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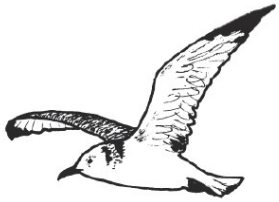


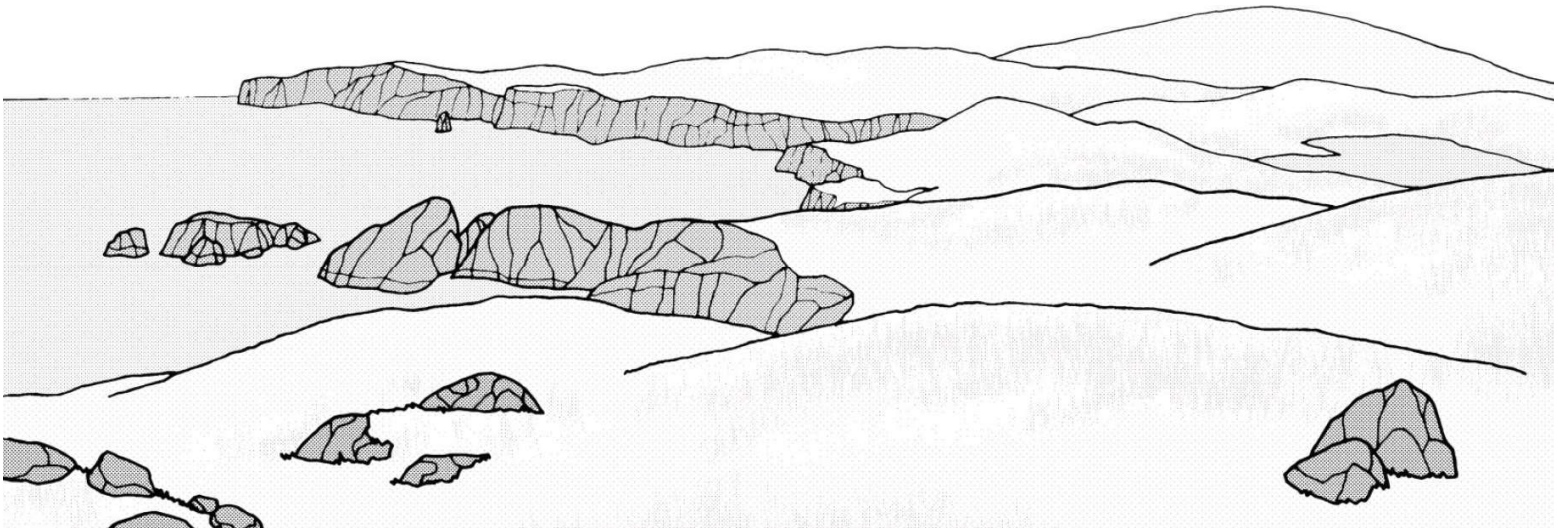
Chemical monitoring in Sullom Voe Sediments

2024

A report to the Shetland Oil Terminal Environmental Advisory Group

by

SGS United Kingdom Limited



TITLE:	**Chemical and Macrobenthic Monitoring in Sullom Voe Sediments - 2024**
SUB-TITLE:	**Chemical Report – Total Aliphatic Hydrocarbons and Poly-Aromatic Hydrocarbons**
CLIENT:	**The Sullom Voe Association Limited**
REPORT REF:	**MD24-01423**
STATUS:	**Final Report**

Prepared on behalf of SGS United Kingdom Limited

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NON-TECHNICAL SUMMARY

As part of an ongoing monitoring programme, SGS United Kingdom Limited was commissioned by the Shetland Oil Terminal Environmental Advisory Group, representing the Sullom Voe Association, to undertake a combined benthic and chemistry survey in Sullom Voe in June 2024.

The results and findings of the chemical analysis are presented within this report, the benthic elements of the survey are covered in a separate report by Eco Marine Consultants. The sediment samples that were analysed were collected during the Sullom Voe survey conducted 16th to 20th June 2024. 24 subtidal samples were taken aboard the *MV Sullom Shearwater* using a Day Grab and 6 intertidal samples were taken using handheld tools.

The main findings of this report are:

- All samples taken from subtidal and intertidal stations were analysed for Total Aliphatic Hydrocarbon content (TAH). The TAH concentrations in 2024 were broadly consistent with the trend in concentrations since 2004, which is of stable and slightly decreasing concentrations of hydrocarbons. Where some change in the TAH had been observed against the 2021 results (Eg SV1) the 2024 result tended to follow the historic trend and not be a significant change. The characteristic chromatographic pattern of hydrocarbons at each station appears unchanged since previous surveys.

- The Total Aliphatic Hydrocarbons content of the sediment consists of a large number of individual chemicals originating from natural and petrochemical sources. The portion of the unresolved complex mixture continued to be observed as a greater proportion of the TAH. This indicates that there are no new input of crude oil and that the oil present in the sediment is chemically degrading.

- At 9 subtidal stations the Poly Aromatic Hydrocarbons (PAH) content of the sediments was determined. In 2024 the PAH concentrations were similar to the concentrations since 2004 and there was little evidence of change in the concentrations of PAHs in the sediments.

- In 2024, the Total Aliphatic Hydrocarbons and the Poly Aromatic Hydrocarbons at the Orka Voe stations were similar to those observed in 2021, the stations had been re-established in 2016 and there is limited historic data to assess if this change is significant.

- The Intertidal stations at Houb of Scatsta and Gluss Voe continue to have very low Total Aliphatic Hydrocarbon content and do not appear to be affected by terminal activity.

- Sediment composition across the Sullom Voe area has been variable over recent surveys, especially in relation to the mud content. Changes in sediment composition reflect natural variability, which is observed in the dataset over the duration of the monitoring period. 7 of the 24 subtidal stations recorded their highest mud contents in 2024.

- From the analysis of subtidal and intertidal stations around the Sullom Voe taken in 2024, there has been no detectable fresh input of crude oil or other petrochemical products from the terminal or associated activities.

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1 INTRODUCTION

This is one of two reports detailing the findings of the 31st chemical and macrobenthic monitoring survey carried out in June 2024 on marine sediments around the oil terminal at Sullom Voe which was conducted by SGS United Kingdom Limited for the Shetland Oil Terminal Environmental Advisory Group. This report details the findings of a monitoring survey, the scope of the survey is not dictated by regulatory bodies. This report covers the chemical analysis of sediments taken from the Sullom Voe area. The macrobenthic monitoring element of the survey is detailed in report SGSSUL0624 prepared by Eco Marine Consultants Limited.

The survey comprised of 30 stations in Sullom Voe. The survey involved sampling sediment of six soft shore stations from the Houb of Scatsta and Gluss Voe and twenty four subtidal sediment stations obtained by Day grab. Of the subtidal stations, 4 were located in Orka Voe, and 20 from Sullom Voe, Garths Voe and southern Yell Sound. Stations SV36B and OV1B which had been relocated in 2016 but did not yield satisfactory grab samples in 2016, 2018 and 2021 have not been included in the 2024 survey as alternative locations could not be identified within the permitted area for sampling. Station SV37B was relocated in 2024 to SV37C an area slightly to the north which was closer to an area of sediment on the seabed.

1.1 AIMS AND OBJECTIVES

The overarching aim of the 2024 chemistry survey was to determine the current condition of the Hydrocarbon components of chemical origin in the sediments present at the Sullom Voe and in the surrounding areas. Additionally, the report has assessed the status of the hydrocarbon components in the sediments by examining data collected in 2024 alongside historical data to determine any changes over time.

The project objectives were therefore as follows:

- To undertake a subtidal survey of Sullom Voe, Garth's Voe and Orka Voe in line with the historic methodology.
- To undertake an intertidal survey of Gluss Voe and Houb of Scatsa in line with the historic methodology.
- To undertake analysis of the sediment samples for particle size distribution, total organic carbon content, total aliphatic hydrocarbon content and poly aromatic hydrocarbon content.
- To analyse the 2024 data in relation to the historic data to identify any trends or changes.
- To provide a technical report to detail the findings of the project.

The survey was conducted from the Shetland Island Council work vessel *MV Sullom Shearwater* by SGS United Kingdom Limited and Eco Marine Consultants personnel. The hydrocarbon analysis was performed by SGS United Kingdom Limited and the macrobenthic analysis was performed by Eco Marine Consultants Limited.

2 METHODOLOGY

2.1 SAMPLE STATION LOCATIONS

The positions and depths of the sampling stations are described in Table 1 and illustrated in Figures 1A. In 2016 revised coordinates were established for stations OV2-OV5, these stations have been labelled with post-fix B. In 2021 revised coordinates were established for soft shore stations HS1 and GV1 these stations have been labelled with post-fix A and B respectively. In 2024 revised coordinates were established for station SV37, this station has been labelled with post-fix C. In 2024 three satisfactory grabs were obtained at the Orka Voe re-established stations (OV2B-OV5B). At station SV37C 3 satisfactory grabs were retrieved from the five grab sample attempts. At Station SV34 only 2 grabs were obtained due to operational reasons.

The soft shore stations were sampled at the lowest tidal position during the survey dates. Due to strong winds and tidal movement, the relocated Gluss Voe GV1B and Housta Scatsa HS1A were sampled at the closest position to the target coordinates and the coordinates recorded. The sediment type is unlikely to be significantly different between the original and the revised station.

The station locations were determined using the *MV Sullom Shearwater* dGPS and the soft shore locations were determined using handheld GPS.

