^5		
Rotating biological contactor	80	1.6×10^5	1.1×10^5	2.3×10^5	2	6.7×10^5		
Tertiary	179	1.3×10^3	7.5×10^2	2.2×10^3	8	9.1×10^2		
Reedbed/grass plot	71	1.3×10^4	5.4×10^3	3.4×10^4	2	1.5×10^4		
Ultraviolet disinfection	108	2.8×10^2	1.7×10^2	4.4×10^2	6	3.6×10^2		

Source: Kay, D. et al (2008) Faecal indicator organism concentrations in sewage and treated effluents. *Water Research* 42, 442-454.

Comparison of faecal indicator concentrations (average numbers/g wet weight) excreted in the faeces of warm-blooded animals

Animal	Faecal coliforms (FC) number	Excretion (g/day)	FC Load (numbers /day)
Chicken	1,300,000	182	2.3×10^8
Cow	230,000	23,600	5.4×10^9
Duck	33,000,000	336	1.1×10^{10}
Horse	12,600	20,000	2.5×10^8
Pig	3,300,000	2,700	8.9×10^8
Sheep	16,000,000	1,130	1.8×10^{10}
Turkey	290,000	448	1.3×10^8
Human	13,000,000	150	1.9×10^9

Source: Adapted from Geldreich 1978 by Ashbolt et al in World Health Organisation (WHO) Guidelines, Standards and Health. 2001. Ed. by Fewtrell and Bartram. IWA Publishing, London.

Hydrographic Methods

Introduction

This document outlines the methodology used by Cefas to fulfil the requirements of the sanitary survey procedure with regard to hydrographic evaluation of shellfish production areas. It is written as far as possible to be understandable by someone who is not an expert in oceanography or computer modelling. This document collects together information common to all hydrographic assessments avoiding the repetition of information in each individual report.

The hydrography at most sites will be assessed on the basis of bathymetry and tidal flow software only and is not discussed in any detail in this document. Selected sites will be assessed in more detail using either: 1) a hydrodynamic model, or 2) an extended consideration of sources, available field studies and expert assessment. This document will focus on this more detailed hydrographic assessment and describes the common methodology applied to all sites.

The regulations require an appreciation of the hydrography and currents within a region classified for shellfish production.

Background processes

This section gives an overview of the hydrographic processes relevant to sanitary surveys.

Movement in the estuarine and coastal waters is generally driven by one of three mechanisms: 1) Tides, 2) Winds, 3) Density differences. Unless tidal flows are weak they usually dominate over the short term (~12 hours) and move material over the length of the tidal excursion. The tidal residual flow acts over longer time scales to give a net direction of transport. Whilst tidal flows generally move material in more or less the same direction at all depths, wind and density driven flows often move material in different directions at the surface and at the bed. Typical vertical profiles are depicted in figure 1. However, it should be understood that in a given water body, movement will often be the sum of all three processes.

