Sanitary Survey Report
and
Sampling Plan
for Sruwaddacon Bay

Produced by

AQUAFACT International Services Ltd

In conjunction with

The Sea Fisheries Protection Authority

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Statement of use

Under EU Regulation 2019/627 which lays down uniform practical arrangements for the performance of official controls on products of animal origin intended for human consumption, a sanitary survey relevant to bivalve mollusc production in Sruwaddacon Bay was undertaken in 2020. This will provide an appropriate hygiene classification zoning and monitoring plan based on the best available information with detailed supporting evidence. Aquafact undertook the desktop component of the work on behalf of the SFPA.

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Disclaimer:

Every effort is made in preparing the material and content of this sanitary survey for publication but no responsibility is accepted by or on behalf of the SFPA for any errors, omissions or misleading statements on these pages.

Revisions

Revision No.	Date	Comment
1	01/02/21	Interim report for SFPA review
2	27/04/21	Draft Final report for SFPA review
3	06/07/21	Draft Final report for SFPA review V2
4	25/08/21	SFPA amendments to Draft Final report V3
5	06/09/21	Draft Final report for SFPA review V4
6	16/09/21	Draft Final report for SFPA review V5

Document and QA Approval

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Glossary

ANOVA	Analysis Of Variance
BMCPA	Bivalve Mollusc Classified Production Area
CSO	Central Statistics Office
CSO	Combined Sewer Overflow
ED	Electoral Divisions
Depuration	The process of purification or removal of impurities
E. coli	*Escherichia coli*
Geometric Mean	The nth root of the product of n numbers (The average of the logarithmic values of a data set, converted back to a base 10 number).
GIS	Geographical Information Systems
GPS	Global Positioning System
I-WeBS	Irish Wetland Bird Survey
MPN	Most Probable Number
p.e.	Population Equivalent
PSU	Practical Salinity Units
RMP	Representative Monitoring Point
SAC	Special Area of Conservation
SFPA	Sea Fisheries Protection Authority
SPA	Special Protection Area
WTP	Water Treatment Plant
WWTW	Waste Water Treatment Works

1. Introduction

Consumption of raw or lightly cooked bivalve molluscs can results in illness due to the presence of micro-organisms, many of which are derived from faecal contamination of the marine environment. Shellfish contaminated with pathogenic microorganisms may cause infectious disease in humans and such outbreaks are more likely to occur close to our coasts where production areas are impacted by sources of human and animal faecal contamination.

The risk of contamination of bivalve molluscs with pathogenic microorganisms is assessed through microbiological monitoring programmes. This assessment results in the classification of bivalve mollusc production areas, which in turn governs the level of treatment required before human consumption of the shellfish.

Under EU regulations sanitary surveys of bivalve mollusc production areas and their associated hydrological catchments and coastal waters are required in order to establish the appropriate representative monitoring points for these monitoring programmes.

Specifically under regulation (EU) 2017/625 and its subsequent implementing regulation (EU) 2019/627, there is a requirement to carry out a sanitary survey before classifying any shellfish production or relaying area. Article 56 of Implementing Regulation 627 of 219 states:

1. Before classifying a production or relaying area, the competent authorities shall carry out a sanitary survey that includes:

- An inventory of the sources of pollution of human or animal origin likely to be a source of contamination for the production area;
- An examination of the quantities of organic pollutants released during the different periods of the year, according to the seasonal variations of human and animal populations in the catchment area, rainfall readings, waste-water treatment, *etc*.;
- Determination of the characteristics of the circulation of pollutants by virtue of current patterns, bathymetry and the tidal cycle in the production area.

2. The competent authorities shall carry out a sanitary survey fulfilling the requirements set out in paragraph 1 in all classified production and relaying areas, unless carried out previously.

3. The competent authorities may be assisted by other official bodies or food business operators under conditions established by the competent authorities in relation to the performance of this survey.

In addition Article 57 of the same regulation requires competent authorities to establish a monitoring programme for live bivalve mollusc production areas that is based on an examination of the sanitary survey described above.

Currently, the Sea Fisheries Protection Authority in conjunction with AQUAFACT International services Ltd are conducting sanitary surveys for new bivalve mollusc production areas and for those existing classified production areas which were previously not surveyed.

This report contains the documents relevant to the sanitary survey of the bivalve mollusc production area at Sruwaddacon Bay, County Mayo. It identifies the representative monitoring point and supporting sampling plan for pacific oysters in Sruwaddacon Bay. It also sets out the production area boundaries in the Bay.

2. Overview of the Fishery/Production Area

2.1. Description of the Area

Sruwaddacon Bay BMCPA is located along the western coast of Ireland (See Figure 2.1). Sruwaddacon Bay is a 2.9km^2 narrow bay made up mostly of sandflats with a deeper channel running the length of the bay. Depths in the channel range from 0 to 5m at low water, with most of the channel less than 2m deep. The area is approximately 5km long and approximately 0.76km at its widest point. Sruwaddacon Bay drains a catchment of 177.5km^2, the catchment is dominated by two rivers which drain three quarters of the catchment the Glenamoy River and the Muingnabo River. The catchment on the southern side of the bay is drained by a series of small streams.

Figure 2.1: Location of Sruwaddacon Bay

Sruwaddacon Bay is designated as part of a Special Area of Conservation (SAC) which is the Glenamoy Bog Complex SAC (See Figure 2.2). The site is designated for the presence of a number of important habitats and species (NPWS, 2013a). Blacksod Bay/Broad Haven Bay SPA is located within the catchment of Sruwaddacon Bay. There are a number of other SPAs nearby including Carrowmore Lake SPA, Stags of Broad Haven SPA and Illanmaster SPA. All SPAs in the area can be seen in Figure 2.2.

Blacksod Bay/Broad Haven Bay SPA is situated in the extreme north-west of Co. Mayo and is comprised of a number of bays and inlets including Sruwaddacon Bay, Moyrahan Bay, Traw-Kirtaun, Blind Harbour, Tullaghan Bay and the various sheltered bays and inlets in Blacksod Bay, including Trawmore Bay, Feorinyeeo Bay, Saleen Harbour, Elly Bay and Elly Harbour.

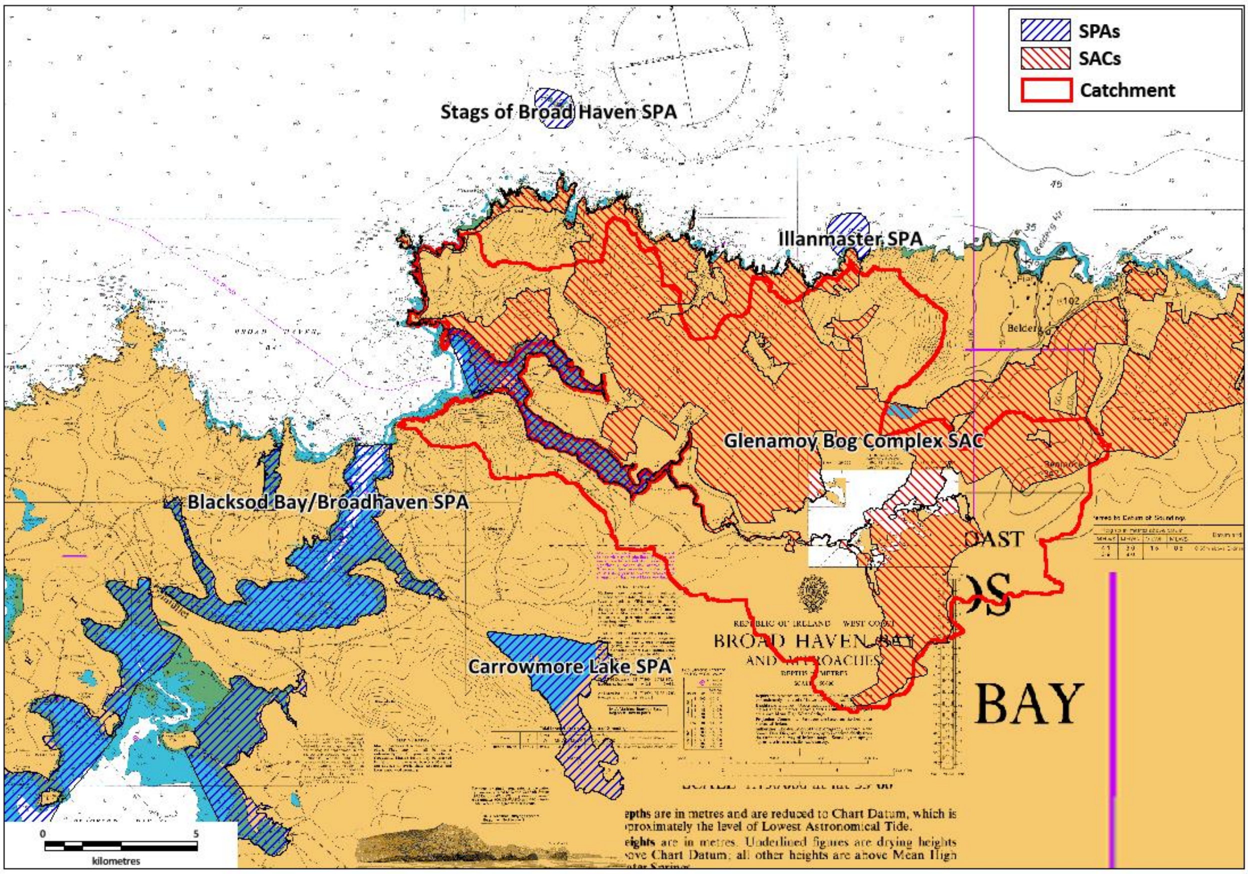

Figure 2.2: Location of Natura 2000 sites in the vicinity of Sruwaddacon Bay.

The Sruwaddacon Bay supports a diversity of fish species. Species present include flounder, four species of goby, plaice, eel, long spined sea scorpion, 5-bearded rockling, 15-spined stickleback, Pollack and sand smelt (IFI, 2008).

Land cover within the Sruwaddacon Bay catchment is a mixture of peat bogs, coniferous forests, pastures, transitional woodland/shrub, and agricultural land with significant areas of natural vegetation, beaches, dunes, sands and sparsely vegetated areas. The human population in the area is quite low and settlement patterns tend to be well dispersed with no large towns.

2.2. Sruwaddacon Shellfish Fisheries

2.2.1. Location/Extent of Growing/Harvesting Area

Sruwaddacon Bay covers an area of approximately 2.9km^2 and is currently not a designated shellfish water or a Classified Bivalve Mollusc Production Area.

Figure 2.3 shows the current locations of licensed aquaculture sites within Sruwaddacon Bay. There are two areas licensed for pacific oysters with a total area of 0.042km^2. No other bivalve mollusc species are currently commercially harvested within the proposed Sruwaddacon Bay classified area.

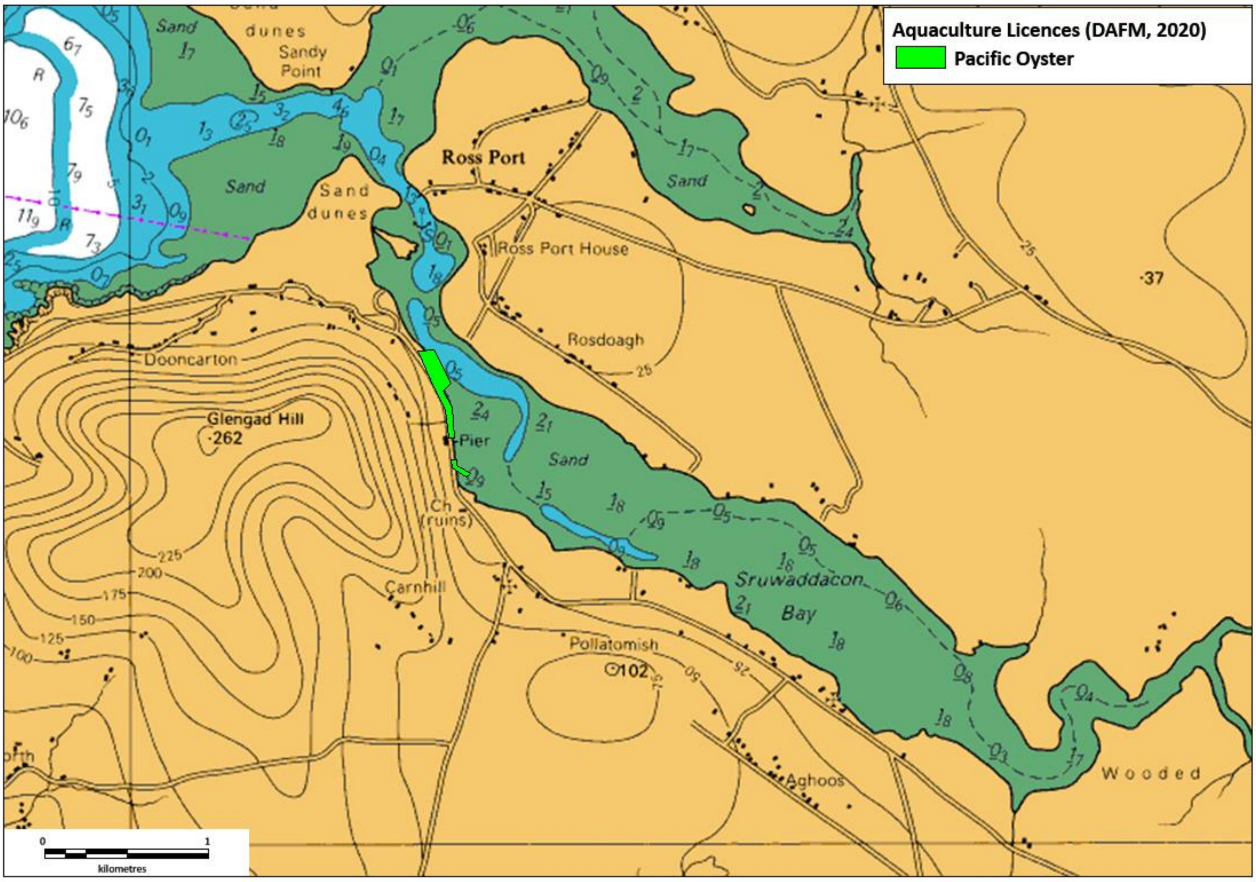

Figure 2.3: Licensed aquaculture sites within Sruwaddacon Bay (Source: DAFM, 2020).

2.2.2. Description of Bivalve Species

*2.2.2.1. Pacific Oysters (*Crassostrea gigas*)*

General Biology

Pacific oysters are not native to Irish waters as they were introduced from the Pacific coasts of Asia. They can be found in intertidal and subtidal zones. They prefer to attach to hard or rocky surfaces in shallow or sheltered waters but have been known to attach to muddy or sandy areas when the preferred habitat is scarce. They can also be found on the shells of other animals. Larvae often settle on the shells of adults, and great masses of oysters can grow together to form oyster reefs.

Pacific oysters need a temperature of above 18°C to reproduce (PMFSC [Pacific States Marine Fisheries Commission], 1996). The larvae are planktonic and spend several weeks in this phase. Then after that time, once an acceptable location has been found the oyster drops out of the plankton and attaches itself to its chosen surface, at which point it is known as 'spat'. It spends the first year of its attached life as a male, before eventually becoming female. Un-harvested oysters can live up to 30 years.

Distribution

Figure 2.4 shows the location of the licensed intertidal farmed Pacific oyster sites in Sruwaddacon Bay. The site covers an area of 0.042km^2.

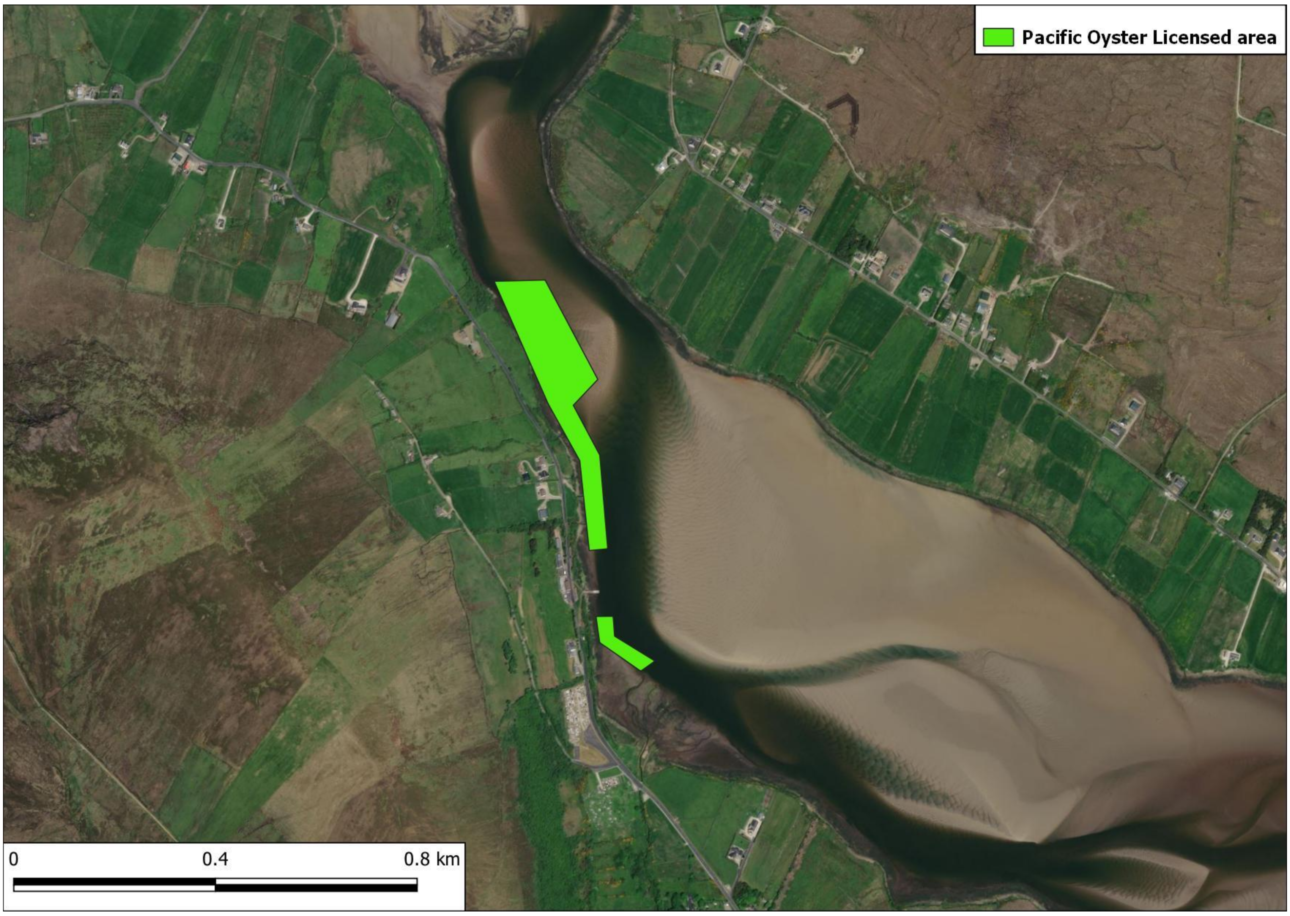

Figure 2.4: Licensed Pacific oyster harvesting sites in Sruwaddacon Bay (Source: DAFM, 2020).

Fishery

There is currently no active commercial pacific oyster production in Sruwaddacon Bay. In the past the bay had been classified and some on-growing took place but this classification has since lapsed again due to a lack of commercial activity. There are two areas licensed for pacific oysters, both along the shore under Glengad Hill. It is the intention of the licensee who occupies both sites to begin active production in the near future.

The oysters will be grown in the normal method using bags and trestles with seed oysters brought in for on-growing to commercial size. It would be expected that harvesting would take place year round when the farm is fully active.

3. Overall Assessment of Pollution Sources likely to be a Source of Contamination on Shellfish

3.1. Human population

Sruwaddacon Bay catchment has a population of 837 with no towns or large urban areas. The population of the Sruwaddacon catchment is well below the average density for rural Ireland with only 4.7 people per km^2 as opposed to 27 people per km^2 nationally in rural areas (CSO, 2016). The 2016 census recorded 468 households in the catchment of which 16% are vacant and 9% are holiday homes.

3.2. Boating

Only three piers/slipways were noted during the desktop and shoreline surveys and only one boat was observed. It is anticipated that due to the small size, lack of overnight staying vessels and the small numbers that impacts will be virtually nil.

3.3. Sewage Discharges

The sewage from almost all of the households (94.5%) is treated by means of their own septic tanks or other individual treatment systems. Although there is a high percentage of households on private treatment systems the overall numbers are low and the settlement pattern is well dispersed throughout the catchment with no large towns evident. Without firm data on the locations of these septic tanks it is difficult to use this data in the selection of the specific RMP location.

There are no WWTP's in the catchment and the housing density is very low. Only one industrial facility is present and the only discharge is for run-off from the facility, this is not expected to have any impact on faecal contamination levels due to its distance from the production area and its lack of faecal content.

The shoreline survey revealed very few human inputs aside from a concrete pipe at the pier at Rossport (Table 6.8, map ID 24) and a small bore pipe at Kilcommon (map ID 53). The latter was not flowing at the time of the survey and its origin was unclear.

3.4. Agriculture Sources

Agricultural land (pastures 10.6% and land principally occupied by agriculture, with significant areas of natural vegetation 2.2%) accounts for only 12.8% of the Sruwaddacon Bay catchment. It is notable though that much of the pasture land and better grazing areas are located in proximity to the actual production area shores and along the valley of the Glenamoy River which is the largest freshwater input entering Sruwaddacon Bay. This was confirmed during the shoreline survey.

There are 2,137 cattle in the catchment with the highest number of cattle occurring in Knocknalower (749). The density of cattle in the catchment is low at 0.25 cows/ha of farmland, which is less than a fifth of the average national stocking density for cattle of 1.45 cows/ha of farmland. There are 27,331 sheep in the catchment with the highest number of sheep occurring in Knocknalower (7,654). The stocking density for sheep in the catchment (3.14 sheep/ha of farmland) is three times that of the national average of 1.04 sheep/ha (Agri-census data – Section 5.15).

Due to the numbers of animals quoted above it is expected that sheep are one of the principal contaminant sources in the production area particularly after periods of elevated rainfall when surface water runoff may bring faecal contamination into the bay. Numerous sheep were noted during the shoreline survey and at times actually upon the foreshore.

In the area around Pollathomas, where the existing licences are located, any diffuse agricultural run-off may be exacerbated further by the steeper incline of the surrounding land. As detailed above Knocknalower ED, within which Pollathomas lays, has a significantly higher density of sheep and cattle than the rest of the catchment.

Water sampling during the shoreline survey showed some evidence of faecal contamination, albeit mostly at low levels, in all of the samples including those taken from the main ebbing saltwater channel. It is expected that diffuse agricultural inputs may be responsible for this faecal contamination.

3.5. Rivers and Streams

Sruwaddacon Bay drains a catchment of 177.5km^2, the catchment is dominated by two rivers which drain 75.9% of the catchment the Glenamoy River and the Muingnabo River. The catchment on the southern side of the bay is drained by a series of small streams. Curraunboy Bay is the smaller bay just north of

Sruwaddacon Bay. As the mouths of these bays join before entering Broad Haven Bay the catchment of Curraunboy Bay was assessed as part of Sruwaddacon catchment. The Gweedaney River is the principal river flowing into Curraunboy Bay and accounts for 10.8% of the entire Sruwaddacon Catchment for the purposes of this study. The remainder of Curraunboy is drained by small streams.

The current (2010-2015) WFD status of the Glenamoy River is of Good status, although the higher reaches of the river are of High status. The Muingnabo River is of good status also. While the Gweedaney River is of moderate status. All other streams flowing into Sruwaddacon have not been assigned a status. The bay itself is characterised as high status.

The two main rivers enter Sruwaddacon at the head of the estuary at Gortacragher, some distance from the oyster growing area. It is expected that these two rivers will bring diffuse agricultural contamination into the production area and due to there size and the percentage of the catchment they drain will likely be the main drivers of contamination levels within the production area. Flow data was available from the Glenamoy River and was typical of a spate river with periods of very high flows before falling back rapidly to quite low flows. It is during these spate flows that the influence of these rivers on contaminants entering the production area is likely to be highest.

It is also worth noting that salinity levels vary quite significantly within the production area even at the seaward mouth of the bay which indicate the strong freshwater influence of the spate rivers, streams and field drains. It thus expected that freshwater influence will impact upon the two oyster licences with more concentrated impacts during the latter parts of the ebb tide as the flow is concentrated into the main channel.

It was noted though during the shoreline survey that two streams drain into the production area close to the licensed sites and these may have the potential for more localised impacts. Both when sampled showed evidence of faecal contamination with the stream down tide of the pier, which discharges immediately adjacent the licenced area, recording a relatively high *E. coli* result (Section 7.2, Station 5).

Quite a large number of field drains, 44 in total, were also identified during the shoreline survey and collectively these have the potential, particularly after heavy rain to add to faecal contamination levels entering the production area. Concentrations of these field drains were noted at Polathomas, Kilcommon and Rossport South.

3.6. Movement of Contaminants

Sruwaddacon Bay is a narrow bay made up mostly of sandflats with a deeper channel running the length of the bay. The bay is completely intertidal apart from this channel. Depths in the channel range from 0 to 5m at low water, with most of the channel less than 2m deep. The stage of the tide is the main factor influencing water movement in the bay.

Wilson (2007) found that the mean depth averaged velocity ranged from 0.56m/s at the mouth of the bay to 0.23m/s in the inner part of the bay. With maximum depth averaged velocities ranging from 1.22m/s to 0.60m/s. A model of the tidal flow showed that currents are highest in the channel particularly at the constricted mouth of the bay.

The water movement in the bay generally follows the channel and so any contaminants that enters the bay will typically follow this channel. It has been identified that one of the main sources of contamination in the catchment is from sheep farming. This faecal contamination through diffuse agricultural run off is washed into rivers, streams and drains during high levels of rainfall. As the Glenamoy River and the Muingnabo River drain 75.9% of the catchment the confluence of these two rivers is likely to be one of the main sources of contamination in the bay. As such contamination entering the bay at this point will follow the main channel on the ebbing tide and so flow directly past the licensed areas. Due to the inter-tidal nature of the production area such contamination will be concentrated into the main channel on the ebbing tide.

Also, the highest recorded *E. coli* result from the shoreline survey water sampling was taken from a stream discharging directly to the licensed areas. The Electoral Division that this stream is located in has almost double the sheep numbers as any other ED in the catchment. The steep slope of this area will mean that faecal contamination will be washed off the land easier than in flatter areas. The discharge from this stream will directly impact the shellfish of the licensed area due to its immediate proximity upstream and downstream of the oyster licenses. However, as this stream is small the discharge will be diluted into the bay relatively quickly reducing the level of impact on the licensed beds.

3.7. Wildlife

Sruwaddacon bay is part of the Blacksod Bay/Broad Haven Bay SPA and is in close proximity to Carrowmore Lake SPA, Stags of Broad Haven SPA and Illanmaster SPA. A large diversity of bird species are found in the areas including: Great Northern Diver, Light-bellied Brent Goose, Common Scoter, Red-breasted

Merganser, Ringed Plover, Sanderling, breeding Dunlin, Slavonian Grebes, Sandwich Tern, Storm Petrel and Leach's Petrel. Although no specific bird counts are available for Sruwaddacon Bay it can be assumed that a proportion of these birds visit the actual production area. The numbers of birds visiting the site are likely to increase in winter due to the arrival of over wintering water birds.

Both Common (Phoca vitulina) and Grey seals (Haliochoerus grypus) have been recorded within Sruwaddacon Bay. However, only individuals or small groups have been recorded and no haul-out sites are listed. Other aquatic mammals that may occur in Sruwaddacon Bay include Otter (Lutra lutra), Bottlenosed Dolphin (Tursiops truncatus) and Harbour Porpoise (Phocoena phocoena).

The bird and marine mammal populations that visit the site may contribute to the background bacteriological levels within the bay but their impacts will be largely diffuse and so will have little bearing on the actual locations of the RMP itself.

3.8. Seasonality

In 2017, 324,000 overseas tourists visited Co. Mayo, and 503,000 domestic tourists visited Co. Mayo. The main tourist attractions in the catchment area Ballyglass Lighthouse, Dooncarton Stone Circle, Carrowteige Loop, Portacloy-loop Cliff Walk and Belderrig Valley. As these tourist attractions do not appear in the top tourist attractions for mayo only a small proportion of these tourists are likely to visit the area. The number of holiday homes accounts for 9% of the permanent households in the catchment. For Ireland as a whole, in 2017 most tourists visited between July and September (31%), followed by April to June (27%), October to December (23%) and January to March (18%). There is no reason to expect this trend to be any different in the West region. As tourism numbers in the area are relatively low it is unlikely that there will be a seasonal impact on the shellfish area from tourism.