Table 1 - Positions of sampling stations, June 2024

Station	Location	Station Position				Depth (m)
Yell Sound and north of Calback Ness						
SV1	Inner Basin	60º	24.097'N	001º	22.161'W	45m
SV3	Southern Sullom Voe	60º	25.524'N	001º	20.947'W	24m
SV4	Southern Sullom Voe	60º	26.010'N	001º	20.614'W	27m
SV5	Fugla Ness	60º	26.676'N	001º	19.251'W	25m
SV7	Jetty Grid	60º	27.201'N	001º	16.831'W	20m
SV8	Jetty Grid	60º	27.174'N	001º	17.826'W	23m
SV8A	Jetty Grid	60º	27.794'N	001º	18.951'W	27m
SV9	Outer Voe	60º	27.902'N	001º	19.503'W	15m
SV10	Outer Voe	60º	28.541'N	001º	18.875'W	32m
SV11	Outer Voe	60º	28.793'N	001º	17.719'W	39m
SV17	Jetty Grid	60º	27.487'N	001º	18.190'W	28m
SV12	Little Roe	60º	30.244'N	001º	17.224'W	51m
SV33	Calbeck Ness	60º	29.526'N	001º	17.588'W	52m
SV34	Calbeck Ness	60º	29.576'N	001º	17.277'W	51m
SV35	Calbeck Ness	60º	27.453'N	001º	15.798'W	18m
SV37C	Calbeck Ness	60º	28.831'N	001º	14.802'W	36m
SV6	Garths Voe	60º	26.778'N	001º	16.233'W	8.2m
SV6A	Garths Voe	60º	26.760'N	001º	16.206'W	6.6m
SV6F	Garths Voe	60º	26.698'N	001º	16.121'W	4.7m
SV32	Garths Voe	60º	26.973'N	001º	16.299'W	11m
Orka Voe						
OV2B	Orka Voe	60º	27.779'N	001º	15.988'W	19m
OV3B	Orka Voe	60º	28.876'N	001º	15.901'W	21m
OV4B	Orka Voe	60º	28.877'N	001º	15.911'W	21m
OV5B	Orka Voe	60º	28.939'N	001º	15.905'W	21m
Gluss Voe						
GV1B	Gluss Voe	60º	28.817'N	001º	21.011'W	Intertidal
GV2	Gluss Voe	60º	28.805'N	001º	21.069'W	Intertidal
GV3	Gluss Voe	60º	28.760'N	001º	21.190'W	Intertidal
Houb of Scatsta						
HS1A	Houb of Scatsta	60º	26.423'N	001º	16.995'W	Intertidal
HS2	Houb of Scatsta	60º	26.369'N	001º	16.852'W	Intertidal
HS3	Houb of Scatsta	60º	26.355'N	001º	16.753'W	Intertidal

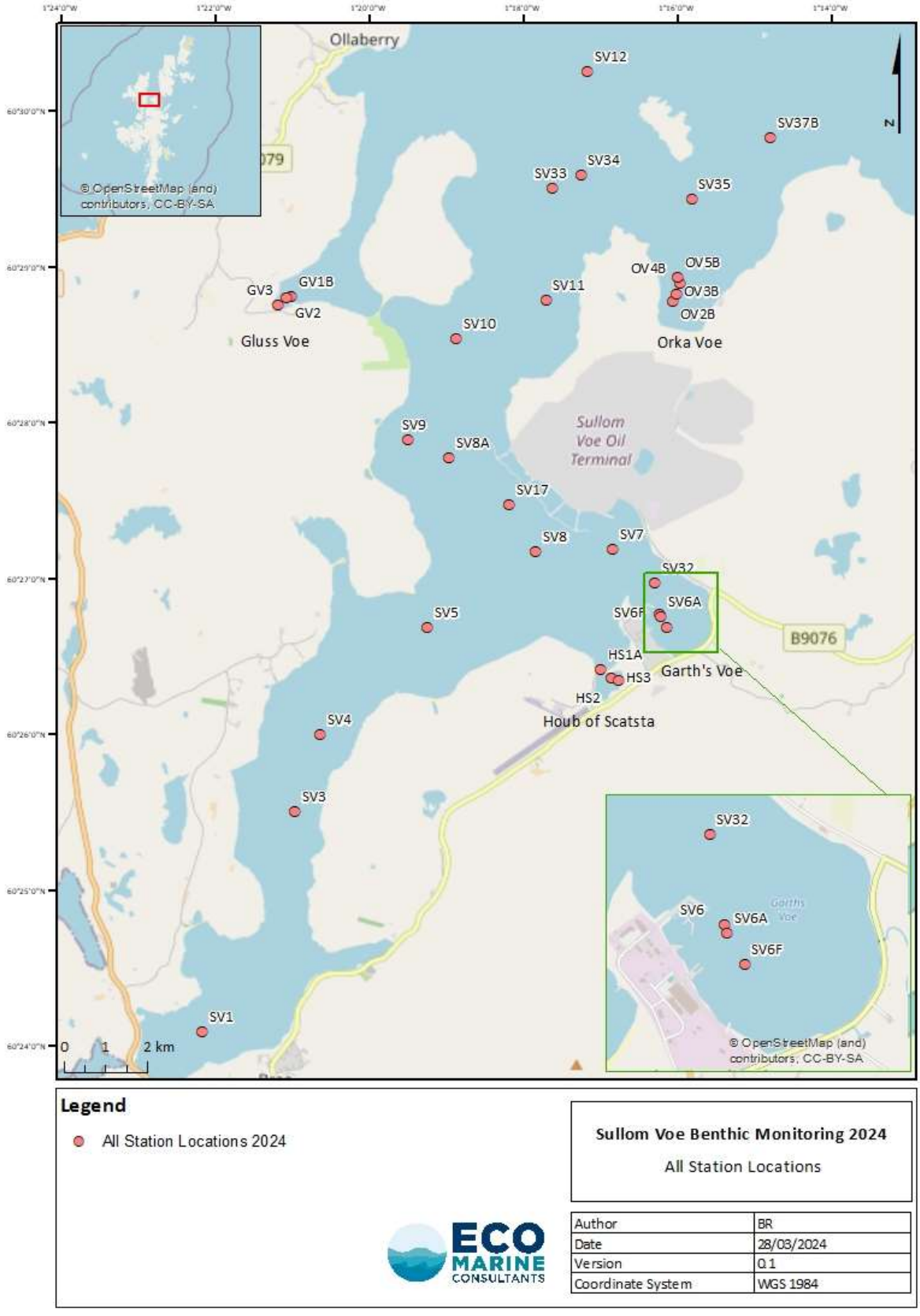

Figure 1 - The location and distribution of target stations at Sullom Voe in 2024.

2.2 FIELD SAMPLING METHODS

The sampling methods for the core parameters were the same as those used in previous surveys. Method details are provided in more depth within the “Terms of Reference” document.

In summary, seabed sediment samples were collected using a Day grab which had a surface area of 0.1m^2. Grabs were taken and sub-sampled for the analysis of the following parameters: sediment grain size; organic matter and total aliphatic hydrocarbons and aromatic hydrocarbons.

As in previous surveys the subsamples for sediment grain size and organic matter were taken from each of the grab samples to make a composite sample.

Individual sub-samples of sediment for hydrocarbon analysis were taken from each of the three Day grab samples identified for macrobenthic analysis. The hydrocarbon subsample was taken from the top 2 cm of sediment in the Day grab sampler as standard practice for this survey.

Particle size analysis, organic carbon and hydrocarbon sub-samples were frozen after collection, and were kept frozen during transportation to the analytical laboratory.
Once the particle size, organic carbon and hydrocarbon subsamples had been obtained from the Day grab sample the remaining sediment was used for the analysis of benthic macrofauna. The sediment was carefully washed through a 1mm mesh stainless steel sieve and preserved in approximately 5-10% solution of buffered formalin in seawater.

Samples of sediment for hydrocarbon analysis and particle size distribution were taken at each of the soft shore stations in Gluss Voe and the Houb of Scatsta.

2.3 LABORATORY METHODS

The laboratory method details are provided in more depth within the “Terms of Reference” document.

A summary of each method and a discussion of the approach to the interpretation of the data are given below.

2.3.1 SEDIMENT GRAIN SIZE ANALYSIS AND ORGANIC MATTER

The particle size analysis for the 2024 survey was subcontracted to Ocean Ecology Limited. The 2024 particle size analysis was performed using NMBAQC methodology and Oceans Ecology participate in the NMBAQC proficiency testing protocols.

Ocean Ecology Limited achieved a “good” status in each aspect of their analysis of the 2024 PSA NMBAQC proficiency testing scheme.

The total organic carbon analysis for the 2024 survey was subcontracted to SOCOTEC Marine Department and was determined by in-house test method WSLM59. The laboratory holds ISO 17025 and MMO accreditation for this test method. The method includes air drying the samples, carbonate removal by sulphurous acid treatment, before combustion at 1600°C and NDIR (non-dispersive infrared) detection. This method is similar to British Standard method BS 13137 which has been used in recent surveys, however prior to this total organic carbon has been determined gravimetrically by loss on heating at 450°C and presented as percent weight of sample.

2.3.2 SEDIMENT HYDROCARBON ANALYSIS

The analytical procedures used in the present study are the same as those used since 1992 when gravimetric analyses were replaced by improved methods, which are detailed in the “terms of reference” document reference.

The hydrocarbon analysis was performed by SGS United Kingdom. In previous surveys up to 2014, the hydrocarbon analysis had been performed by SGS M-Scan limited.

In order to ensure that the effects of changing laboratory were minimised, a copy of the extraction method was given to SGS United Kingdom and validated by analysing certified reference materials and also by performing spike and recovery experiments. The quality control requirements were taken from Marine Management Organisation guidance for chemical determinands November 2024.

To improve the quality of the hydrocarbon measurement, blanks and certified reference materials were extracted alongside the samples, at a frequency of 1 per 6 sediment samples.

SGS United Kingdom participates in the LGC CONTEST proficiency testing scheme for total petroleum hydrocarbon testing in soil samples and achieved a “good” status in the 2024 round using their in-house method.

The hydrocarbon analysis was performed at an ISO 17025 accredited laboratory, and while the test method itself was not within the scope of the ISO 17025 accreditation the analysis was performed under the same quality management system.

The concentrations of total aliphatic hydrocarbons (TAH), unresolved complex mixture (UCM), and other selected parameters have been calculated by integration of Gas chromatography (GC) data.

The concentrations of 2-6 ring polycyclic aromatic hydrocarbons (PAH; parent PAH and alkylated homologues) in nine selected sediments were determined using Gas Chromatography with Mass Selective Detection (GC-MS).

2.3.3 SEDIMENT MAJOR AND TRACE ELEMENT ANALYSIS

Major and trace element analysis was not performed in the 2024 survey. The analysis is next scheduled to be performed at the 2027 survey.

3 RESULTS AND DISCUSSION

3.1 INTRODUCTION

The Results and Discussion section will present the raw data for selected test parameters and then present the 2024 data for each station against the historical survey data utilising "control" type charts. It is hoped that the charts will enable a visual assessment of the current data points against the historic data so that changes can be more easily identified.

For each test parameter, basic statistical tools have been used to aid interpretation of the data; mean results and limits based on standard deviations of the historic data set. The charts comprise of the historic and current data points, a trend line (using all the historic data points), and standard deviation lines which are equivalent to -3,-2,-1,+1,+2 and +3 standard deviations. The standard deviations for the hydrocarbon analysis (total aliphatic hydrocarbon content, the percentage unresolved complex mixture to total aliphatic hydrocarbon content, and the poly-aromatic hydrocarbon content) have been calculated using the historic data set from 2004 to 2021.

The standard deviations have been used to help assess if there has been a significant change in the 2024 result against the mean results for 2004-2021. Where historic mean results and standard deviations are referenced in the report they have been calculated from the data set 2004-2021, unless stated otherwise. Stations that have changed position have not been included in this assessment, once more data is available from the re-established sites the trend analysis of the sites will be incorporated into the reports.