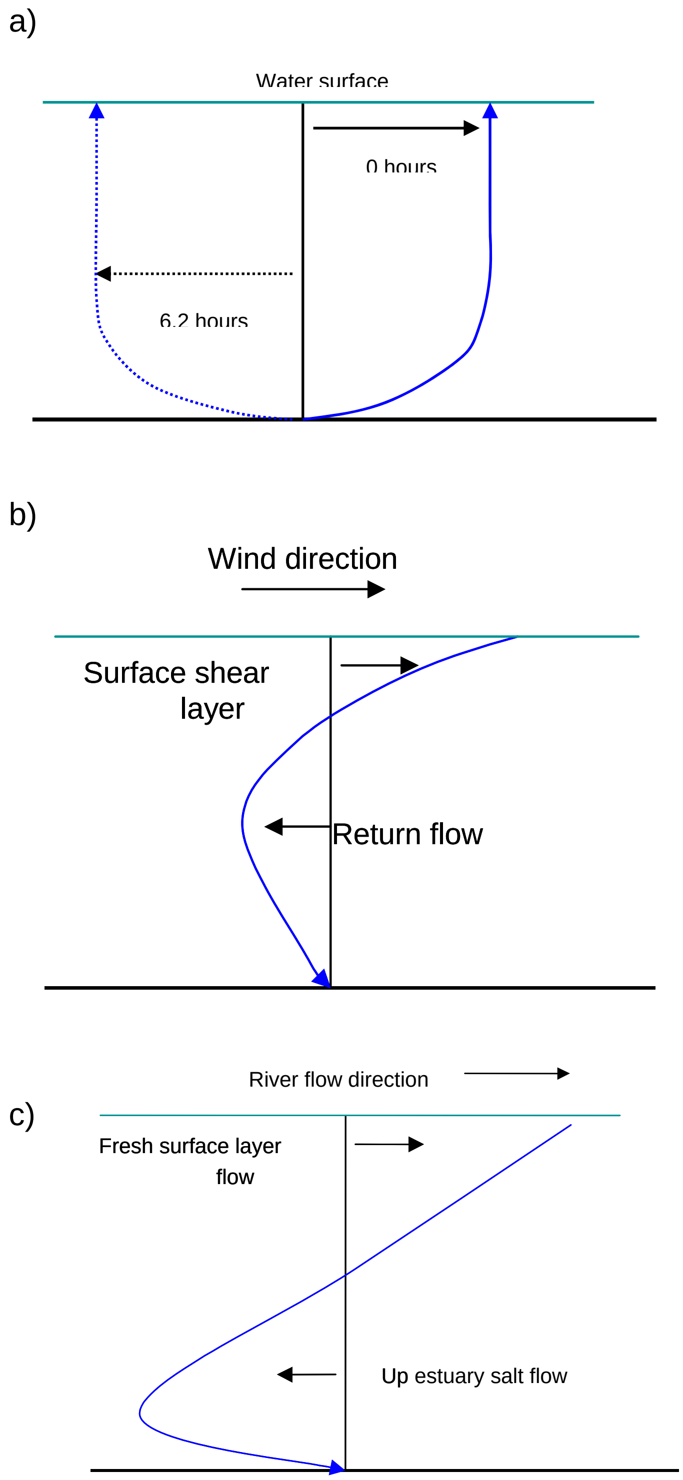

Figure 1. Typical vertical profiles for water currents. The black vertical line indicates zero velocity so portions of the profile to the left and right indicate flow moving in opposite directions. a) Peak tidal flow profiles. Profiles are shown 6.2 hours apart as the main tidal current reverses direction over a period of 6.2 hours. b) wind driven current profile, c) density driven current profile.

In sea lochs, mechanisms such as “wind rows” can transport sources of contamination at the edge of the loch to production areas further offshore. Wind rows are generated by winds directed along the main length of the loch. An illustration of the waters movements generated in this way is given in Figure 2. As can be seen the water circulates in a series of cell that draw material across the loch at right angles to the wind direction. This is a particularly common situation for lochs with high land on either side as these tend to act as a steering mechanism to align winds along the water body.

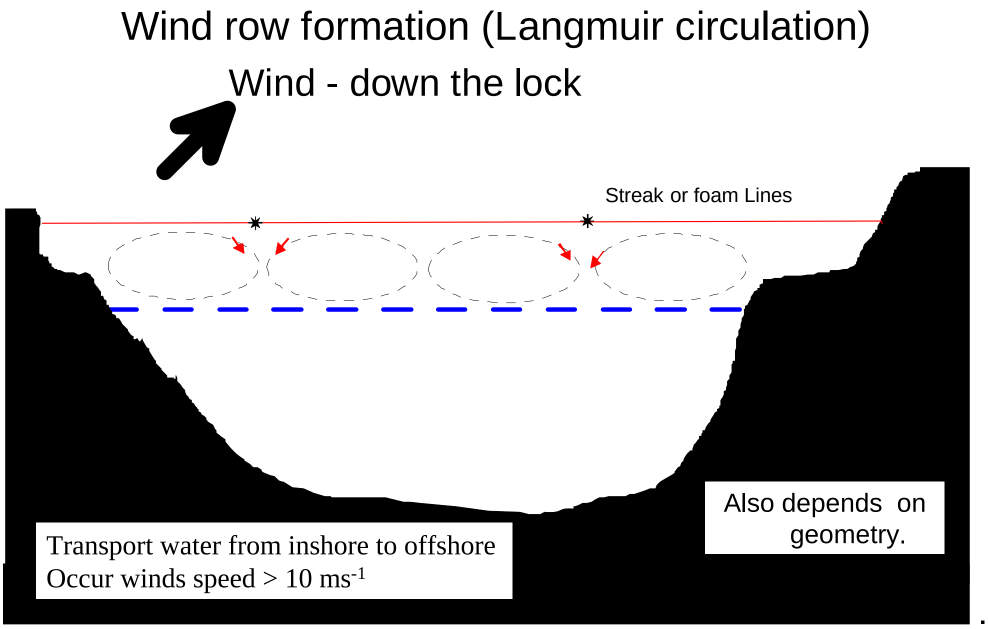

Figure 2: Schematic of wind driven ‘wind row’ currents. The dotted blue line indicates the depth of the surface fresh(er) water layer usually found in sea lochs.

