Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

AQUACULTURE MODELLING SCREENING & RISK IDENTIFICATION REPORT: Chalmers Hope (CHA1)

Version One: July 2020

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Scope of report

As part of the SEPA Aquaculture Regulatory Framework it is recommended that a proposed application for a marine fin fish aquaculture site should undergo a Screening Modelling and Risk Identification process. SEPA carries out this work and this is described on the SEPA aquaculture website Pre-application section:

(https://www.sepa.org.uk/regulations/water/aquaculture/pre-application/)

This report presents information arising from that process. Screening modelling methods are outlined and maps and tables describing the modelled outputs are shown. Risks arising from consideration of the model output are listed. Conclusions and recommendations are made regarding the proposed site.

Executive summary

SEPA has received a proposal for a marine fin fish aquaculture site called Chalmers Hope (CHA1). This is located to the north-east of Hoy at location: 328734, 1001300 (Easting, Northing). The proposed weight of fish to be farmed at this site is 2500t. This will replace the existing 1000t Chalmers Hope (CHA1) site at location: 328614, 1001123.

Following screening modelling and risk identification we have concluded the following:

- It is possible that discharges from Chalmers Hope (CHA1) will be able to comply with the relevant aspects of the SEPA Aquaculture Regulatory Framework.
- Features at risk, identified at this stage, do not appear to influence the feasibility of the proposed site with respect to the regulatory framework. These risks should be examined using a detailed marine model.
- Chalmers Hope (CHA1) is suitable to progress to the next stage of the pre-application process outlined on the SEPA website. It is strongly recommended that default NewDepomod modelling is undertaken prior to any marine modelling, to ensure the proposed biomass can be supported.

List of abbreviations

SEPA	Scottish Environment Protection Agency

List of chemical abbreviations

AZA	Azamethiphos
PMF	Priority Marine Feature
MPA	Marine Protected Area

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1 Introduction

Screening Modelling and Risk Identification are important steps in the SEPA regulatory framework for marine pen fish farms. They are carried out by SEPA at the pre-application stage, which is described in detail at:

https://www.sepa.org.uk/regulations/water/aquaculture/pre-application/.

This document briefly describes the objectives of screening and risk identification and summarises the methods used. Screening output for the proposed site is then presented with comments. Risks identified from the screening output are detailed. Conclusions and recommendations about the suitability of the proposed site are then made.

1.1 The objectives of screening modelling and risk identification

A summary of the modelling methods employed during screening modelling is outlined in section 1.2. The objectives of screening modelling and risk identification are outlined below.

1.1.1 Screening modelling

Marine Modelling technology can be used to simulate and predict the potential influence of discharges on the marine environment. SEPA will require the majority of proposed farms to conduct **detailed** marine modelling, as outlined in our Aquaculture Modelling guidance [1] and on the SEPA Website.

Marine modelling can also be used at an earlier stage to provide an initial estimate of the influence of material discharged from a proposed site.

SEPA will carry out marine modelling at the screening and risk identification stage. This is a simplified version of the detailed modelling required of the applicant. However, it will be sufficient to perform an initial risk assessment of a proposal. Screening marine modelling will also include discharges from other relevant aquaculture sites and major sources.

The objectives of the simplified screening modelling are to:

- Produce maps of the predicted dispersive and erosive capacity of the sea areas in the vicinity of aquaculture sites
- Produce maps of the predicted spread of sediment discharged from aquaculture sites
- Produce maps of the predicted spread of bath treatment medicines from aquaculture sites
- Present an analysis of the potential influence of sediment and bath treatment discharges from the proposed site alongside existing sites within the surrounding sea area
- Present information on the sensitive features and sites of interest within the surrounding sea area, which must be addressed during pre-application work
- Present a summary of the suitability of the proposal with respect to the dispersal of waste and how this may be modelled.

1.1.2 Risk identification

Maps and analysis of screening output will be compared to information relating to sensitive features and relevant areas of interest. These may include:

- Marine Protected Area (MPA)
- Special Area of Conservation (SAC)
- Priority Marine Feature (PMF)
- Any site identified via consideration of other permitted or regulatory activities.

SEPA Staff will meet to discuss screening model output and the relevant sensitive features information. Following this meeting, a list of identified risks will be added to this report.

1.1.3 Conclusion of screening modelling and risk identification

Following the identification of risks, SEPA will present a summary of the suitability of the proposal with respect to the:

- Dispersal of waste from the proposed site and other sources
- Risks posed to sensitive features
- Likely level of modelling that will be required to address the risks identified.

1.2 Screening modelling methods

Marine models divide the sea up into a "grid" of boxes or triangles (often called cells). Each of these is given a water depth. For the screening modelling presented in this report the Marine Scotland "Pentland Firth and Orkney Waters" (PFOW) has been used. An image of the PFOW model grid is shown in Figure 1. This grid has been set up within a marine modelling software package called MIKE 21 which is manufactured by the company DHI A/S (https://www.dhigroup.com/).

Marine models carry out calculations across a grid to work out how seawater moves and mixes in response to tidal and weather forces. Marine models can also be used to simulate how seawater moves and mixes due to salinity and temperature differences across an area, particularly in response to inputs of freshwater from rivers. For pollutant impact assessments the mixing (dispersion) of dissolved (bath medicine) and particulate (sediment) pollutants can also be estimated. Calculations within a marine model can be performed in three dimensions (3D), where the grid is split into layers to better represent how properties of the sea change with depth. Two dimensional (2D) models can also be created where processes over the water depth are simplified. The amount of mixing in a marine model can be varied using settings in the software.

Screening modelling is currently carried out with 2D models using average mixing settings in the model software. In many areas, this approach will be sufficient to make an initial estimate of the influence of a proposed site. Our screening assessment will take into account factors which may limit a 2D approach. We will also consider whether a particular location is adequately represented by the available models.

1.2.1 Water movement and mixing modelling

Water movement and mixing modelling (hydrodynamics) has been carried out to generate one month of results. The boundaries (edge(s) of) the model have been driven using the "wider domain" Scottish Shelf Model [2]. Wind forces and freshwater inputs have been applied to the model from the same source. The results generated are an estimate of the average water movement and mixing conditions within the model area.

1.2.2 Sediment waste modelling

Screening modelling provides a precautionary and <u>**indicative**</u> estimate of the size, location and intensity of waste organic material released from aquaculture sites.

The release of sediment from sources within the model area is simulated using one month of hydrodynamic results along with particle tracking modelling technology. Virtual particles are continually introduced to the model grid to represent the potential dispersion of sediment from the sources. Particles in the model are moved and mixed by the hydrodynamics. Additionally, particles are assigned simplified properties, which allow them to settle through the water and be re-suspended (eroded and lifted) from the sea bed.

1.2.3 Bath medicine modelling

Screening modelling provides a precautionary and <u>**indicative**</u> estimate of the size, location and concentration of bath medicine releases.