The below outlines how the standard deviations are presented and should be interpreted;

-1 and +1 standard deviation lines are coloured yellow.
-2 and +2 standard deviation lines are coloured orange.
-3 and +3 standard deviation lines are coloured red.

-1 to +1 SD	indicates little change against the historic data.
-2 to -1 and +1 to +2 SD	indicates some change against the historic data.
-2 to -3 and +2 to +3 SD	indicates significant change against the historic data.
<-3 and >+3 SD	indicates very significant change against the historic data

Standard deviations lines are not included where the line is outside the scope of the measurement eg <0 concentration or outside 0-100%.

3.2 SEDIMENT CHARACTERISATION

The results of the analyses of sediment particle distribution for 2024, organic matter and sediment type classification according to Folk (1954) are given in Tables 2, 3 and 4. Combined Particle size distribution (PSD) graphs are included as Appendix 1 and 2.

The 2024 PSD analysis was performed by Oceans Ecology Limited.

The particle size distribution was performed by the NMBAQC methodology in 2024 which is consistent with the 2016, 2018 and 2021 surveys but different from previous years. Now that the methodology is standardised to the NMBAQC methodology, it should enable better interpretation of PSA data trends. Due to potential inconsistencies in PSA methodology in surveys up to 2016, it is difficult to interpret the 2016 -2021 data sets robustly in context of the historical data.

The Sullom Voe stations continue to be contain predominantly sand and mud range particles. Some stations have high gravel contents including SV17 in the Jetty area. The changes in the particle size distribution is very varied between the stations, some stations, particularly more sheltered stations, have demonstrated very little change in their particle distribution while other stations have seen more dramatic changes.

The mud content results since 2016 are on average across the stations 13% higher than in studies 2006-2014. The mud content for 2024 are generally comparable to the 2021 results and most do not differ by more than 15% when the results are directly compared, with the exception of SV17. At station SV17, which is close to the Jetty area, we typically see some variation in the particle distribution between surveys, there was 19.9% less mud than in 2021, however the mud content change is less significant when compared to the mean mud contents between 2004-2014 and 2004-2021. At station SV1 located in the Inner Voe the mud content (40.1%) was almost identical to the 2021 level (40.2%), which are the lowest mud contents observed over the course of the project. Between 2016-2018 the mud content at SV1 was 80-85%, this station has shown a high level of variation in the mud/gravel/sand portions over the duration of the project, with results ranging from 40.1% to 91.9%. The terrestrial ingress of organic matter (twigs etc) may have a significant impact on the particle size analysis.

Particle size discussion in relation to the macrobenthic analysis is detailed in report SGSSUL0624 section 3.1.5 by Eco Marine Consultants Limited.

For the review of particle size distribution results in context of the historical data, no standard deviation lines have been included on the charts. Standard deviation limits could be included in these charts once more data is available analysed using the NMBAQC protocols.

The total organic content analysis was performed by SOCOTEC and determined using an in-house method WSLM59. The results for total organic content were lower for most stations than in 2021, however higher results were obtained for SV1, SV6A and SV6F. The analysis was performed to a standard methodology and the laboratory holds ISO 17025 and Marine Management Organisation accreditation for this analytical method.

Table 2 - Physical parameters of sediments from Sullom Voe stations, June 2024.

STATION	Phi Mean	Phi Skewness	Phi Kurtosis	% Mud	% Sand	% Gravel	% Organic Content	Textural Group
1	3.518	0.125	0.872	40.1	59.6	0.3	20.8	Slightly Gravelly Muddy Sand
3	3.323	-0.209	1.129	47.3	45.6	7.1	4.0	Gravelly Mud
4	4.244	-0.091	1.443	54.0	38.9	7.1	4.1	Gravelly Mud
5	3.623	-0.188	1.154	51.5	41.9	6.6	3.8	Gravelly Mud
7	3.639	-0.160	1.274	48.1	43.1	8.8	6.3	Gravelly Mud
8	3.757	-0.057	0.928	48.8	47.6	3.6	2.6	Slightly Gravelly Sandy Mud
8A	3.835	0.138	1.150	40.8	55.3	3.9	1.8	Slightly Gravelly Muddy Sand
9	4.109	-0.143	1.277	55.1	39.3	5.6	5.8	Gravelly Mud
10	4.744	0.196	0.978	58.0	39.9	2.1	3.2	Slightly Gravelly Sandy Mud
11	4.882	0.265	0.898	61.7	37.2	1.1	3.3	Slightly Gravelly Sandy Mud
17	-0.459	0.163	1.181	14.4	46.0	39.7	1.8	Muddy Sandy Gravel
12	1.796	0.025	1.528	12.1	81.5	6.3	1.1	Gravelly Muddy Sand
33	3.624	0.034	2.201	31.9	58.9	9.2	2.2	Gravelly Muddy Sand
34	3.882	0.306	1.160	38.2	61.4	0.5	1.6	Slightly Gravelly Muddy Sand
35	1.399	0.115	1.211	14.6	70.3	15.0	0.7	Gravelly Muddy Sand
37C	0.532	0.056	1.047	3.7	86.8	9.6	0.9	Gravelly Sand
6	3.224	-0.052	1.144	36.6	56.9	6.5	4.3	Gravelly Muddy Sand
6A	3.158	0.050	1.011	32.4	64.8	2.8	12.2	Slightly Gravelly Muddy Sand
6F	3.286	0.063	1.053	34.2	65.8	0.0	13.2	Muddy Sand
32	3.898	0.076	1.058	45.4	52.4	2.2	10.5	Slightly Gravelly Muddy Sand

Table 3 - Physical parameters of sediments from Orka Voe shore stations, June 2024.

STATION	Phi Mean	Phi Skewness	Phi Kurtosis	% Mud	% Sand	% Gravel	% Organic Content	Textural Group
OV2B	3.803	0.371	1.181	34.0	64.5	1.5	1.0	Slightly Gravelly Muddy Sand
OV3B	3.656	0.284	1.349	32.2	66.9	0.9	0.9	Slightly Gravelly Muddy Sand
OV4B	3.549	0.251	1.284	31.5	68.	0.5	0.9	Slightly Gravelly Muddy Sand
OV5B	3.384	0.209	1.277	29.7	70.1	0.2	0.7	Slightly Gravelly Muddy Sand

Table 4 - Physical parameters of sediments from soft shore stations, June 2024

STATION	Phi Mean	Phi Skewness	Phi Kurtosis	% Mud	% Sand	% Gravel	% Organic Content	Textural Group
GV1	-0.573	0.236	0.950	6.3	46.1	47.6	0.2	Muddy Sandy Gravel
GV2	0.921	-0.085	1.062	12.0	66.0	22.0	0.1	Gravelly Muddy Sand
GV3	-0.121	0.294	0.939	8.4	48.0	43.6	0.3	Muddy Sandy Gravel
HS1	-1.474	0.163	0.920	3.6	38.8	57.5	0.1	Sandy Gravel
HS2	2.318	0.143	1.292	11.3	88.7	0.0	0.2	Muddy Sand
HS3	1.963	0.049	1.969	9.7	85.1	5.2	0.5	Gravelly Muddy Sand

3.3 HYDROCARBONS

3.3.1 GAS CHROMATOGRAPHY OF ALIPHATIC HYDROCARBONS

The total aliphatic hydrocarbon (TAH) and unresolved complex mixture (UCM) results are detailed in table 5 below. Comparison charts with previous year's data are provided for each station in Section 3.4

3.3.1.1 Quality Control

3.3.1.1.1 Extraction Blanks

Blanks were analysed with each batch of 6 samples and the levels were found to between 0.6 to 4.0 µg.g^{-1} based on 50g dry weight basis. There was a small cluster of peaks which were impurities in the solvent which would be present in the sample chromatograms. The amount of total aliphatic hydrocarbon determined in the extraction blank was subtracted when quantifying the results for the sample analysis.

3.3.1.1.2 Quality Control Sample

2.5g certified reference material (CRM), which consisted of dried sediment spiked with diesel range organics at 885 ± 121 mg/Kg was analysed using the test method. The CRM was analysed prior to the survey samples as three batches of 5 CRM aliquots, then alongside the survey samples within each batch of 6 samples. The percentage recoveries for the certified reference material had a mean of 96%, (85% in 2021 and 87% in 2018) and relative standard deviation of 8.2% (6.7% in 2021 and 8.5% in 2018). The results were within the expected method performance.

Figure 2- Certified Reference Material percentage recovery chart

3.3.1.2 Analysis of Three Grab Samples

In 2024 each grab sample which was to be tested for macrobenthic analysis was sub-sampled and analysed for hydrocarbon analysis. The sub-sample for hydrocarbon analysis was taken from the top 2cm of the grab. In surveys prior to 2014 a composite sample was prepared and used for the hydrocarbon analysis.

The variation between the replicate results for tidal stations in 2024 was lower than in 2021 and ranged between 1 and 16.6%. The estimate of uncertainty from the CRM analysis (2x standard deviation of the CRM results) was 15.6% which correlates with the maximum variation seen between replicates. There doesn't appear to be a correlation for the sediment composition or the station locations and the variation between replicates. The variation is mostly likely to be associated with laboratory variables and methodology.

The soft shore stations at Gluss Voe and Houba Scatsa were again at low concentrations (<10µg.g^{-1}) where the uncertainty of measurement is higher at the reporting limit of the method. The standard deviations between replicates were within 30, although HS3 replicates were just within this limit at 27.6%.

The relative standard deviation of the all stations where the Total Aliphatic Hydrocarbon was <10µg.g^{-1} were within 30 percent relative standard deviation.

3.3.1.3 Total Aliphatic Hydrocarbon Results

The total aliphatic hydrocarbon (TAH) results are detailed in table 6 below.

The gas chromatograms obtained during the Total Aliphatic Hydrocarbon analysis of the sediment sample in 2024 did not show any fundamental changes in the oil profile, when compared to the traces for 2014, 2016, 2018 and 2021. There continues to be evidence of weathered or aged hydrocarbons at most stations, observed as an unresolved complex mixture. While there are some resolved peaks observed in the TAH analysis they do not conform to the uniform distribution across all carbon bands that would be expected from a fresh Forties crude oil distribution. The gas chromatogram patterns are very similar across the stations with only the relative intensities differing.