In terms of agriculture, numbers of sheep would be expected to be higher in Spring/Summer when lambs would be present but at this time of the year there will also be more extensive grazing in the hills and thus impacts would be more widely spread. As there is a high density of sheep in the catchment this may be significant.

In County Mayo the spreading of slurry or farmyard manure is limited by legislation with a closed period from the 1st of November to the 15th January. From mid-January to the end of October there would be a potential risk of faecal contamination through diffuse run-off from this activity, if it coincides with a period of rainfall then that risk is raised further. Much of the land though within the catchment is rough grazing and cow densities are comparatively low so this risk may be a lot less significant in the Sruwaddacon catchment compared to other parts of Mayo.

There may also be an increase in wading bird and wildfowl numbers during Autumn/winter due to migrating species. However, it is difficult to identify the level of impact due to low availability of data on numbers and behaviour of bird species in the area.

Analysis of rainfall data for the area has shown that August to March are the months with higher rainfall. During this period faecal contamination may enter the bay in run-off from the land. The highest loading from the land would be expected in August and September as faecal load will have been accumulating over the dryer period of April to July. Although significant rainfall events can occur earlier in the summer they are generally less persistent. Along with this the ground is less saturated and so a higher percentage of the rainfall will enter ground waters and be absorbed by vegetation.

3.9. Shoreline survey

Inventory of Pollution Sources

In total 68 features were identified, of which 15 rivers/streams were identified, 44 drains, 3 piers, 5 locations with sheep and 1 location with cattle. Sheep were recorded at a number of locations during the shoreline survey with approximately 40 recorded in Curraunboy Bay on the foreshore at two locations. A further 45+ sheep were recorded on the land surrounding Sruwaddacon Bay and over a 100 were recorded to the North West at the mouth of the bay. Cows were recorded in low numbers at two locations both on the eastern shore of Sruwaddacon Bay. Evidence of Enteromorpha algae and possible enrichment was noted at two rivers and two streams. One of these rivers/streams discharge close to the licensed shellfish areas.

Bacteriological Sampling Results

Water sampling was also carried out as part of the shoreline survey with ten water samples being taken. Six of these were freshwater and four were seawater. Only one of the ten sample showed very high *E. coli* levels. This sample was taken from a small stream which discharges just above the licensed shellfish areas. It was noted that sheep were grazing on the farmland upstream. However, two seawater samples taken either side of the stream recorded lower levels and so the impact from this small stream may be quickly diluted upon meeting the tide. Slightly elevated levels were also recorded in the Muingnabo River, Glenamoy River and just downstream of the confluence of the two rivers. Together these two rivers drain 75.9% of the bays catchment and so will be the main potential source of bacterial contamination due to run-off from the land.

The lack of man-made discharges or pipes was quite noticeable during the shoreline survey. As such the impact due to human activities is likely to be relatively low, similarly there are no WWTW or commercial facilities discharging to the bay. The Vermilion Exploration and Production Ireland Limited facility has a one discharge to the bay, however, this is for surface water run-off from the facility and so will not contain sewage.

4. Recommendation Amendments

It is recommended that the boundary for the new Bivalve Mollusc Production Area will include Sruwaddacon Bay and Curraunboy Bay (Figure 4.1, Table 4.1). The inner extent of the production area in both Sruwaddacon Bay and Curraunboy Bay has been limited due to the potential presence of contamination from the Glenmoy, Muingnabo and Gweedaney Rivers. The main source of bacteriological contamination is in run-off from land with high stocking densities of sheep. As such bacteriological load is likely to be highest closer to the mouths of these rivers. The excluded area is also likely to be suboptimal for shellfish production due to lower salinities and longer periods of exposure. The BMPA boundary can be seen in Figure 4.1.

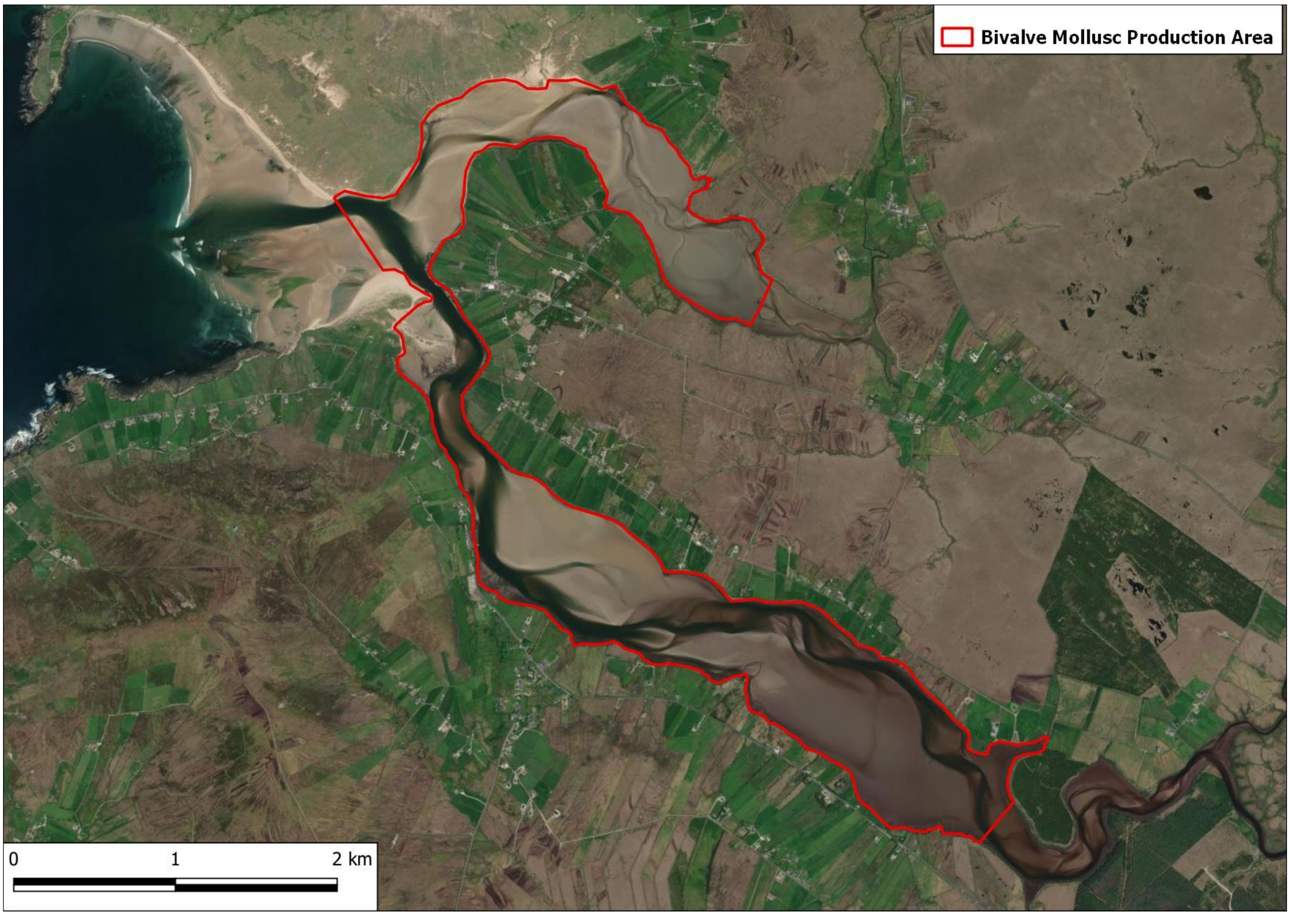

Figure 4.1: Sruwaddacon Bay new BMPA.

Table 4.1: Coordinates of the Production Area.

Corner	Longitude	Latitude	Easting	Northing
NW	-9.81749	54.29101	81700.0	339545.7
NW	-9.81284	54.28699	81991.7	339090.1
SW	-9.75622	54.25525	85590.2	335464.1
SW	-9.75297	54.25751	85808.2	335709.8
NE	-9.77802	54.28392	84250.1	338690.9
NE	-9.77592	54.28649	84394.4	338972.9

5. Representative Monitoring Points and Sampling Plan

5.1. *Pacific Oysters (Crassostrea gigas)*

It is recommended that the location of RMP 1 for Pacific oysters is situated on the south western shore of the bay in the larger of the two licensed areas. (Figure 5.1, Table 5.1).

This RMP will adequately capture any contamination emanating from the two principal rivers entering the production area, on the ebbing tide waters from these will flow over and across the oyster licences at this point. Similarly the cumulative waters from most of the other smaller streams and field drains upstream will be carried over the RMP on the same ebbing tide. The sampling point here is sited at the edge of the main channel also and should reflect any contamination emanating on that downstream flow.

The shoreline survey sampling revealed moderate levels of faecal contamination from a small stream coming off the hill adjacent to the RMP. The RMP, should also reflect the effect of any contamination from this stream.

Microbiological Sampling Plan

It is recommended that 12 – 18 individuals of market size (minimum shell length 7.5 cms) should be collected for microbiological monitoring of the bivalve mollusc production area. As harvesting can take place throughout the year, sampling needs to be on a monthly basis all year round.

Table 5.1: Coordinates of each RMP and its relevant species.

RMP	Site Code	Species	Longitude	Latitude	Easting	Northing
RMP 1	MO-BN-SB	Pacific Oysters	-9.80404	54.27298	82,541	337,506

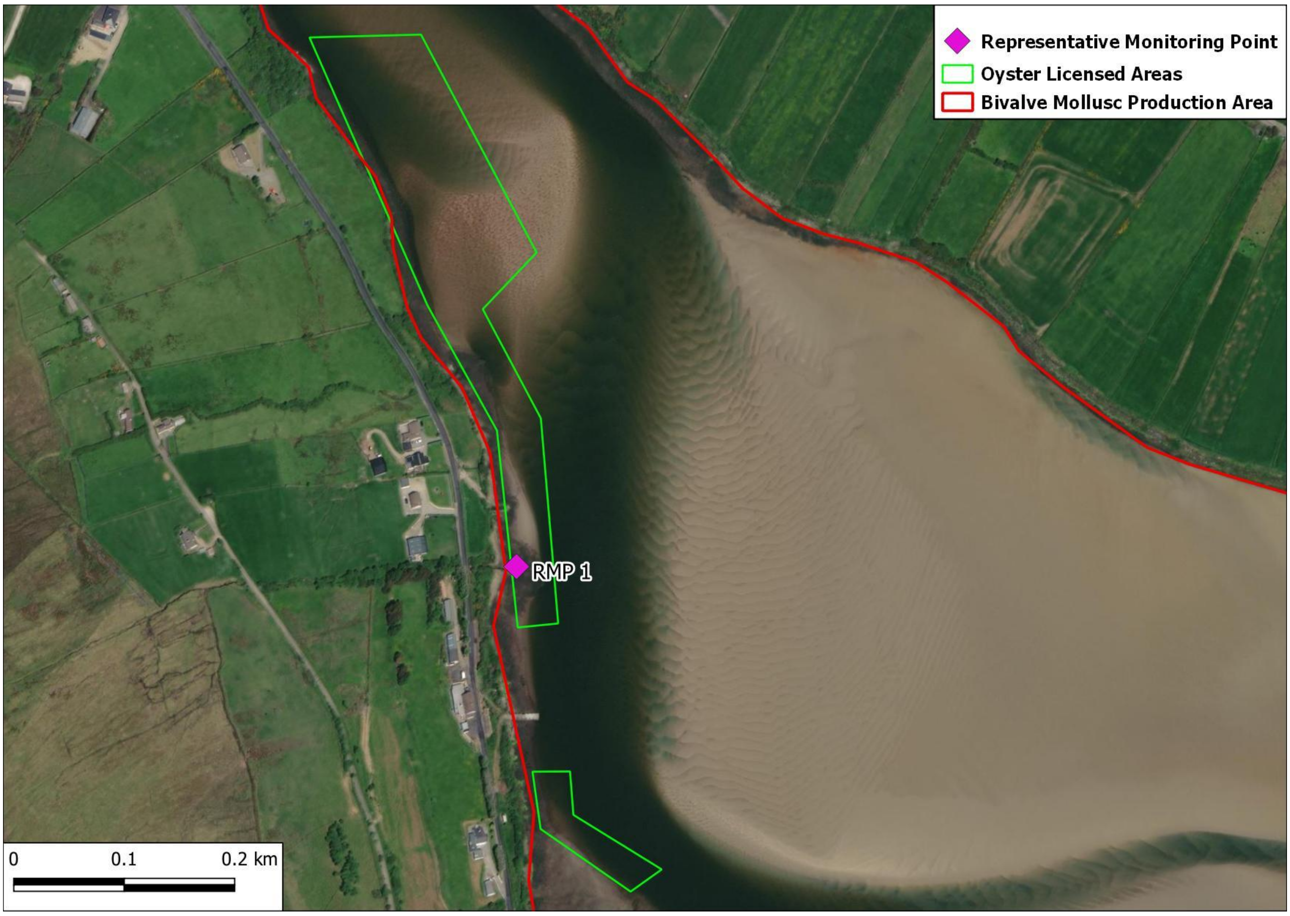

Figure 5.1: Bivalve Mollusc Classified Production Area with RMP for Sruwaddacon Bay.

5.2. *Species Specific RMP maps.*

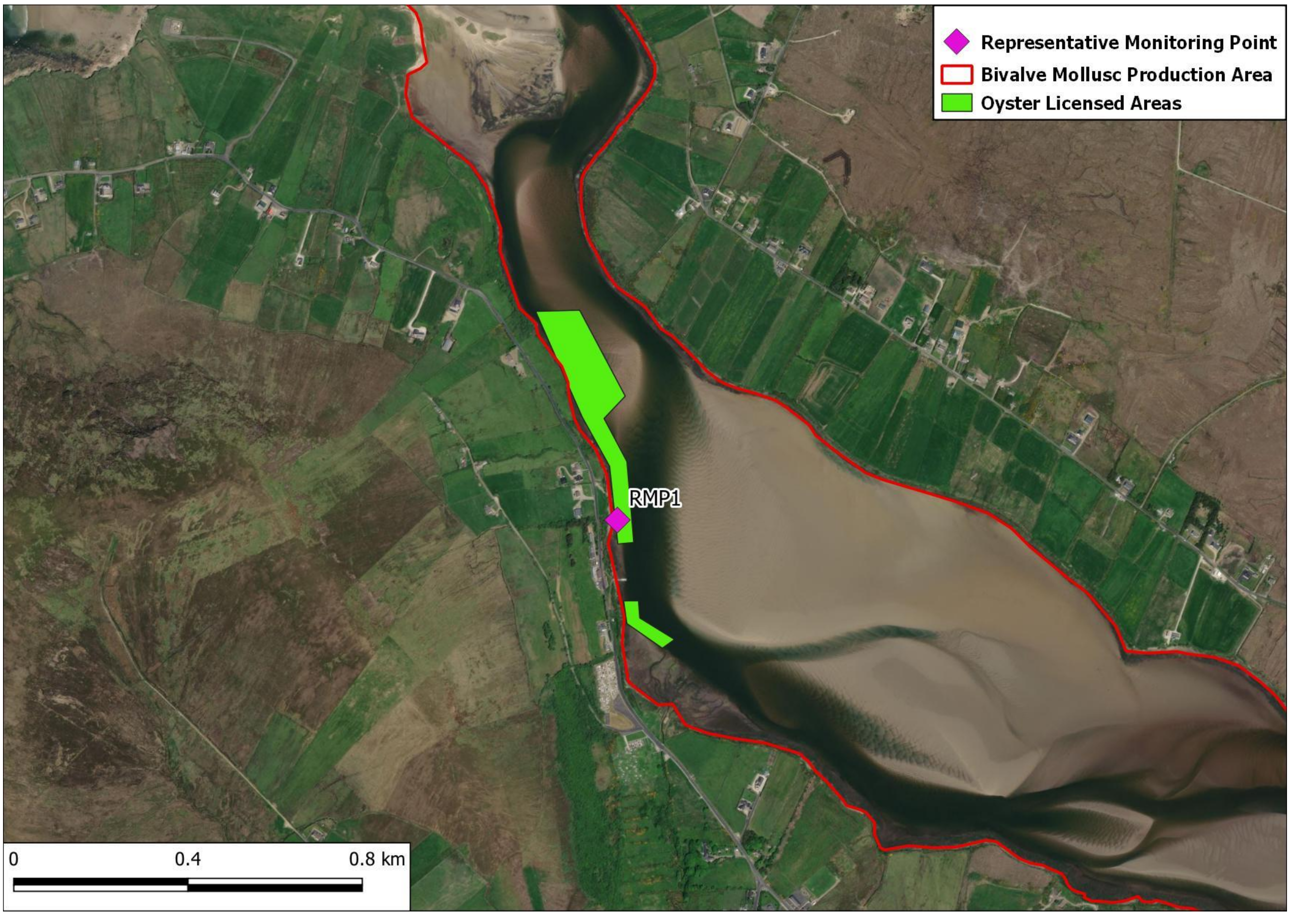

Figure 5.2: Location of the pacific oyster RMP within Sruwaddacon Bay.

5.3. General Sampling Method

All collection and transport of shellfish samples for *E.coli* testing under the Sampling Plan identified as part of the Sruwaddacon Bay Sanitary Survey should follow the Sea Fisheries Protection Authority's own Code of Practice for the Microbiological Monitoring of Bivalve Mollusc Production Areas (SFPA, 2020). The guidance notes are found at Appendix 9.2 of that document.

6. Appendix 1: Identification of Pollution Sources

This section documents all pollution sources identified during the desktop and shoreline survey within the Sruwaddacon Bay catchment area.

6.1. Desktop Survey

Pollution sources were considered within the catchment area of Sruwaddacon Bay (see Figure 6.1). The catchment area covers an area of 177.5km^2, approximately 24km east west at its widest point and 16km north south at its longest point.

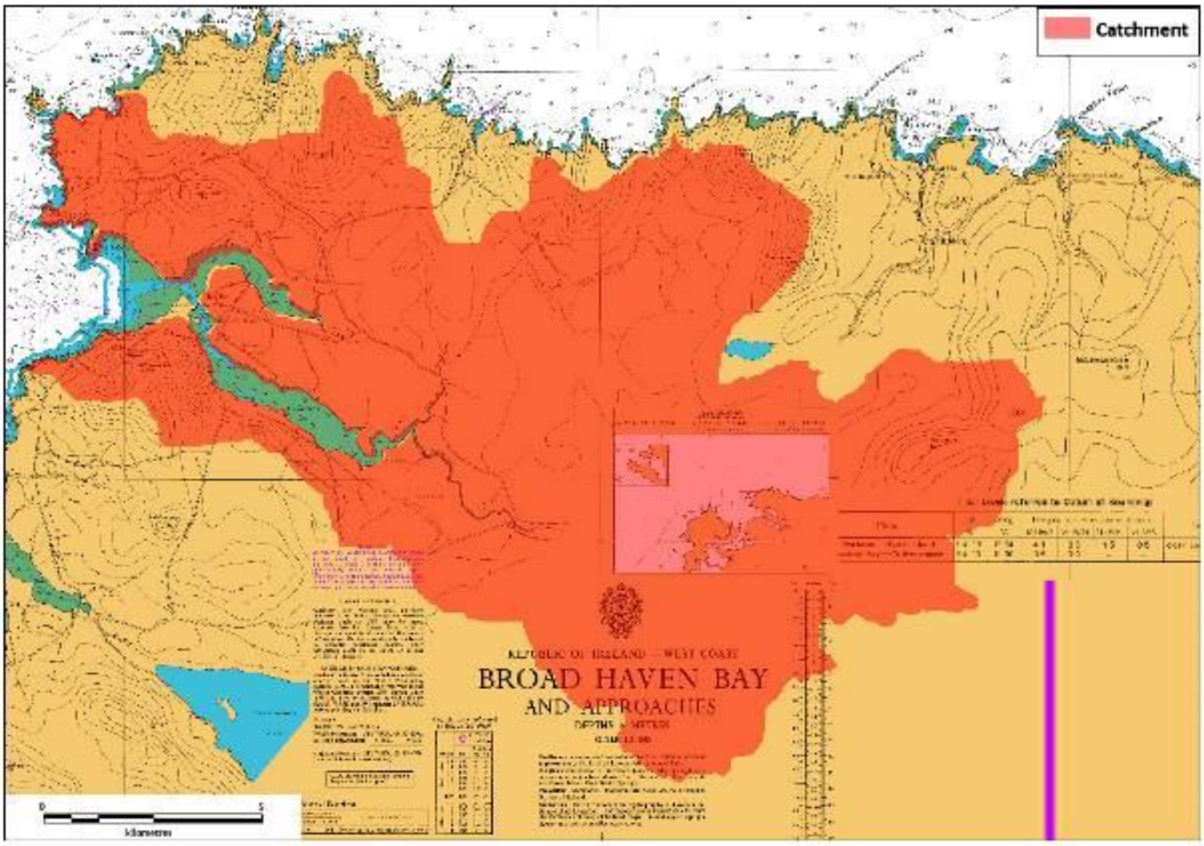

Figure 6.1: Sruwaddacon Bay catchment area used for assessment of the pollution sources.

6.1.1. Human Population

Population census data used by the Central Statistics Office (CSO) is given in units of Electoral Divisions (ED). Figure 6.2 shows the EDs within the catchment area. The population data were obtained through the Central Statistics Office (CSO) online Small Area Population Statistics (SAPS) (CSO, 2019a) for the year 2016. Figure 6.3 shows the human population within Sruwaddacon Bay catchment area and

Table 6.1 shows these data in tabular form.

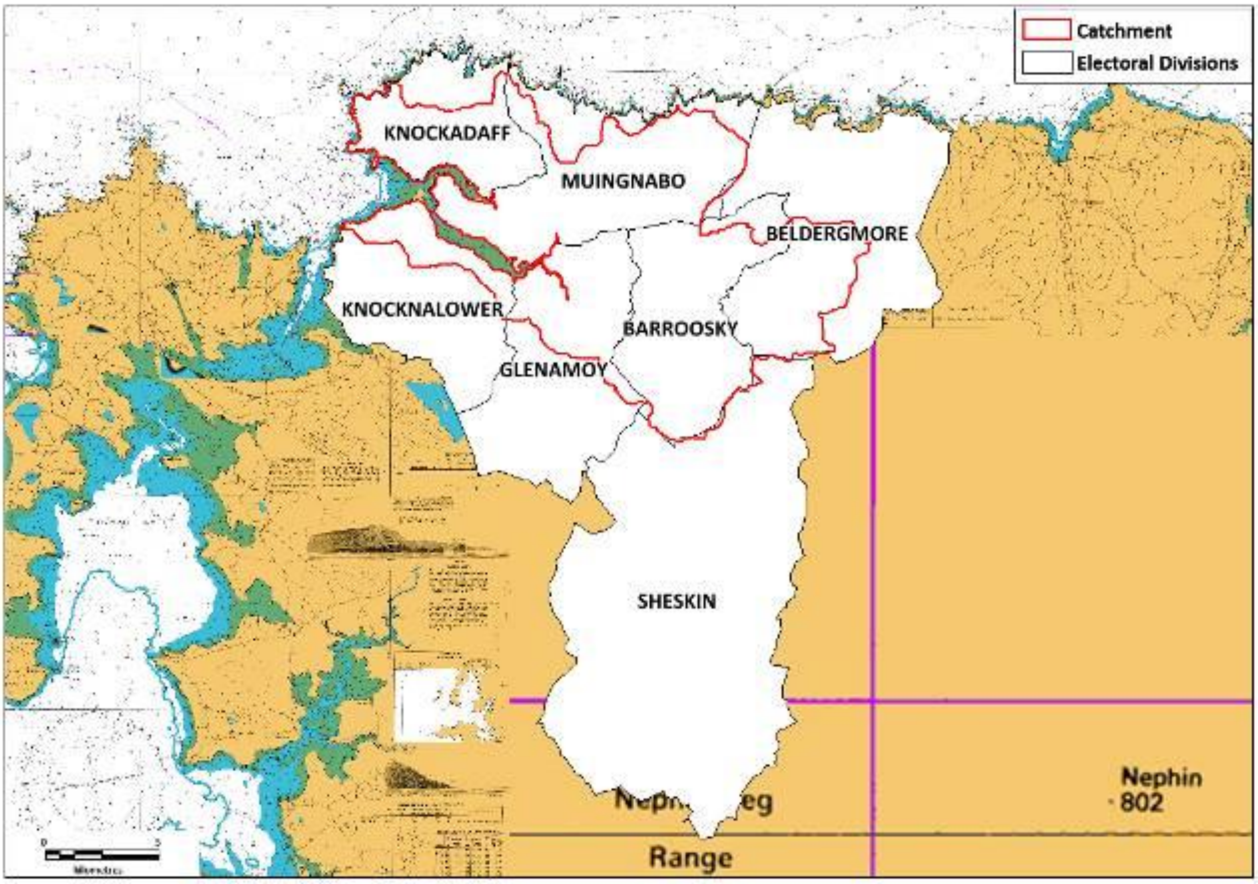

Figure 6.2: Electoral Divisions within the Sruwaddacon Bay Catchment Area.

The Sruwaddacon Bay Catchment Area overlaps 7 EDs (All partially). The EDs that are partially within the catchment are Barroosky, Beldergmore, Glenamoy, Knockadaff, Knocknalower, Muingnabo and Sheskin. Knocknalower contains the largest population (757) followed by Knockadaff (337) and Muingnabo (241).

These 7 EDs accommodate a total population of 1,898. As all of these EDs only partially overlap the catchment area, an attempt was made to estimate the actual population within the catchment. The percentage of the ED lying within the catchment was calculated in GIS and from this value the population size was calculated *e.g*. if 50% of ED lies within catchment area then 50% of the total population was taken to be the population size of the area within the catchment. Using this method, the population of the catchment areas is estimated at 837 people.

Table 6.1 shows this estimation.

There are no towns/urban centres within the catchment area.

There are 1,039 households within the 7 EDs within the catchment area. Of this, 17% are vacant (173) and a further 9% are holiday homes (90). Of the 468 houses actually within the catchment (based on the % of the ED within the catchment), 16% are vacant and 9% are holiday homes. Table 6.2 shows the number of households in each ED and the proportion actually within the catchment area.

Human population in given areas is obtainable from census data; however, relating this information to the level of microbial contamination in coastal waters is difficult and is constrained by the geographic boundaries used. Nonetheless, it is clear that areas with a higher population will have higher levels of sewage and wastewater entering the Sruwaddacon Bay system. Therefore, the highest levels of sewage and waste would be expected to enter from the Knocknalower ED, although the population even there is low. As holiday homes only account for 9% of the dwellings in the catchment they are unlikely to cause a significant increase in the sewage and waste water levels relative to the permanent population.

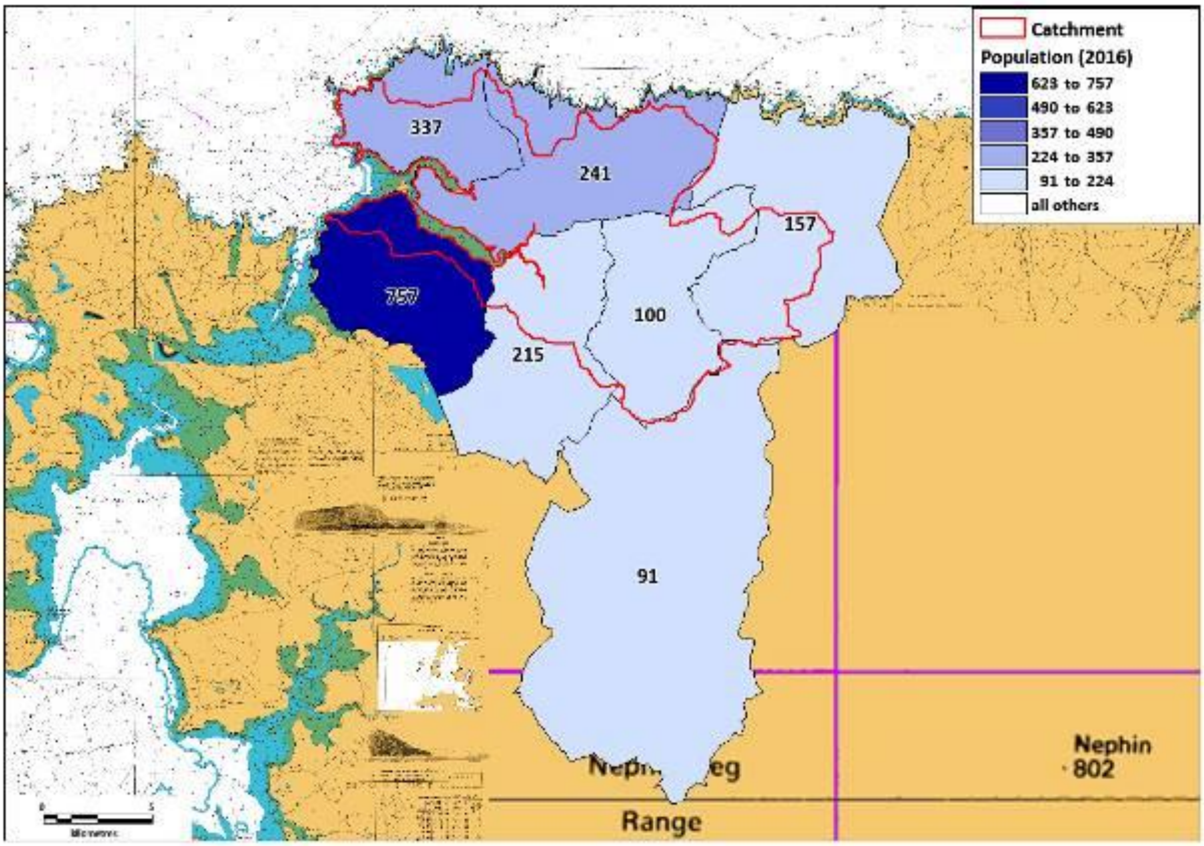

Figure 6.3: Human population within the Sruwaddacon Bay Catchment Area (Source: CSO, 2019a).