The release of bath treatment medicine from sources within the model area is simulated using hydrodynamic results along with particle tracking modelling technology. Virtual particles are introduced to the model grid to represent the potential dispersion of bath medicines from the sources. Particles in the model are moved and mixed by the hydrodynamics. Releases of bath medicines are simulated under worst case mixing (dispersion) conditions, which occur under neap tides. The maximum treatment amount likely to be used at each site is released into the model at the same time and plumes are tracked over the following 96 hours (4 days). Treatment amounts used at screening have been derived from an analysis of historical data. Additionally, all bath medicine particles are concentrated within the top 5 m of the sea area. As all bath medicines are likely to disperse in a similar way, only Azamethiphos (AZA) has been modelled at the screening stage.

1.2.4 Nutrient assessment

Whilst nutrients are not directly modelled during screening, the dispersion of bath medicine releases will give an indication of the likely level of nutrient dispersion. This will be considered alongside any pre-existing nutrient assessment information that may be available.

1.2.5 Analysis of modelling output

SEPA processes the screening modelling output and places it into a standard analysis application built in TIBCO Spotfire. The application allows for the production of standard maps and tables, which are presented below.

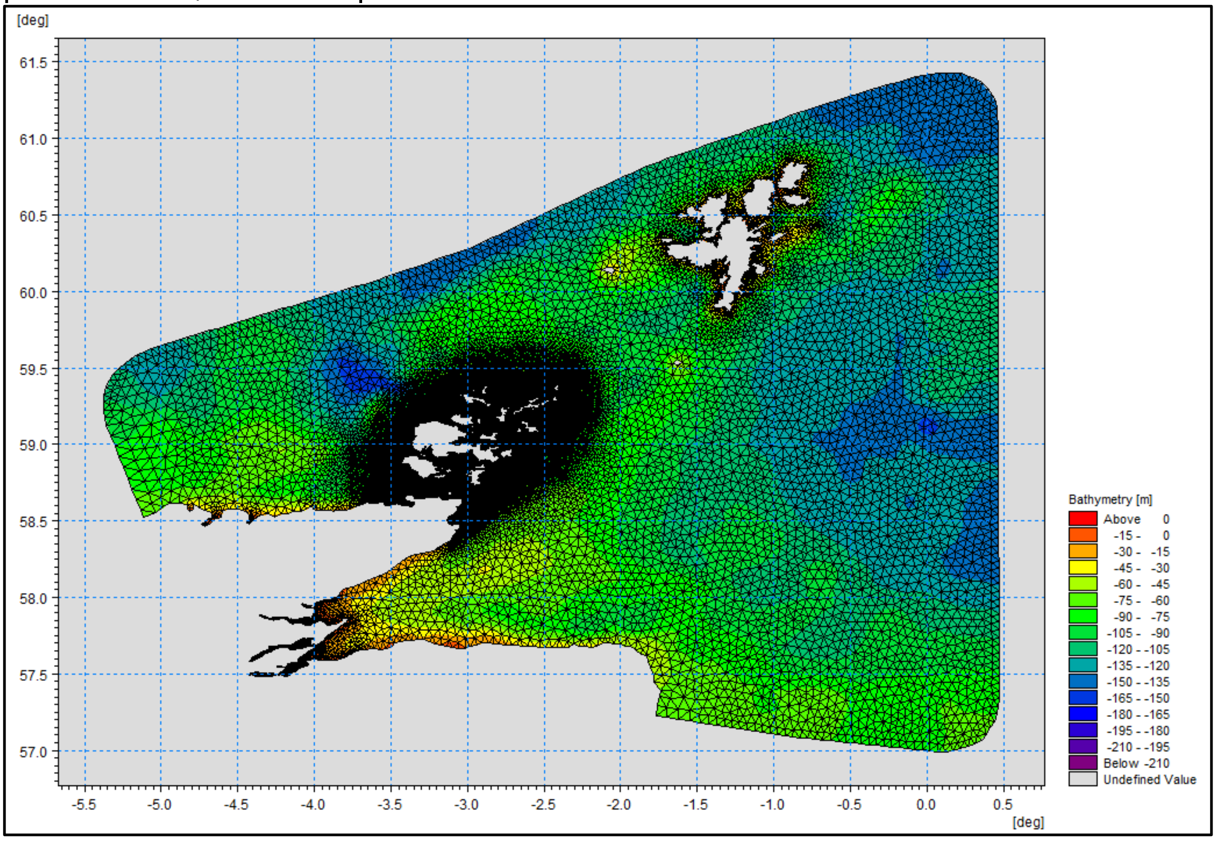

Figure 1: Pentland Firth and Orkney Waters model grid.

2 Screening modelling

Please note that all maps are collated at the end of this section.

2.1 Site proposal

Screening modelling has been carried out for a proposed new farm: Chalmers Hope (CHA1). The proposal is to site the farm at location: 328734, 1001300 (Easting, Northing). The proposed weight of the fish to be farmed at this location is 2500 tonnes. For the screening modelling presented here all relevant licenced sites and current applications, have been modelled in conjunction with the proposed new site.

2.1.1 Accuracy of model in the area surrounding the proposed site

The Pentland Firth and Orkney Waters model used for screening modelling has been compared against observed current meter data. This comparison indicates that the model provides a good description of the physical processes in the vicinity of the proposed site. The model cell size (resolution) is relatively good in the vicinity of the proposed site. Results from screening modelling should be treated with a low degree of caution. We believe that model output at this location is useful for screening purposes.

2.2 Dispersion and erosion capacity maps

Modelled water movement in a sea area can be analysed and presented to show the capacity of the water to move and disperse discharged substances. It is also possible to show the capacity available to erode substances from the seabed. This information is a useful guide to the potential size of a marine fin fish aquaculture farm at a particular location.

Marine fin fish aquaculture farms using open-net pens will benefit from operating in locations where there are strong, repeating, water currents to erode and disperse waste.

For the purposes of screening we consider locations which meet the following water flow criteria to be generally suitable for larger farms:

Locations with average water flow speeds of greater than, or equal to, 0.12 metres per second (0.23 knots)
Locations where water flow speeds are often above the threshold of 0.095 meters per second (0.18 knots).

Locations with these properties are likely to disperse discharged material rapidly, and regularly erode sediment discharged to the seabed. In general, we would look for these properties to be maintained over a large area around a proposed site.

The thresholds stated above are indicative.

A map of modelled average water flow speed for the area surrounding the proposed site is shown in Figure 2. The average water flow speed in each cell of the model grid (see section 1.2) has been assigned a shade. The key for the shading is shown in the top left of the figure. Grid cells that have average speeds less than 0.12 m/s (metres per second) are marked on the figure. The greater the shading, the slower the average current speed and the lower the capacity for dispersion.

Figure 3 is a map of the percentage of time the modelled water flow speed in a grid cell is above 0.095 m/s (metres per second). The greater the shading, the lower the capacity for material to be eroded from the seabed.