The total aliphatic hydrocarbon (TAH) concentrations for 2024 were broadly comparable with the results in 2021. The average TAH result was 33.3 µg.g^{-1} for all stations (excluding OV2B-OV5B), in 2021 this was 28.4 µg.g^{-1}, in 2018 this was 29.9 µg.g^{-1}, in 2016 this was 33.2 µg.g^{-1} for the same stations. There is very little change in the TAH concentration between 2016 and 2024. The 2024 TAH results for each station, except SV33 and SV34, were within 1 standard deviation to the historic mean for results 2004-2024 indicating there had been little change. For Outer Voe stations SV33 and SV34 the TAH results were -1.3 and -1.2 standard deviation from the historic mean 2004-2024, indicating there had been some change. However, the 2024 results are consistent with recent results since 2016 and the historic mean may not reflect the recent results due to notably higher TAH concentrations reported in 2004-2008. The trend at SV33 and SV34 is not observed at the other Outer Voe stations SV12 and SV35.

While the 2024 TAH results at some stations were slightly higher than in 2021 and recent surveys, the trend of the 2024 total aliphatic hydrocarbon (TAH) results fits with the general observation of that the concentration of hydrocarbons in the sediments within the Sullom Voe are stable and following a decreasing trend.

The hydrocarbon concentrations at Orka Voe OV2-OV5 were comparable to the results from 2021 however 2021-2024 TAH levels show a significant decrease in concentration compared to the 2018 levels. See Table 5.

Table 5 – Total Aliphatic Hydrocarbons concentrations 2018, 2021 and 2024 for Orka Voe.

		2024 Survey		2021 Survey		2018 Survey	
Area	Station	Mean Total Aliphatics (µg/g)	Relative Standard Deviation of Total Aliphatics (%)	Mean Total Aliphatics (µg/g)	Relative Standard Deviation of Total Aliphatics (%)	Mean Total Aliphatics (µg/g)	Relative Standard Deviation of Total Aliphatics (%)
Orka Voe	OV2B	4.8	*3.9*	5.1	*9*	*24*	*13*
	OV3B	5.3	*3.8*	5.4	*10.1*	21.5	*22*
	OV4B	5.8	*3.2*	5.1	*13.8*	18.4	*14*
	OV5B	5.2	*11.8*	5.4	*7.1*	12.7	*13*

3.3.1.4 Unresolved Complex Mixture Results

The unresolved complex mixture (UCM) results are detailed in table 6 below.

The UCM is expressed in the analytical units $\mu g.g^{-1}$ and also as a percentage of the TAH concentration. The UCM in $\mu g.g^{-1}$ demonstrated evidence of increasing slightly on average across all the stations.

The average UCM ($\mu g.g^{-1}$) result was 21.6 $\mu g.g^{-1}$ for all stations (except SV36B, SV37B and OV1B-OV5B) in 2021, in 2021 this was 17 µg.g-1, in 2018 this was 17.0 $\mu g.g^{-1}$, in 2016 this was 23.3 $\mu g.g^{-1}$, the historic mean UCM result for the period 2004-2018 was 19.5 $\mu g.g^{-1}$ for the same stations. There has been little change in the UCM concentration during the period 2016-2024.

For all stations, the relative standard deviation of the historic data set 2004-2016 was <30% for each station. The average UCM as a % of TAH result was 60.8% for all stations (except SV36B, SV37B and OV1B-OV5B) in 2024, in 2021 this was also 60.8%, in 2018 this was 65.4%, in 2016 this was 65.4%, and the historic mean UCM result for the period 2004-2018 was 52.3% for the same stations. The higher UCM portion of the overall TAH, could be accounted for due to weathering or aging effects of the hydrocarbon components present.

Table 6 - Summary of parameters from GC analysis of aliphatic hydrocarbons in all stations, June 2024

STATION	Mean Total Aliphatics (µg/g)	Relative Standard Deviation of Total Aliphatics (%)	Mean UCM (µg/g)	UCM of Total Aliphatics (%)	Relative Standard Deviation of % UCM (%)
SV1	177	*15.5*	113	63.8	*19.5*
SV3	27.7	*14.3*	17.5	62.9	*23.4*
SV4	26.0	*16.3*	15.5	59.8	*16.3*
SV5	29.9	*7.0*	21.0	70.4	*7.1*
SV7	48.8	*16.0*	33.0	67.7	*16.0*
SV8	18.2	*10.0*	12.5	68.7	*11.6*
SV8A	12.4	*0.8*	8.6	69.3	*3.4*
SV9	34	*4.8*	22.5	66.1	*3.5*
SV10	16.4	*1.6*	10.4	63.4	*14.2*
SV11	19.0	*8.6*	12.2	64.0	*21.8*
SV17	10.7	*4.3*	7.3	68.6	*20.0*
SV12	2.8	*16.6*	1.9	68.7	*18.8*
SV33	5.3	*14.9*	3.7	69.6	*3.7*
SV34	6.4	*9.6*	4.4	68.7	*8.1*
SV35	2.4	*12.1*	1.5	62.5	*15.2*
SV37B	3.0	*3.4*	2.5	81.6	-
SV6	44.8	*4.8*	28.6	63.8	*6.8*
SV6A	93.9	*13*	59.3	63.2	*7.2*
SV6F	126	*13.2*	82.5	65.5	*17.5*
SV32	109	*6.4*	74.8	68.5	*12.1*
OV2B	4.8	*3.9*	3.2	66.8	*5.1*
OV3B	5.3	*3.8*	3.7	68.9	*3.6*
OV4B	5.8	*3.2*	3.8	66.9	*10.6*
OV5B	5.2	*11.8*	3.8	72.7	*14.7*
GV1B	2.6	*10.9*	1.2	45.4	*10.7*
GV2	1.7	*10.5*	0.5	31.3	*12.5*
GV3	2.2	*14.9*	1.0	46.8	*4.0*
HS1A	3.1	*10.2*	1.7	55.9	*15.7*
HS2	6.0	*15.4*	2.1	36.0	*6.7*
HS3	5.5	*27.6*	2.6	48.2	*22.4*

µg/g results are expressed on a dry weight basis.
UCM – Unresolved Complex Mixture

3.3.2 GC/MS - POLYCYCLIC AROMATIC HYDROCARBONS (PAHS)

3.3.2.1 Polycyclic Aromatic Hydrocarbons (PAHs)

The polycyclic aromatic hydrocarbon (PAH) results are detailed in tables 7 and 8 below. Comparison charts with previous year's data are provided for each station in section 3.4

Solvent extracts of sediment sub-samples from 9 stations were analysed for concentration of 2-6 ring PAHs. These results along with the percentage of 4-6 ring PAHs of the total PAHs, were compared to the historic data available for the stations between 2004-2021. The station OV5B was analysed but not assessed against historic data as their coordinates had been re-established in 2016.

As with the GC traces for the aliphatic fractions, the distribution of aromatic hydrocarbons in the total ion chromatogram (TIC) traces for the sediments in 2024 are very similar to the 2021 survey. Complex mixtures of PAH were detected by gas chromatography with mass chromatography (GC-MS) including alkyl substituted compounds as well as their un-substituted (parent) homologues.

In petroleum products there are substantial amounts of alkylated PAH. Hence a relatively high proportion of these derivatives with respect to the non-alkylated parent PAH indicates a petrogenic input. Petrogenic aromatic hydrocarbon distributions in sediments differ from those of fresh crude oils, as the latter are dominated by alkylnaphthalenes and alkylphenanthrenes. These components are preferentially removed by the processes of weathering.

In 2024, the total 2-6 ring PAH results demonstrated little evidence of change across the seven stations analysed against the 2021 results and the historic data for 2004-2021. The average 2-6 ring PAH result was 1137 $ng.g^{-1}$ for all valid stations (except the Orka Voe stations) in 2024, this was 1203 $ng.g^{-1}$ in 2021, 1230 $ng.g^{-1}$ in 2018, and in 2016 this was 1310 $ng.g^{-1}$, the historic mean 2-6 ring PAH result for the period 2004-2016 was 1317 $\mu g.g^{-1}$ for the same stations. The average number of standard deviations from the historic mean (for period 2004-2014) across all valid stations was -0.5, this demonstrates that there has been little change in the overall PAH concentration in the Sullom Voe area.

Table 7 - Concentrations of 2-6 ring aromatic hydrocarbons in selected sediments, 2024 (ng.g^{-1} dry weight sediment; ppb).

Station	SV1	SV4	SV7	SV17	SV34
Naphthalene(N)	13	3.4	20	7.8	3.1
C1-Naphthalenes	20	8.1	12	3.8	6.7
C2-Naphthalenes	116	23	50	13.4	8.0
C3-Naphthalenes	35	8.4	30	7.5	0.8
C4-Naphthalenes	8.0	1.5	10	2.1	0.6
Total Naphtalenes(N)	**192**	**44**	**122**	**35**	**19**
Phenanthrene/Anthracene(P)	18	8.6	43	40	3.0
C1-Phenanthrenes/Anthracenes	26	14	19	19	5.2
C2-Phenanthrenes/Anthracenes	39	6.8	35	38	3.7
C3-Phenanthrenes/Anthracenes	11	6.7	47	5.7	1.3
Total Phenathrenes(P)	**94**	**36**	**144**	**103**	**13**
Dibenzothiophene(D)	1.3	7.8	5.1	5.7	6.2
C1-Dibenzothiophenes	23	2.7	33	2.6	0.7
C2-Dibenzothiophenes	19	1.3	15	1.9	0.4
C3-Dibenzothiophenes	12	0.3	11	1.4	0.3
Total Dibenzothiophenes(D)	**55**	**12**	**64**	**12**	**7.6**
ΣNPD	**342**	**92**	**331**	**149**	**40**
Fluoranthene/Pyrene	183	53	350	260	19
C1-Fluoranthenes/Pyrenes	58	14	93	54	5.9
C2-Fluoranthenes/Pyrenes	61	10	95	37	3.0
C3-Fluoranthenes/Pyrenes	52	13	52	8.2	1.8
Total Fluoranthenes/Pyrenes	**354**	**90**	**590**	**359**	**30**
Benzanthracene/Chrysene	106	30	143	152	10
C1-Benzanthracenes/Chrysenes	50	13	58	17	3.1
C2-Benzanthracenes/Chrysenes	29	6.5	68	2.6	2.3
Total Benzanthracenes/Chrysenes	**185**	**50**	**269**	**171**	**15**
Benzofluorathenes/Benzopyrene	227	65	285	187	27.6
C1-Benzofluorathenes/Benzopyrenes	173	39	121	66	13
C2-Benzofluorathenes/Benzopyrenes	132	24	62	13	5.3
Total Benzofluorathenes/Benzpyrenes	**532**	**128**	**468**	**266**	**46**
m/z 276	307	78	179	74	27
C1-m/z276*	46	8.3	42	22	6.9
c2-m/z276*	28	10	14	6.9	3.5
Total m/z276*	**381**	**96**	**235**	**103**	**37**
Total 2-6 ring PAH	**1794**	**456**	**1893**	**1048**	**168**
% 4-6 ring PAHs as a % of the total PAHs	**80.9**	**79.8**	**82.5**	**85.8**	**76.4**

Table 8 - Concentrations of 2-6 ring aromatic hydrocarbons in selected sediments, 2024 (ng.g^{-1} dry weight sediment; ppb).