Table 6.1: Human population within the Sruwaddacon Bay Catchment Area (Source: CSO, 2019a).

Electoral Division	Population (2016)	% ED in Catchment	Estimated Population
Barroosky	100	90.3	90
Beldergmore	157	30.5	48
Glenamoy	215	40.9	88
Knockadaff	337	73.5	248
Knocknalower	757	22.5	171
Muingnabo	241	79.7	192
Sheskin	91	0.4	0

Table 6.2: Households within the EDs in the Sruwaddacon Bay Catchment Areas (Source: CSO, 2019a).

Electoral Division	Total Households	No. Occupied*	Unoccupied holiday homes	Vacant houses	Total Households in Catchment	No. Occupied in Catchment	Unoccupied holiday homes in Catchment	Vacant houses in Catchment
Barroosky	66	43	11	12	60	39	10	11
Beldergmore	95	65	7	23	29	20	2	7
Glenamoy	107	83	10	14	44	34	4	6
Knockadaff	172	134	11	27	126	99	8	20
Knocknalower	394	296	37	61	89	67	8	14
Muingnabo	151	115	13	23	120	92	10	18
Sheskin	54	40	1	13	0	0	0	0

* This figure includes those houses temporarily unoccupied on census night.

6.1.2. Tourism

In 2017, 3.6 million tourists visited the west Region of Ireland (Failte Ireland, 2018a). This figure was made up of 1,900,000 overseas tourists, 1,600,000 domestic tourists and 109,000 Northern Irish tourists. Of the overseas tourists, 324,000 visited Co. Mayo, and of the domestic tourists 503,000 visited Co. Mayo (Failte Ireland, 2018b). The main tourist attractions in the area are Ballyglass Lighthouse, Dooncarton Stone Circle, Carrowteige Loop, Portacloy-loop Cliff Walk and Belderrig Valley.

The attractions located inside the catchment area include Carrowteige Loop and Portacloy-loop Cliff Walk. For Ireland as a whole, in 2017 most tourists visited between July and September (31%), followed by April to June (27%), October to December (23%) and January to March (18%). There is no reason to expect this trend to be any different in the West region.

At the time of writing there was no available information on aqua-tourism businesses within Sruwaddacon Bay. There are also no Green or Blue Flag beaches within Sruwaddacon Bay and just two slips.

Papadakis *et al.* (1997) found significant correlations between the number of swimmers present on beaches and the presence of pathogenic bacteria. In 2007, Elmir *et al.* (2007) showed the role of human skin as an intermediate mechanism of pathogen transmission to the water column. However, as there are no monitored beaches or bathing water locations within the bay the numbers of swimmers is likely to be low, and so will not impact on the bacteriological quality of the bay.

6.1.3. Sewage Discharges

Sewage effluent can vary in nature depending on the degree to which the sewage has been treated. Discharges of sewage effluent can arise from a number of different sources and be continuous or intermittent in nature:

- treated effluent from urban sewage treatment plants (continuous);
- storm discharges from urban sewage treatment plants (intermittent);
- effluent from 'package' sewage treatment plants serving small populations (continuous);
- combined sewer and emergency overflows from sewerage systems (intermittent);
- septic tanks (intermittent);
- crude sewage discharges at some estuarine and coastal locations (continuous).

Treatment of sewage ranges from:

- none at all (crude sewage);
- preliminary (screening and/or maceration to remove/disguise solid matter);
- primary (settling to remove suspended solids as sewage sludge). Typically removes 40% of BOD (Biochemical Oxygen Demand), 60% of suspended solids; 17% of nitrogen and 20% of phosphorus from the untreated sewage;
- secondary (settling and biological treatment to reduce the organic matter content). Typically removes 95% of BOD, 95% of suspended solids, 29% of nitrogen and 35% of phosphorus from the untreated sewage. Nutrient removal steps can be incorporated into secondary treatment which can reduce ammonia - N down to 5 mg/l and phosphorus to 2mg/l.
- tertiary (settling, biological treatment and an effluent polishing step which may involve a reed bed (unlikely for a coastal works) or a treatment to reduce the load of micro-organisms in the effluent)., typically removes 100% of BOD, 100% of suspended solids, 33% of nitrogen and 38% of phosphorus from the untreated sewage.

6.1.3.1. Water Treatment Works

There are no waste water or sewage treatment works within the Sruwaddacon Bay catchment (EPA, 2019a). The waste water from households in the catchment is treated by means of private treatment systems, group septic tanks or have no treatment.

6.1.3.2. Continuous Discharges

There is no geo-referenced database for septic tanks and on-site domestic waste water treatment systems. In order to estimate the numbers of these domestic sewage facilities within the catchment, information on the number of permanent private households and their sewage facilities was sourced from the 2016 census (CSO, 2019a). Of the 757 permanent private households in the 7 EDs, 2.5% (19, likely group treatment system as no WWTP in catchment) were connected to a public sewer/treatment system and 94.1% (712) had septic tanks or other individual treatment systems. The estimate for the total number of private permanent households actually within the catchment (based on % within the catchment) is 342 and of this 2% (7) are on the public system while 94.5% (324) households have their own septic tanks or other individual treatment systems. Table 6.3 shows this information at the ED level and an estimation (based on % within the catchment) of the numbers actually within the catchment.

Table 6.3: Sewage facilities at permanent households in the catchment area (CSO, 2019a).

Electoral Division	Entire ED						Catchment %					
	Permanent Private Household	Public Sewage Scheme	Individual Septic Tank	Other individual treatment	Other /Not Stated	No sewage facility	Permanent Private Households	Public Sewage Scheme	Individual Septic Tank	Other individual treatment	Other /Not Stated	No sewage facility
Barroosky	43	0	41	2	0	0	39	0	37	2	0	0
Beldergmore	61	1	56	1	0	3	19	0	17	0	0	1
Glenamoy	80	5	64	6	0	5	33	2	26	2	0	2
Knockadaff	131	1	115	9	1	5	96	1	85	7	1	4
Knocknalower	288	10	258	11	1	8	65	2	58	2	0	2
Muingnabo	114	2	100	9	0	3	91	2	80	7	0	2
Sheskin	40	0	39	1	0	0	0	0	0	0	0	0

6.1.3.3. Rainfall Dependent / Emergency Sewage Discharges

As there are no WWTPs within the catchment there are also no rainfall dependant sewage discharges such as storm water overflows.

6.1.4. Industrial Discharges

There is only one industrial facility within the Sruwaddacon Bay catchment (EPA, 2019b). This is the Vermilion Exploration and Production Ireland Limited facility and is located just at the edge of the catchment (see Figure 6.4). There is one emission to water from this facility (Table 6.4). This discharge is for surface water run-off from the facility and so will not contain sewage. There are no section 4 discharges in the catchment (EPA, 2019c).

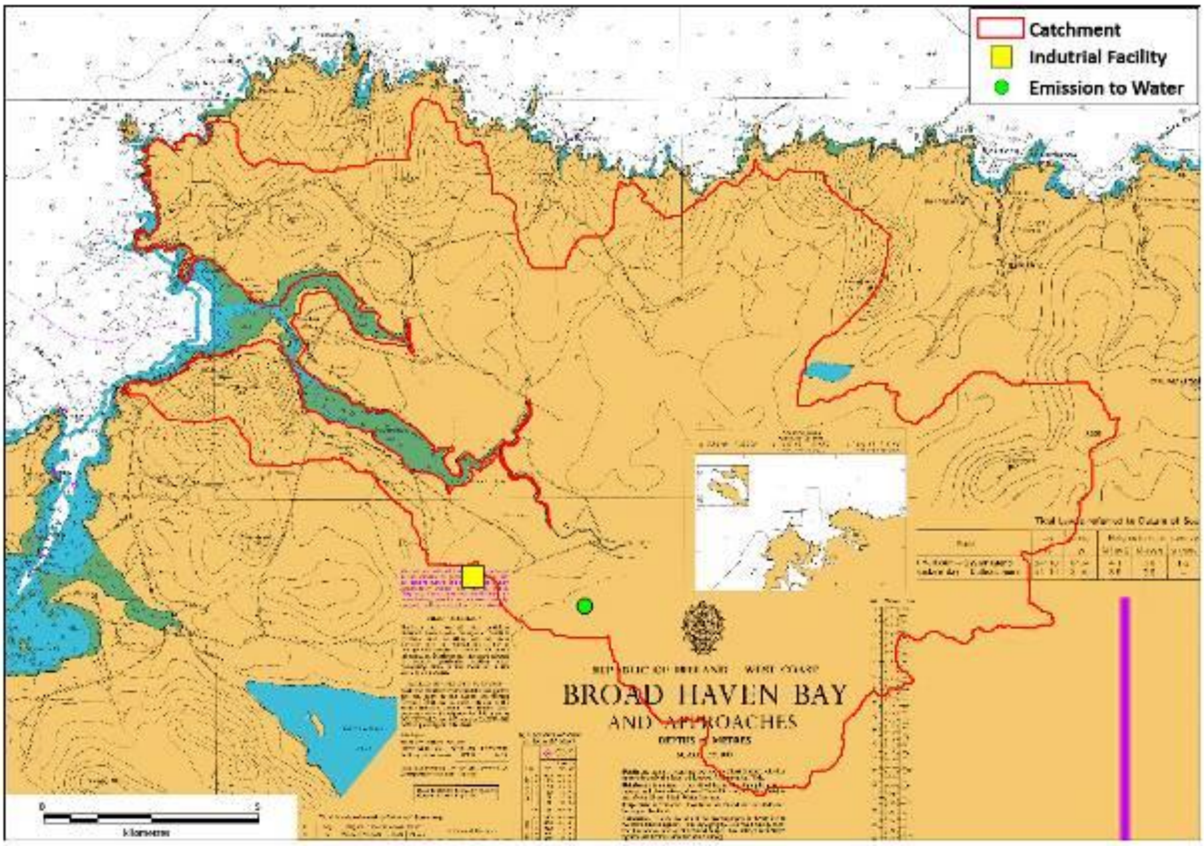

Figure 6.4: Location of Industrial facilities and associated discharge in the Sruwaddacon Bay catchment.

Table 6.4: Details of the Industrial facility emission to water in the Sruwaddacon Bay catchment (EPA, 2019b).

Discharge Code	Licence holder	County	Longitude	Latitude	Easting	Northing
P0738-03_SW1_EW	Vermilion Exploration and Production Ireland Limited	Mayo	-9.703102	54.228129	88,980	332,363

6.1.5. Landuse Discharges

Figure 6.5 shows the Corine landuse (EPA, 2019d) within the Sruwaddacon Bay catchment area. Figure 7.5 shows all rivers/streams within the catchment area. Within the catchment area, land use is dominated by peat bogs (118.1km^2, 66.7%), coniferous forests (23.1km^2; 13%), pastures (18.8km^2, 10.64%) and Transitional woodland/shrub (9.4km^2; 5.3%), followed by, Land principally occupied by agriculture, with significant areas of natural vegetation (3.9km^2; 2.2%), Beaches, dunes, sands (2.9km^2; 1.6%), Sparsely vegetated areas (0.7km^2; 0.4%) and Industrial and commercial units (0.1km^2; 0.05%) (See Figure 6.6).

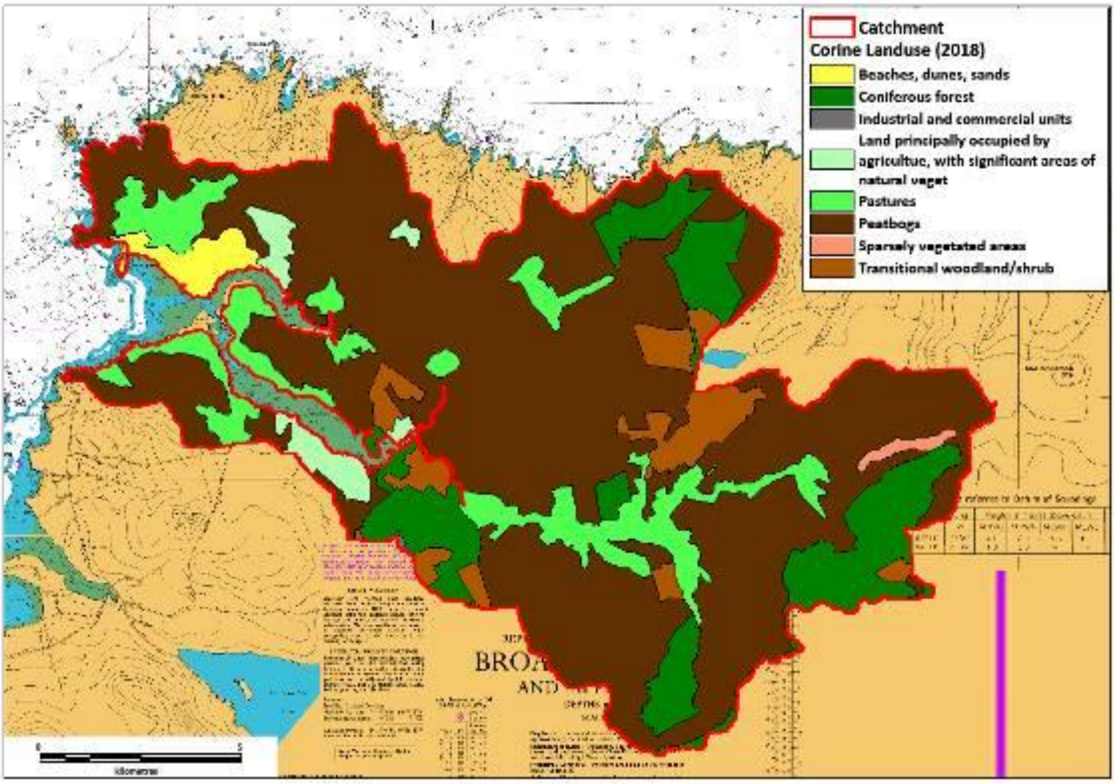

Figure 6.5: Landuse within the Sruwaddacon Bay Catchment Area (Source: EPA, 2019d).

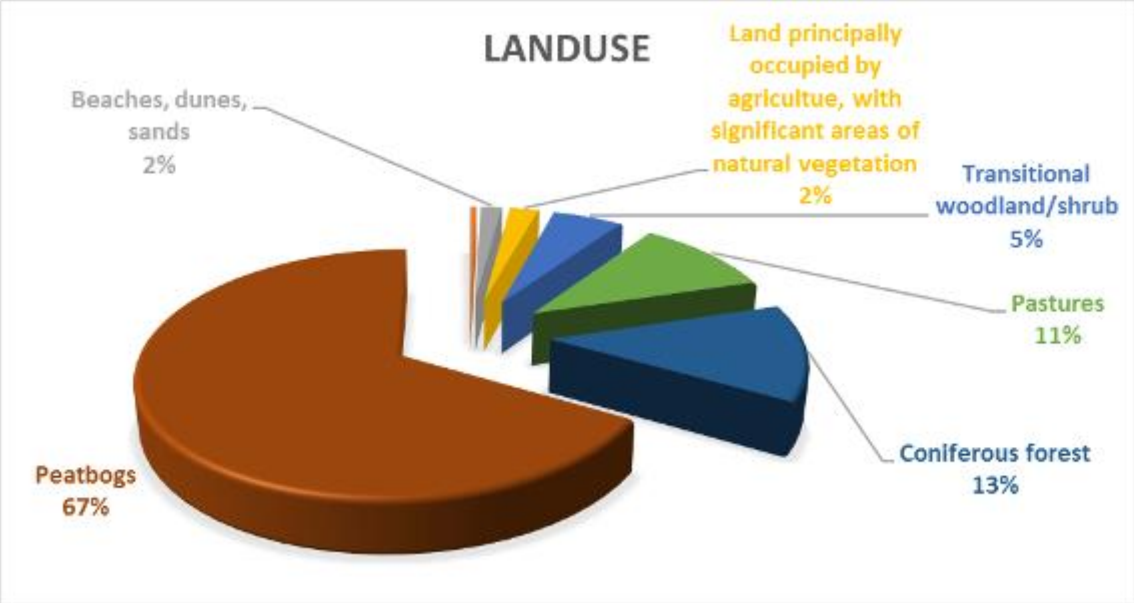

Figure 6.6: Breakdown of landuse within the Sruwaddacon Bay Catchment Area (only landuse ≥1% is labelled).

Data from the Census of Agriculture 2010 (CSO, 2019b) can be seen in Table 6.5 below. Figure 6.7 to Figure 6.14 show thematic maps for each category in Table 6.5.

Numbers of farms within the catchment range from 0 in Sheskin to 162 in Knocknalower. The total area farmed within the catchment varies from 0 ha in Sheskin to 2,183 ha in Knocknalower. The average farm size ranges from 0 ha in Sheskin to 36.9 ha in Barroosky.

Total grass and rough grazing (combination of total pasture, total silage, total hay and rough grazing) accounted for almost all of the area farmed, ranging from 0 ha in Sheskin to 2,183 ha in Knocknalower. Total crops range from 0 ha in all areas with the exception of 16 ha in Beldergmore.

The total number of cattle within the catchment range from 0 in Sheskin to 749 in Knocknalower. The total number of sheep within the catchment range from 0 in Sheskin to 7,654 in Knocknalower. The total number of horses within the catchment range from 0 at Sheskin to 31 in Knocknalower.

The total area farmed in the entire ED's shown in Figure 6.7 to Figure 6.14 amounts to 8,710 ha. However, as most of these ED's only partially overlap the catchment area, an attempt was made to estimate the actual area farmed within the catchment. The percentage of the ED lying within the catchment was calculated in GIS and from this value the area farmed was calculated *e.g.* if 50% of ED lies within catchment area then 50% of the area farmed was taken to be the area farmed within the catchment. Using this method, the area farmed within the catchment is estimated at 4,445 ha. This represents 51% of the area.

Table 6.5: Farm census data for all EDs within the Sruwaddacon Bay Catchment Area (Source: CSO, 2019b).

ED Name	County	No. Farms	Area Farmed (ha)	Avg. Farm Size (ha)	Total Crops (ha)	Total Grass & Rough Grazing (ha)*	Cattle	Sheep	Horses
Glenamoy	MAYO	65	1193	18.4	0	1193	205	3199	13
Barroosky	MAYO	43	1585	36.9	0	1585	324	3055	4
Knockadaff	MAYO	88	558	6.3	0	558	99	4737	5
Sheskin	MAYO	0	0	0	0	0	0	0	0
Beldergmore	MAYO	62	1870	30.2	16	1855	447	4439	7
Knocknalower	MAYO	162	2183	13.5	0	2183	749	7654	31
Muingnabo	MAYO	82	1321	16.1	0	1321	313	4247	7

* Total Grass and Rough Grazing was taken to be the sum of Total Pasture, Total Silage, Total Hay and Rough Grazing.

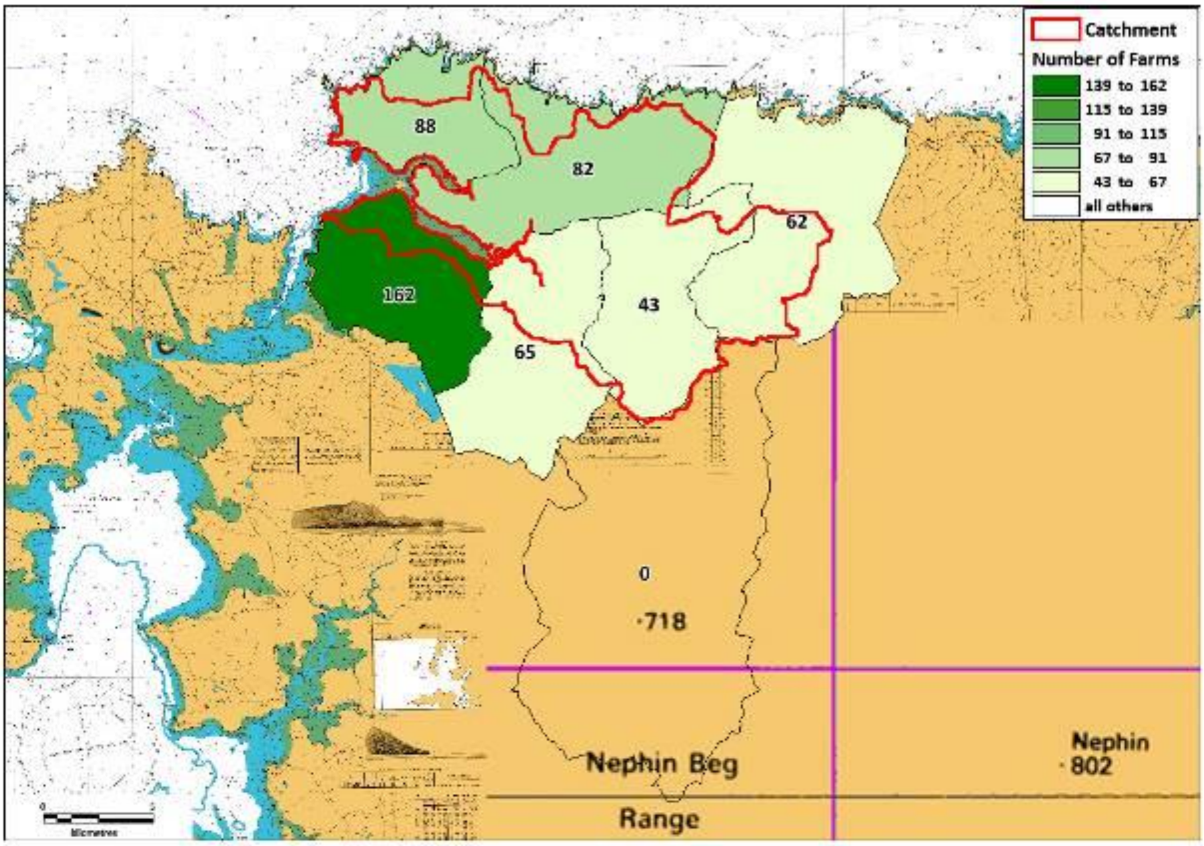

Figure 6.7: Number of farms within the Sruwaddacon Bay Catchment Area (Source: CSO, 2019b).

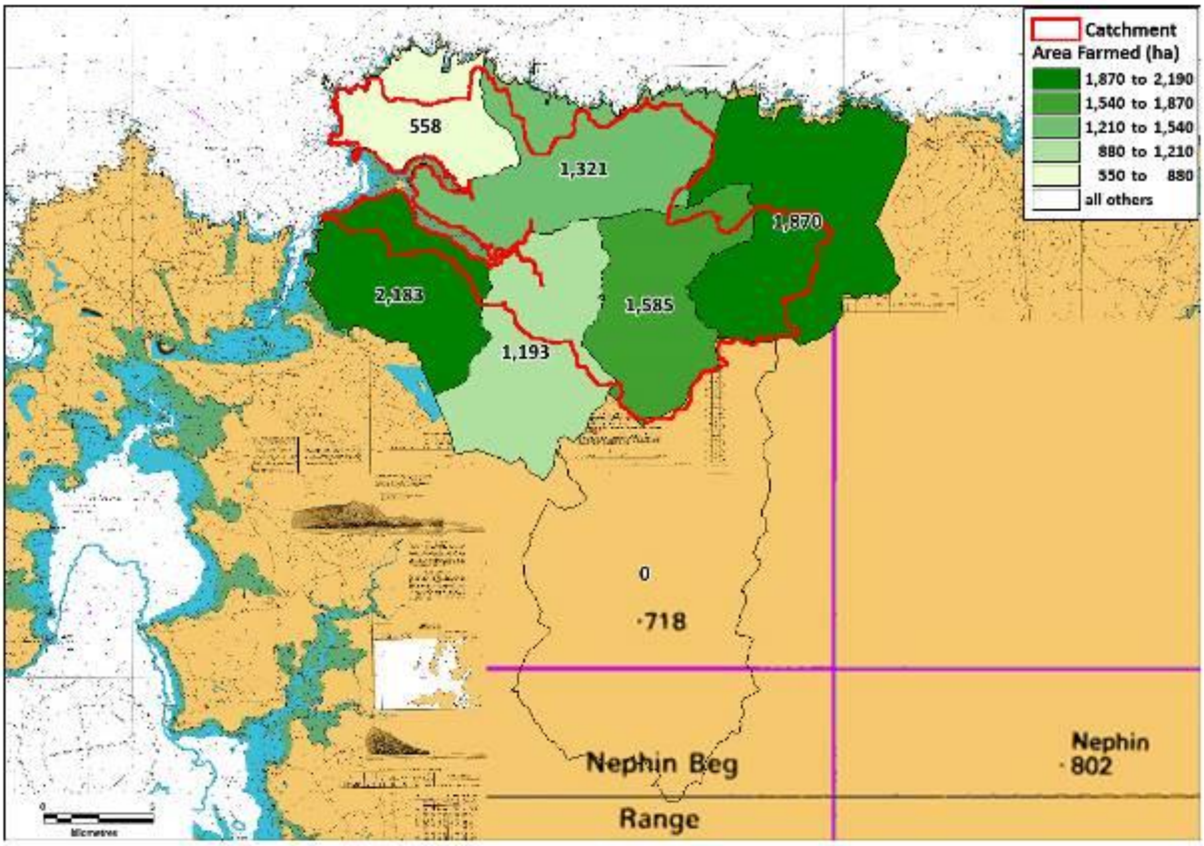

Figure 6.8: Area farmed (ha) within the Sruwaddacon Bay Catchment Area (Source: CSO, 2019b).

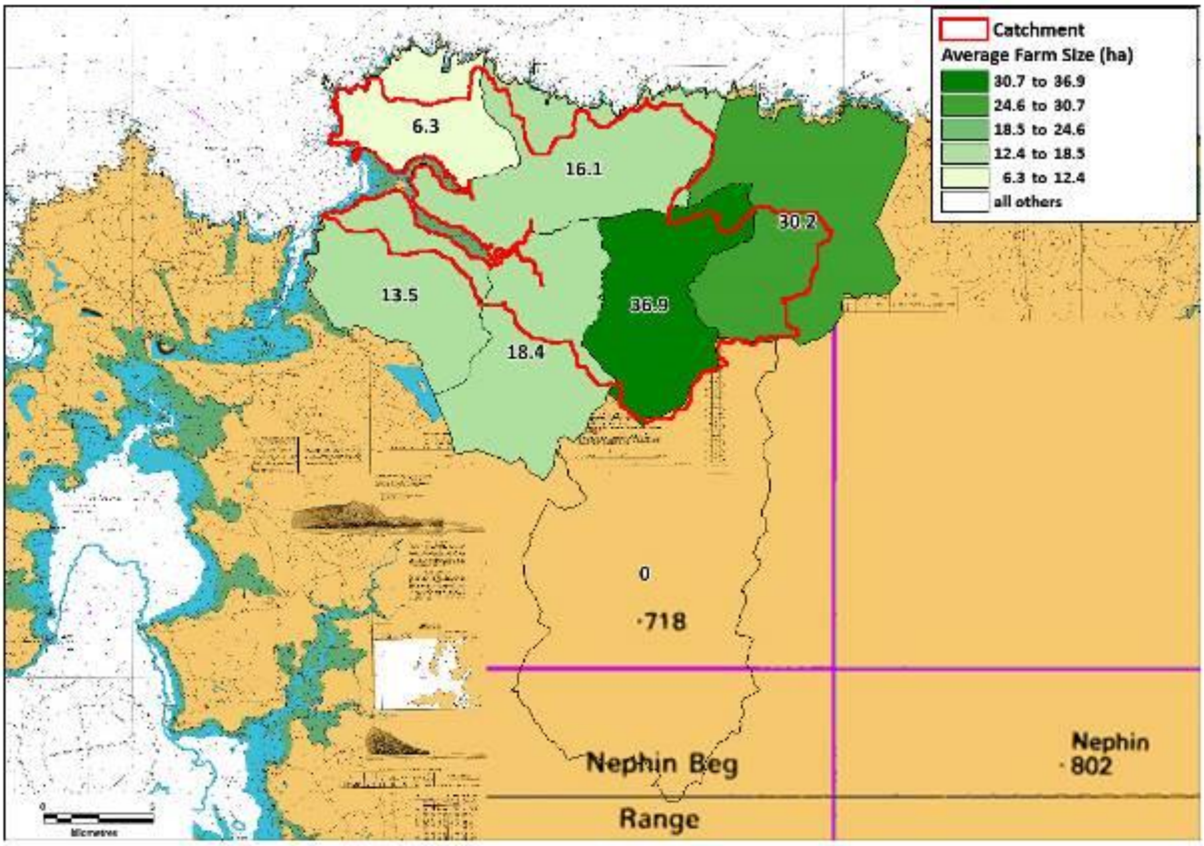

Figure 6.9: Average farm size (ha) within the Sruwaddacon Bay Catchment Area (Source: CSO, 2019b).