Licenced aquaculture farms in the vicinity of the proposed site are also marked on Figure 2 and Figure 3. Discharges of material from these sites have been included in the screening modelling.

Based on the maps of the modelled water flow properties we can make the following observations about the proposed site location:

- It lies in a high dispersion area. However, an area of lower dispersion is shown to be present in the surrounding bays, and in Scapa Flow, which is to the East of the site.
- It lies in an area where water flow generally has a high capacity to erode material on the seabed. However, an area of lower erosion is shown to be present in the surrounding bays, and in Scapa Flow, which is to the East of the site.

2.3 Sediment influence maps and analysis

Modelled particles in a sea area can be analysed for each modelled grid cell and presented to show the potential influence of discharged sediment on the surrounding sea area.

2.3.1 Sediment influence maps

Figure 4 shows a map of the modelled average sediment intensity over one month (time average) for the proposed site only. Grid cells within the model that are influenced by modelled sediment are shaded according to the intensity of the influence in grams per square metre (g/m^2).

Values less than 1 g/m^2 have been excluded from the map and subsequent calculations. These low concentration cells are produced by the particle tracking approach but they are not considered to be representative of the main influence of a discharge.

The shading key is shown in the top left of the figure. Cells which are shaded black are similar to the average intensity in the total area of influence shown in the map. Cells shaded pink are similar to the median (middle value in the range) intensity value shown on the map. White shaded cells are similar to the minimum intensity value shown on the map.

- The average and median sediment intensity over the area of influence is 2.96 g/m^2 and 1.95 g/m^2 respectively.
- Cells influenced by the proposed site appear to lie relatively close to the modelled farm sites Lyrawa Bay (LYR1) and Pegal Bay (PEG1).

Figure 5 shows a map of the modelled average sediment intensity over one month for the proposed site and other relevant sites. Grid cells within the model that are influenced by modelled sediment are shaded according to the intensity of the influence in grams per square metre (g/m^2). The shading key is shown in the top left of the figure and is in a similar format as that shown in Figure 4. The average sediment intensity, after including all relevant sites, is increased.

- The average and median sediment intensity over the area of influence is 11.96 g/m^2 and 2.10 g/m^2 respectively.
- Cells influenced by other modelled sites do not appear to lie close to the proposed site.

2.3.2 Sediment influence analysis

Model grid cells can be analysed to estimate the size and concentration of the potential sediment influence from the modelled sites.

- The total area of sediment influenced by all modelled sites is estimated to be 5.58 square kilometres (km^2).
- As shown in Figure 5, the average and median intensity over this area is 11.16 and 2.10 g/m^2 respectively.
- The total weight of fish that generates this modelled influence is 9360.9 tonnes.

Table 1 shows the information for each individual site modelled. It is important to note that the total area of influence for all sites is not the sum of the numbers in Table 1. The total area of influence worked out above takes into account that the individual areas of influence from different sites will overlap.

Table 1: Sediment influence information for each site.

Site Name	Average Intensity (g/m^2)	Area of Influence (km^2)	Median Intensity (g/m^2)	Max weight Of Fish (tonnes)
CHA1	2.96	1.17	1.95	2500
CAV1	6.43	3.82	1.95	2500
LYR1	327.31	0.02	327.48	400
ORE1	357.31	0.02	327.31	450
PEG1	23.93	0.22	2.99	400
SCAP1	2.45	0.37	1.71	968

TOYN1	23.85	0.70	4.43	1342.9
WFAR1	1.83	0.04	1.76	800

There are no Environmental Standards for sediment intensity. However, we consider that:

- underneath farm pens, an intensity of 2000 g/m^2 or less is likely to lead to an acceptable sea bed ecological outcome
- at the edge of the mixing zone, an intensity of 250 g/m^2 or less is likely to lead to an acceptable sea bed mixing zone outcome

The estimate of influence detailed above is indicative. The values presented are lower than the sediment intensity values given above. However, we recognise that low sediment concentrations may be useful for the identification of risks.

2.4 Bath medicine influence maps and analysis

Modelled particles in a sea area can be analysed for each modelled grid cell and presented to show the potential influence of discharged bath medicine on the surrounding sea area. Results presented are for the AZA medicine (see section 1.2.3).

2.4.1 Bath medicine influence maps

Figure 6 shows a map of the modelled average AZA concentration over four days for the proposed site only. Grid cells within the model which experience an AZA influence are shaded according to the concentration of AZA in nanograms per litre (ng/l).

Values less than 10 ng/l have been excluded from the map and subsequent calculations. These low concentration cells are produced by the particle tracking approach but they are not considered to be representative of the main influence of a discharge.

Please note that the Environmental Standard for Azamethiphos with the lowest concentration is 40 ng/l. This must be met 72 hours after the material has been discharged. The estimate of influence detailed here is precautionary. In the information presented below areas of influence above 40 ng/l have been quoted. However the average and median concentrations are quoted for the entire area of influence above 10 ng/l.

The shading key is shown in the top left of the figure. Cells which are shaded black are similar to the average concentration in the total area of influence shown in the map. Cells shaded pink are similar to the median (middle value in the range) concentration shown on the map. White shaded cells are similar to the minimum concentration value shown on the map.

- The average and median concentration over the total area of influence is 94.93 ng/l and 73.29 ng/l respectively.
- Cells influenced by the proposed site appear to lie relatively close to the modelled farm sites Lyrawa Bay (LYR1) and Pegal Bay (PEG1).

Figure 7 shows a map of the modelled average AZA influence over four days for the proposed site and other relevant sites. The average AZA influence, after including all relevant sites, is increased.

- The average and median AZA concentration over the total area of influence is 59.62 ng/l and 31.18 ng/l respectively.
- Cells influenced by modelled site SCAP1 appear to be in the vicinity of the proposed site.

2.4.2 Bath medicine influence analysis

Model grid cells can be analysed to estimate the size and concentration of the potential AZA influence from the modelled sites.

- The area of AZA influence above 40 ng/l from all sites modelled is estimated to be 3.90 square kilometres (km^2).
- As shown in Figure 7, the average and median concentration over the total area of influence is 59.62 and 31.18 ng/l respectively.
- The total weight of fish that generates this modelled influence is 9360.9 tonnes.

Table 2 shows the information for each individual site modelled. It is important to note that the total area of influence above 40 ng/l for all sites quoted above is not the sum of the numbers in Table 2. The total area of influence worked out above takes into account that the individual areas of influence above 40 ng/l from different sites will overlap.

Table 2: Azamethiphos influence information for each site.