Station	SV6	SV6F	OV5B
Naphthalene(N)	9.6	4.1	8.0
C1-Naphthalenes	9.9	1.4	3.4
C2-Naphthalenes	33	25	4.0
C3-Naphthalenes	6.0	10	2.8
C4-Naphthalenes	3.3	4.0	0.4
Total Naphtalenes(N)	**62**	**45**	**19**
Phenanthrene/Anthracene(P)	15	24	4.3
C1-Phenanthrenes/Anthracenes	49	28	5.8
C2-Phenanthrenes/Anthracenes	65	56	3.6
C3-Phenanthrenes/Anthracenes	15	36	0.8
Total Phenathrenes(P)	**144**	**144**	**15**
Dibenzothiophene(D)	6.1	17	<0.1
C1-Dibenzothiophenes	5.7	11	<0.1
C2-Dibenzothiophenes	3.9	13	<0.1
C3-Dibenzothiophenes	3.4	8.5	<0.1
Total Dibenzothiophenes(D)	**19**	**50**	**<0.1**
ΣNPD	**224**	**238**	**34**
Fluoranthene/Pyrene	191	243	3.2
C1-Fluoranthenes/Pyrenes	55	83	13
C2-Fluoranthenes/Pyrenes	34	66	3.8
C3-Fluoranthenes/Pyrenes	26	88	1.1
Total Fluoranthenes/Pyrenes	**306**	**480**	**21**
Benzanthracene/Chrysene	60	96	3.2
C1-Benzanthracenes/Chrysenes	30	64	1.4
C2-Benzanthracenes/Chrysenes	11	32	0.5
Total Benzanthracenes/Chrysenes	**101**	**192**	**5.1**
Benzofluorathenes/Benzopyrene	82	199	11
C1-Benzofluorathenes/Benzopyrenes	53	129	0.6
C2-Benzofluorathenes/Benzopyrenes	25	69	<0.1
Total Benzofluorathenes/Benzpyrenes	**160**	**397**	**12**
m/z 276	106	192	13
C1-m/z276*	38	30	4.0
c2-m/z276*	90	44	1.1
Total m/z276*	**234**	**266**	**18**
Total 2-6 ring PAH	**1025**	**1573**	**90.1**
% 4-6 ring PAHs as a % of the total PAHs	**78.1**	**84.9**	**62.2**

3.3.3 ICP-OES/ICP-MS – Elemental Analysis

3.3.3.1 Elemental Analysis

No elemental analysis was performed in 2024, the next elemental analysis is scheduled for the 2027 survey.

3.4 Sullom Voe Stations - 2024 Data viewed against Historic Data

3.4.1 Inner Basin and Southern Sullom Voe (Stations 1, 3, 4 and 5)

3.4.1.1 Inner Basin Station SV1

For station SV1, the mud content in 2024 was 40.1%, which 0.1% lower than in 2021. The total organic content for station SV1 in 2024 was 20.8%, which was 7.6% higher than the 2021 result.

The mean concentration of total aliphatic hydrocarbons (TAH) at station SV1 was 177 µg/g (dry matter) which is very close to the historic mean (2004-2021) for this station. The relative standard deviation between the 3 TAH replicates was 15.5% indicating moderate variation in the sediment composition for TAH, the average relative standard deviation between the 3 replicates in 2024 was 10.2%. The 2024 TAH result was within 1 standard deviation of the historic mean for the results from 2004-2021. This suggests little change in the overall TAH concentration at station SV1. The percentage of UCM in the TAH continued to be higher that the historic mean and was +1.0 standard deviations from the historic mean 2004-2021, indicating there has been little recent change in the composition of oil profile.

The concentration of 2-6 ring PAH concentration at station SV1 was 1794 ng/g in 2024, which was similar to the result to the 2021 result 1760 ng/g. The 2024 2-6 ring PAH result was -1.0 standard deviations of the historic mean for the results from 2004-2021. This suggests little change in the overall PAH concentration at station SV1. The percentage of 4-6 ring PAHs to the total PAHs was within 1 standard deviations from the historic mean indicating there has been little change.