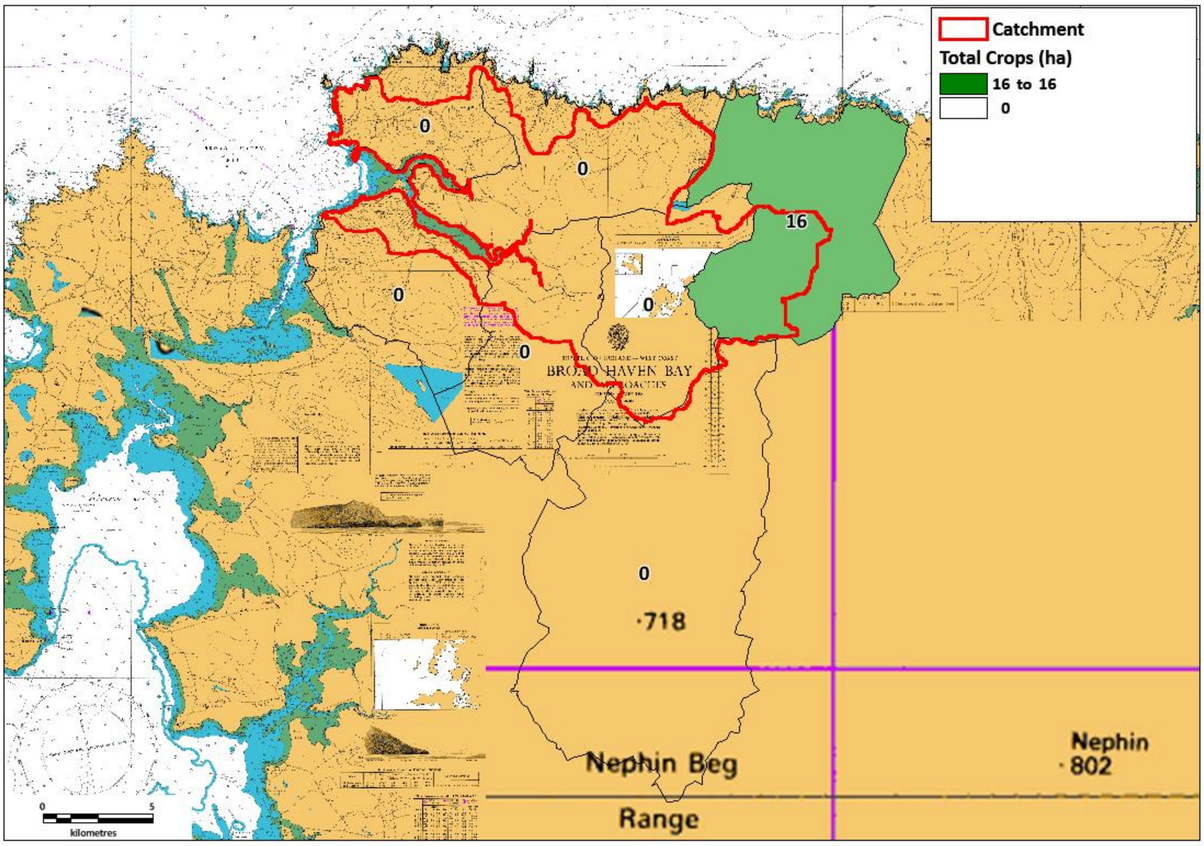

Figure 6.10: Total crops within the Sruwaddacon Bay Catchment Area (Source: CSO, 2019b).

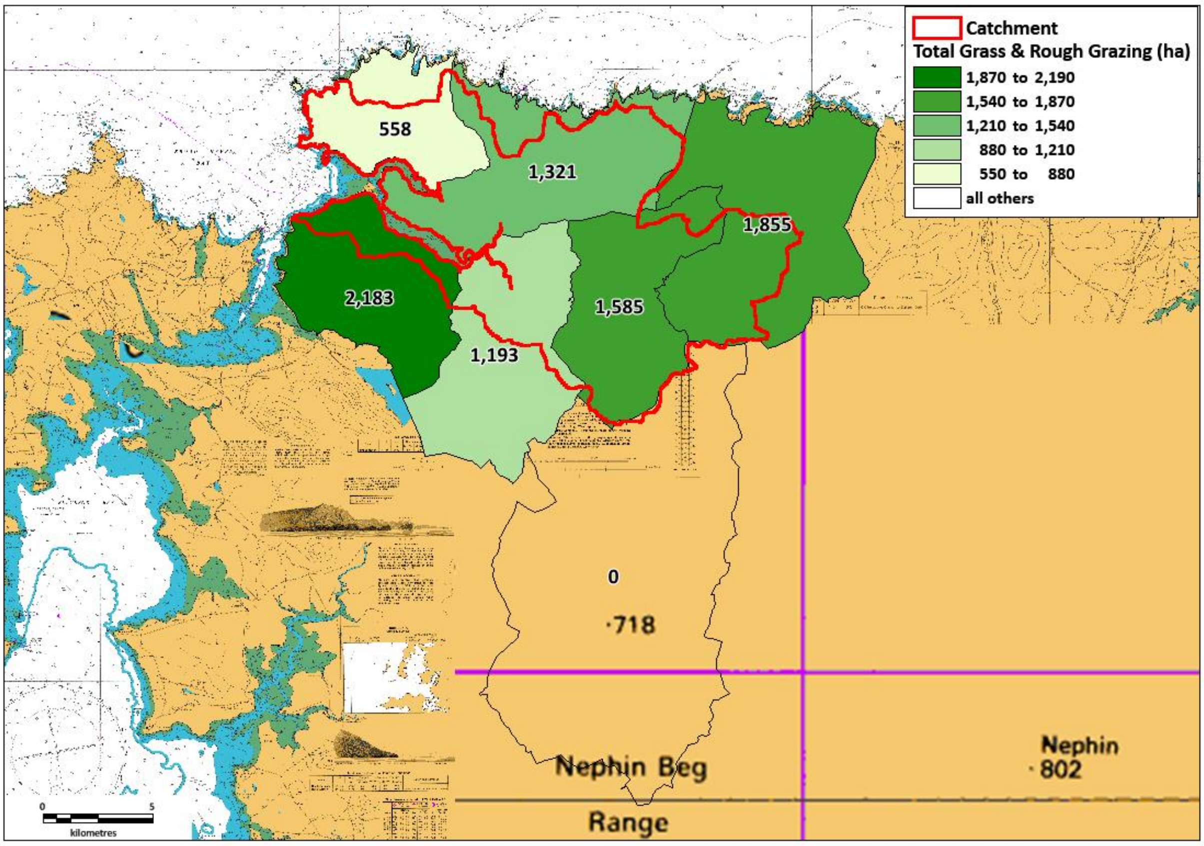

Figure 6.11: Total grass and rough grazing within the Sruwaddacon Bay Catchment Area (Source: CSO, 2019b).

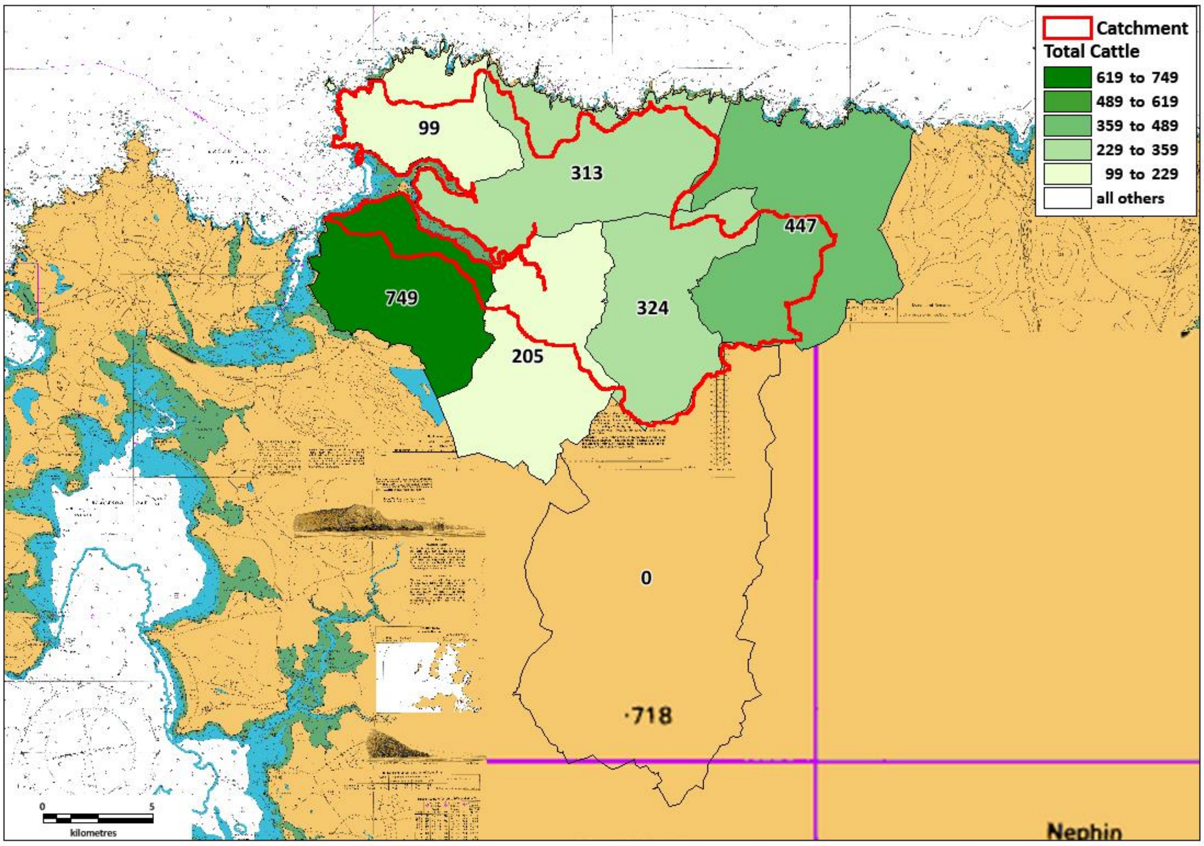

Figure 6.12: Cattle within the Sruwaddacon Bay Catchment Area (Source: CSO, 2019b).

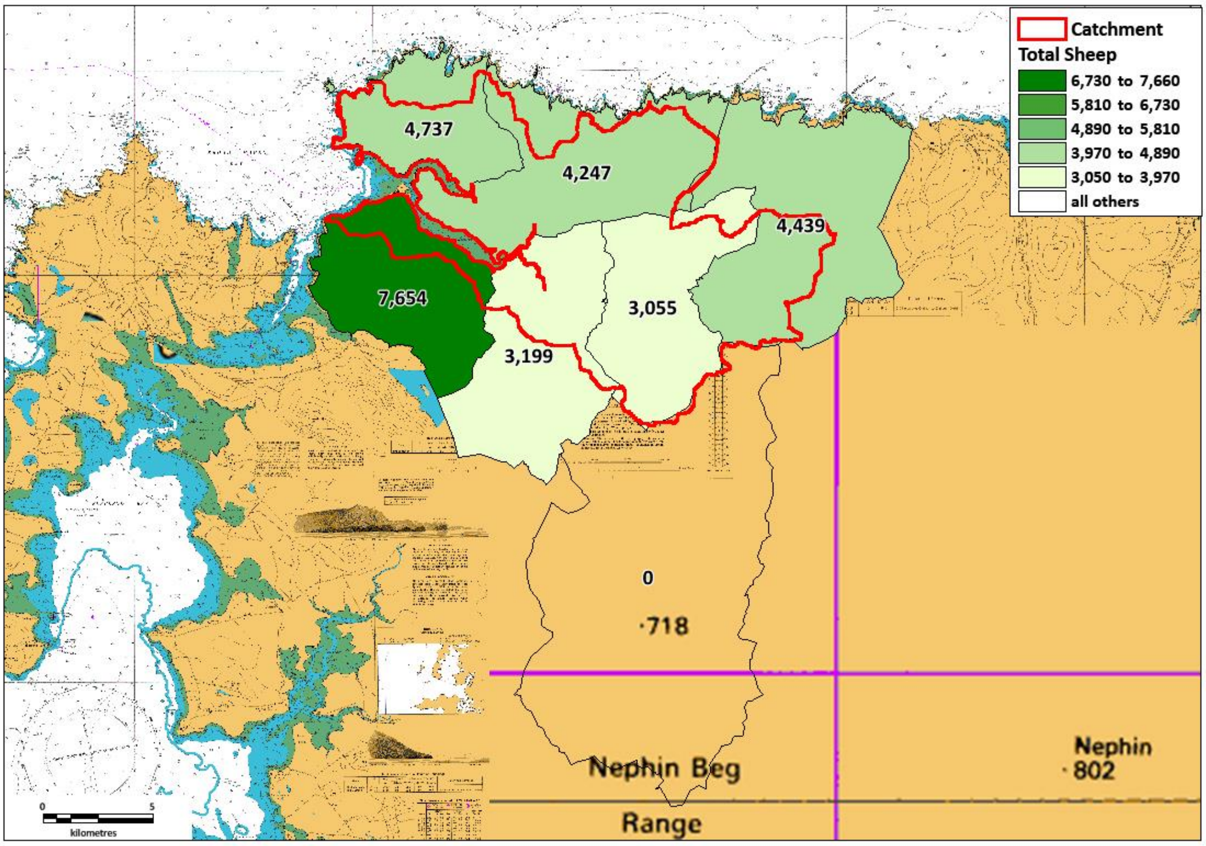

Figure 6.13: Sheep within the Sruwaddacon Bay Catchment Area (Source: CSO, 2019b).

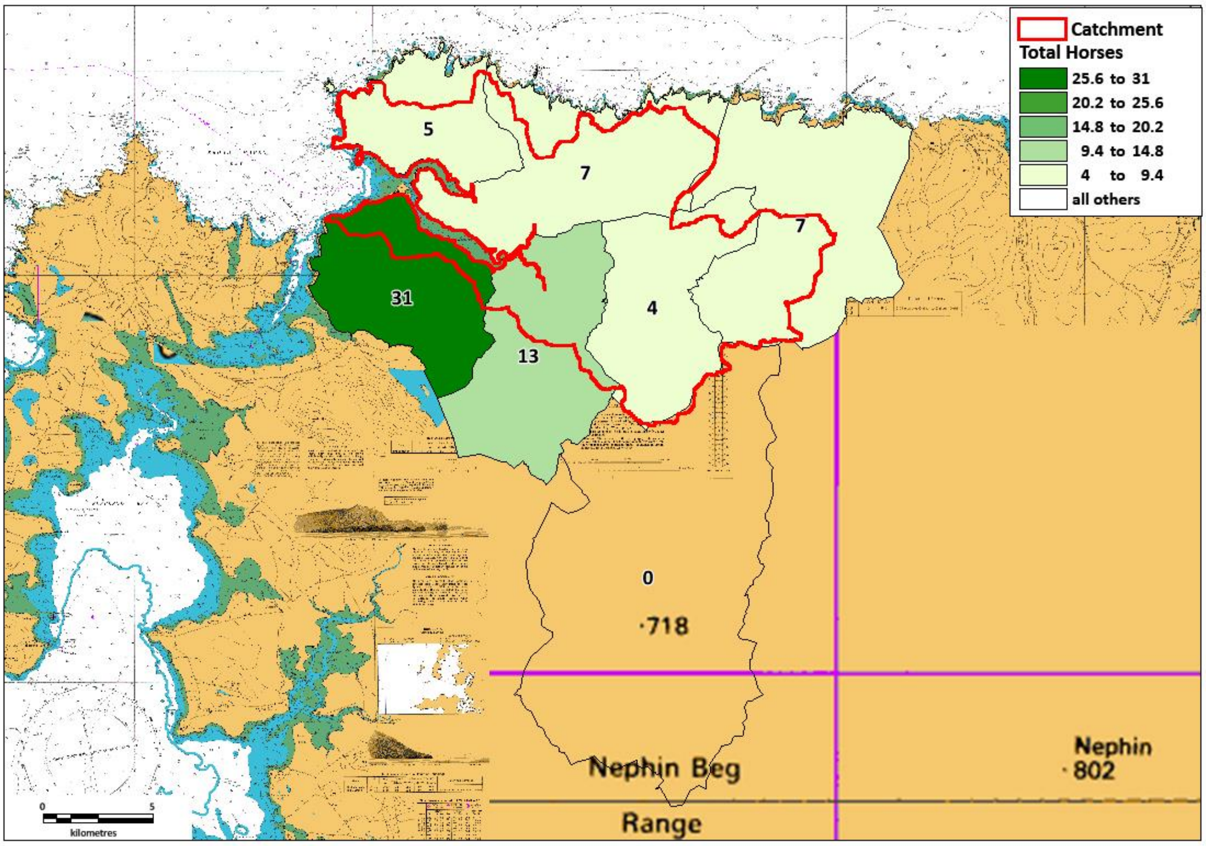

Figure 6.14: Horses within the Sruwaddacon Bay Catchment Area (Source: CSO, 2019b).

A number of studies have reported a strong association between intensive livestock farming areas and faecal indicator concentrations of microorganisms in streams and coastal waters due to run-off from manure, especially during high flow conditions, both from point and non-point sources of contamination (*e.g.* Crowther *et al.,* 2002). Table 6.6 shows the potential daily loading of *E. coli* from livestock (compared to humans and birds). It can be seen that sheep rank the worst, followed by pigs, cows, birds, humans and poultry.

Table 6.6: Potential daily loading of *E. coli* (Jones & White, 1984).

Source	Faecal Production (g/day)	Average Number (*E. coli*/g)	Daily Load (*E. coli*)	Rank
Man	150	13×10^6	1.9×10^9	5
Cow	23600	0.23×10^6	5.4×10^9	3
Sheep	1130	16×10^6	18.1×10^9	1
Chicken	182	1.3×10^6	0.24×10^9	6
Pig	2700	3.3×10^6	8.9×10^9	2
Gull	15.3	131.2×10^6	2×10^9	4

The largest majority of livestock in the area are sheep (27,331). Cattle are also present but in lower numbers (2,137). The majority of agricultural land use in the area is total grass and rough grazing. Sheep are present in relatively large numbers throughout with the highest numbers in the east in Knocknalower ED, where the highest numbers of cattle are also present although still in small numbers. Sheep numbers would be expected to increase in spring following the birth of lambs and decrease in the autumn as they are sent to market. Therefore, larger quantities of livestock droppings will be deposited during this period, though it may not impact the fishery until washed into the sea during and/or after periods of rainfall unless deposited directly on the shoreline.

6.1.6. Other Pollution Sources

6.1.6.1. Shipping

Operational waste from vessels, if not properly managed, can end up in the sea where the potential for contamination or pollution occurs. Wastes generated or landed in ports and harbours can be broadly divided into a) operational and domestic waste from ships and boats, b) waste from commercial cargo activities and c) wastes generated from maintenance activities and associated maritime industry activities.

Marpol Annex IV defines sewage as “drainage from medical premises, toilets, urinals, spaces containing live animals and other waste waters when mixed with sewage waste streams”. Although adopted in 1973, the Annex did not come into effect until September 2003, with subsequent amendments entered into force in

August 2005. Annex IV requires ships to be equipped with either a sewage treatment plant, a sewage comminuting and disinfecting system or a sewage holding tank. Within 3 miles of shore, Annex IV requires that sewage discharges be treated by a certified Marine Sanitation Device (MSD) prior to discharge into the ocean. Sewage discharges made between 3 and 12 miles of shore must be treated by no less than maceration and chlorination and sewage discharged greater than 12 miles from shore are unrestricted. Annex IV also established certain sewage reception facility standards and responsibilities for ports and contracting parties.

Ship sewage originates from water-borne human waste, wastewaters generated in preparing food, washing dishes, laundries, showers, toilets and medical facilities. However, as waste enters the marine environment from many sources, it makes the identification of specific impacts from ship/boat waste very difficult. It is widely recognised that the majority of pollution entering the marine environment comes from land based sources and atmospheric inputs from land based industrial activities, with only an estimated 12% originating from shipping activities (GESAMP [Joint Group of Experts on the Scientific Aspects of Marine environmental Pollution], 1990).

Figure 6.15 shows all boat facilities and activities in Sruwaddacon Bay. Table 6.7 details these facilities. There are no commercial ports or harbours in Sruwaddacon Bay. There are no ferries operating in Sruwaddacon Bay. There are only two slipway/piers located along the shorelines of Sruwaddacon Bay. There is no evidence from satellite imagery of any moorings within the bay. Boat activity in the bay is expected to be low and mostly made up of small craft.

While data on sewage discharge levels from boating activities in the area are not available, it is highly unlikely that any discharges from the small number of vessels in the area would have any negative impacts on water quality.

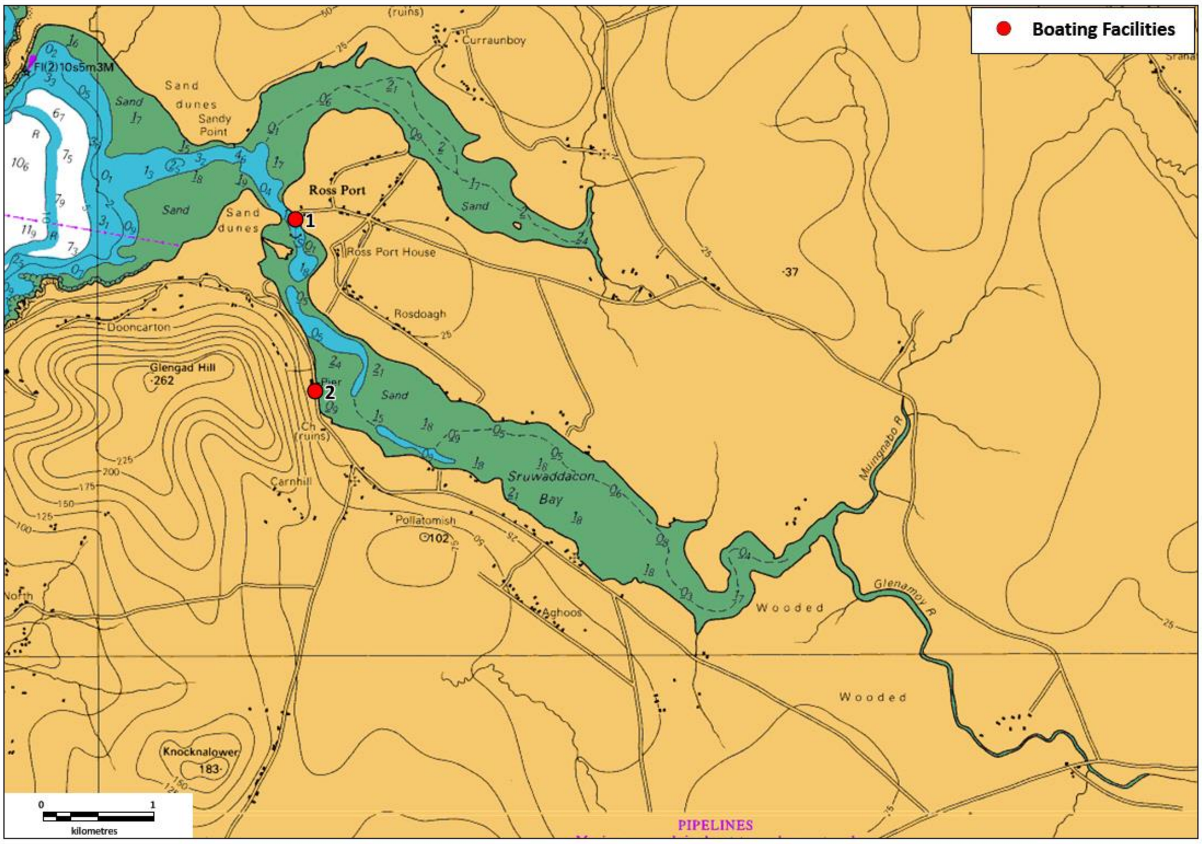

Figure 6.15: Location of all boating facilities and activities in Sruwaddacon Bay.

Table 6.7: Boating facilities in the Sruwaddacon Bay. Map Code refers to Figure 5.15.

Map Code	Feature
1	Slip/Pier
2	Slip/Pier

6.1.6.2. Wildlife

Birds

It is important to document the bird populations in the Sruwaddacon Bay area as bird faeces are rich in faecal bacteria (Oshira & Fujioka, 1995) and have been shown to be a source of faecal contamination in the marine environment (Jones *et al.,* 1978; Standridge *et al.,* 1979; Levesque *et al.,* 1993, Alderisio & DeLuca 1999, Levesque *et al.,* 2000, Ishii *et al.,* 2007).

Blacksod Bay/Broad Haven Bay SPA is located within the catchment of Sruwaddacon Bay. There are a number of other SPAs nearby including Carrowmore Lake SPA, Stags of Broad Haven SPA and Illanmaster SPA. All SPAs in the area can be seen in Figure 2.2**Error! Reference source not found.**.

Blacksod Bay/Broad Haven Bay SPA Situated in the extreme north-west of Co. Mayo, this site comprises a number of bays and inlets including Sruwaddacon Bay, Moyrahan Bay, Traw-Kirtaun, Blind Harbour, Tullaghan Bay, and the various sheltered bays and inlets in Blacksod Bay, including Trawmore Bay, Feorinyeeo Bay, Saleen Harbour, Elly Bay and Elly Harbour. The site is a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for the following species: Great Northern Diver (67), Light-bellied Brent Goose (279), Common Scoter (510), Red-breasted Merganser (83), Ringed Plover (590), Sanderling (171), breeding Dunlin (subsp. *schinzii*) (1,255), Bar-tailed Godwit (664), Curlew (567) and Sandwich Tern (81 pairs in 1995). Slavonian Grebes are known to occur in Blacksod Bay in winter months. The E.U. Birds Directive pays particular attention to wetlands and, as these form part of this SPA, the site and its associated waterbirds are of special conservation interest for Wetland & Waterbirds. A number of wader species breed within the areas of machair in the SPA, including a nationally important population of Dunlin (subsp. schinzii) – 24 pairs (NPWS, 2013b).

Carrowmore Lake SPA Carrowmore Lake is a large, fairly shallow, oligotrophic/mesotrophic lake in Co. Mayo. The lake generally has a stony bottom and shoreline, and overlies Dalradian schists and quartzite. Stands of emergent, swamp vegetation occur, especially in sheltered areas. The lake has one substantial island, Derreens Island, and several small islands; these are dominated by a grassy sward. Carrowmore Lake is set in a landscape dominated by blanket bogs. The site is a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for the following species: Sandwich Tern (NPWS, 2015a).

The Stags of Broad Haven are a group of four precipitous rocky islets, totalling 4 ha, rising to almost 100 m, located about 2 km north of Benwee Head, Co. Mayo. The surrounding seas to a distance of 500 m are included in the site. The site is a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for the following species: Storm Petrel and Leach's Petrel (NPWS, 2015b).

Illanmaster is a steep, rocky island situated just off the north Co. Mayo coast. It rises to 107 m and is topped with a maritime grassy sward. The surrounding seas to a distance of 500 m are included in the site. The southern boundary of the site adjoins the mainland shoreline. While close to the mainland, access to the island is difficult. The site is a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for the following species: Storm Petrel. (NPWS, 2015c).