Site Name	Average Conc. (ng/l)	Area of Influence Above 40 ng/l (km^2)	Median Conc. (ng/l)	Weight Of Fish (tonnes)
CHA1	94.93	1.87	73.29	2500
CAV1	21.01	0	22.14	2500
LYR1	29.80	0.26	23.50	400
ORE1	0	0	0	450
PEG1	23.29	0.05	22.65	400
SCAP1	15.85	0	14.39	968

TOYN1	41.32	1.77	38.14	1342.9
WFAR1	17.16	0.02	14.58	800

Please note that the Environmental Standard for Azamethiphos with the lowest concentration is 40 ng/l. This must be met 72 hours after the material has been discharged. The estimate of influence detailed above is precautionary. The values presented are close to the 40 ng/l standard. Detailed modelling will be required to demonstrate compliance with all Environmental Standards.

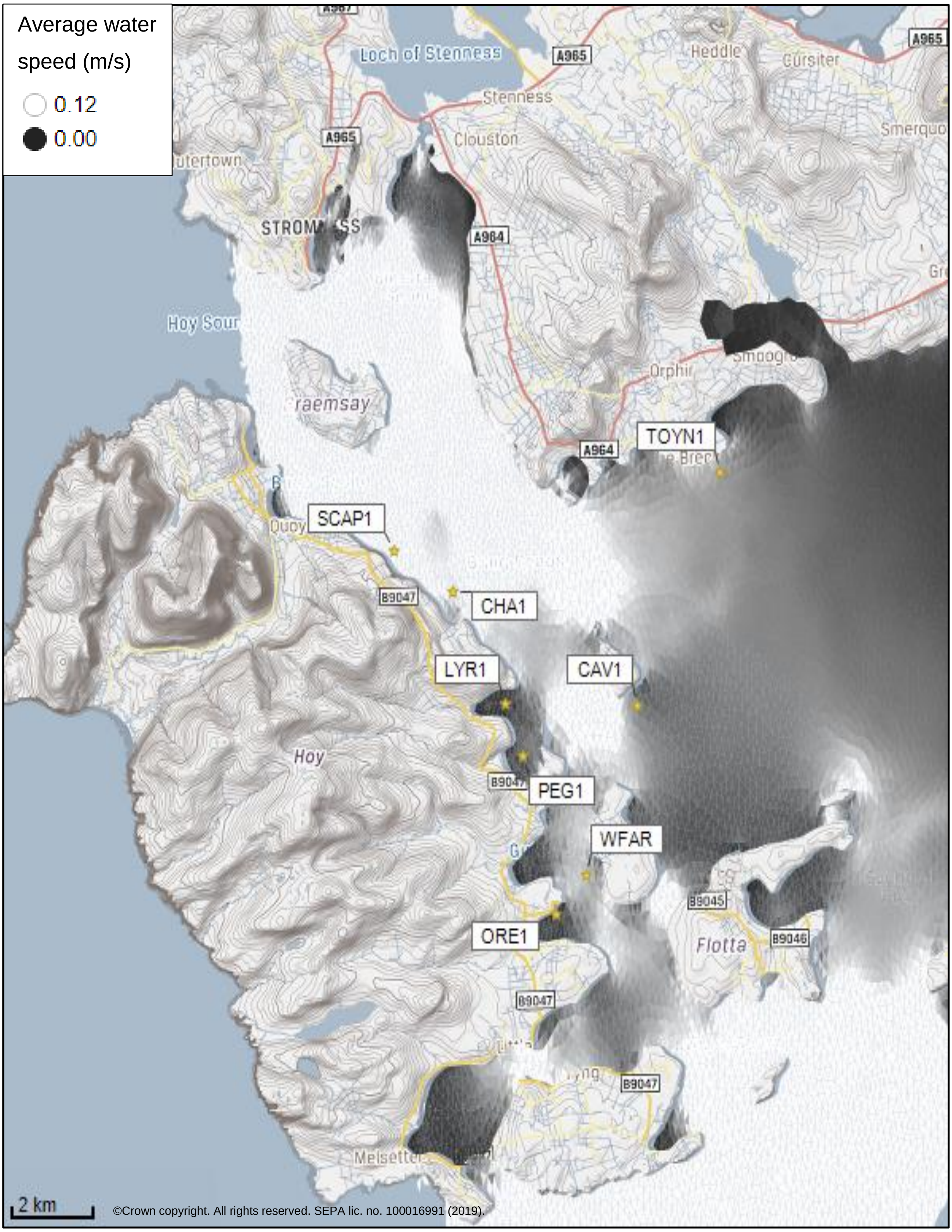

Figure 2: Modelled average water speed (metres per second – m/s) in the sea area surrounding the proposed site (Chalmers Hope (CHA1)).