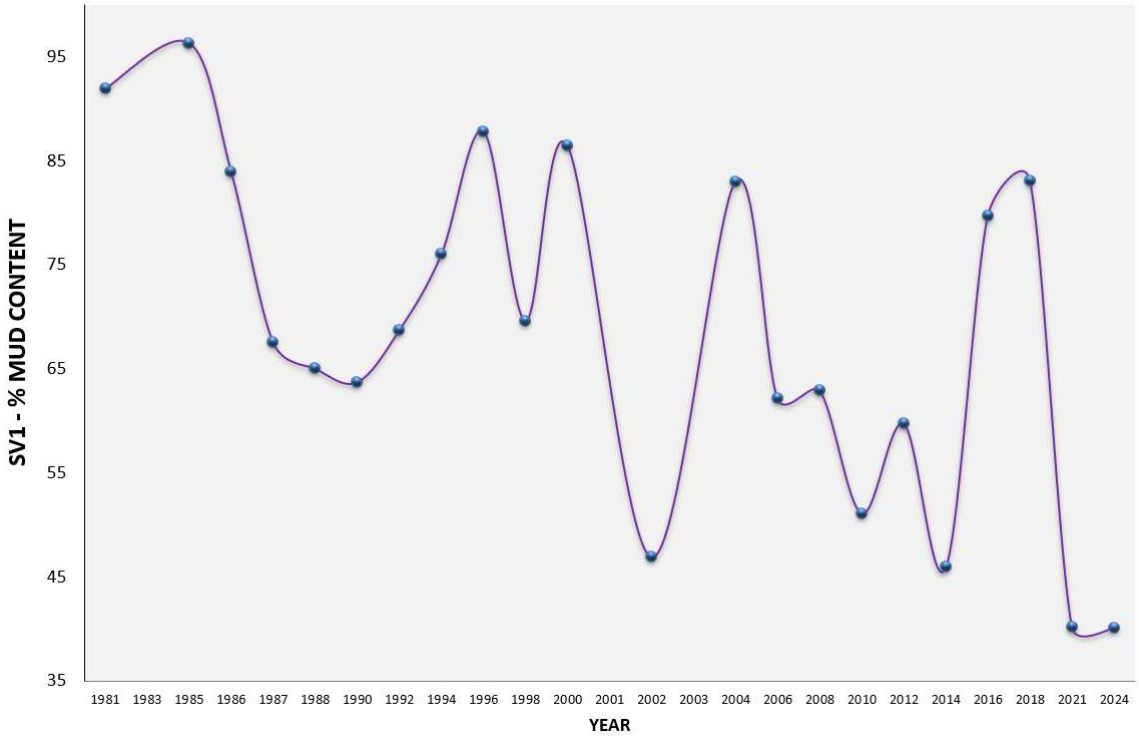

Figure 3 - SV1 Percentage Mud content

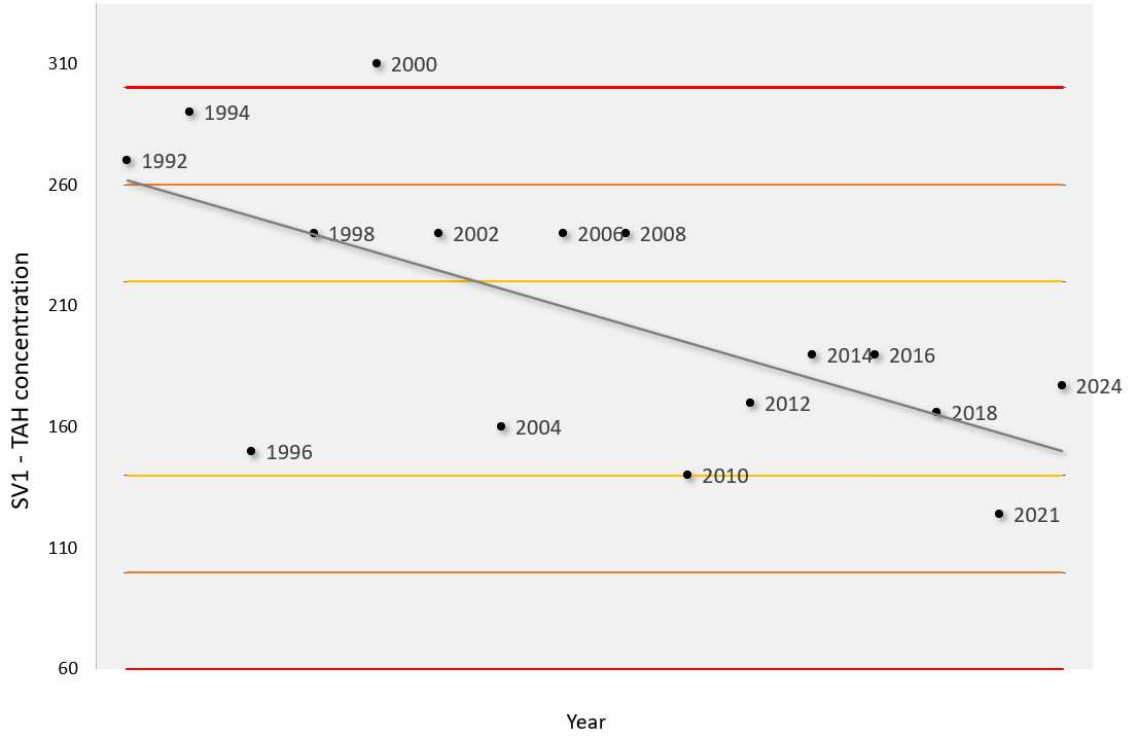

Figure 4 - SV1 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

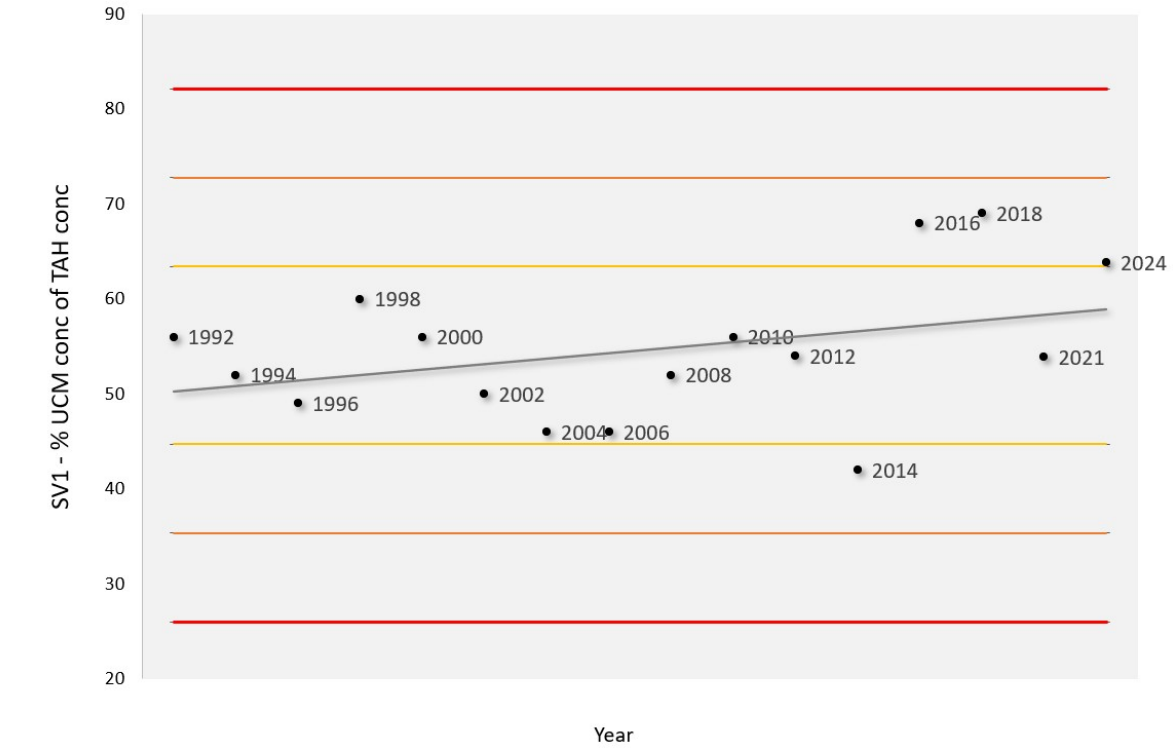

Figure 5 – SV1 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

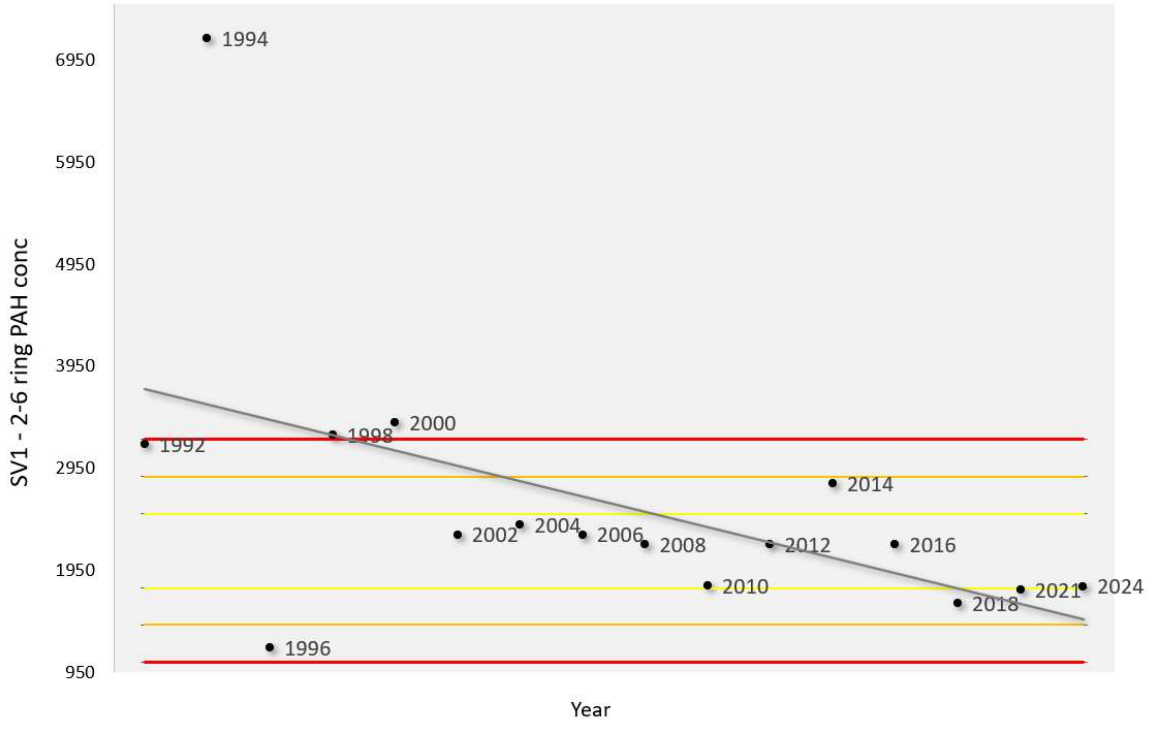

Figure 6 - SV1 2-6 ring PAH concentration (ng.g^{-1} dry sed.)

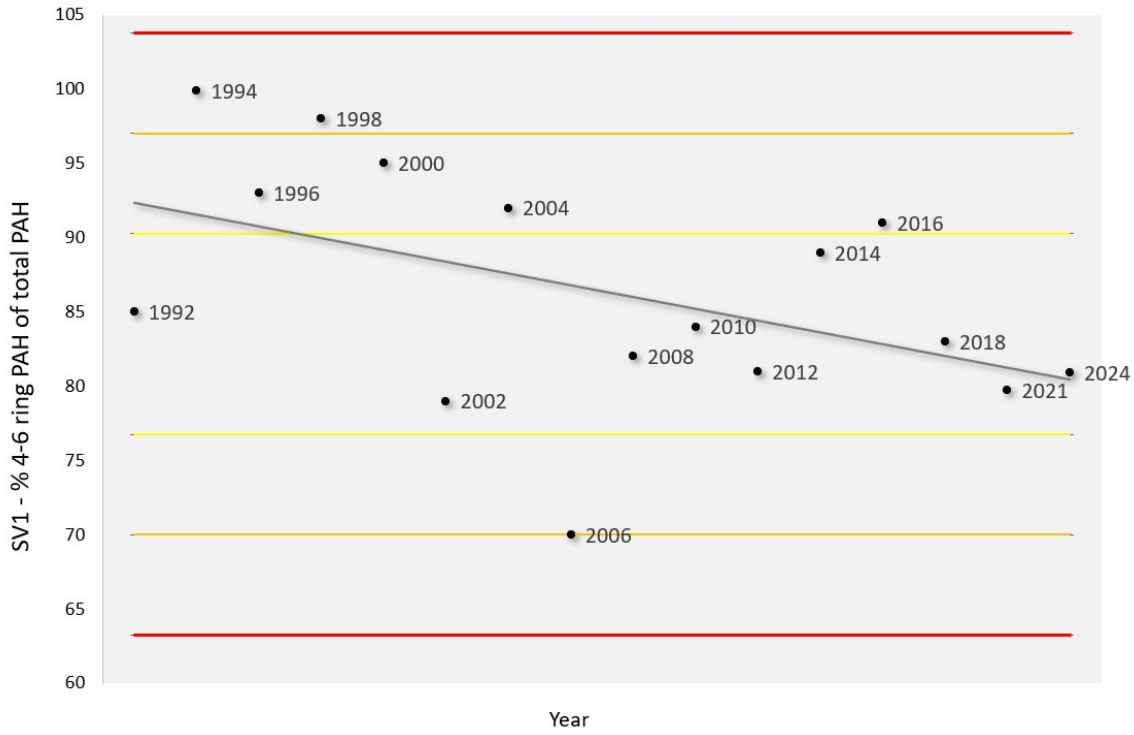

Figure 7 - SV1 4-6 ring PAHs as a percentage of the total PAHs (%)

3.4.1.2 Southern Sullom Voe SV3

For station SV3, the mud content in 2021 was 47.3%, which 9.0% higher than in 2021. The organic content for station SV3 in 2024 was 4.0%, which was 2.9% lower than the 2021 result.

The mean concentration of total aliphatic hydrocarbons (TAH) at station SV3 was 27.7 µg/g (dry matter) and is very close to the historic mean for this station (2004-2021). The relative standard deviation between the 3 TAH replicates was 14.3% indicating low variation in the sediment composition for TAH. The 2024 mean TAH result was within 1 standard deviation of the historic mean for the results from 2004-2021. This suggests little change in the overall TAH concentration at station SV3. The percentage of UCM in the TAH was similar to the 2016-2021 results which were higher than the historic mean result 2004-2021. The 2024 percentage of UCM in the TAH was within 1 standard deviation of the historic mean for 2004-2021, this indicates little change to the composition of oil profile.