Aquatic mammals

Both Common (*Phoca vitulina)* and Grey seals (*Haliochoerus grypus*) have been recorded within Sruwaddacon Bay (See Figure 6.16 and Figure 6.17). However, only individuals or small groups have been recorded and no haul-out sites are listed. Other aquatic mammals that may occur in Sruwaddacon Bay include Otter (*Lutra lutra),* Bottlenosed Dolphin (*Tursiops truncatus)* and Harbour Porpoise (*Phocoena phocoena*).

Figure 6.16: Common Seal locations in Sruwaddacon Bay (Biodiversity Ireland).

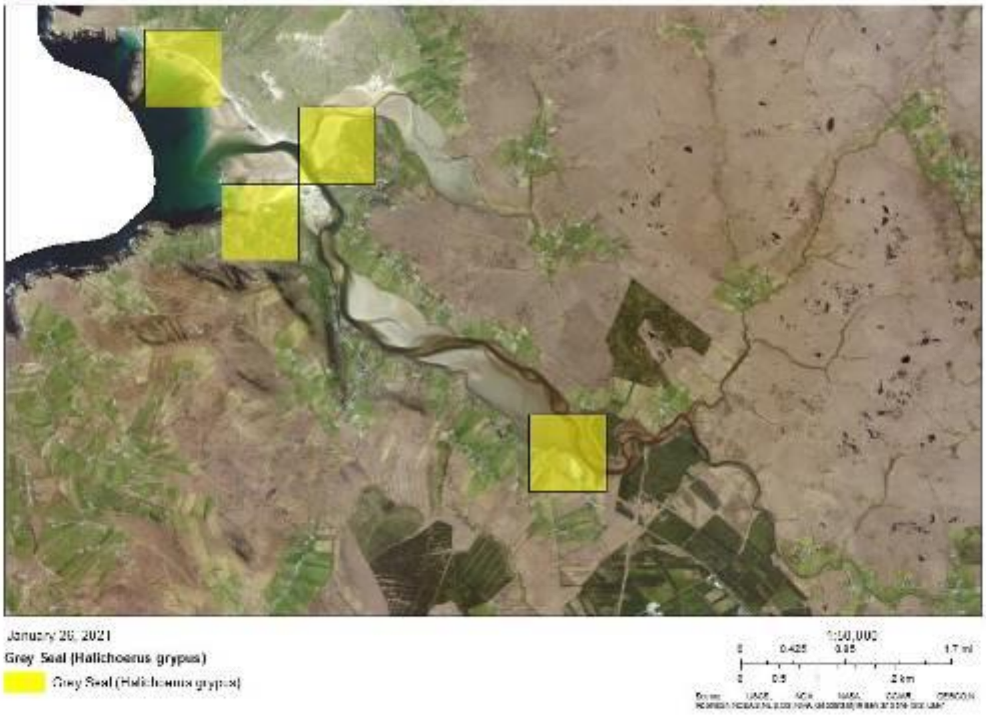

Figure 6.17: Grey Seal Locations in the Sruwaddacon Bay area (Biodiversity Ireland).

No estimates of the volumes of seal faeces are available although it is reasonable to assume that what is ingested and not assimilated in the gut must pass. Assuming 6% of a median body weight for grey seals of 185kg, that would equate to 11.1kg 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 x 104 CFU *E. coli* per gram dry weight of faeces (Lisle *et al.,* 2004). *Salmonella* and *Campylobacter* spp. have also been found in wild seals (Stoddard *et al.,* 2005).

All aquatic mammals that occur in the BMPA are likely to contribute to background levels of faecal contamination within the area particularly during the haul-out periods.

6.2. Shoreline Survey

6.2.1. Shoreline Survey Report

A shoreline survey was carried out by the Sea Fisheries Protection Authority. Figure 6.18 shows the GPS (Global Positioning System) and photography sites accounted for during the 5 survey days between October and February. All of the shoreline was walked where possible with the exception of the south western shore from the bay mouth towards Dooncarton where access was limited.

The aim of this survey was to identify/confirm and mark all discharges, pollution sources, waterways and marinas along the shoreline. GPS coordinates were recorded for all features and marked on a map. In addition, all features were photographed digitally (where possible). Notes were made on the numbers and types of farm animals obvious from the shoreline and on wild fowl/populations of wild animals with an estimation of their numbers.

Figure 6.18: Locations of GPS and Photograph Sites.

Figure 6.18 shows the locations of all features observed during the shoreline survey. In total 68 features were identified, of which 15 rivers/streams were identified, 44 drains, 3 piers, 5 locations with sheep and 1 location with cattle. Figure 6.19 to Figure 6.34 show aerial imagery of the location of the features and

Appendix 4 shows images of most of these features. Table 6.8 details all features identified and the numbering used is cross-referenced to Figure 6.19 to Figure 6.34.

Table 6.8: Features identified during the shoreline survey. Refer to Figure 6.19– Figure 6.34 for locations and Appendix 4 for photographs.

Map ID	Observation	Comments	Longitude	Latitude	Easting	Northing
1	Pier	Pier, only one boat moored off the pier. Used for commercial fishing	-9.843877	54.297234	80000.2	340282.4
2	Stream	Flowing. No observations	-9.83531	54.30056	80567.5	340638.1
3	Sheep	Sheep, 100 + over large area of mature dunes	-9.83267	54.301115	80741.0	340695.4
4	Stream	Flowing. No observations	-9.83183	54.29939	80790.7	340502.0
5	Drain	Natural drain through sand dunes	-9.82333	54.29347	81327.0	339828.8
6	Drain	Natural drain through sand dunes	-9.82093	54.29229	81479.8	339693.4
7	Stream	Flowing. No observations	-9.80919	54.2951	82252.2	339986.5
8	Drain	Natural drain through sand dunes	-9.80688	54.29628	82406.0	340113.9
9	Drain	Natural drain through sand dunes	-9.80264	54.29743	82685.3	340234.9
10	Stream	Stream flowing off hill and farms. Enrichment evident	-9.79707	54.29758	83048.3	340242.3
11	Stream	Flowing. No observations	-9.79086	54.2972	83451.5	340189.7
12	Drain (x 2)	Good flow from both	-9.78154	54.29195	84043.5	339590.1
13	Drain	Good flow	-9.7765	54.28878	84362.7	339229.0
14	Sheep	Sheep on foreshore, approx 10 in number	-9.77619	54.28831	84381.6	339176.2
15	River	In spate	-9.76497	54.2878	85110.8	339101.1
16	Stream	Flowing, through mixed rough pasture/bog	-9.76344	54.28009	85188.9	338240.5
17	Stream	Flowing, through mixed rough pasture/bog	-9.76435	54.28019	85130.0	338253.1
18	Drain	Flowing off hill, mixed rough grazing. Field drain.	-9.78739	54.28824	83652.1	339186.8
19	Sheep	Approximately 30 sheep on foreshore	-9.79059	54.29013	83449.1	339402.4
20	Drain	Flowing, some Enteromorpha aglae evident.	-9.79212	54.29037	83350.2	339431.7
21	Drain	Field drain, flowing. Through pasture with cows.	-9.80725	54.28824	82359.0	339219.7
22	Sheep	Sheep, 30+	-9.806082	54.287813	82433.8	339170.3
23	Drain	Concrete pipe alongside pier, some discolouration	-9.80637	54.28581	82409.3	338947.8
24	Pier	Pier, no boats moored there.	-9.80641	54.28571	82406.4	338936.8
25	Drain	Drain flowing alongside left hand side of pier from concrete culvert	-9.80611	54.28572	82426.0	338937.4

Map ID	Observation	Comments	Longitude	Latitude	Easting	Northing
26	Drain	Field drain, flowing. Through pasture land.	-9.80285	54.28187	82627.3	338503.4
27	Drain	Field drain, flowing. Through pasture land.	-9.80291	54.2773	82610.4	337994.9
28	Drain	Field drain, flowing.	-9.80124	54.27635	82716.5	337886.4
29	Drain	Large field drain, flowing.	-9.79776	54.27029	82926.0	337206.2
30	Drain	Field drain, flowing. Through rough grazing land.	-9.78254	54.27005	83916.8	337154.3
31	Drain	Field drain, flowing. Through rough grazing land.	-9.78048	54.26923	84048.7	337059.7
32	Drain	Drain, concrete structure below dwelling house	-9.77859	54.26883	84170.7	337012.0
33	Drain	Field drain, flowing. Through pasture.	-9.7729	54.26856	84540.6	336972.7
34	Drain	Field drain, flowing. Through pasture.	-9.76647	54.26607	84952.5	336685.0
35	Drain	Field drain, flowing. Through rough grazing area.	-9.76492	54.26552	85052.0	336621.3
36	Drain	Field drain, flowing. Through rough grazing area.	-9.76407	54.26532	85106.8	336597.6
37	Drain	Field drain, flowing. Through rough grazing area.	-9.76023	54.26316	85351.0	336351.0
38	Drain	Field drain, flowing. Flowing through pasture land.	-9.75716	54.26102	85545.1	336107.8
39	Cows	Cows 10 + on pasture land	-9.75614	54.26087	85611.1	336089.5
40	River (Glenamoy)	Large river, good flow. Flowing through large catchment	-9.73255	54.25873	87142.4	335813.3
41	Drain	Field drain, through forestry and bog	-9.73562	54.25872	86942.3	335817.1
42	Drain	Field drain, through forestry and bog	-9.74133	54.25642	86563.9	335570.3
43	Drain	Field drain, through forestry and bog	-9.74365	54.2547	86408.0	335382.6
44	Drain	Field drain	-9.74679	54.25303	86198.8	335201.8
45	Stream	Flowing strongly, through bog/rough pasture	-9.75161	54.2516	85880.7	335050.4
46	Drain	Field drain, flowing through heath/bog	-9.75254	54.25345	85825.2	335257.8
47	Drain	Field drain, flowing through heath/bog	-9.75559	54.25506	85630.9	335442.0
48	Drain	Field drain, flowing through rough grazing land	-9.75747	54.25556	85509.8	335500.7
49	Drain	Field drain, flowing through rough grazing land	-9.75961	54.25571	85370.7	335520.8
50	Drain	Field drain, flowing through rough grazing land	-9.76127	54.25586	85263.0	335540.2
51	Drain	Field drain, flowing through rough grazing land	-9.76221	54.2559	85201.8	335546.2

Map ID	Observation	Comments	Longitude	Latitude	Easting	Northing
52	Stream	Field drain, flowing through rough grazing land	-9.76476	54.2563	85036.8	335594.9
53	Drain	Field drain, flowing through rough grazing land	-9.76699	54.2574	84894.5	335720.9
54	Pipe	Grey pipe, not flowing. Not possible to identify origin	-9.76773	54.25787	84847.6	335774.4
55	Drain	Field drain, flowing through rough grazing land	-9.77153	54.26028	84606.7	336048.9
56	Drain	Field drain, flowing through rough grazing land	-9.77594	54.26187	84323.8	336233.1
57	Drain	Field drain, flowing through rough grazing land	-9.77723	54.26243	84241.3	336297.5
58	Drain	Field drain, flowing through rough grazing land	-9.77767	54.26248	84212.8	336303.8
59	Drain	Field drain. Low flow. Through rough grazing land.	-9.78563	54.2651	83701.6	336608.5
60	Drain	Field drain. Low flow, through rough grazing area.	-9.7876	54.26526	83573.7	336629.5
61	Stream	Stream flowing through rough grazing land. Good flow.	-9.78826	54.2656	83531.6	336668.5
62	Stream	Stream flowing through rough grazing land. Good flow.	-9.79466	54.26622	83116.4	336748.1
63	River	Small river, good flow. Some Enteromorpha algae evidenct. Flows through farmland/rough grazing	-9.80222	54.26905	82631.9	337075.6
64	Drain	Flowing off high bank beside road. Likely field rain related.	-9.80377	54.27022	82534.3	337208.4
65	Pier	Small pier, no boats or berths noted.	-9.8041	54.27179	82517.3	337383.7
66	Stream	Stream flowing of steep hill, sheep on pasture above.	-9.80408	54.27296	82521.9	337513.8
67	Drain	Field drain from hill above	-9.80483	54.27343	82474.4	337567.4
68	Sheep	Approx 15 on grassland	-9.813355	54.2834	81947.6	338691.3

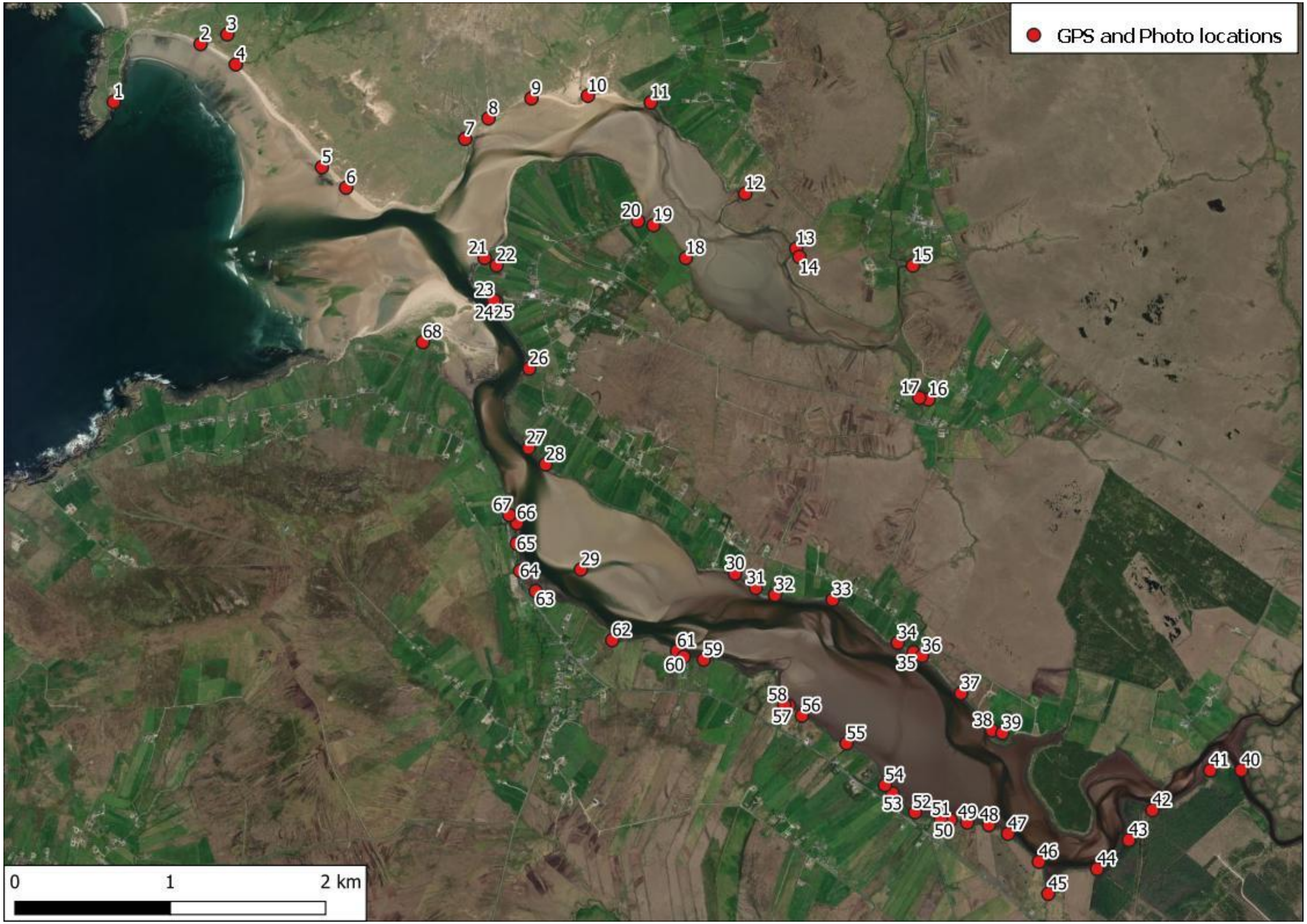

Figure 6.19: All features (numbering cross-reference to Table 6.8) identified during the shoreline survey.

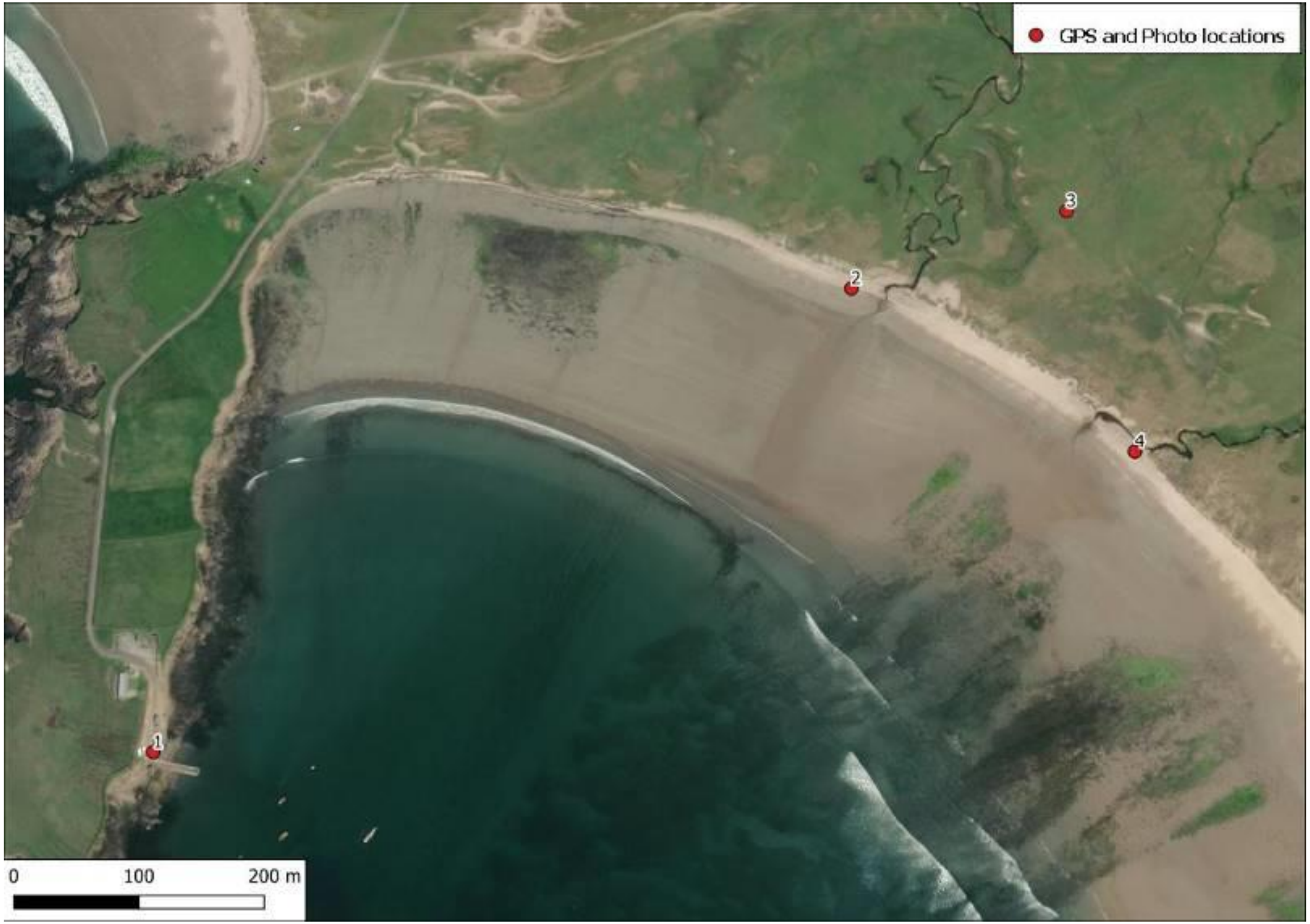

Figure 6.20: Features 1-4 (numbering cross-reference to Table 6.8) identified during the shoreline survey.

Figure 6.21: Features 5-6 (numbering cross-reference to Table 6.8) identified during the shoreline survey.

Figure 6.22: Features 7-11 (numbering cross-reference to Table 6.8) identified during the shoreline survey.

Figure 6.23: Features 12-15 (numbering cross-reference to Table 6.8) identified during the shoreline survey.

Figure 6.24: Features 16-17 (numbering cross-reference to Table 6.8) identified during the shoreline survey.

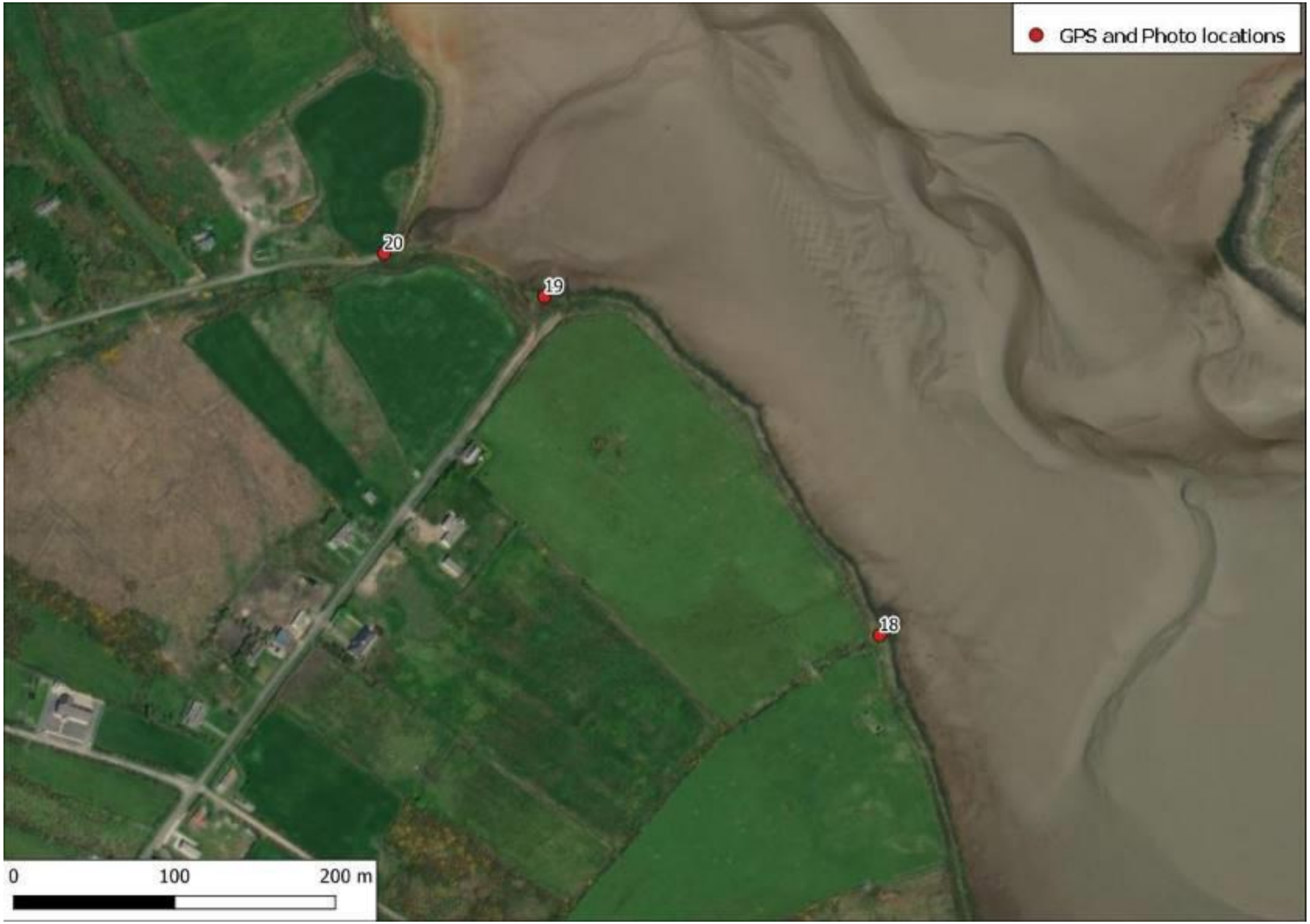

Figure 6.25: Features 18-20 (numbering cross-reference to Table 6.8) identified during the shoreline survey.

Figure 6.26: Features 21-25 (numbering cross-reference to Table 6.8) identified during the shoreline survey.

Figure 6.27: Features 26-28 (numbering cross-reference to Table 6.8) identified during the shoreline survey.

Figure 6.28: Features 30-33 (numbering cross-reference to Table 6.8) identified during the shoreline survey.

Figure 6.29: Features 34-39 (numbering cross-reference to Table 6.8) identified during the shoreline survey.

Figure 6.30: Features 40-44 (numbering cross-reference to Table 6.8) identified during the shoreline survey.

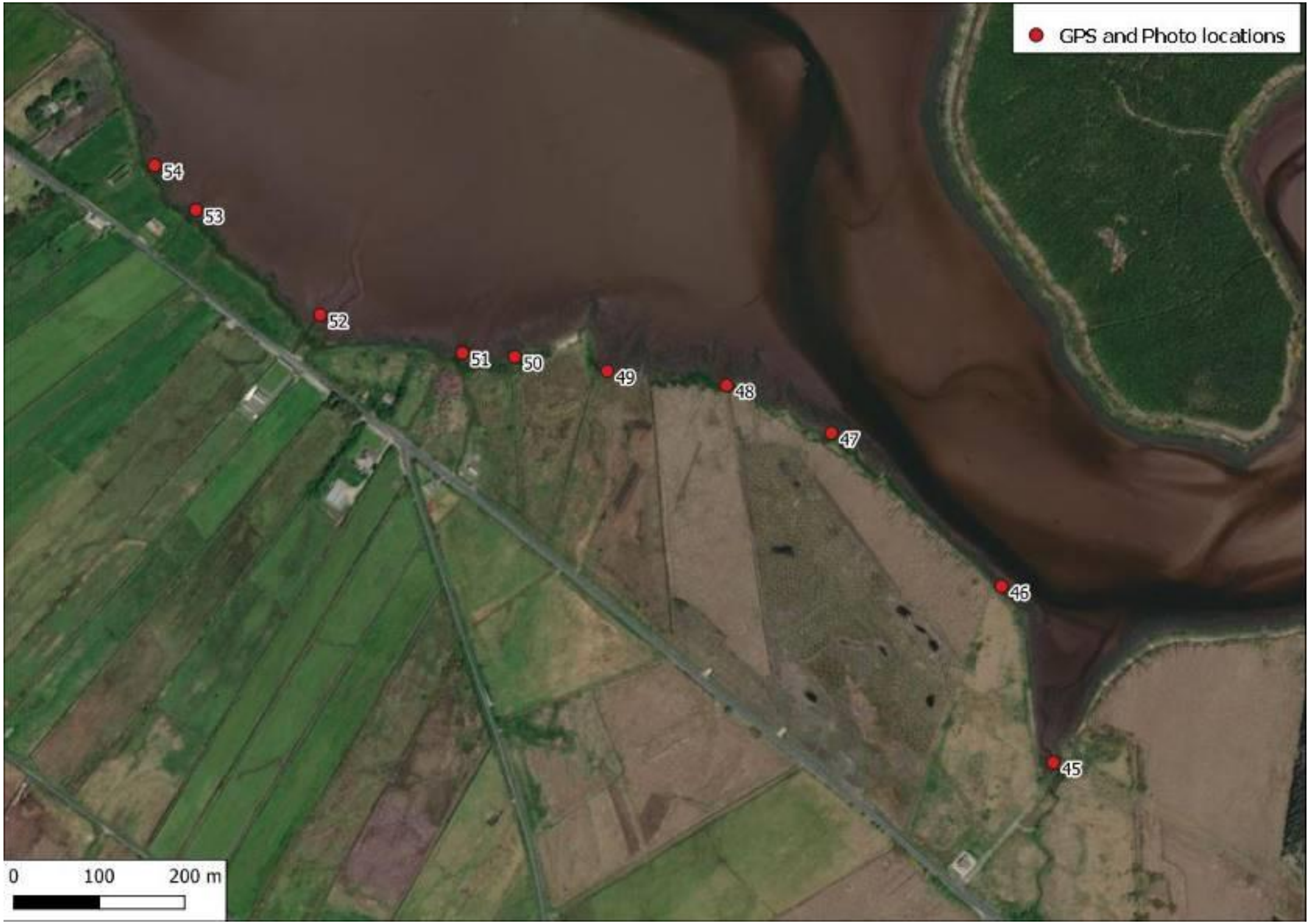

Figure 6.31: Features 45-54 (numbering cross-reference to Table 6.8) identified during the shoreline survey.