Shoreline Survey Report

Burwick: Shalders Ayre
SI 416

Scottish Sanitary Survey Project

Shoreline Survey Report

Prod. area:	Burwick
Site name:	Shalders Ayre (SI 416 821 08)
Species:	Common mussels
Harvester:	J. Georgeson, Suthra Voe Shellfish
Local Authority:	Shetland Islands Council
Status:	New Site
Date Surveyed:	30 April-1 May 2008
Surveyed by:	Michelle Price-Hayward, Sean Williamson, Jessica Larkham
Existing RMP:	Not yet established
Area Surveyed:	See Map in Figure 1

Weather observations
Dry, partly cloudy. No rain 2 weeks prior to survey, 7.2mm at Lerwick Monday 29 May, 2.4mm Wednesday. Temp 8-9C.

Site Observations
Specific observations made on site are listed in Table 1 and mapped in Figure 1. The locations of the mussel lines were marked at the ends of the floats, not at the anchors, using a hand-held GPS receiver. Accuracy recorded by the unit was to within 7 meters.

Fishery
There are currently two single longlines with 10 metre droppers situated at one end of the seabed lease area (See Figure 1). The harvester reported that the lines had been stripped by ducks in places. On the day of survey, there was insufficient stock from which to collect depth specific samples except in one case. There is no plan to harvest in the immediate future as the owner is considering sale of the lease.

An additional line was visited on the offshore side of Whaleback Skerry, just outside the entrance to Scalloway Harbour. This is not a classified site and was originally placed to attract Eider ducks from feeding on nearby mussel farms. There was a large amount of stock on the line and the harvester, K. Pottinger, expressed interest in getting this line classified for harvest in autumn 2008.

Sewage/Faecal Sources
Human - The southeast corner of the lease area lies within 100 metres of the outfall from the Maa Ness septic tank outfall to the north of the entrance to Scalloway Harbour. The Maa Ness septic tank discharges up to 35 L/s of septic tank effluent and is designed to serve a population of 1700. An overflow with 6mm screening operates at flow rates in excess of 35 L/s, for example after heavy rainfall. The septic tanks were observed (Table 1, No. 28) as well as the discharge pipe, inspection hatch and location of discharge (Table 1, Nos. 1, 26 & 27).

Though a sampling officer had noted a foul odour near the site during a previous visit, no odour was detected on the day of survey. The discharge could be observed as an area of distinct ‘boiling’ currents offshore from an observed discharge pipe. Water sample number 1 (see Table 2) was collected from this area of turbulent water flow and showed an *E.coli* concentration of 1100 colony forming units (cfu) per 100 ml.

Sheep are grazed (156 were observed during the survey) on the surrounding hills. A number of small streams, ground seeps and drains were observed along the shoreline that would provide a means for carrying waste to the sea. Many of these streams had very little water flow on the day due to the lack of rain during the previous fortnight.

The largest stream observed flowing in the area discharged at Bur Wick approximately 1km north northeast of the northern end of the mussel lines. A water sample collected from this stream contained a 170 cfu *E.coli* /100 ml.

Seasonal Population
No caravans, car parks or campsites were observed on the shoreline adjacent to the fishery. Little in the way of tourist facilities appeared to be available in the area, with few B&Bs located in Scalloway.

Boats/Shipping
Scalloway Harbour lies to the south of the lease and is an important port on the west coast of Shetland for fishing and survey boats. A barge was observed a kilometre or more offshore of the mussel farm (see photograph in Figure 7). During the week of the survey, 15 fishing vessels were recorded as having landed at Scalloway harbour.

There are facilities for visiting boats in Scalloway Harbour but no sewage pumpout facilities. There are two marinas with berths for small boats, one in Scalloway Harbour and the other in the East Voe of Scalloway with space for approximately 200 boats.

Land Use
Land use in the area is predominantly sheep grazing. A farm located at Bur Wick, approximately 1km northeast of the mussel farm at Shalders Ayre, had a small arable field sown to Shetland Oats and grazing on which >100 sheep were observed. The farm lay uphill of a bay and the shoreline of the bay had accumulated a thick layer of debris, including fishing nets, floats, plastic containers and other items. None of them appeared to be of sanitary origin and some were labelled in Norwegian or French.

The area immediately adjacent the lease is remote with no human settlements.

The town of Scalloway lies to the east of the site and is the second largest settlement in Shetland. The entrance to Scalloway Voe and Scalloway harbour lies approximately 1km south of the mussel farm at Shalders Ayre and <1km to the east of the mussel line at Whaleback Skerry.