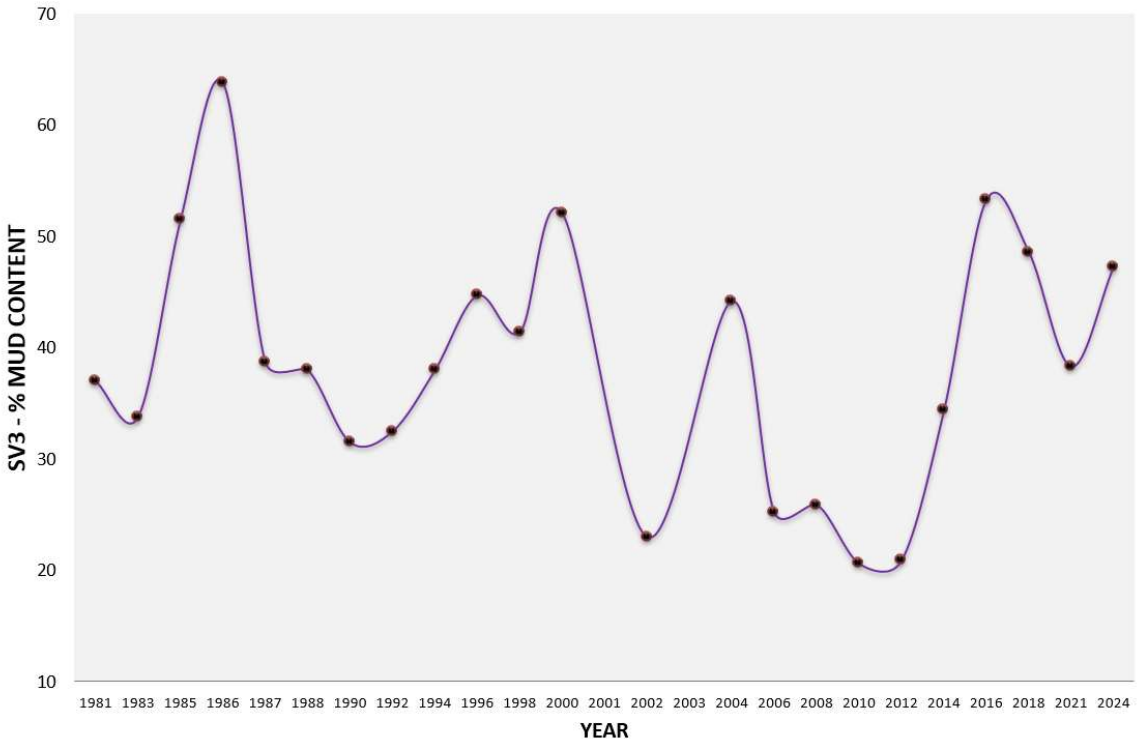

Figure 8 – SV3 Percentage Mud content

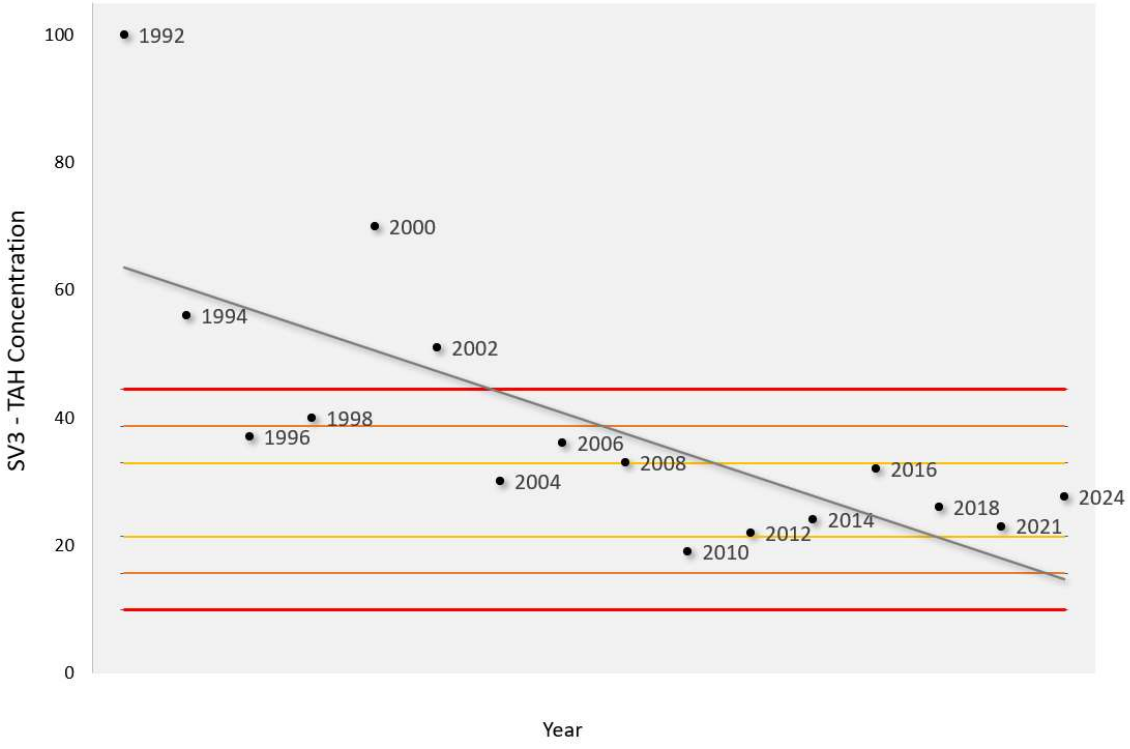

Figure 9 – SV3 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

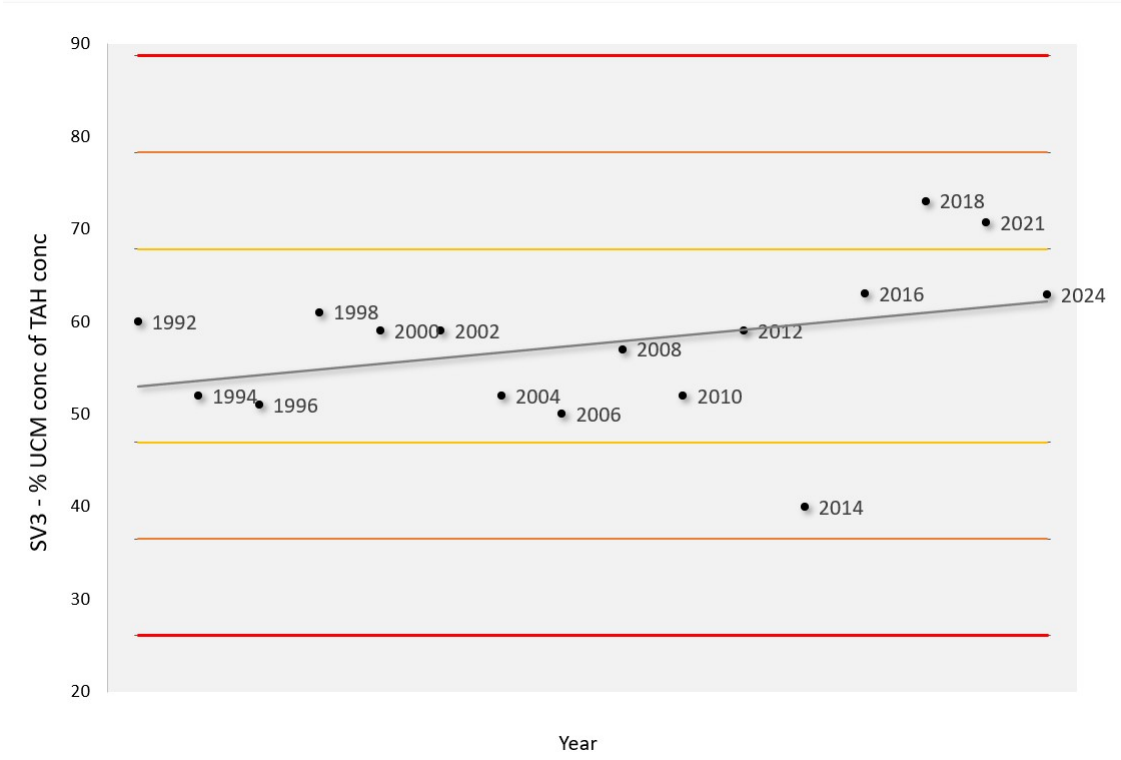

Figure 10 – SV3 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.1.3 Southern Sullom Voe SV4

For station SV4, the mud content in 2024 was 54.0%, which was 11.4% higher than in 2021 but is in a similar range to the 2016-2021 results. The 2024 mud content result was the highest result recorded at this station. The total organic content for station SV4 in 2024 was 4.1%, which was a 0.4% lower than the 2021 result.

The concentration of total aliphatic hydrocarbons (TAH) at station SV4 in 2024 was 26.0 µg/g (dry matter) and is very close to the historic mean for this station (2004-2021). The 2024 result was within 1 standard deviation from the historic mean for results 2004-2021, indicating that there had been little change. The relative standard deviation between the 3 TAH grab replicates was 16.3% indicating moderate variation in the sediment composition for TAH. The percentage of UCM in the TAH in 2024 was similar to the historic mean result 2004-2021, indicating little change to the composition of oil profile.

The concentration of 2-6 ring PAH concentration at station SV4 in 2024 was 456 ng/g which is close to the 2021 result of 420ng/g and the historic mean 2004-2021. The 2024 result was within 1 standard deviation from the historic mean, indicating there was little change. The percentage of 4-6 ring PAHs of the total PAHs was within 1 standard deviations from the historic mean for 2004-2021, indicating little change.