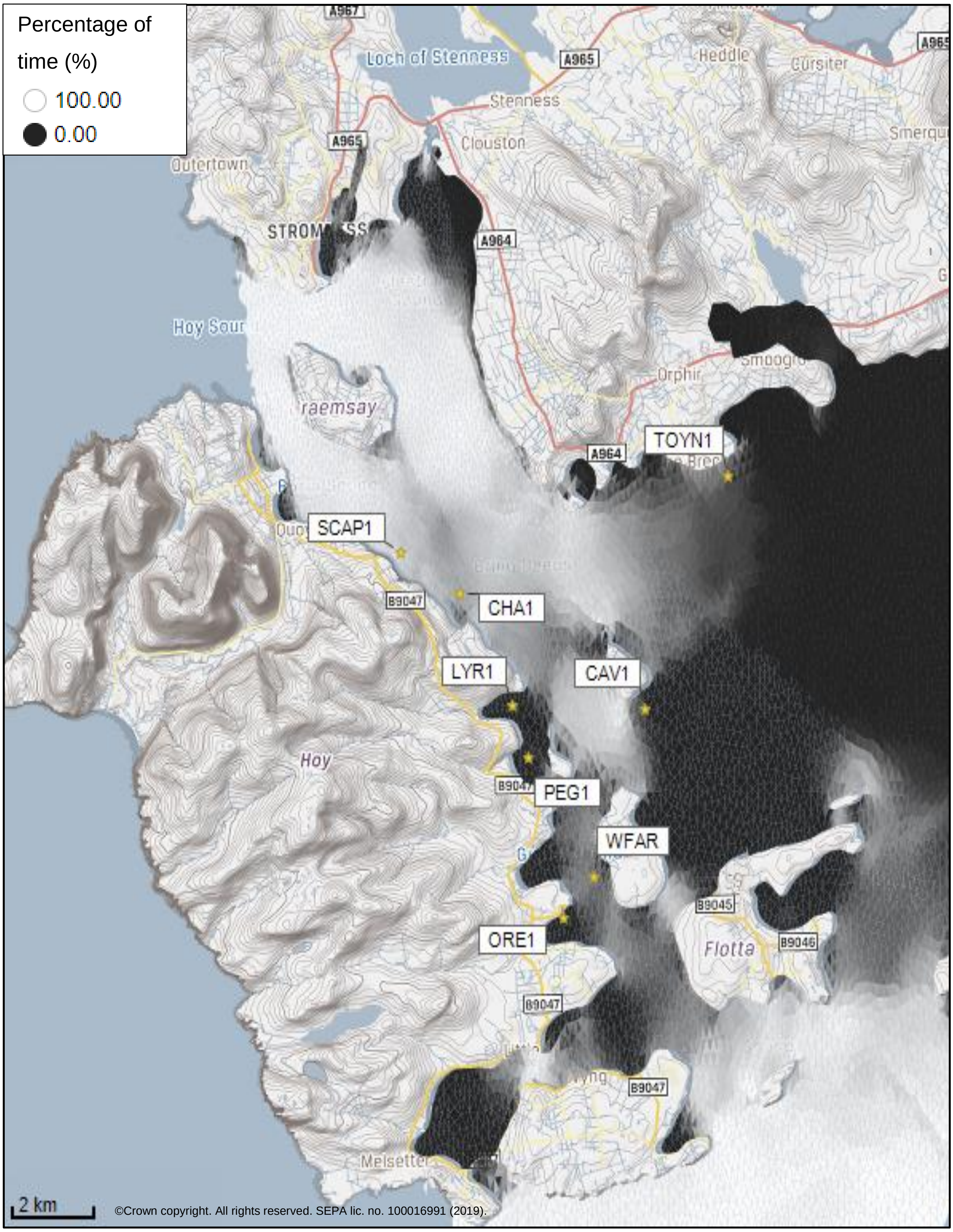

Figure 3: Modelled percentage of time the water flow speed is above 0.095 m/s in the sea area surrounding the proposed site (Chalmers Hope (CHA1)).

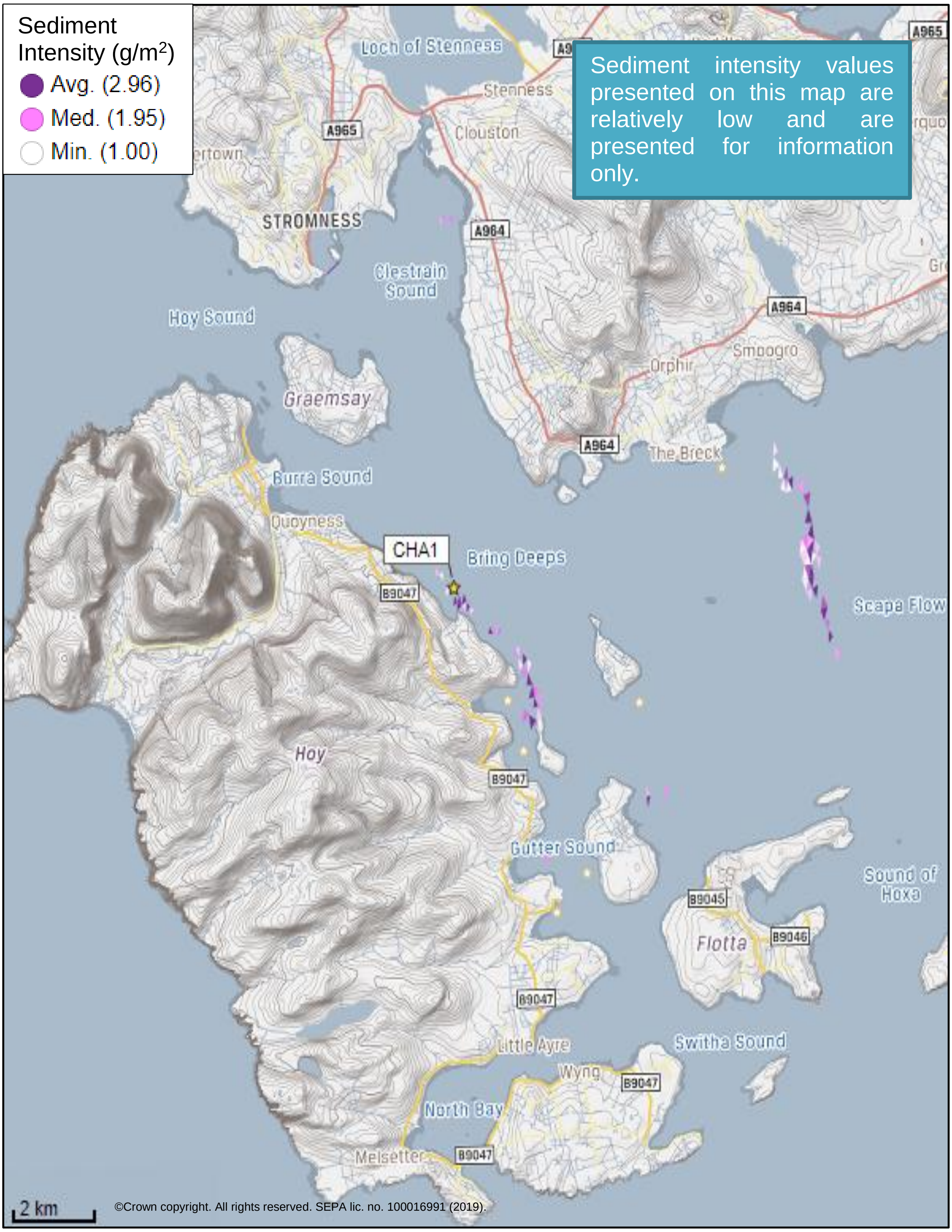

Figure 4: Modelled average sediment intensity over one month for the proposed site only (Chalmers Hope (CHA1)).