Wildlife/Birds
Specific observations taken on site are mapped in Figures 1 and 2 and listed in Table 1. A number of seabirds were observed nesting on a rock east of the mussel lines at Whaleback Skerry. Other than that, no large populations of wild animals or birds were observed during the shoreline survey.

Sampling
Water and shellfish samples were collected at sites marked on the map. The depth at which the shellfish were grown is noted in Table 3. Where the depth states 'all' there was insufficient stock at a given depth to make up a complete sample and so the sample was taken from the full length of the rope. Samples were transferred to cool boxes for transport to the laboratory. All samples were analysed for *E. coli* content. Water sampled at shellfish farms was tested for salinity and temperature using a portable salinity meter. These readings are recorded in Table 1 as salinity in parts per thousand (ppt).

Bacteriology results follow in Tables 2 and 3.

The majority of water samples collected showed low concentrations of *E. coli*, though higher concentrations were found at the two most significant discharges to the area. Sampling of mussels was undertaken on a northbound tide and sample results showed higher levels of contamination present in the mussels collected from the southeastern corner of the mussel lines. This corner was situated closest to the septic tank outfall at Maa Ness. At the northern end of the line where it was possible to take a sample from more than one depth on the same rope, higher concentrations of *E. coli* were found at the bottom of the rope than at the top.

Summary

- Current shellfish farm sits at northern extreme of lease area.
- The outfall for the Maa Ness septic tanks lies within 100m of the southern corner of the lease area and constitutes a significant point source of faecal bacteria to the fishery.
- The site lies along a busy shipping route and approach to the port of Scalloway.
- *E. coli* concentrations were higher in mussels collected from the southern extremity of the long lines than in those collected from the northern end.
- An additional site at Whaleback Skerry was sampled due to proximity and the harvester's intent to apply for classification in order to harvest.