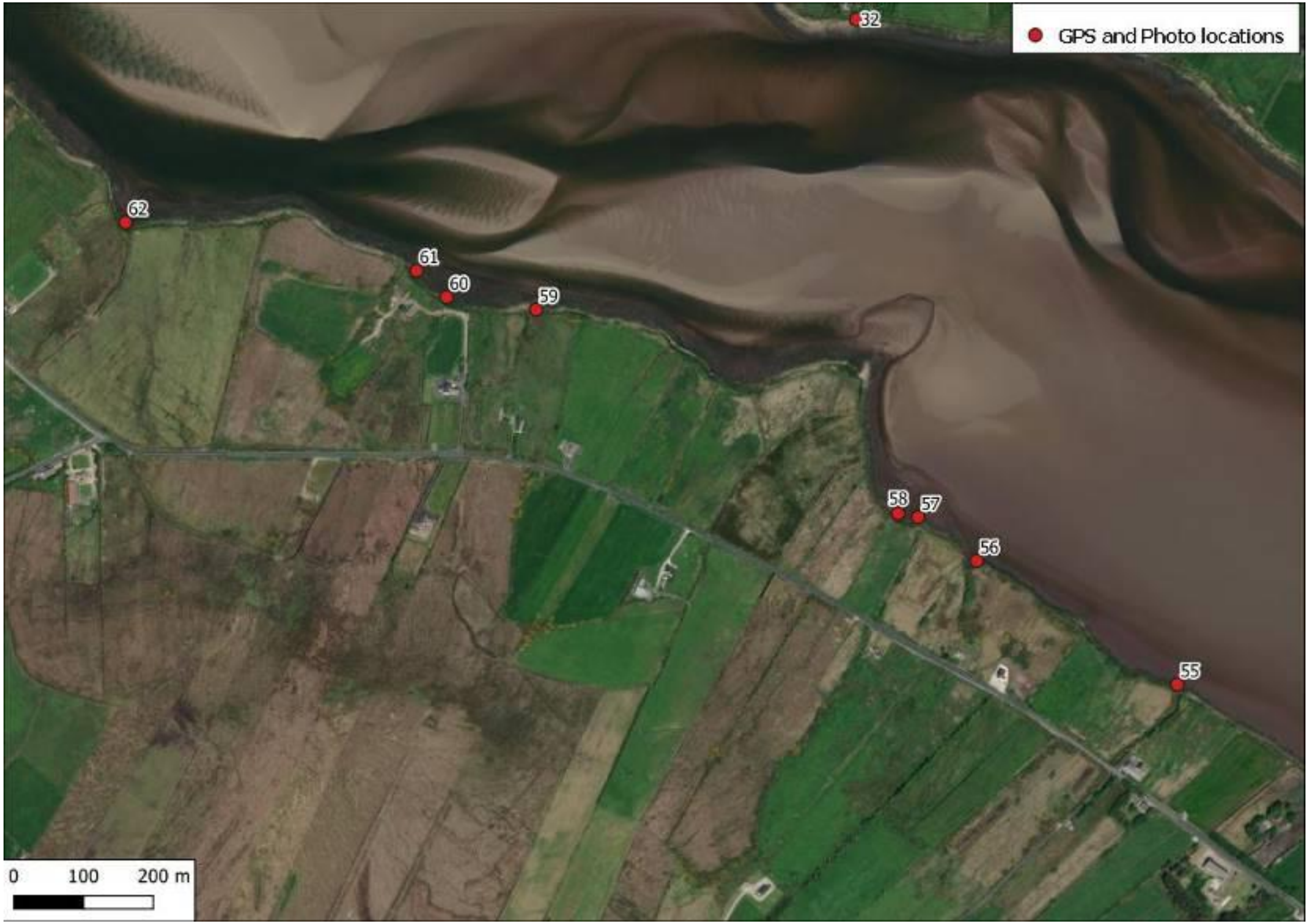

Figure 6.32: Features 55-62 (numbering cross-reference to Table 6.8) identified during the shoreline survey.

Figure 6.33: Features 63-67 & 29 (numbering cross-reference to Table 6.8) identified during the shoreline survey.

Figure 6.34: Features 68 (numbering cross-reference to Table 6.8) identified during the shoreline survey.

6.2.2. Locations of Sources

Figure 6.35 shows all watercourses discharging into Sruwaddacon Bay and Table 6.9 provides cross-referenced details for this map. Figure 6.36 shows all discharges in the Sruwaddacon Bay catchment area and Table 6.10 provides cross-referenced details for the industrial discharge, drain and pipe discharges.

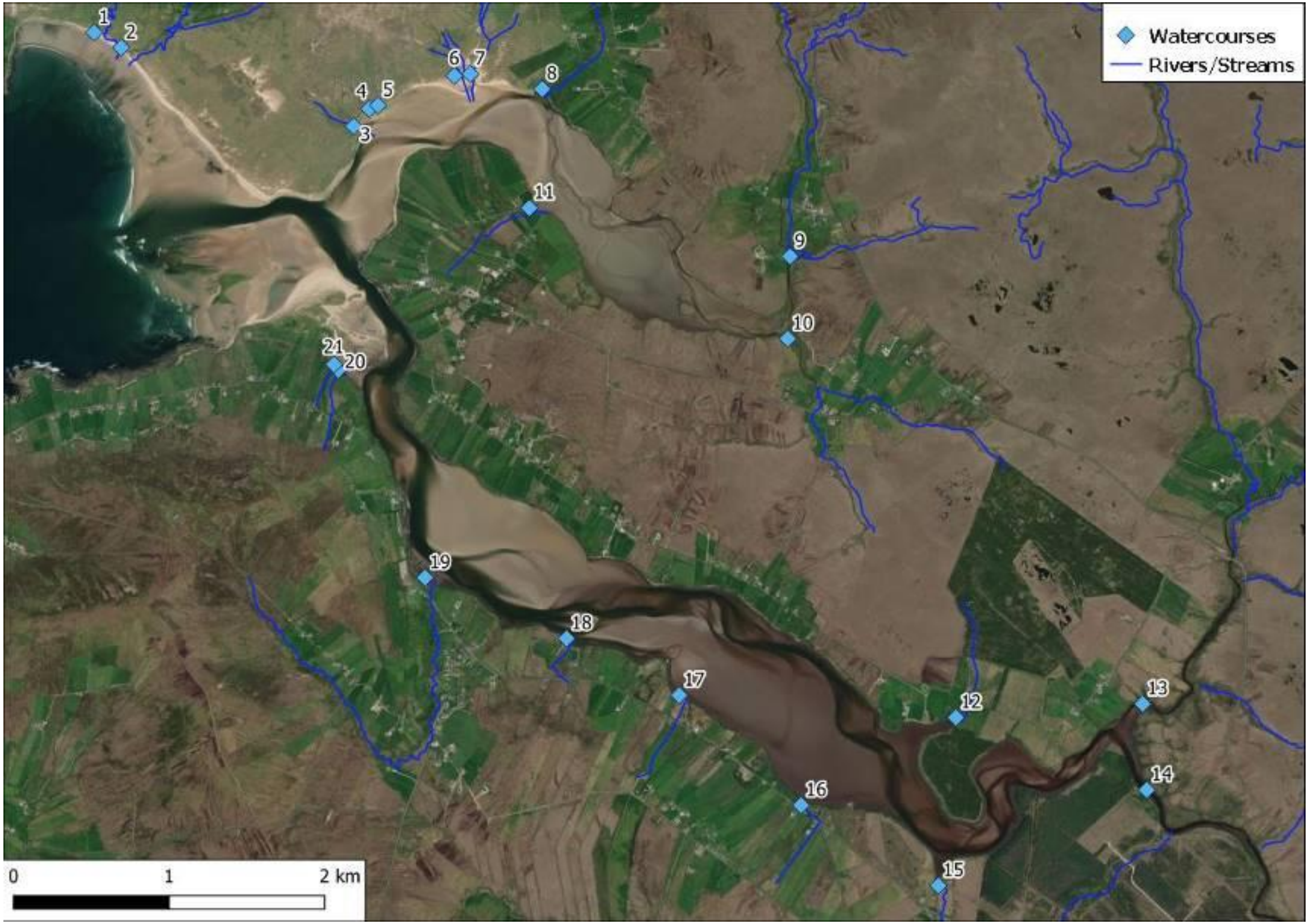

Figure 6.35: Location of all watercourses discharging into Sruwaddacon Bay.

Table 6.9: Cross-referenced table for Figure 6.35 Watercourses.

Map ID	Watercourse
1	Unnamed stream
2	Unnamed stream
3	Unnamed stream
4	Unnamed stream
5	Unnamed stream
6	Unnamed stream
7	Unnamed stream
8	Unnamed stream
9	Gweedaney River
10	Unnamed stream
11	Unnamed stream
12	Unnamed stream
13	Muingnabo River
14	Glenamoy River
15	Unnamed stream
16	Unnamed stream
17	Unnamed stream
18	Unnamed stream
19	Unnamed stream
20	Unnamed stream
21	Unnamed stream

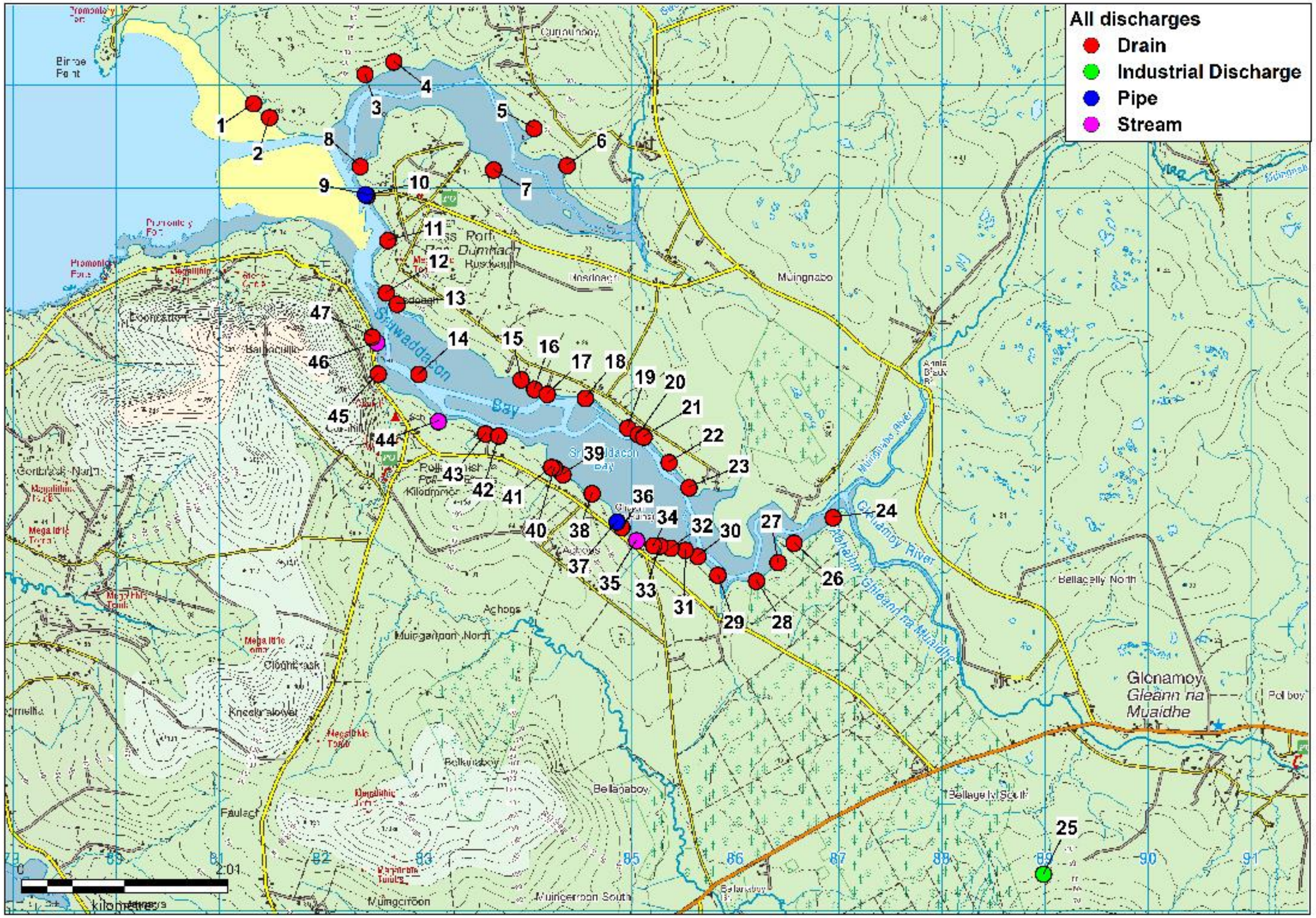

Figure 6.36: Locations of all discharges within Sruwaddacon Bay Catchment Area.

Table 6.10: Cross-referenced table for Figure 6.36 Discharges.

Map ID	Discharge	Description	Latitude	Longitude	Easting	Northing
1	Drain	Natural drain through sand dunes	54.29347	-9.82333	81327.0	339828.8
2	Drain	Natural drain through sand dunes	54.29229	-9.82093	81479.8	339693.4
3	Drain	Natural drain through sand dunes	54.29628	-9.80688	82406.0	340113.9
4	Drain	Natural drain through sand dunes	54.29743	-9.80264	82685.3	340234.9
5	Drain (x 2)	Good flow from both	54.29195	-9.78154	84043.5	339590.1
6	Drain	Good flow	54.28878	-9.77650	84362.7	339229.0
7	Drain	Flowing off hill, mixed rough grazing. Field drain.	54.28824	-9.78739	83652.1	339186.8
8	Drain	Field drain, flowing. Through pasture with cows.	54.28824	-9.80725	82359.0	339219.7
9	Pipe	Concrete pipe alongside pier, some discolouration	54.28581	-9.80637	82409.3	338947.8
10	Drain	Drain flowing alongside left hand side of pier from concrete culvert	54.28572	-9.80611	82426.0	338937.4
11	Drain	Field drain, flowing.	54.28187	-9.80285	82627.3	338503.4
12	Drain	Field drain, flowing.	54.27730	-9.80291	82610.4	337994.9
13	Drain	Field drain, flowing.	54.27635	-9.80124	82716.5	337886.4
14	Drain	Large field drain, flowing.	54.27029	-9.79776	82926.0	337206.2
15	Drain	Field drain, flowing.	54.27005	-9.78254	83916.8	337154.3
16	Drain	Field drain, flowing.	54.26923	-9.78048	84048.7	337059.7
17	Drain	Drain, concrete structure below dwelling house	54.26883	-9.77859	84170.7	337012.0
18	Drain	Field drain, flowing.	54.26856	-9.77290	84540.6	336972.7
19	Drain	Field drain, flowing.	54.26607	-9.76647	84952.5	336685.0
20	Drain	Field drain, flowing.	54.26552	-9.76492	85052.0	336621.3
21	Drain	Field drain, flowing.	54.26532	-9.76407	85106.8	336597.6
22	Drain	Field drain, flowing.	54.26316	-9.76023	85351.0	336351.0
23	Drain	Field drain, flowing.	54.26102	-9.75716	85545.1	336107.8
24	Drain	Field drain, through forestry and bog	54.25872	-9.73562	86942.3	335817.1

Map ID	Discharge	Description	Latitude	Longitude	Easting	Northing
25	Industrial discharge	Surface water runoff from industrial facility.	54.22813	-9.70310	88980.0	332363.0
26	Drain	Field drain, through forestry and bog	54.25642	-9.74133	86563.9	335570.3
27	Drain	Field drain, through forestry and bog	54.25470	-9.74365	86408.0	335382.6
28	Drain	Field drain	54.25303	-9.74679	86198.8	335201.8
29	Drain	Field drain, flowing through heath/bog	54.25345	-9.75254	85825.2	335257.8
30	Drain	Field drain, flowing through heath/bog	54.25506	-9.75559	85630.9	335442.0
31	Drain	Field drain, flowing through rough grazing land	54.25556	-9.75747	85509.8	335500.7
32	Drain	Field drain, flowing through rough grazing land	54.25571	-9.75961	85370.7	335520.8
33	Drain	Field drain, flowing through rough grazing land	54.25586	-9.76127	85263.0	335540.2
34	Drain	Field drain, flowing through rough grazing land	54.25590	-9.76221	85201.8	335546.2
35	Stream	Field drain, flowing through rough grazing land	54.25630	-9.76476	85036.8	335594.9
36	Drain	Field drain, flowing through rough grazing land	54.25740	-9.76699	84894.5	335720.9
37	Pipe	Grey pipe, not flowing. Not possible to identify origin	54.25787	-9.76773	84847.6	335774.4
38	Drain	Field drain, flowing through rough grazing land	54.26028	-9.77153	84606.7	336048.9
39	Drain	Field drain, flowing through rough grazing land	54.26187	-9.77594	84323.8	336233.1
40	Drain	Field drain, flowing through rough grazing land	54.26243	-9.77723	84241.3	336297.5
41	Drain	Field drain, flowing through rough grazing land	54.26248	-9.77767	84212.8	336303.8
42	Drain	Field drain.	54.26510	-9.78563	83701.6	336608.5
43	Drain	Field drain.	54.26526	-9.78760	83573.7	336629.5
44	Stream	Stream flowing through rough grazing land. Good flow.	54.26622	-9.79466	83116.4	336748.1
45	Drain	Flowing off high bank beside road. Likely field rain related.	54.27022	-9.80377	82534.3	337208.4
46	Stream	Stream flowing of steep hill, sheep on pasture above.	54.27296	-9.80408	82521.9	337513.8
47	Drain	Field drain from hill above	54.27343	-9.80483	82474.4	337567.4

7. Appendix 2: Hydrography/Hydrodynamics

7.1. Simple/Complex Models

An oceanographic survey of Sruwaddacon Bay was carried out by Wilson (2007) for the Shell gas pipeline. A model of tidal flow was produced as part of this. The results of this model have been used to describe the hydrodynamics of Sruwaddacon Bay below.

7.2. Depth

Sruwaddacon Bay is a narrow bay made up mostly of sandflats with a deeper channel running the length of the bay. Starting from the inner end of the bay, the channel runs along the northern side of the bay up until about halfway where is travels westward to the southern side of the bay and follows this shoreline until it reaches the mouth of the bay. The bay is completely intertidal apart from this channel. Depths in the channel range from 0 to 5m at low water, with most of the channel less than 2m deep (Wilson, 2007). Figure 7.1 shows water depth in the area.

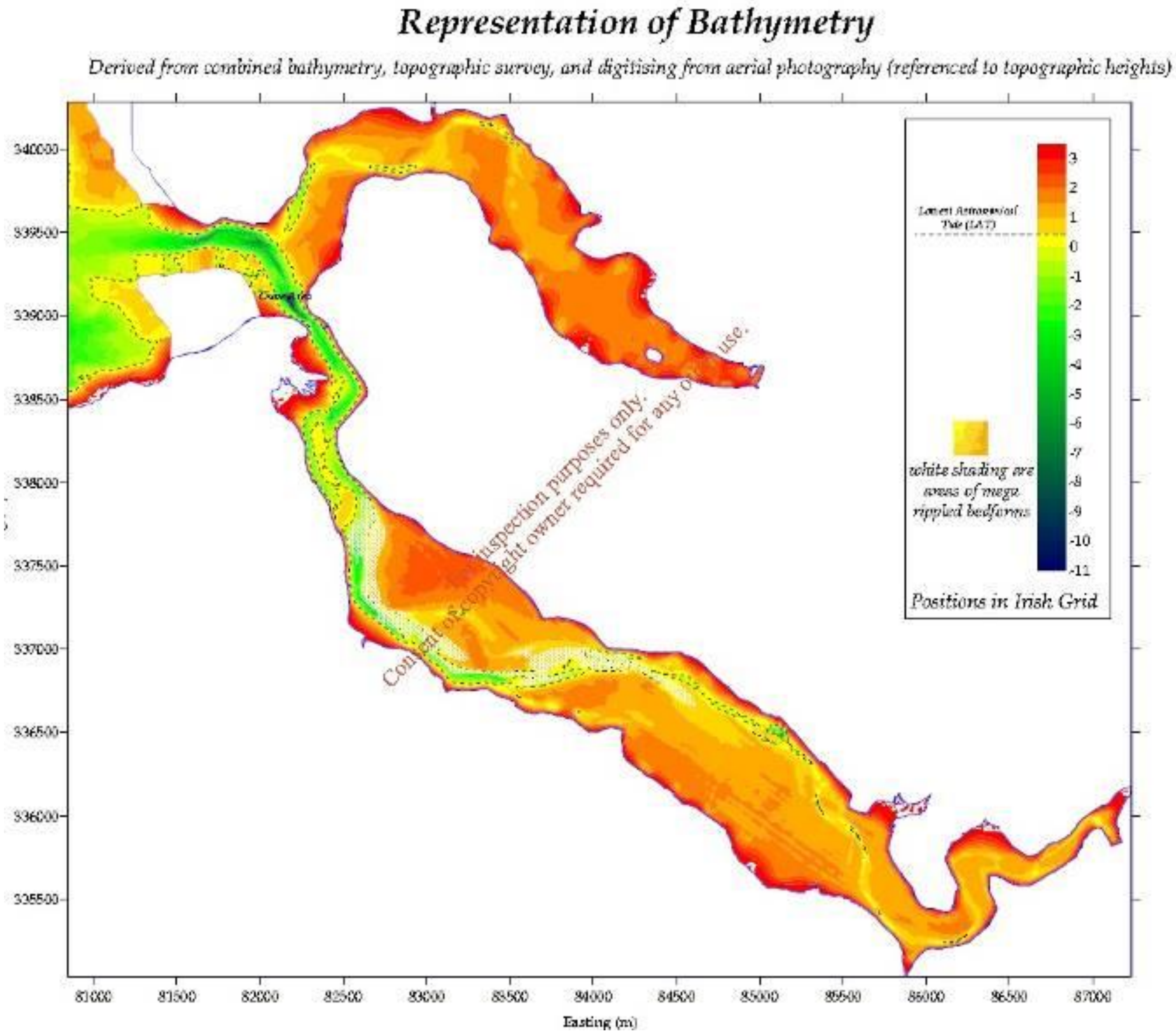

Figure 7.1: Sruwaddacon Bay Bathymetry (Sourced: Wilson, 2007).

7.3. Tides & Currents

The measured spring tidal ranges in Sruwaddacon Bay varied from 3.5m at the mouth of the bay to 2.9 m at the inner part of the bay (Wilson, 2007). Wilson (2007) found that the maximum depth averaged velocity was 1.22m/s at the mouth of the bay, with a mean velocity of 0.56m/s. The maximum depth averaged velocity was 1.0m/s approximately half way into the bay, with a mean velocity of 0.37m/s. The maximum depth averaged velocity in the inner part of the bay was 0.60m/s, with a mean velocity of 0.23m/s. A model of the tidal flow showed that currents are highest in the channel particularly at the constricted mouth of the bay (Wilson, 2007). Figure 7.2 and Figure 7.3 show the model outputs from the tidal flow model from Highwater + 0 hours to high water +12 hours. It can be seen by these diagrams that most of the water movement follows the channel.

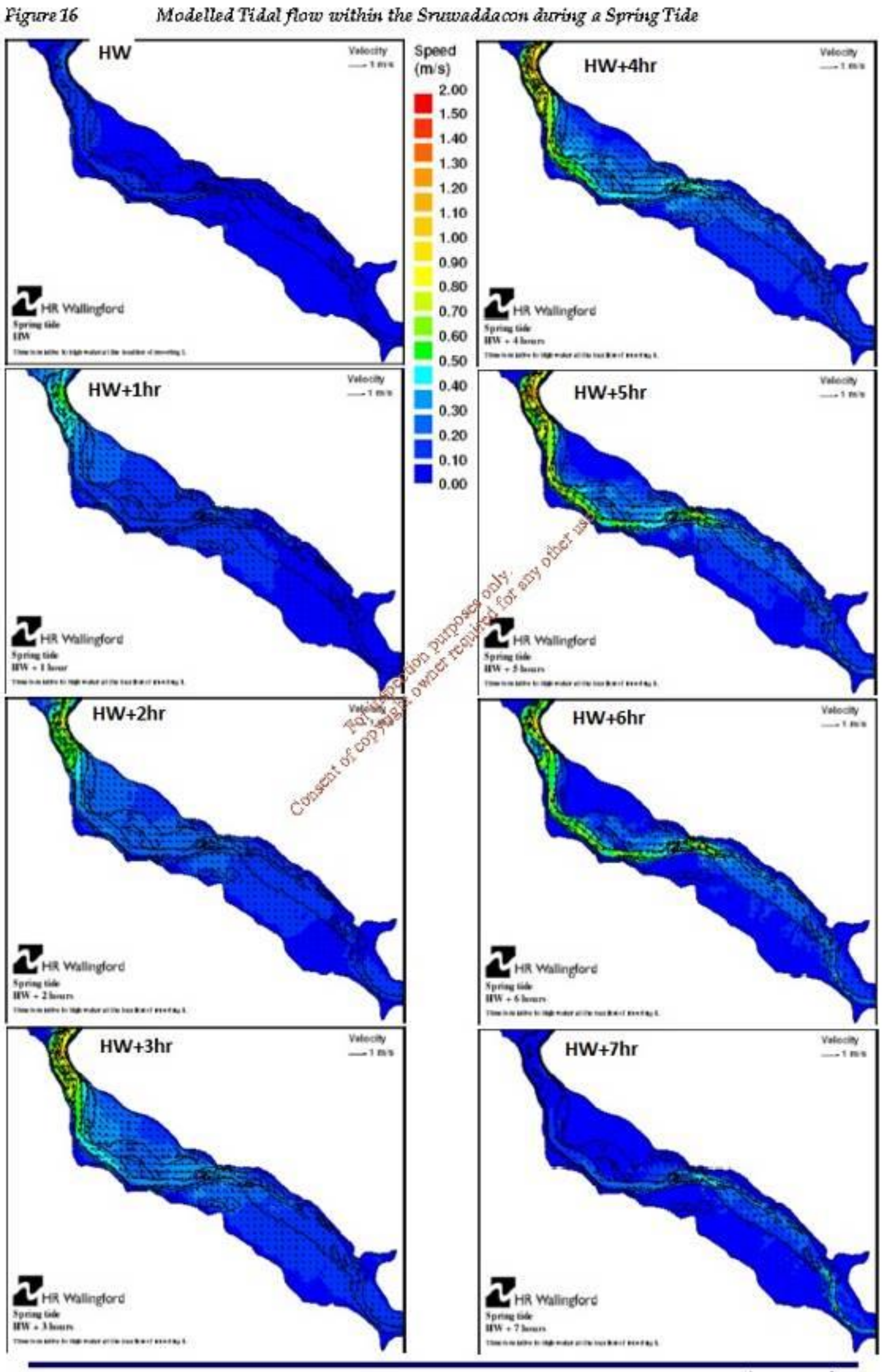

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Figure 7.2: Predicted Sruwaddacon Bay tidal flow patterns High water (HW) +0 hours to +7 hours (Wilson, 2007).

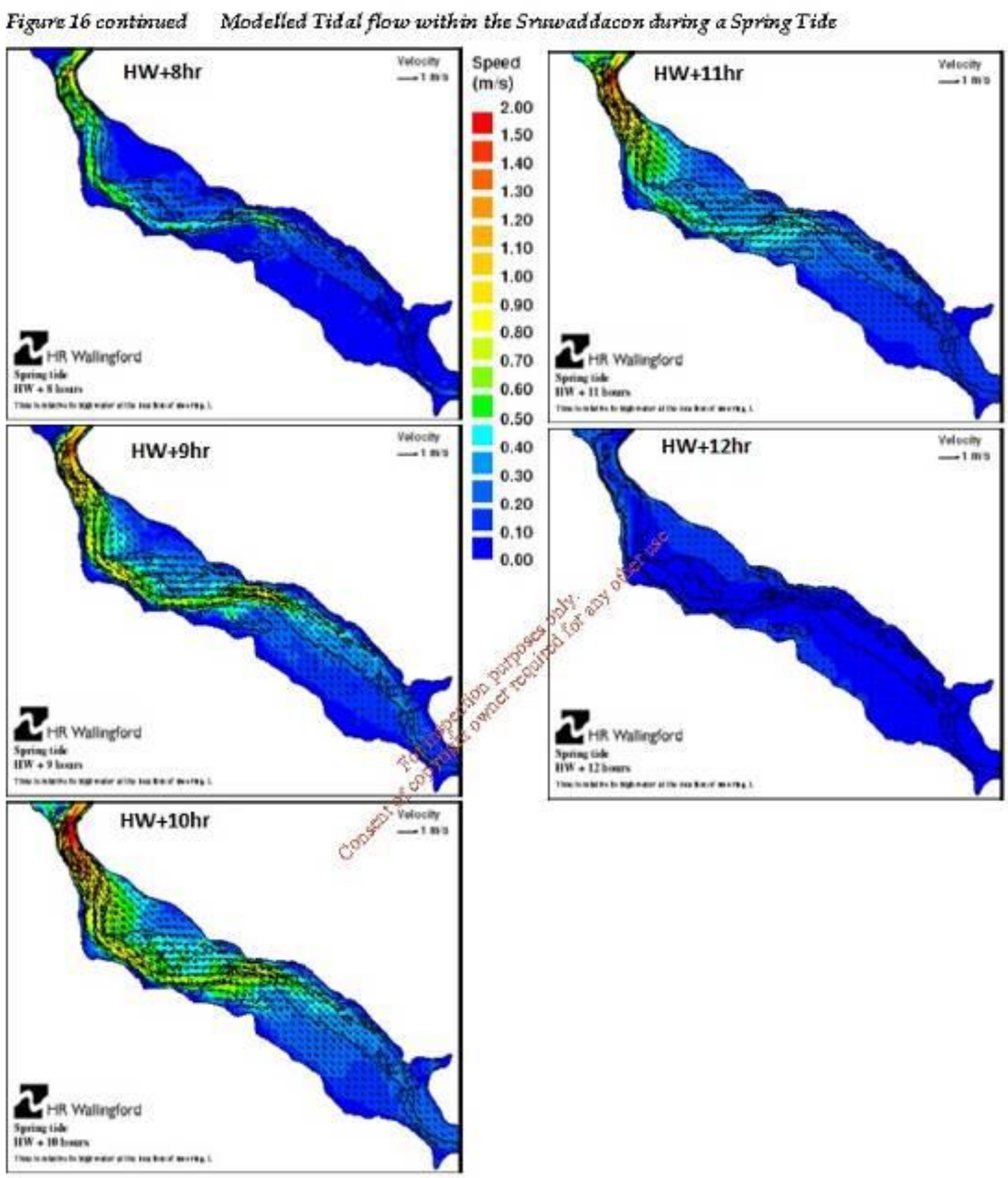

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Figure 7.3: Predicted Sruwaddacon Bay tidal flow patterns High water (HW) +8 hours to +12 hours (Wilson, 2007).