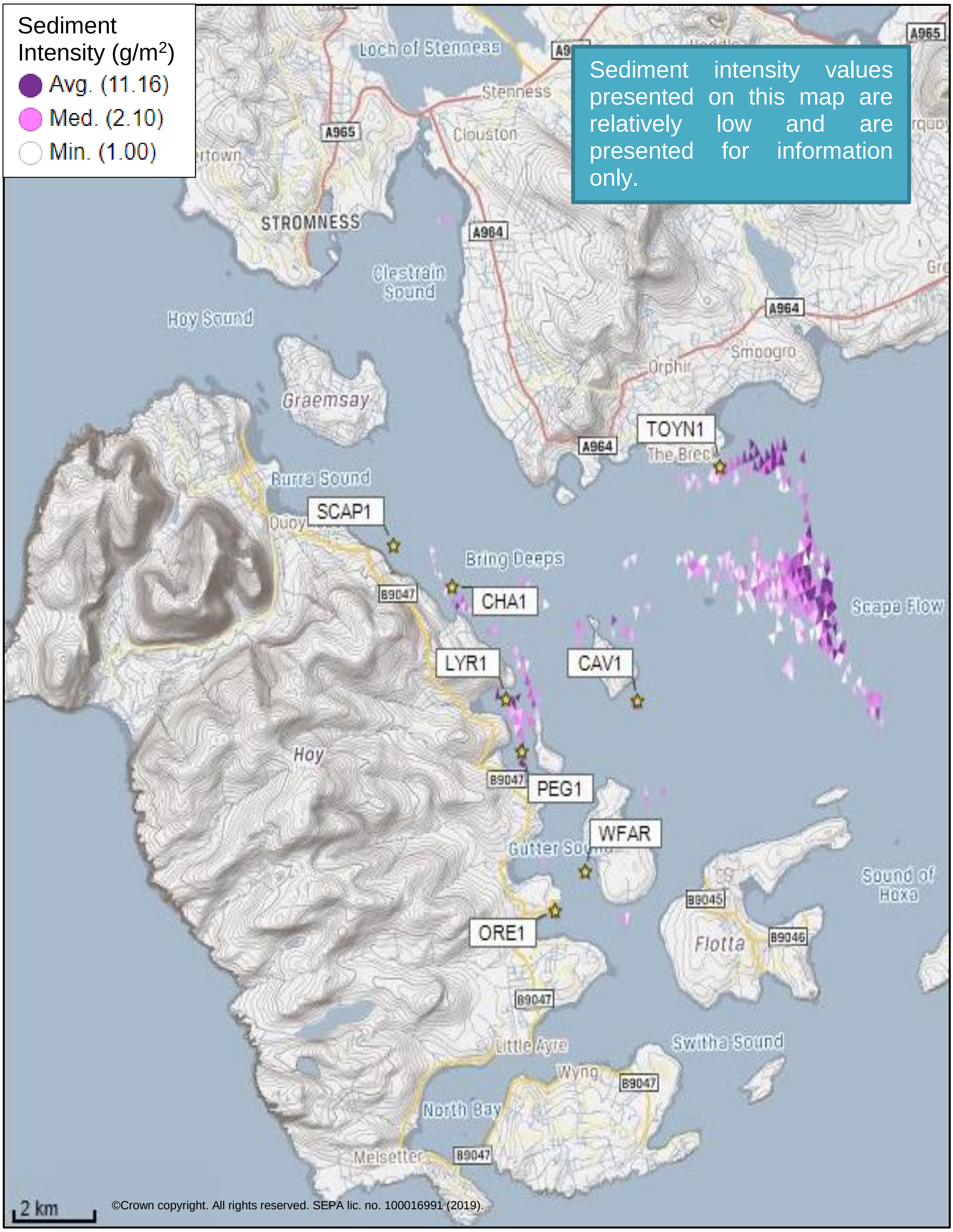

Figure 5: Modelled average sediment intensity over one month for the proposed site (Chalmers Hope (CHA1)) and other relevant sites.

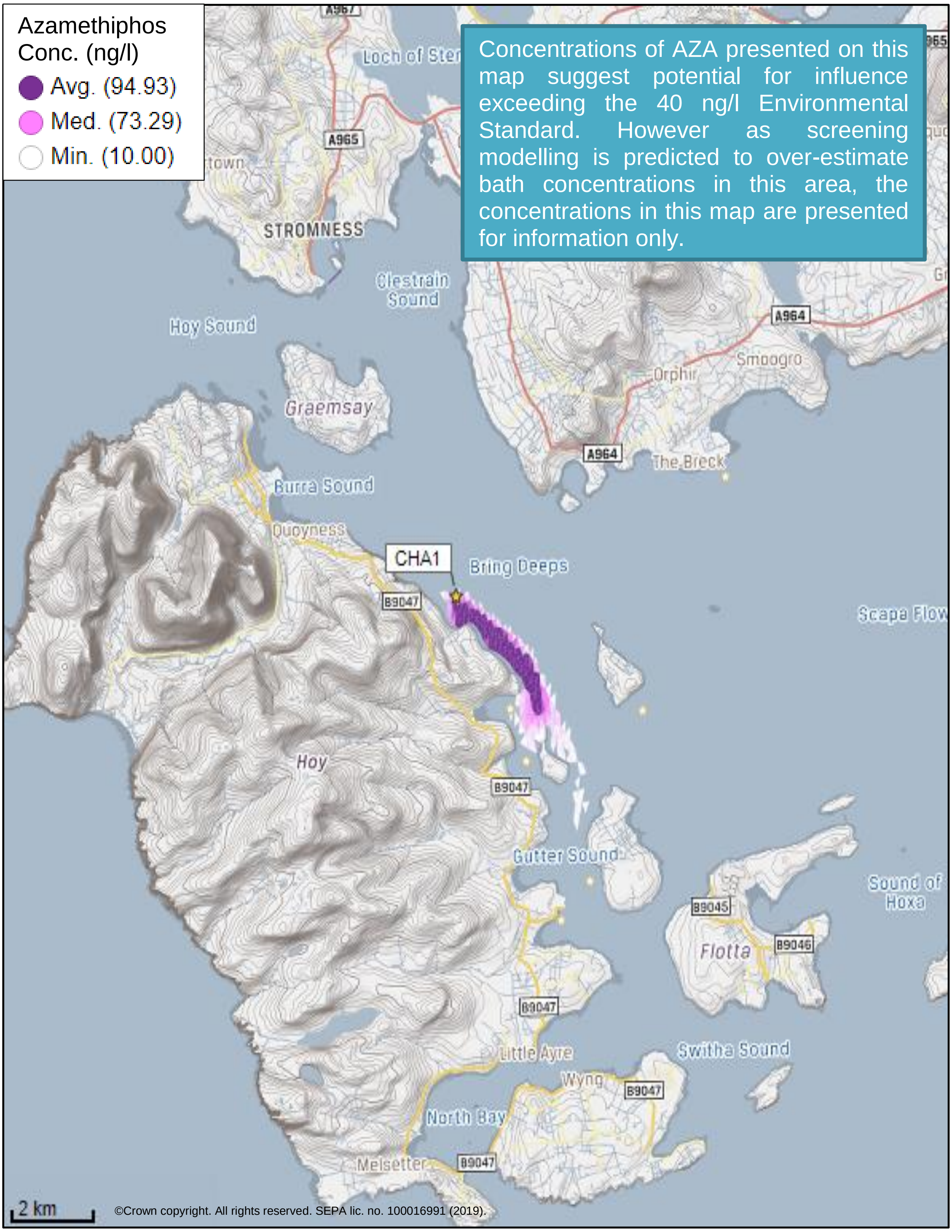

Figure 6: Modelled average Azamethiphos concentration over four days from neap tide release for the proposed site only (Chalmers Hope (CHA1)).