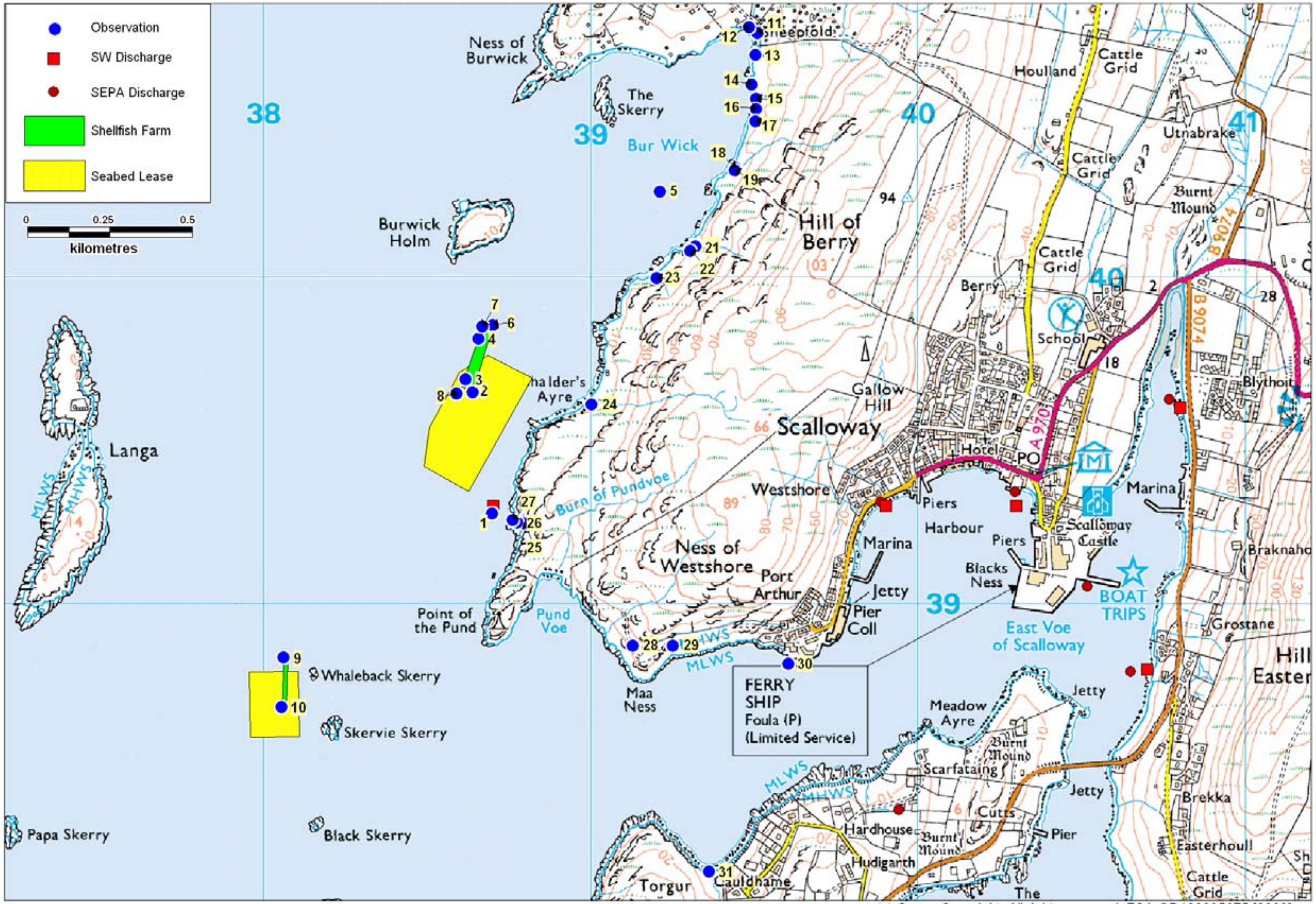

Figure 1. Map of Shoreline Observations

Table 1. Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Description
1	30/04/2008	10:43	HU 38698 39279	438698	1139279		Seawater sample 1, est. location of output from outfall, strong current. 10 metres out . Salinity 35.1 ppt, temperature 8.4°C
2	30/04/2008	10:49	HU 38638 39651	438638	1139651		Corner of mussel line, Shalders Ayre shellfish sample 1, seawater sample 1
3	30/04/2008	11:00	HU 38617 39689	438617	1139689	Figure 5	Shalders Ayre shellfish sample 2, seawater sample 2
4	30/04/2008	11:06	HU 38657 39813	438657	1139813	Figure 6	Corner of mussel line. Shellfish sample 3 (5m depth) & 4 (10m depth)
5	30/04/2008	11:18	HU 39212 40265	439212	1140265	Figure 7	Barge observed passing offshore of fishery
6	30/04/2008	11:22	HU 38700 39855	438700	1139855		Corner of mussel lines
7	30/04/2008	11:24	HU 38669 39852	438669	1139852		Corner of mussel lines, middle part of the line has sunk
8	30/04/2008	11:25	HU 38590 39646	438590	1139646		6 sheep on island nearest farm
9	30/04/2008	11:28	HU 38061 38838	438061	1138838	Figure 14	End of new mussel line. Whaleback Skerry shellfish sample 1, water sample 1. 5 metres out - 35.1 salinity, 8.5°C
10	30/04/2008	11:39	HU 38054 38687	438054	1138687		End of new mussel line. Water sample 2, Shellfish sample 2. Salinity 35.1, 8.5°C. Towards Scalloway harbour on a rock island there are lots of birds nesting
11	01/05/2008	10:00	HU 39509 40749	439509	1140749	Figure 8	Burwick. Beach covered in debris/waste (mainly plastic items, fishing nets - evidence of rubbish from France and Norway). Spoke to farmer who claims to have witnessed the sewage plumes in the bay most evenings. 24 sheep to right of beach. 2 houses to right of beach. Also one arable field, sowed with Shetland Oats
12	01/05/2008	10:22	HU 39484 40768	439484	1140768	Figure 9	Stream 0.08m x 1.0m. Burwick water sample 3 (freshwater). Flow meter reading 0.7 m/s
13	01/05/2008	10:37	HU 39503 40683	439503	1140683		Small stream 0.24m x 0.06m, flow 0.17 m/s. Burwick water sample 4 (freshwater)
14	01/05/2008	10:46	HU 39492 40591	439492	1140591		Small stream - not enough flow to measure or take sample
15	01/05/2008	10:48	HU 39506 40548	439506	1140548		Small stream - not enough flow to measure or take sample. Est. 100 sheep on shoreline opposite
16	01/05/2008	10:51	HU 39505 40517	439505	1140517		Small stream - not enough flow to measure or take sample
17	01/05/2008	10:52	HU 39442 40338	439503	1140480		Stream. Burwick water sample 5 (freshwater)
18	01/05/2008	10:58	HU 39442 40338	439442	1140338		5 sheep on hill