7.4. Wind and Waves

Wind data from 2016 to 2020 from the Belmullet station (Met Eireann, 2021a) are displayed in Table 7.1 below and wind roses for each year can be seen in Figure 7.4.

In 2016, 19.9% of the wind came from the south, 17.7% came from the southwest and 17% came from the west. The strongest winds (43kn) came from the south. In 2017, 22.7% of the winds came from the southwest, with 19.5% coming from the west and 18.6% coming from the south. The strongest winds (36kn) came from the northwest. In 2018, 21.4% of the wind came from the southwest, 18.5% came from the south and 18% came from the west. The strongest winds (45kn) came from the south. In 2019, 18.8% of the wind came from the southwest, 16.9% came from the west and 16.4% came from the south. The strongest winds (62kn) came from the south. In 2020, 22.3% of the wind came from the southwest, 18.9% came from the west and 15.9% came from the south. The strongest winds (67kn) came from the south. It can be seen from the 2016-2020 wind rose diagram that the prevailing wind direction is southwest.

Table 7.2 shows the seasonal averages from 2016 to 2020. Seasons were selected by grouping the results from the following periods: spring (March-May), summer (June-August), autumn (September-November) and winter (December-February). Seasonal averages over the past 5 years indicate that winds are typically strongest in the winter months (14.1kn), followed by autumn (12.1kn) and spring (11.5kn), with 10.7kn in summer.

Table 7.1: Wind speed and direction data for Belmullet from 2016-2020 (Source: Met Eireann, 2021a).

	2016		2017		2018		2019		2020	
Month	Mean Speed (knots)	Max 10-min Mean Direction (°)	Mean Speed (knots)	Max 10-min Mean Direction (°)	Mean Speed (knots)	Max 10-min Mean Direction (°)	Mean Speed (knots)	Max 10-min Mean Direction (°)	Mean Speed (knots)	Max 10-min Mean Direction (°)
January	13.7	187.4	12.7	183.5	14.7	212.9	11.0	221.6	17.3	214.5
February	13.3	180.0	13.4	180.7	13.0	179.0	15.8	201.8	17.9	228.6
March	12.0	185.2	12.3	163.5	10.4	159.4	14.5	219.0	14.3	171.3
April	11.1	118.3	10.4	222.3	12.3	152.0	11.8	164.3	9.7	140.3
May	10.5	110.0	10.2	172.3	12.9	142.9	9.0	180.6	11.8	149.4
June	9.7	176.0	13.1	181.0	8.9	133.0	11.5	167.7	11.3	145.7
July	10.4	212.9	10.2	178.4	9.9	167.1	10.3	197.7	10.4	215.2
August	12.2	198.4	10.6	229.4	10.6	211.6	11.8	191.0	10.2	144.2
September	14.2	180.3	12.2	211.0	12.4	205.7	10.7	211.3	11.6	191.0
October	9.2	146.8	14.0	221.3	13.7	217.7	12.4	179.0	12.9	197.1
November	10.4	172.3	11.6	224.0	13.7	163.7	9.5	141.3	12.5	213.3
December	15.2	184.2	12.7	211.3	13.0	192.3	14.2	209.4	13.4	212.6

Degrees Direction Key: 0°/360° = N; 23° = NNE; 45° = NE; 68° = ENE; 90° = N; 113° = ESE; 135° = SE; 158° = SSE; 180° = S; 203° = SSW; 225° = SW; 248° = WSW; 270° = W; 293° = WNW; 315° = NW; 338° = NNW

Table 7.2: Seasonal averages (knots) for Belmullet wind data (Source: Met Eireann, 2021a).

Season	2016	2017	2018	2019	2020	5 Year Average
Winter	14.1	12.9	13.6	13.7	16.2	14.1
Spring	11.2	11.0	11.9	11.8	12.0	11.5
Summer	10.7	11.3	9.8	11.2	10.6	10.7
Autumn	11.3	12.6	13.2	10.9	12.3	12.1

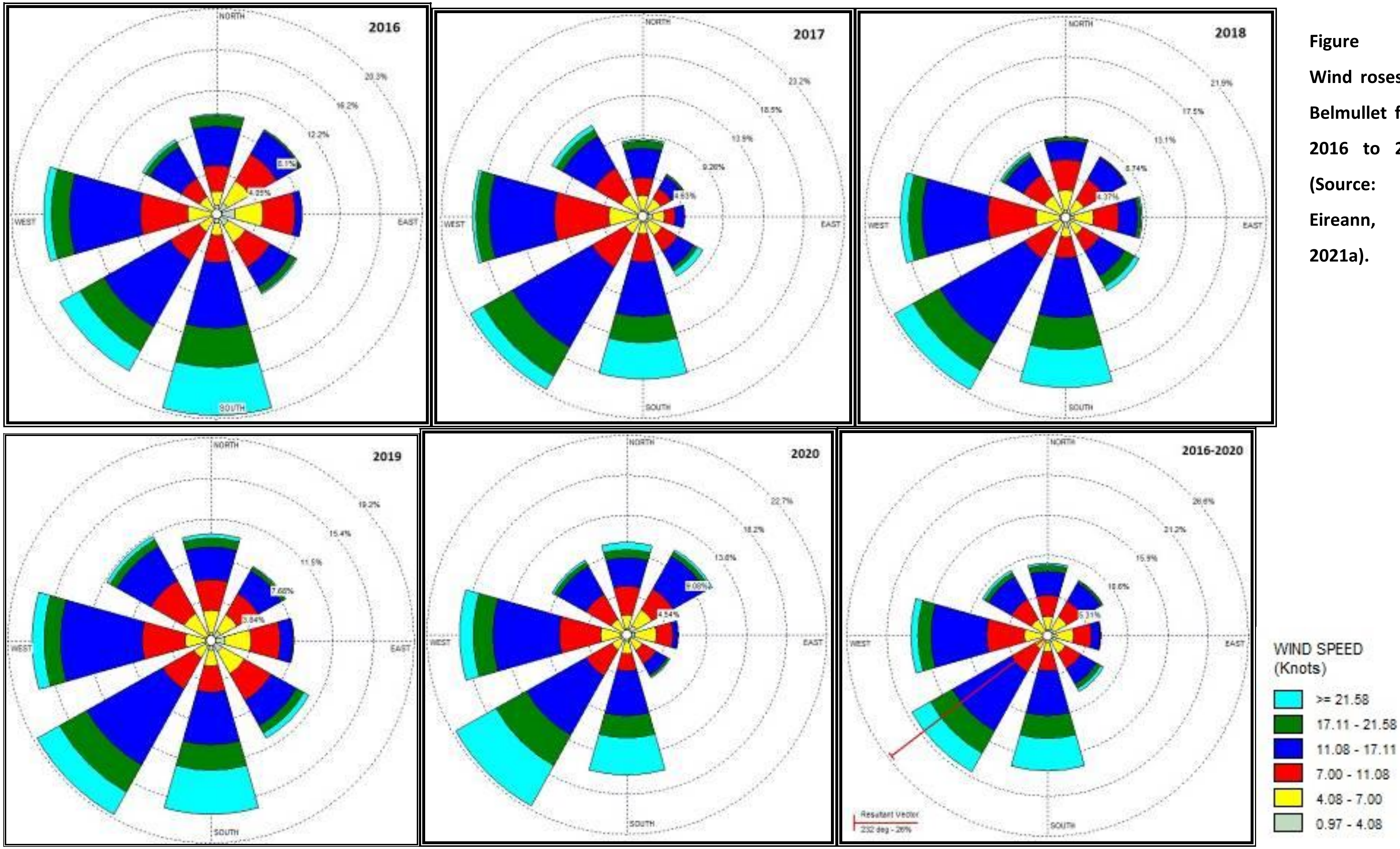

Figure 7.4: Wind roses for Belmullet from 2016 to 2020 (Source: Met Eireann, 2021a).

Wind conditions affect the hydrodynamic conditions in Sruwaddacon Bay by generating wind-induced currents and waves. Of these phenomena, wind-induced waves are an important factor in the process of sediment resuspension and transport. Wind waves are produced by the local prevailing wind. They travel in the direction of the prevailing wind, *i.e.* a southwesterly wind will produce northeasterly moving waves. The height of wind waves depends on:

- the strength of the wind,
- the time the wind has been blowing and
- the fetch.

7.5. River Discharges

Sruwaddacon Bay drains a catchment of 177.5km^2, the catchment is dominated by two rivers which drain 75.9% of the catchment the Glenamoy River (50.1%) and the Muingnabo River (25.8%). The catchment on the southern side of the bay is drained by a series of small streams. Curraunboy Bay is the smaller bay just north of Sruwaddacon Bay. As the mouths of these bays join before entering Broad Haven Bay the catchment of Curraunboy Bay was assessed as part of Sruwaddacon catchment. The Gweedaney River is the main river flowing into Curraunboy Bay and accounts for 10.8% of the entire Sruwaddacon Catchment for the purposes of this study. The remainder of Curraunboy is drained by small streams (Figure 7.5). The mean flow of the Glenamoy River over the last year was 4.57m^3/s and the max flow was 29.8 m^3/s (EPA, 2020). As can be seen in Figure 7.7 the Glenamoy is a spate river with river flow increasing quickly during high rainfall and the dropping off soon after it stops.

The current (2010-2015) WFD status of Sruwaddacon Bay and its associated freshwater sources can be seen in Figure 7.6. Of the river systems flowing directly into the Sruwaddacon Bay BMPA, the Glenaboy River is of Good status, although its upper reaches are of High status. The Muingnabo River is also of Good status and the Gweedaney River is of Moderate status. One small stream flowing into Sruwaddacon Bay is of Good status and three streams flowing into Curraunboy Bay are of Moderate status. The remaining small streams flowing directly into the bay are unassigned. Sruwaddacon Bay Transitional waterbody (TWB) is of High status.

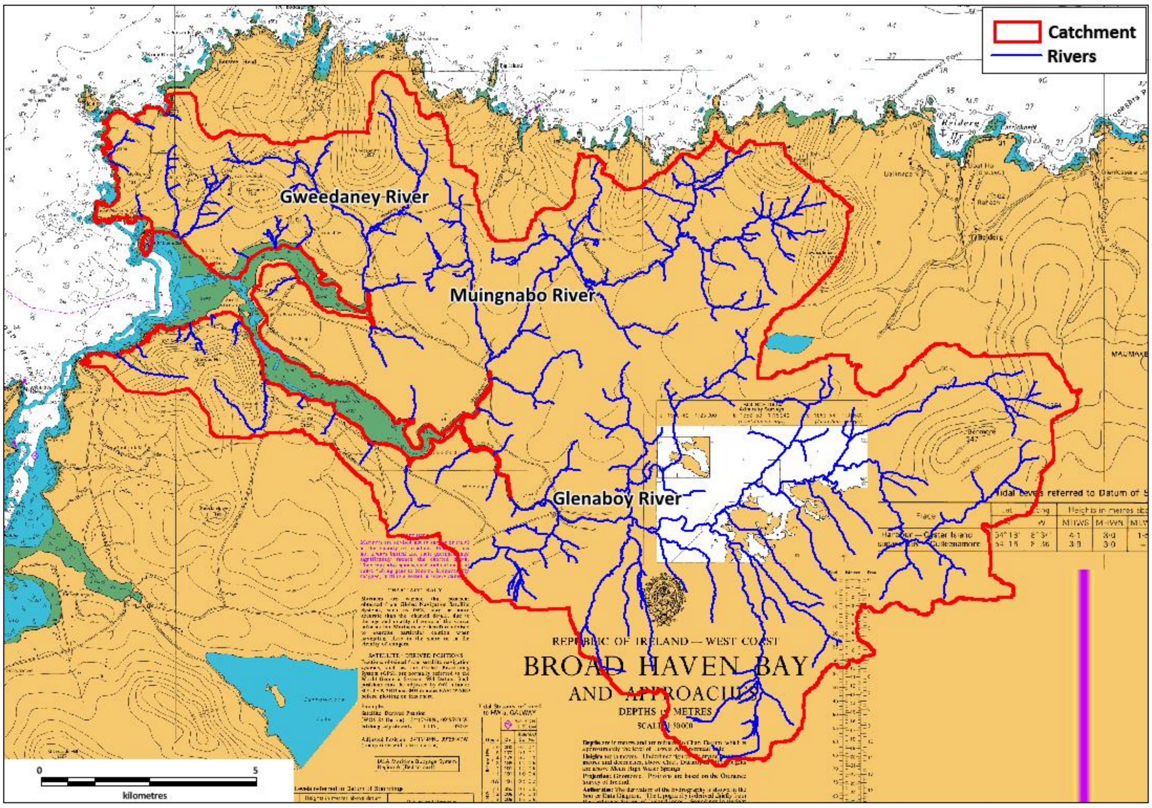

Figure 7.5: Rivers in the Sruwaddacon Bay catchment area (Source: EPA, 2019).

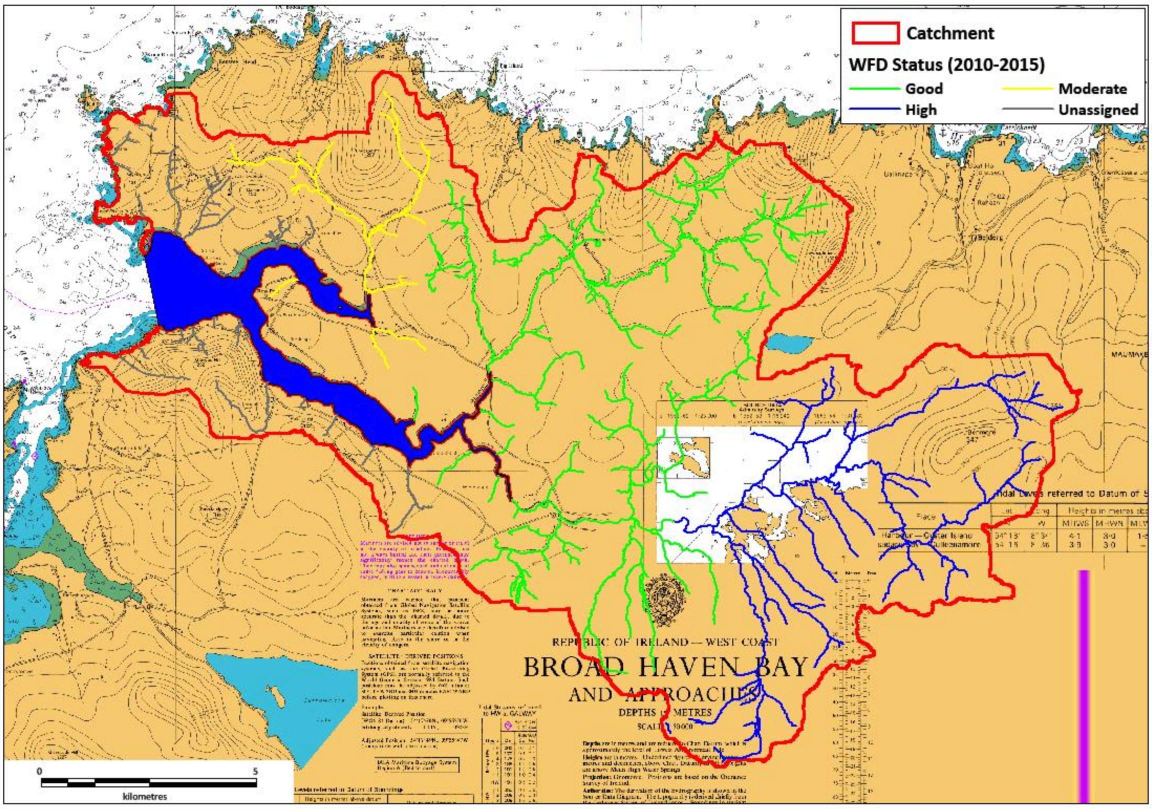

Figure 7.6: WFD Status of the coastal and river waterbodies in the catchment area (Source EPA, 2019).

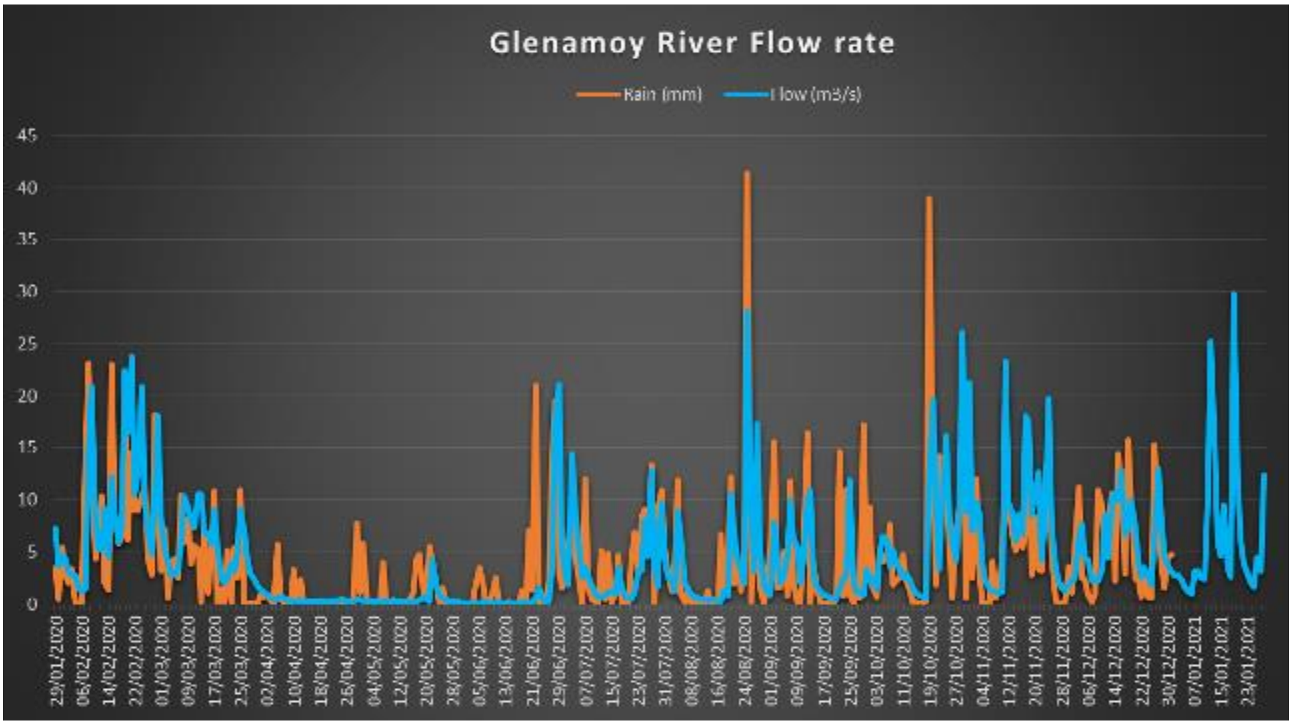

Figure 7.7: Glenamoy River flow (EPA, 2020; Met Eireann, 2021a).

7.6. Rainfall Data

7.6.1. Amount & Time of Year

Figure 7.8 shows the average monthly rainfall data for Ireland (Met Eireann, 2019a) from 1981 to 2010. The wettest months in the Sruwaddacon Bay region over this 30-year period were October to January with the driest months from April to July. Table 7.3 shows the 30-year average monthly rainfall at the Belmullet station which is located at the northern end of the Sruwaddacon Bay production area (Figure 7.9 shows the location of the Belmullet station). During the period 1981 to 2010, average rainfall at Belmullet was lowest in May (70.4mm) and highest in October (145.9mm). The greatest daily total ranged from a low of 25.6 in March to a high of 79.6mm in October. Table 7.4 shows the seasonal averages at Belmullet from 1981 to 2010. Lowest average rainfall over the 30 year period was in spring (80.5mm) with the highest average rainfall experienced in autumn (127.2mm).

Table 7.3: Monthly average rainfall at Belmullet from 1981 to 2010 (Source: Met Eireann, 2019a).

Average Rainfall (mm)	Month	Greatest Daily Total (mm)
134.0	January	44.7
97.1	February	31.3
99.2	March	25.6
72.0	April	25.9
70.4	May	42.2
72.1	June	38.9
79.0	July	33.2
101.9	August	49.5
101.8	September	62.6
145.9	October	79.6
134.0	November	43.0
137.4	December	41.7
1244.8	Year	79.6

Table 7.4: Average seasonal rainfall values (mm) from 1981-2010 at Belmullet (Source: Met Eireann, 2019b).

Season	Average
Spring	80.5
Summer	84.3
Autumn	127.2
Winter	122.8

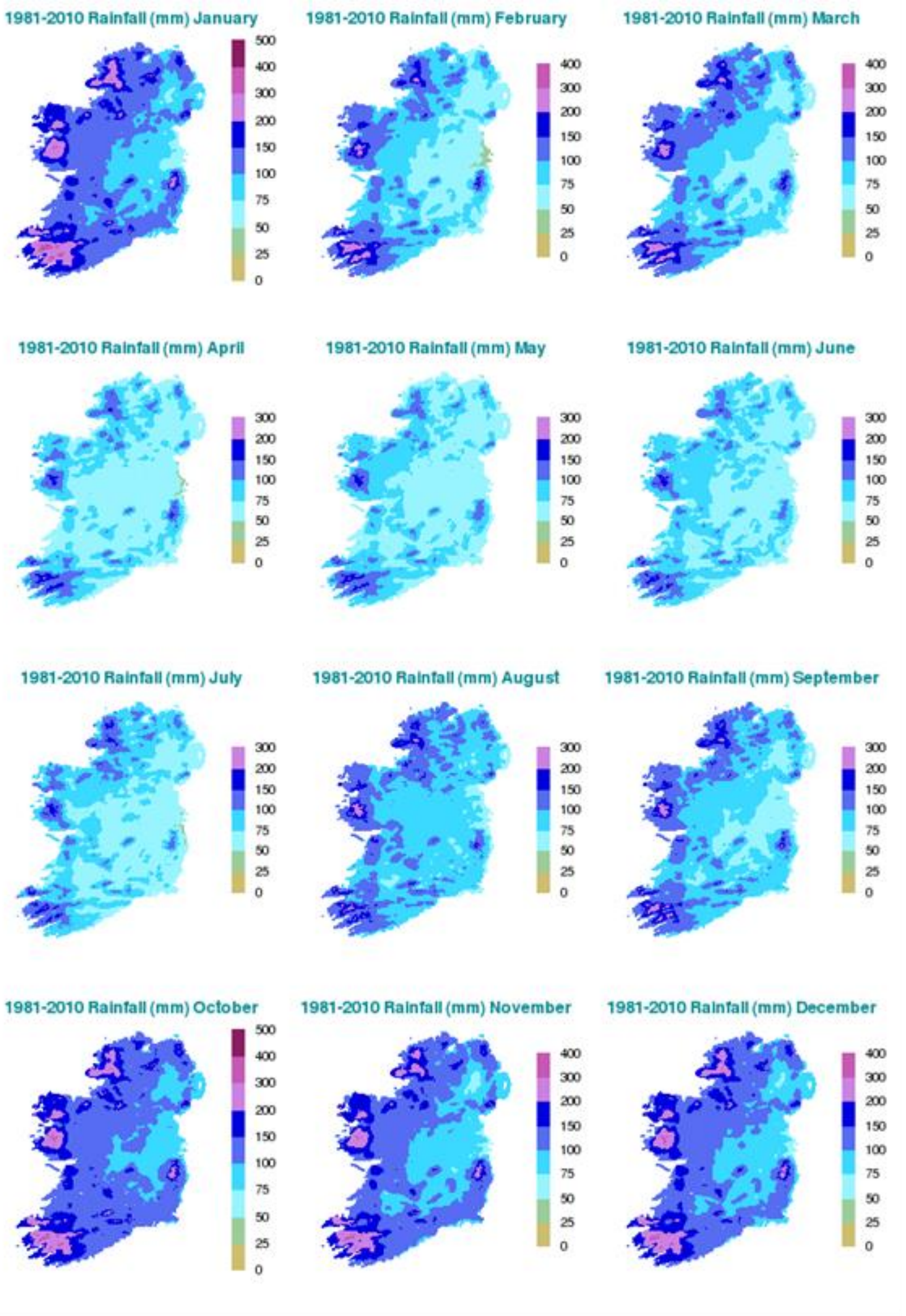

Figure 7.8 Average monthly rainfall (mm) data from 1981 to 2010 for Ireland (Source: Met Eireann, 2019a).

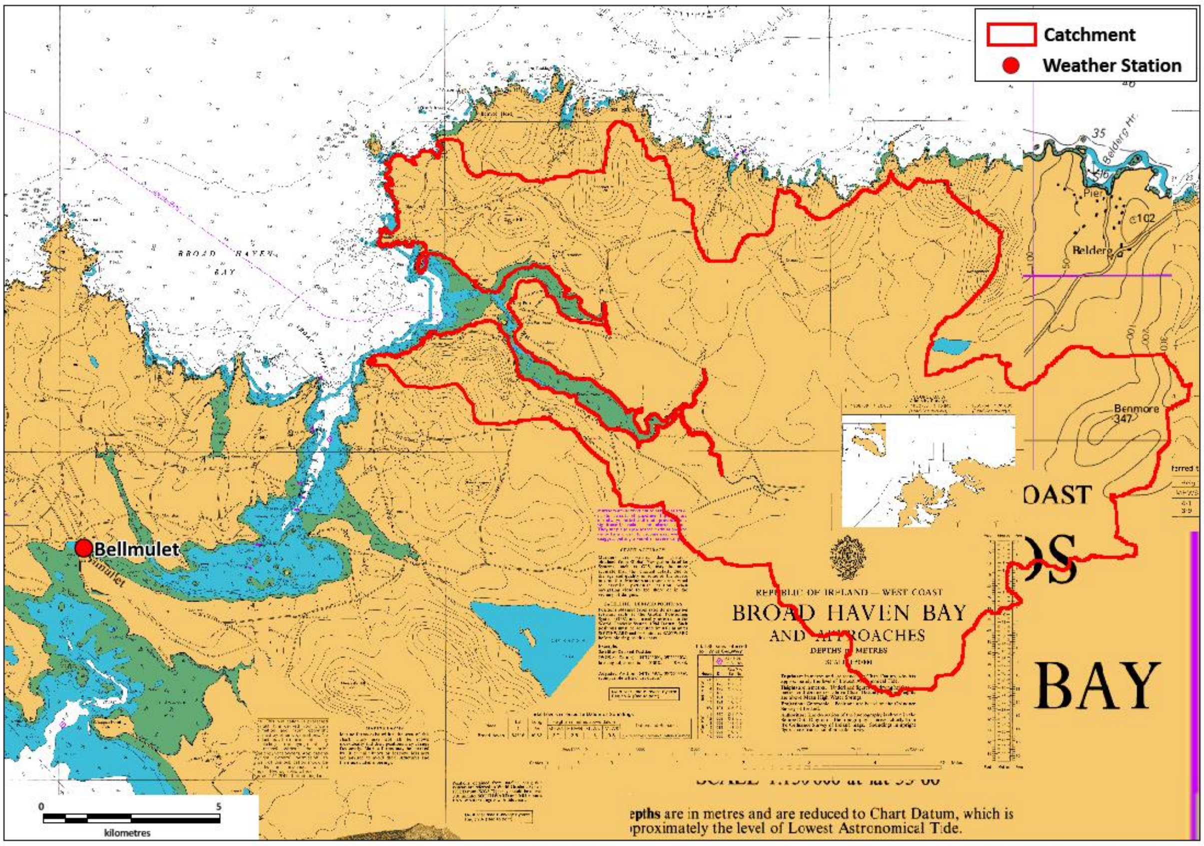

Figure 7.9: Location of Met Eireann weather stations in relation to the Sruwaddacon Bay production area.