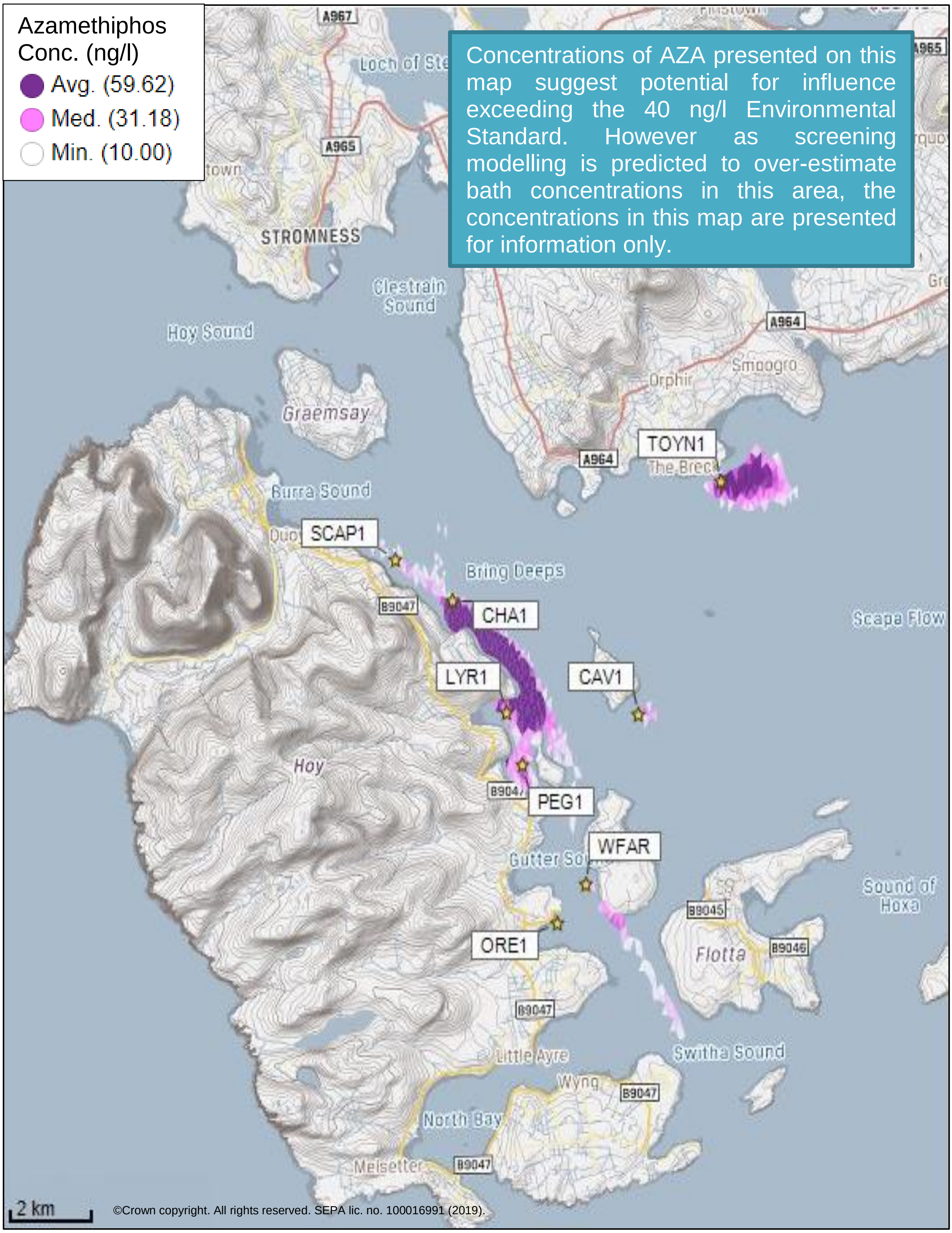

Figure 7: Modelled average Azamethiphos concentration over four days from neap tide release for the proposed site (Chalmers Hope (CHA1)) and other relevant sites.

3 Risk identification

The screening modelling output summarised in section 2 is compared against available information on features of interest (see section 1.1.2). Features which require attention are presented with any additional comments. Identified features will need to be considered during the pre-application phase.

These should be addressed in the applicant "Method Statement". Please refer to the Modelling Method Statement section on the SEPA Website.
(https://www.sepa.org.uk/regulations/water/aquaculture/pre-application/)

3.1 Identified features which require attention

3.1.1 Table of identified features

Based on screening output the following features of interest have been identified.

Table 3: Table of identified features

No.	Feature Name	Feature Type	Location (Easting, Northing)	Brief Reason For Identification
1	LYR1	Fish Farm	(330020, 998900)	At risk from sediment and bath medicine influence.
2	PEG1	Fish Farm	(330400, 997800)	At risk from sediment and bath medicine influence.
3	Maerl or coarse shell gravel with burrowing sea cucumbers	PMF Habitat	(329893, 1002316)	At risk from sediment influence.
4	Maerl beds	PMF Habitat	Shapefile 1 (figure 8)	At risk from sediment influence.
5	Horse Mussel beds	PMF Habitat	Shapefile 2 (figure 8)	At risk from sediment influence.
6	Flame Shell and Horse Mussel Beds	PMF Habitat	Shapefile 3 (figure 8)	At risk from sediment and bath medicine influence.