No.	Date	Time	NGR	East	North	Associated photograph	Description
19	01/05/2008	10:58	HU 39441 40330	439441	1140330		Stream, second small bay - more rubbish
20	01/05/2008	11:07	HU 39321 40100	439321	1140100		4 sheep on hill
21	01/05/2008	11:08	HU 39320 40096	439320	1140096		Small stream
22	01/05/2008	11:09	HU 39304 40082	439304	1140082		Small stream
23	01/05/2008	11:11	HU 39202 39999	439202	1139999		Small stream, BurwIck water sample 6. Note the soil all along the shoreline is completely waterlogged, many field drains
24	01/05/2008	11:25	HU 39002 39612	439002	1139612		Small stream flowing into shingle beach 45mm x 27cm, flow meter reading 0.118 m/s. Burwick water sample 7
25	01/05/2008	11:40	HU 38794 39249	438794	1139249		Inspection cover
26	01/05/2008	11:41	HU 38775 39252	438775	1139252		Outfall inspection hatch
27	01/05/2008	11:45	HU 38761 39260	438761	1139260	Figure 12	Water sample 8. Outfall pipe above ground here
28	01/05/2008	11:56	HU 39129 38874	439129	1138874	Figure 11	Brand new septic tank - smells
29	01/05/2008	12:00	HU 39250 38874	439250	1138874		14 sheep on hill
30	01/05/2008	13:19	HU 39604 38818	439604	1138818		Scalloway harbour, Burwick water sample 9 (seawater)
31	01/05/2008	16:59	HU 39362 38182	439362	1138182		Burwick water sample 10 (seawater). 8 ponies and 2 sheep

Photos referenced in the table can be found attached as Figures 5-14.

Recorded observations apply to the date of survey only. Animal numbers were recorded on the day from the observer's point of view. This does not necessarily equate to total numbers present as natural features may obscure individuals and small groups of animals from view.

Dimensions and flows of watercourses are estimated at the most convenient point of access and not necessarily at the point at which the watercourses enter the voe or loch.

Table 2. Water Sample Results

No.	Date	Sample	Grid Ref	Type	E. coli (cfu/ 100ml)
1	30/04/08	Shalders Ayre 1	HU 38698 39279	seawater	1.1 x 10^{+3}
2	30/04/08	Shalders Ayre 2	HU 38638 39651	seawater	2
3	30/04/08	Shalders Ayre 3	HU 38617 39689	seawater	<1
4	30/04/08	Whaleback Skerry 1	HU 38061 38838	seawater	<1
5	30/04/08	Whaleback Skerry 2	HU 38054 38687	seawater	<1
6	01/05/08	Burwick 3	HU 39484 40768	freshwater	170
7	01/05/08	Burwick 4	HU 39503 40683	freshwater	<1
8	01/05/08	Burwick 5	HU 39503 40480	freshwater	<1
9	01/05/08	Burwick 6	HU 39202 39999	freshwater	<1
10	01/05/08	Burwick 7	HU 39002 39612	freshwater	<1
11	01/05/08	Burwick 8	HU 38761 39260	seawater	<1
12	01/05/08	Burwick 9	HU 39604 38818	seawater	<1
13	01/05/08	Burwick 10	HU 39362 38182	seawater	<1

Table 3. Shellfish Sample Results

No.	Date	Sample	Grid Ref	Type	*E. coli* (cfu/ 100g)	Depth (m)
1	04/30/08	Shalders Ayre 1	HU 38638 39651	mussel	490	all
2	04/30/08	Shalders Ayre 2	HU 38617 39689	mussel	130	all
3	04/30/08	Shalders Ayre 3	HU 38617 39689	mussel	170	5
4	04/30/08	Shalders Ayre 4	HU 38617 39689	mussel	230	10
5	04/30/08	Whaleback Skerry 1	HU 38061 38838	mussel	50	1m
6	04/30/08	Whaleback Skerry 2	HU 38061 38838	mussel	20	1m