Table 7.5 shows total monthly rainfall at the Belmullet Met Eireann station (see Figure 7.9), located approximately 11.5km west of Sruwaddacon Bay from 2016 to 2020 (Met Eireann, 2021a).

Belmullet weather station is located in Belmullet town to the west of Sruwaddacon Bay. Maximum monthly rainfall was in January 2018 (228.3mm) and the lowest monthly rainfall was April 2020 (23.6mm). The 5-year average monthly rainfall ranged from a low of 51.9mm in May to a high of 153.6 mm in February. Annual averages ranged from 99.0mm in 2016 to 126.1mm in 2020.

Table 7.6 shows the total seasonal rainfall at Belmullet from 2016-2020 (Met Eireann, 2021a). The following seasonal fluctuations were observed from 2016-2020: In 2016, summer was the driest season and winter was the wettest, in 2017 spring was the driest and autumn was the wettest. In 2018, summer was the driest and winter was the wettest. In 2019, summer was the driest and winter was the wettest and in 2020 spring was the driest and winter was the wettest. Over the five years spring 2020 was the driest season and winter 2020 was the wettest season.

Table 7.5: Total monthly rainfall (mm) data at Belmullet, Co. Mayo, from 2016 to 2020 (Source: Met Eireann,

2021a).

Year	2016	2017	2018	2019	2020	Monthly 5-yr Average
Jan	189.1	60.0	228.3	92.7	120.1	138.0
Feb	171.6	110.6	123.6	120.2	241.9	153.6
Mar	98.4	108.8	87.4	151.3	111.0	111.4
Apr	57.8	25.2	81.4	84.7	23.6	54.5
May	49.3	49.6	67.4	57.5	35.7	51.9
Jun	100.0	97.6	40.1	86.6	82.7	81.4
Jul	99.3	98.7	64.6	101.0	133.3	99.4
Aug	56.2	134.3	135.2	160.8	121.7	121.6
Sep	145.8	139.6	93.9	104.8	122.1	121.2
Oct	47.8	131.6	135.1	117.1	191.8	124.7
Nov	89.2	143.6	147.5	139.4	156.2	135.2
Dec	83.8	143.5	152.3	150.3	172.6	140.5
Annual Average	99.0	103.6	113.1	113.9	126.1	

Table 7.6: Total seasonal rainfall (mm) at Belmullet from 2016-2020 (Source: Met Eireann, 2021a).

Station	Season/Year	2016	2017	2018	2019	2020
Belmullet	Spring	327.8	244.6	292.4	293.5	170.3
	Summer	248.6	245.9	172.1	348.4	337.7
	Autumn	249.8	405.5	364.2	361.3	470.1
	Winter	362.1	347.1	528.1	363.2	534.6

7.6.2. Frequency of Significant Rainfalls

Figure 7.10 shows the average monthly rainfall at Belmullet from 1981-2010 and Figure 7.11 shows the 5 year monthly average rainfall at Belmullet weather station from 2016-2020. Over the 30-year period from 1981 to 2010, October was the wettest month followed closely by December and then November and January. Over this period, October followed by September had the greatest daily rainfall. Over the past 5 years at Belmullet, February has been the wettest month followed by January, December and November. May was the driest month followed by April and June.

For the 5-year 2016-2020 period, average daily rainfall at Belmullet was 3.6mm, with a maximum of 41.4mm. Over the same period, the number of wet days (rainfall >1mm) a month averaged at 17.5 with the maximum number of 27 days/month.

Met Eireann has developed a depth duration frequency model for the estimation of point rainfall frequencies (Fitzgerald, 2007; Met Eireann, 2021b). For a 1 in 100 year return period, 40.4 mm of rain would be expected over 1 hour and 107.0 mm over 24 hours. Whiles these would be extreme uncommon events, the model predicts that once a year 11.5mm would fall in 1 hour and 38.8mm over a 24 hour period.

Increased faecal contamination of coastal waters is typically associated with high rainfall and storm events through surface water run-off from livestock or other animals present and through sewer and waste water treatment plant overflows (Mallin *et al.,* 2001; Lee & Morgan, 2003). It is therefore expected that run-off due to rainfall will be higher during the October to February period. However, as can be seen in the rainfall data in Table 7.3, heavy rainfall events leading to episodes of high run-off can occur in most months of the year and it is therefore not just the winter months that are at risk of increased contamination. When these occur during generally drier periods in spring and summer months, they are likely to carry higher loadings of faecal material which has accumulated on pastures where greater numbers of livestock are present.

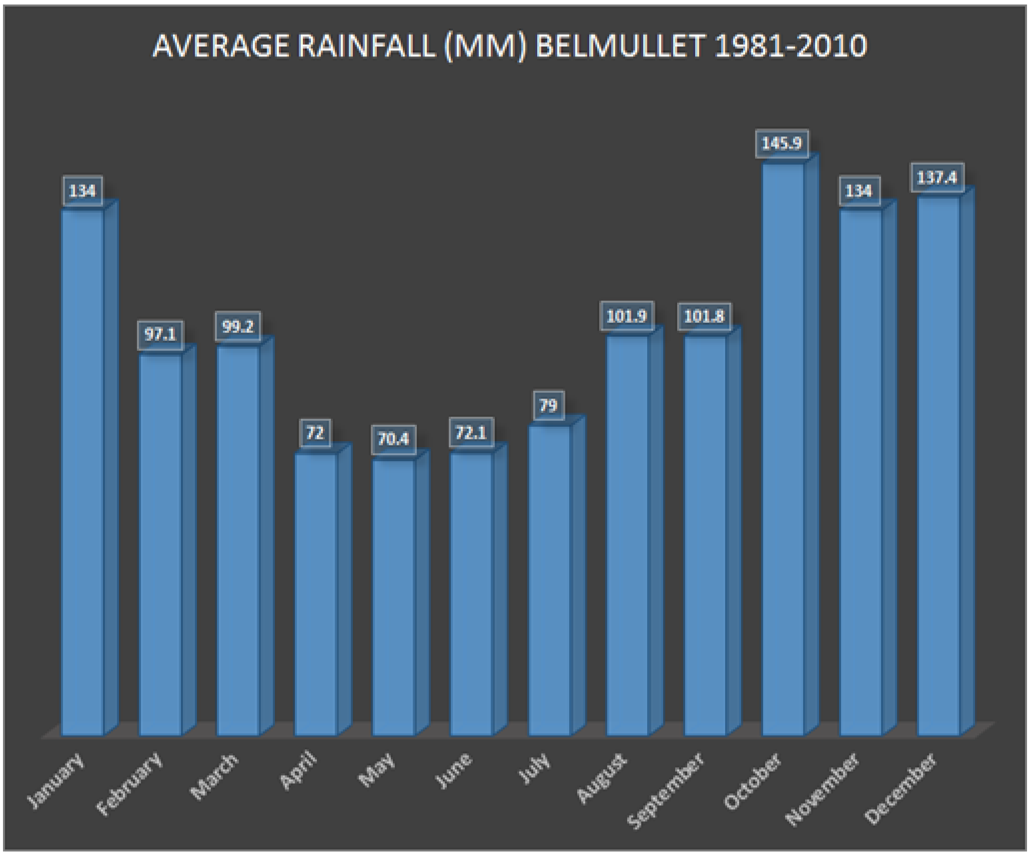

Figure 7.10: Average monthly rainfall (mm) at Belmullet from 1981-2010 (Source: Met Eireann, 2019b).

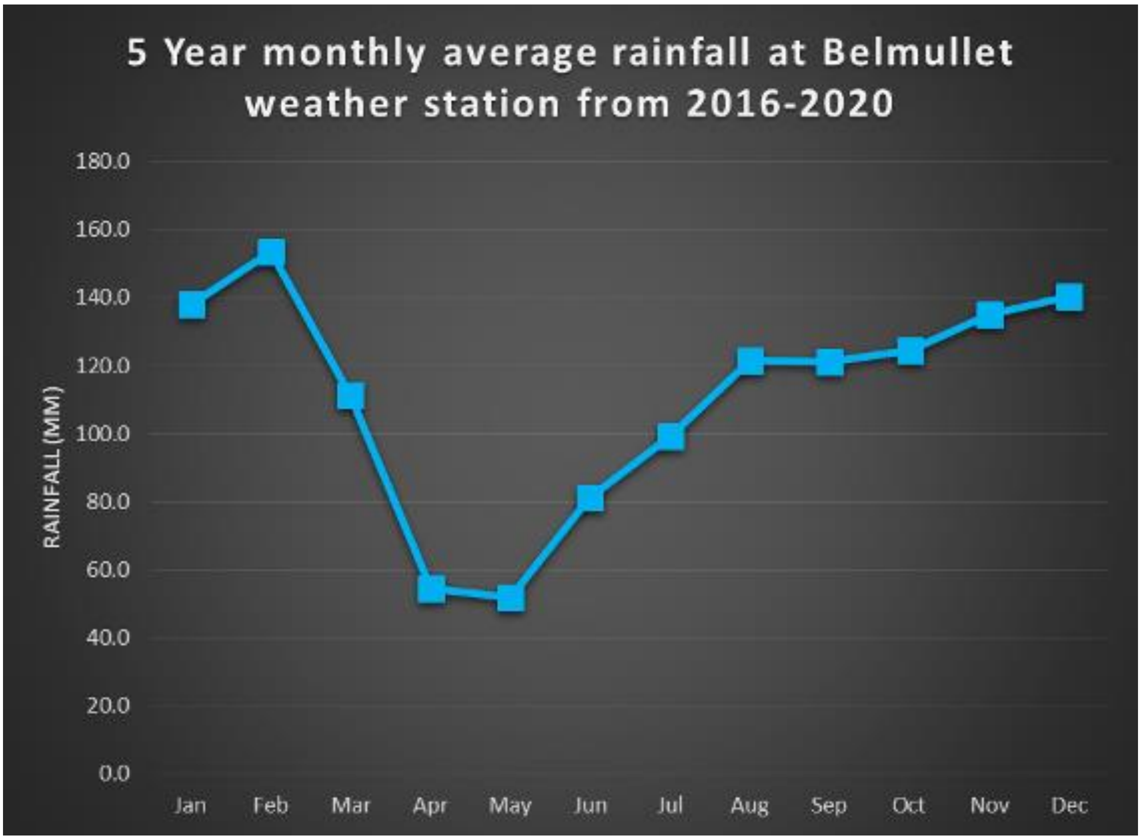

Figure 7.11: 5 year monthly average rainfall (mm) at Belmullet weather station from 2016-2020 (Source: Met Eireann, 2021a).

7.7. Salinity

Wilson (2007) recorded the off bottom salinity in Sruwaddacon Bay over 14 days in 2007. Salinity within the bay ranged from 0.1 to 35PSU varying over the tidal cycle. Salinity was highest at the mouth of the bay and lowest at the start of the Glenaboy River. Salinity at the mouth of the bay ranged from 15 to 35 PSU.

7.8. Turbidity

At the time of writing, no turbidity data were available

7.9. Residence Time

Residence time can be defined as the average amount of time that a molecule of water of a particle spends in a particular system. Residence times are important because of the way they govern productivity rates as well as the vulnerability to water quality degradation. The currents within the bay are dominated by the shallow bathymetry and generally flow parallel to the channel.

At the time of writing, there were no data available on the residence time of Sruwaddacon Bay. However, as the bay is mostly intertidal except for a narrow channel the water in the bay will be flushed out on each tidal cycle. Therefore, the residence time is expected to be less than one day.

7.10. Discussion

Sruwaddacon Bay is a narrow bay made up mostly of sandflats with a deeper channel running the length of the bay. The bay is completely intertidal apart from this channel. Depths in the channel range from 0 to 5m at low water, with most of the channel less than 2m deep. Currents within the bay mostly following the deeper channel. Mean velocity in the bay varies from 0.56 m/s at the mouth of the bay to 0.23 m/s at the inner part of the bay. The Glenamoy is a spate river and so if contamination is present of the surrounding land it will quickly make its way into the bay during high rainfall events. The salinity is quite variable, in the inner bay it can vary from 0.1 to 35 PSU, while at the mouth of the bay it can range from 15 to 35 PSU. This highly variable salinity shows that there is a strong freshwater influence on the bay. The residence time in the bay is expected to be short due the majority of the bay being intertidal.

8. Appendix 3: Shellfish and Water Sampling

8.1. Historical Data

8.1.1. Shellfish Water Quality

The Marine Institute carries out quarterly water quality monitoring as part of the Shellfish Waters Directive in Sruwaddacon Bay. Sampling is confined to the oyster aquaculture area. The EPA carries out monitoring under the Water Framework Directive. However, *E. coli* is not routinely measured under these programmes.

8.1.2. Shellfish Flesh Quality

In accordance with Regulation (EU) 2017/625 and the subsequent implementing regulation (EU) 2017/627 the Sea Fishery Protection Authority is required to classify bivalve mollusc production areas and to fix the boundaries thereof. The process involves regular sampling of shellfish from each area to be classified in order to establish levels of microbiological contamination which subsequently determines which classification should be awarded for that particular area. The SFPA currently do not sample shellfish flesh in Sruwaddacon Bay and no Bivalve Mollusc Production Area exists.

The Regulations stipulate that the competent authority must monitor the levels of E.*coli* within the harvesting area and that according to the sample results, must classify the area as being one of three categories; A, B or C.

An A classification allows for the product to be placed directly on the market, whereas a B or C classification requires the product to go through a process of depuration, heat treatment or relaying before it can be placed on the market. Table 8.1 summarizes this system.

Table 8.1: Classification system for shellfish harvesting areas.

Classification			Permitted Levels	Outcome
(green)	A	<230	Not exceeding 230 *E. coli* 100g flesh/liquid in 80% of samples. Not exceeding 700 *E.coli* 100 g in remaining 20% of samples	May go direct for human consumption if end product standard met.
(yellow)	B	<4600	Not exceeding 4,600 *E. coli* 100g flesh/liquid in 90% of samples. Not exceeding 46,000 *E.coli* 100 in remaining 10% of samples	Must be subject to purification, relaying in Class A area (to meet Category A requirements) or cooked by an approved method.
(red)	C	<46000	Not exceeding 46,000 *E.coli* 100g flesh in all samples	Must be subject to relaying for a period of at least 2 months or cooked by an approved method.
	Above 46,000 *E.coli*/100g flesh			Prohibited. Harvesting not permitted

8.1.3. Norovirus (NoV)

Currently there are no available data to indicate the presence or levels of norovirus contamination of shellfish in the Sruwaddacon Bay.

8.2. Current Data

8.2.1. Sampling Sites & Methodology

Ten water sampling sites were sampled within the Sruwaddacon Bay. The locations of these sites can be seen in Figure 8.1 and Table 8.2 shows the station coordinates.

Table 8.2: Water sample coordinates with date of sampling.

Station	Feature	Latitude	Longitude	Sampling Date
1	Stream	54.26624	-9.79472	15/03/2021
2	Stream	54.26906	-9.80203	15/03/2021
3	Seawater	54.26886	-9.80158	15/03/2021
4	Seawater	54.27218	-9.80389	15/03/2021
5	Stream	54.27301	-9.80422	15/03/2021
6	Seawater	54.27399	-9.80423	15/03/2021
7	Stream	54.25141	-9.75157	26/05/2021
8	Seawater	54.257007	-9.740389	26/05/2021
9	Glenamoy River	54.240939	-9.697774	26/05/2021
10	Muingnabo River	54.270103	-9.722732	26/05/2021

All water samples were collected in sterile plastic water bottles. These samples were stored in a cool box until delivery to the lab for analysis (within 24hrs of collection).

8.2.2. Bacteriological Analysis Results

Table 8.3 shows the water sample analysis results and Figure 8.1 shows the magnitude of the *E. coli* results.

Table 8.3: Water *E. coli* results for Sruwaddacon Bay.

Station No.	*E. coli* (cfu/ 100ml)
1	125
2	45
3	30
4	45
5	1100
6	120
7	130
8	150
9	185
10	160

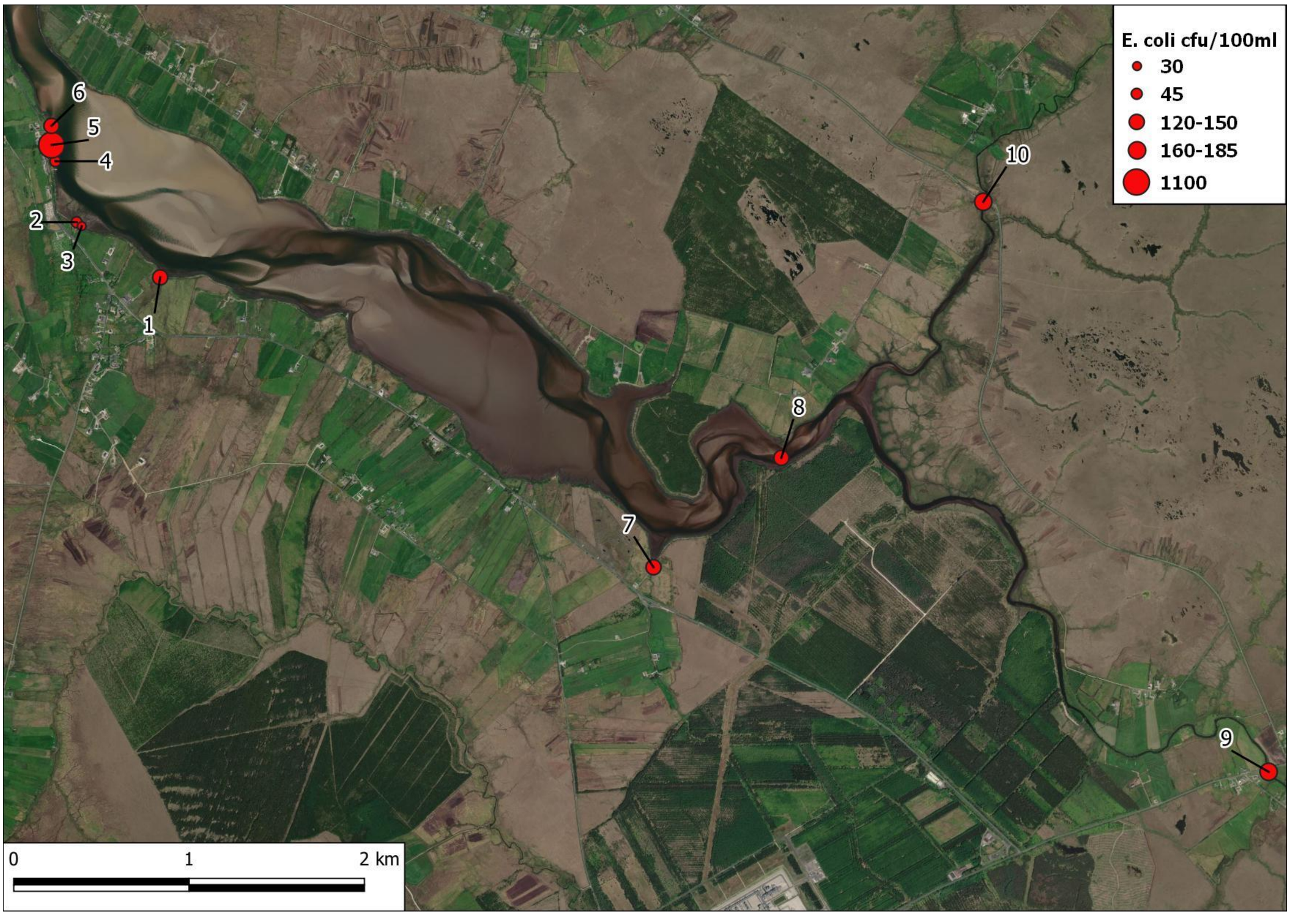

Figure 8.1: Location and magnitude of *E. coli* results from the shore survey.

9. Appendix 4: Shoreline Survey Images


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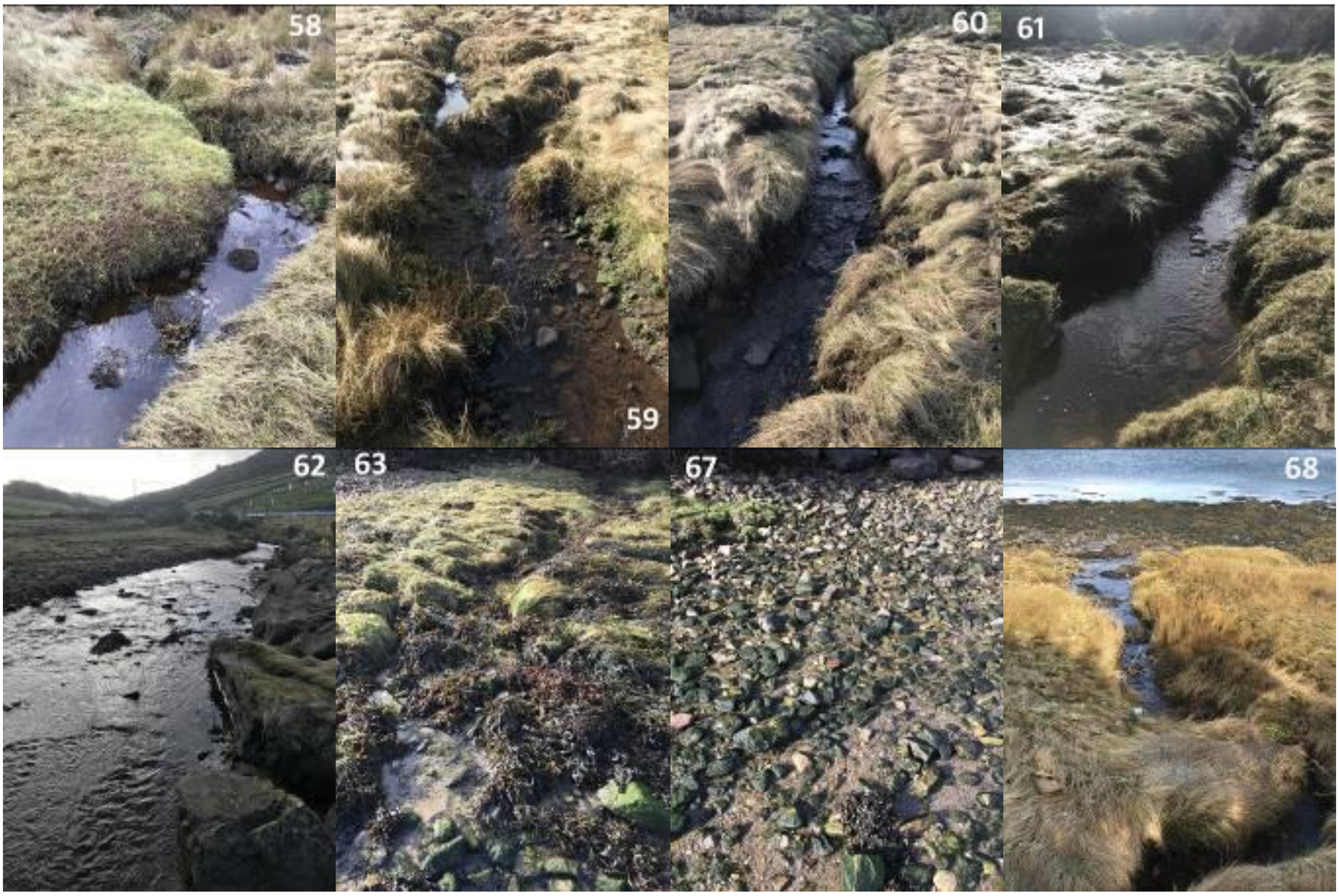
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10. Appendix 5: Species Specific RMPs

Sruwaddacon Bay

Bivalve Mollusc Classified Production Area

Pacific Oyster Monitoring Information

Site Name: Sruwaddacon Bay

Site Identifier: MO-BN-SB

Monitoring Point Coordinates

Latitude: 54.27298 **Longitude:** -9.80404

Species: *Crassostrea gigas*

Sample Depth: From trestle **Sample Frequency:** Monthly

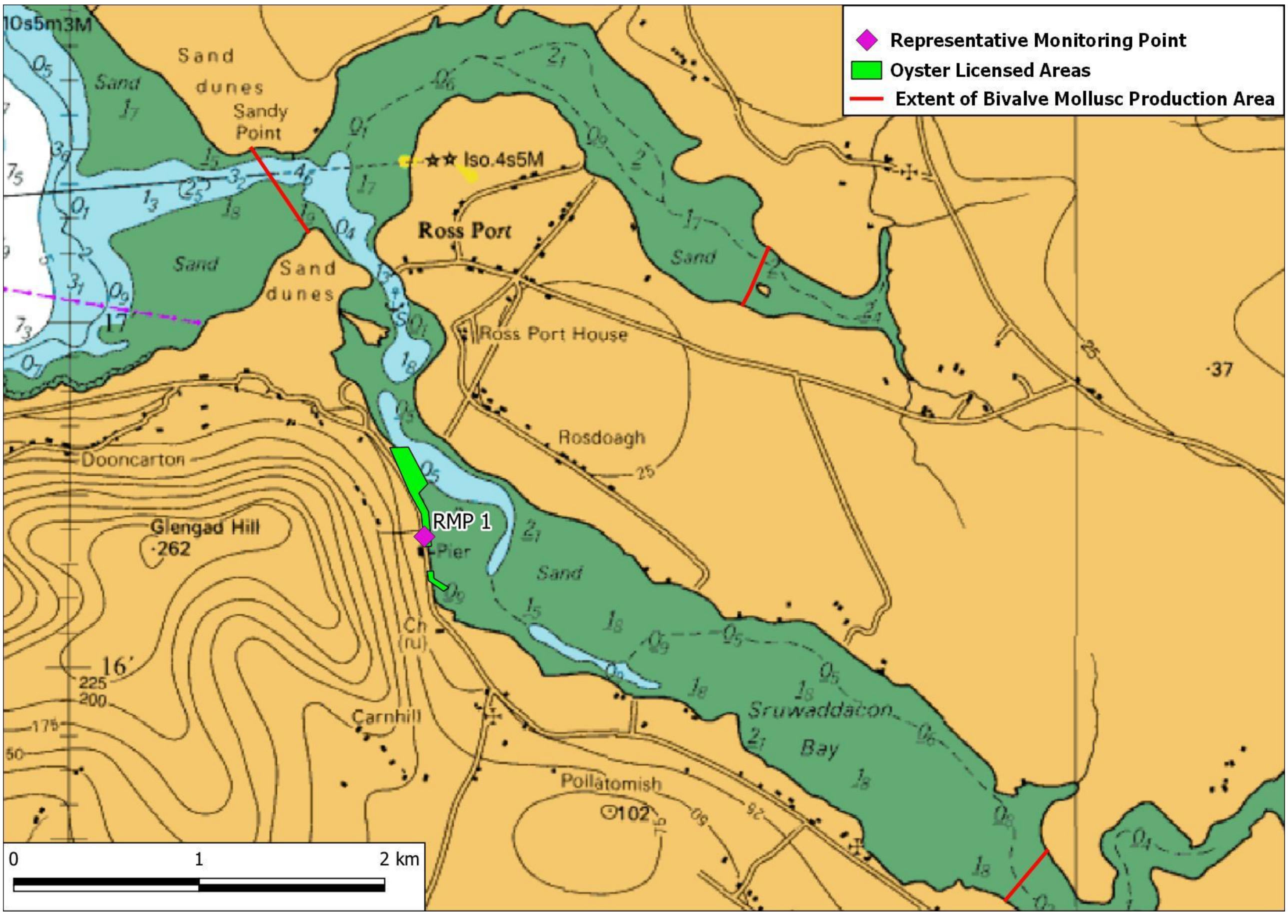
Responsible Authority: Sea Fisheries Protection Authority

Authorised Samplers: SFPA Port Office Killybegs

Maximum Allowed Distance from Sampling Point: The sample must be taken from within 100m of the sampling point.

Sampling Size: Minimum 10 market sized animals

Sampling Method: Taken from trestles at point



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