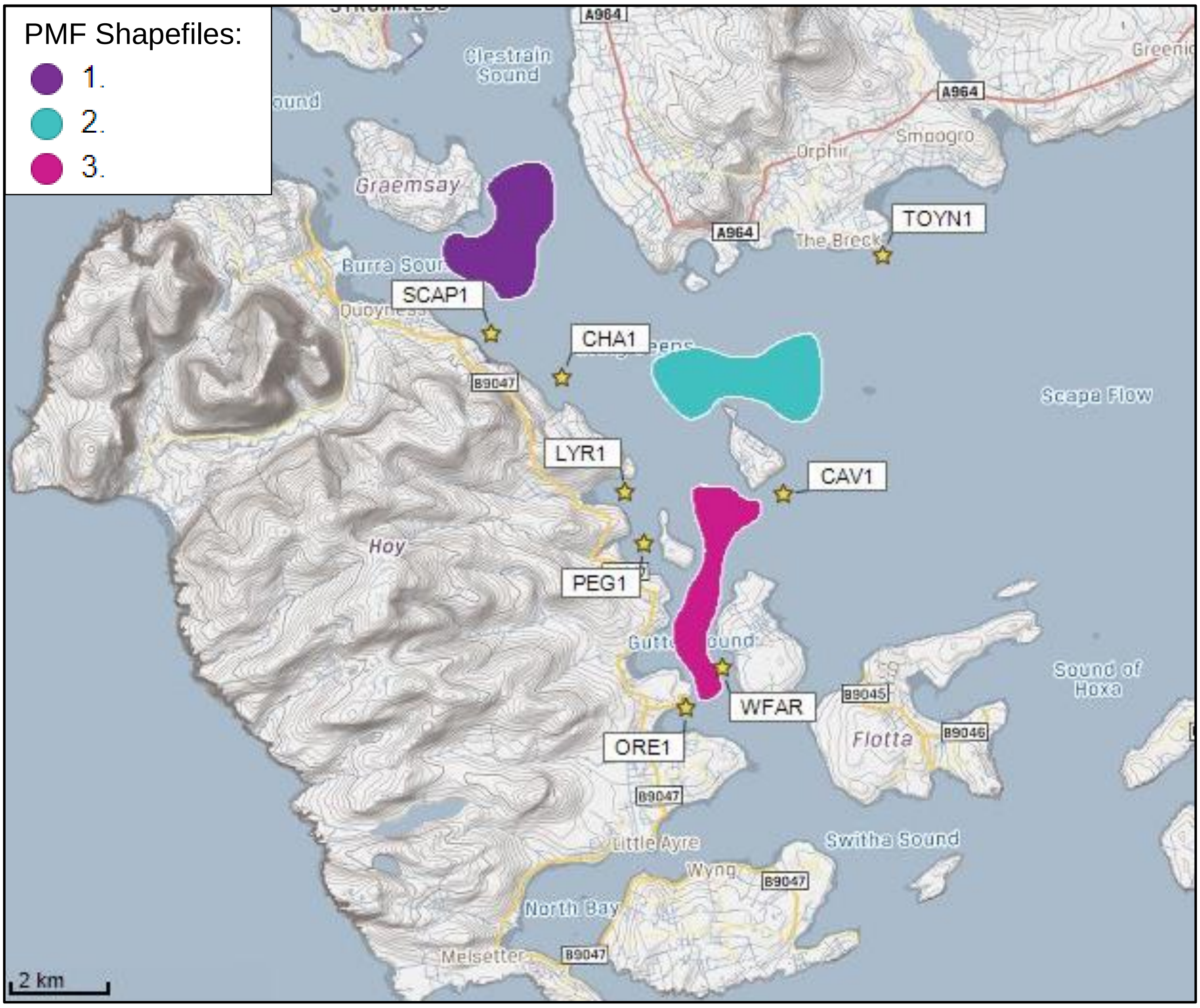

Figure 8: Shapefiles of identified features around the proposed site (Chalmers Hope (CHA1)).

3.2 Additional comments on identified features

Screening modelling predicts relatively high concentrations of bath medicines from Chalmers Hope (CHA1). However the vertical dispersion in this area is expected to be substantially greater than the default vertical dispersion coefficient value used in screening modelling. Combined with the re-concentration of material which is undertaken to provide conservative estimates of influence in stratified areas, the modelling assumptions made are therefore likely to be conservative for this site. This means, due to lack of stratification and the high levels of dispersion which occur in this area, significantly lower concentrations of bath medicines are expected to occur than predicted by screening modelling.

Screening modelling predicts some potential bath and sediment influence on maerl, flame shell and horse mussel beds identified in Figure 8. Therefore, combined with the large biomass at this site, higher resolution marine modelling of baths and sediment discharges should be undertaken. The resolution of this modelling should be sufficient around the features identified in Table 3, to ensure the level of risk from cumulative impacts is low.

Screening modelling suggests sediment and bath medicine plume interactions are also likely to occur between Chalmers Hope (CHA1), Lyrawa Bay (LYR1), Pegal Bay (PEG1) and Bring Head (SCAP1). Therefore, discharges from all licenced farms should be included in the higher resolution marine modelling which is required for Chalmers Hope (CHA1).

4 Conclusion of screening modelling and risk identification

Following screening modelling and risk identification we make a number of conclusions and recommendations.

4.1 Conclusions

4.1.1 Screening Modelling

- The proposed site (Chalmers Hope (CHA1)) is in an area of high dispersion and has a high capacity for erosion of material on the sea bed.
- From sediment and bath treatment modelling:
  - Information presented in section 2 indicates that the sediment influence of Chalmers Hope (CHA1) is likely to be lower than other sites for a similar tonnage.
  - The influence on the surrounding sea area from Chalmers Hope (CHA1) is likely to be low.
  - The areas of influence from Chalmers Hope (CHA1) and the modelled sites Pegal Bay (PEG1), Lyrawa Bay (LYR1) and Bring Hope (SCAP1) may interact.
  - Although screening modelling suggests bath medicine influence may be relatively high from Chalmers Hope (CHA1), the modelling assumptions made in screening are likely to be conservative for this site, and therefore it is likely that discharges of bath medicines from Chalmers Hope (CHA1) will be dispersed to low levels over a moderate area.
  - Chalmers Hope (CHA1) is likely to result in a small increase in the total influence from all sites modelled.
- Due to the dispersive nature of the waters surrounding the site nutrient discharges from Chalmers Hope (CHA1) are unlikely to have a strong influence on the surrounding sea area.

4.1.2 Risk Identification

Although the modelled sediment influence from Chalmers Hope (CHA1) appears to be low, and the screening modelling assumptions suggest the predicted bath medicine influence is conservative, the large tonnage proposed at this site means the risk to the wider environment from sediment and bath influence needs to be assessed. Several features of interest have also been identified, which may be influenced by the proposed site (Chalmers Hope (CHA1)). These will require further attention during pre-application work, and are outlined in section 3. Further detailed modelling will need to demonstrate that these are at a low risk of impact.

The limitations of the simple BathAuto model in areas of high current speeds, means it is likely to recommend very conservative, and therefore impractical quantities, of bath medicines for this site. Use of marine modelling of bath influence will enable more realistic bath medicine treatment quantities to be determined, whilst ensuring the risk to the environment from bath medicine influence is low. An appropriate vertical dispersion coefficient should be determined through calibration.

4.2 Recommendations

4.2.1 Site suitability

Consideration of screening modelling and risk identification suggests that it is possible that discharges from the proposed site will be able to comply with the relevant aspects of the SEPA Aquaculture Regulatory Framework. This must be demonstrated with a detailed marine model.

It is also possible that the site will be able to comply with our mixing zone regulatory framework. This will need to be demonstrated using the NewDepomod model. It is strongly recommended that default NewDepomod modelling is undertaken prior to any marine modelling, to ensure the local impacts of the proposed biomass are acceptable.

Features at risk, identified at this stage, do not appear to influence the feasibility of the proposed site, with respect to the regulatory framework. These risks should be examined using a detailed marine model.

Following the engagement meeting(s), this report will be revised and this should allow to the applicant to submit a method statement which address the issues raised

4.2.2 Further modelling

- Due to the risks identified at screening, as well as large tonnage proposed at this site, 2D marine modelling should be carried out. This marine modelling will also help with the calibration of NewDepomod, should this site wish to expand in the future.
- The marine model should include discharges from Chalmers Hope (CHA1) and all other sites included in the screening model.
- The resolution of the marine model should be relatively fine around the proposed site, and features identified as at risk.
- It is strongly recommended that default NewDepomod modelling is undertaken prior to any marine modelling, to ensure the local impacts of the proposed biomass are acceptable.

5 References

[1] *Regulatory Modelling Guidance For The Aquaculture Sector. Published on SEPA website.*

[2] *http://marine.gov.scot/information/wider-domain-scottish-shelf-model.*