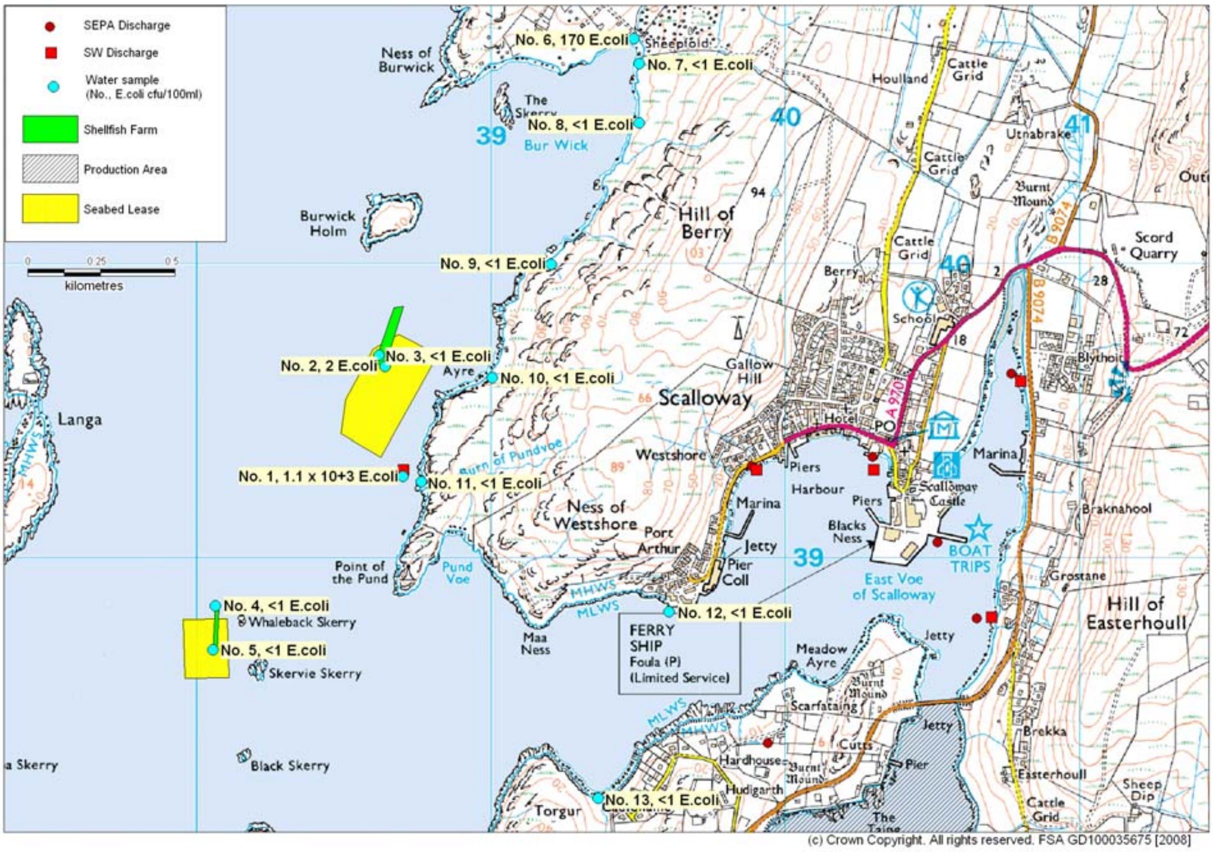

Figure 3. Water sample results map

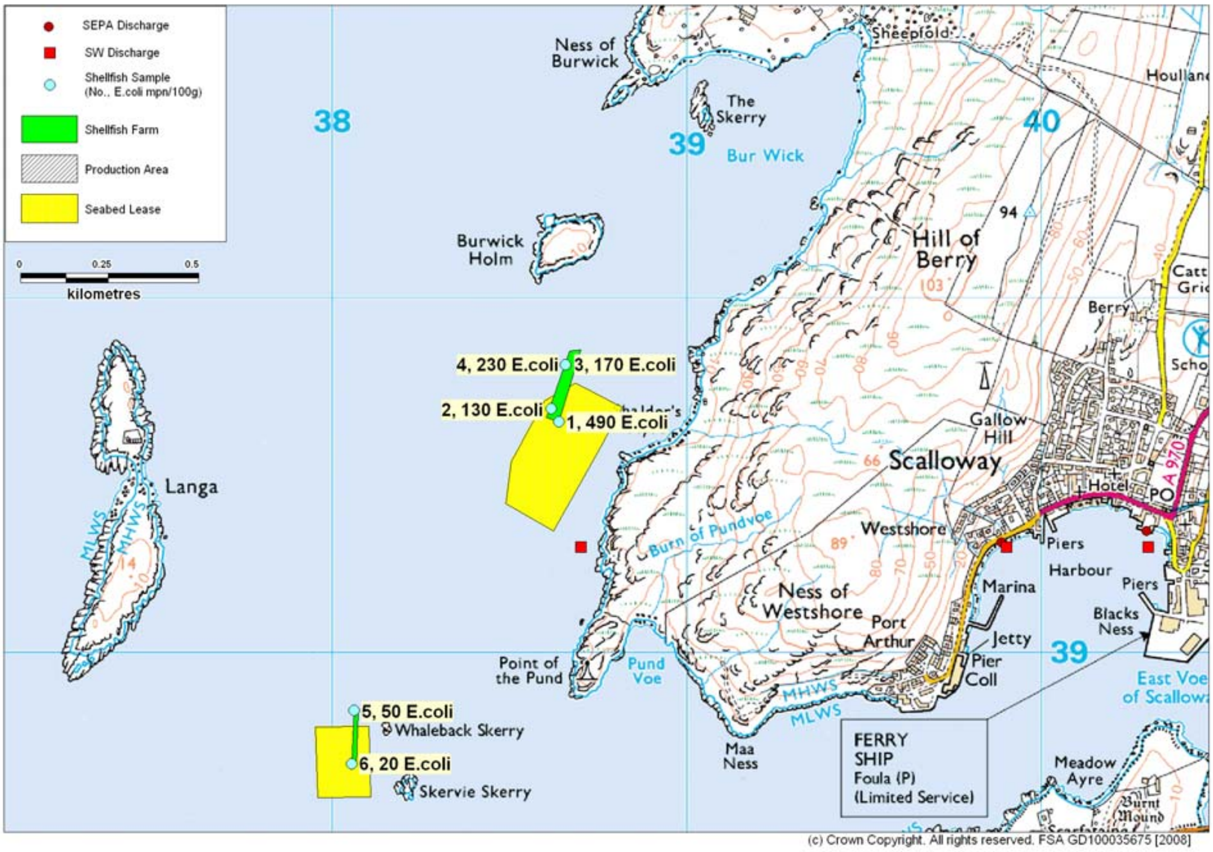

Figure 4. Shellfish sample results map

Photographs

Figure 5. Mussel lines at Shalders Ayre

Figure 6. Sampling at Shalders Ayre

Figure 7. Barge offshore of fishery

Figure 8. Bay at Burwick

Figure 9. Stream at Burwick

Figure 10. Looking northeast toward farm from south shore of bay at Burwick

Figure 11. Maa Ness new septic tank

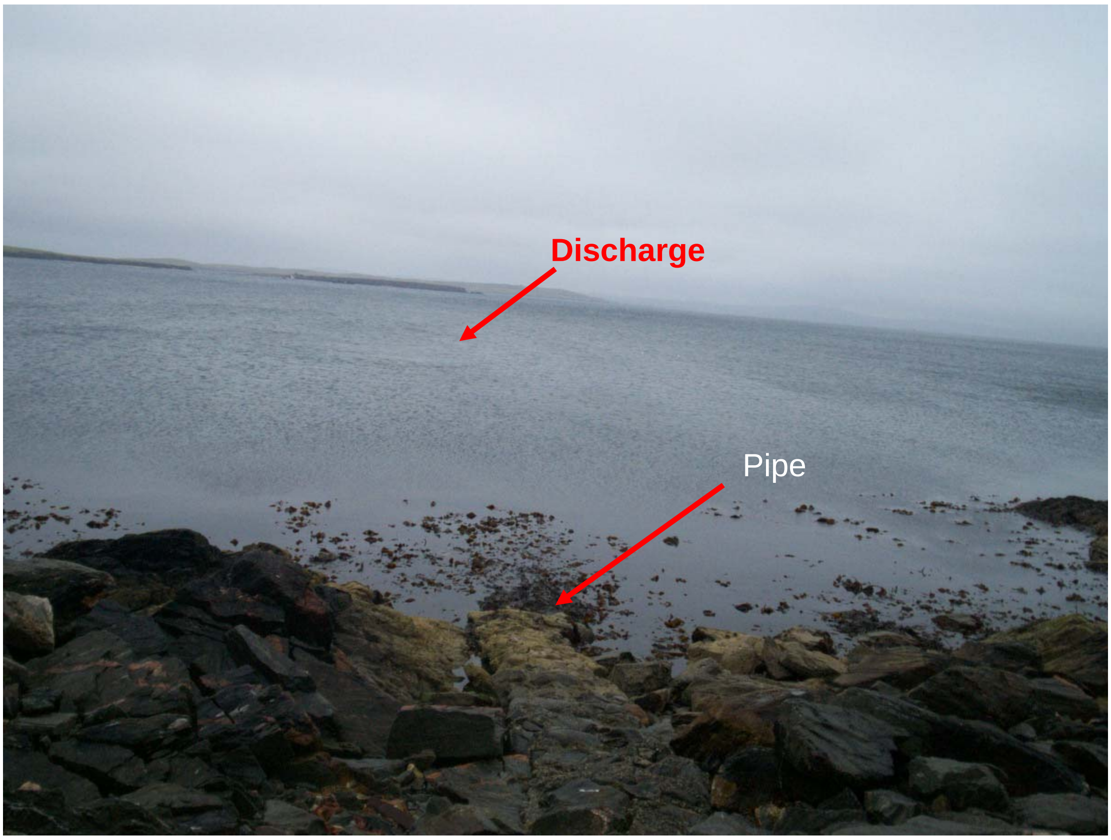

Figure 12. Discharge pipe at Maa Ness

Figure 13. Shalders Ayre viewed from shoreline

Figure 14. Mussel line at Whaleback Skerry