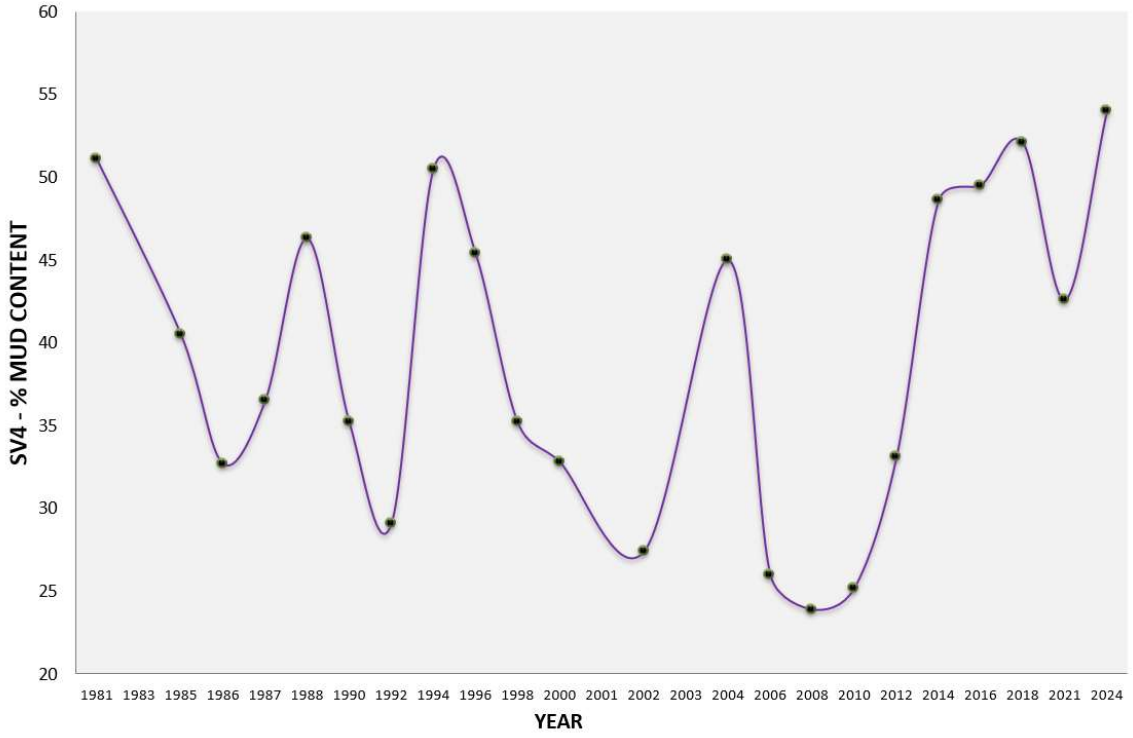

Figure 11 – SV4 Percentage Mud content

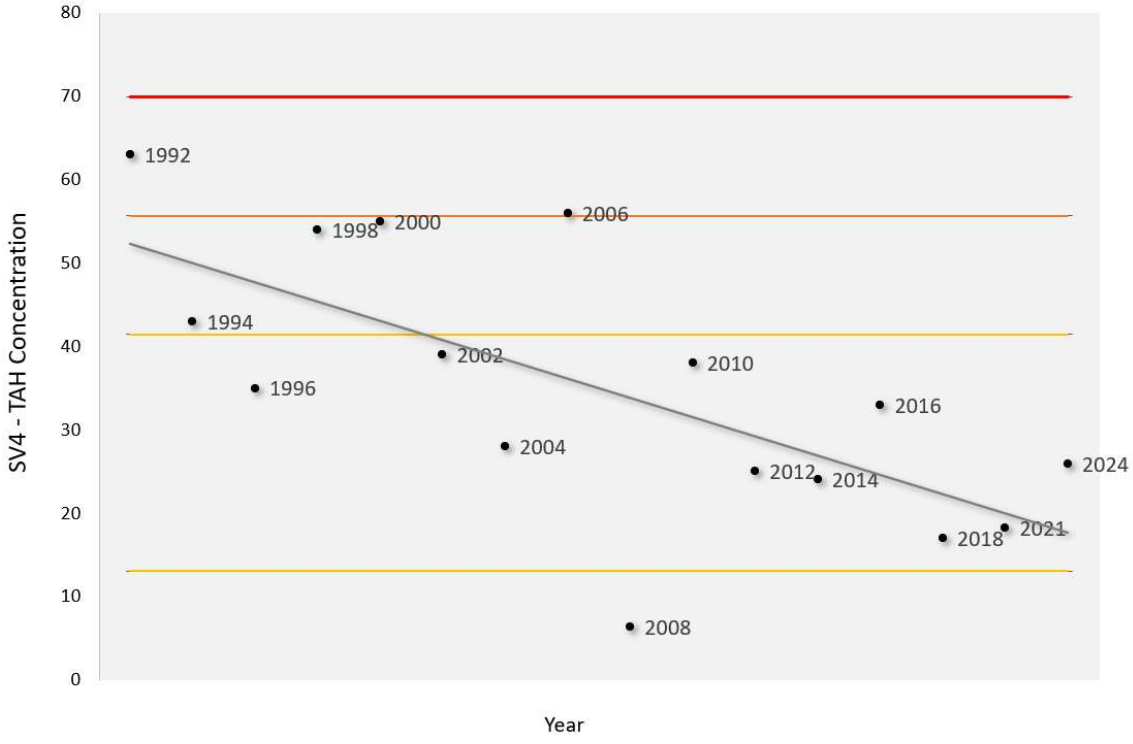

Figure 12 – SV4 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

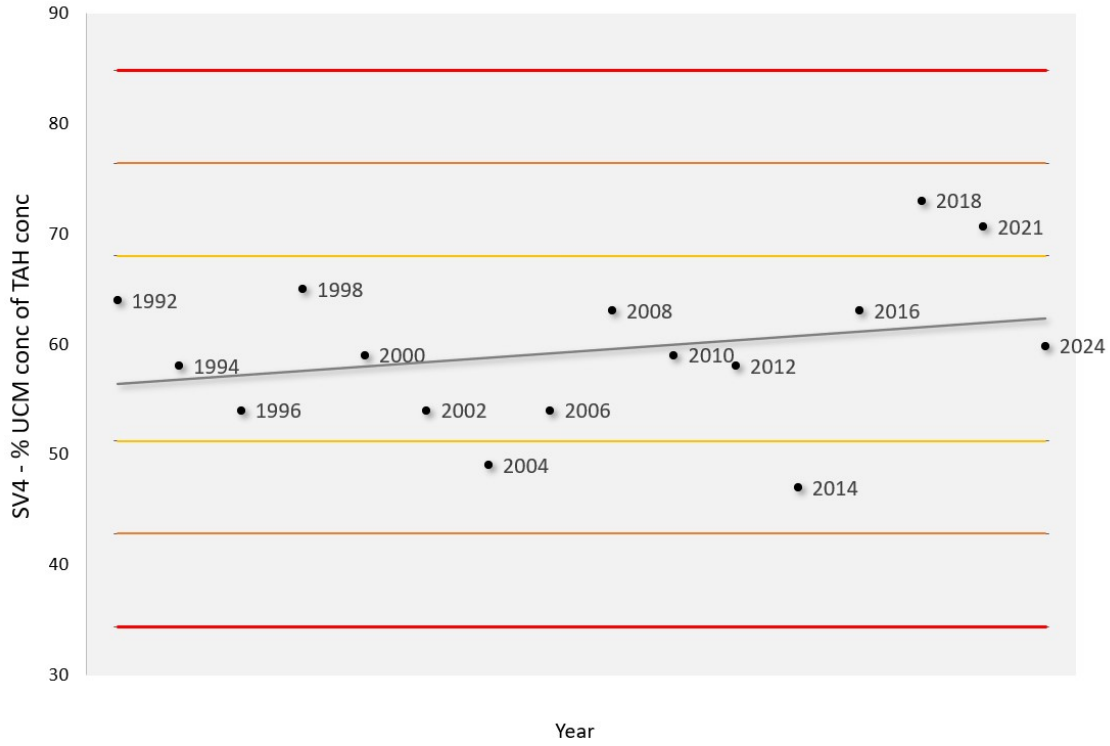

Figure 13 – SV4 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

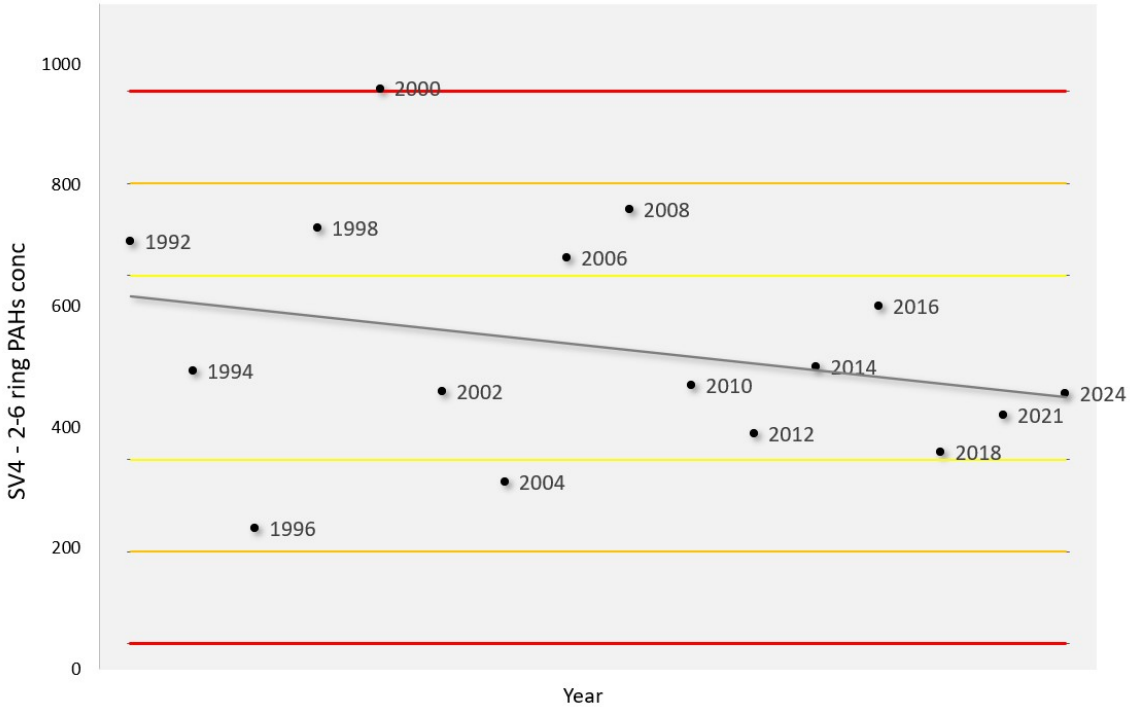

Figure 14 – SV4 2-6 ring PAH concentration (ng.g^{-1} dry sed.)

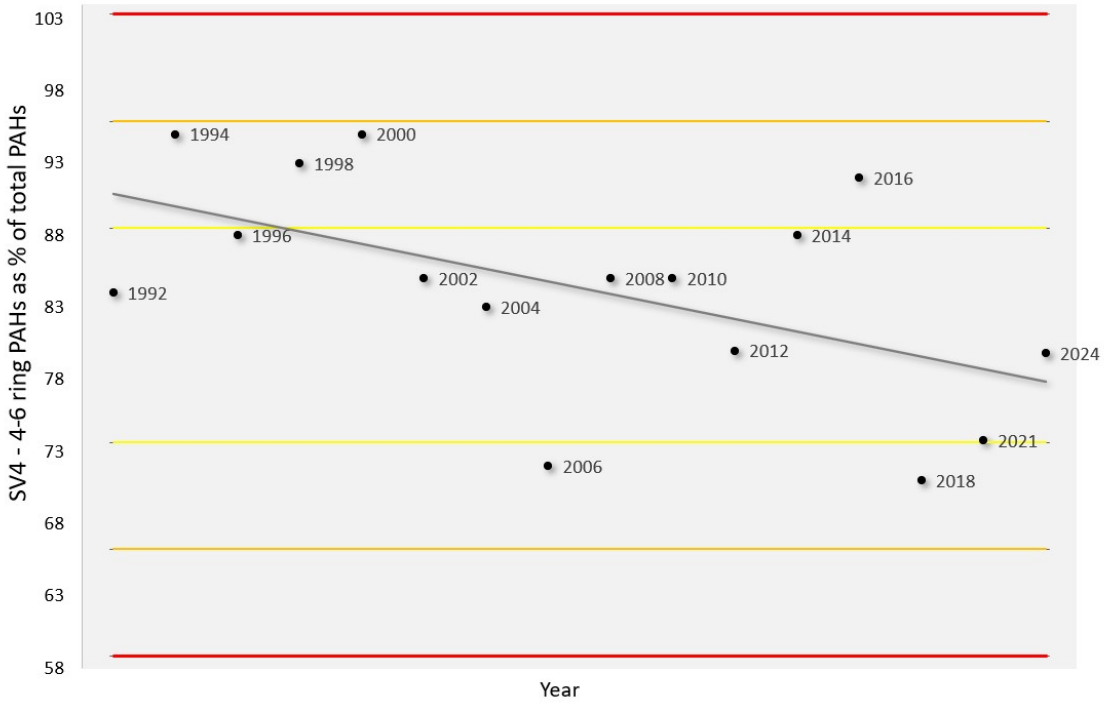

Figure 15 – SV4 4-6 ring PAHs as a percentage of the total PAHs (%)

3.4.1.4 Fluga Ness SV5

For station SV5, the mud content in 2024 was 51.5%, which was 11% higher than in 2021. The organic content for station SV5 in 2024 was 3.8%, which was 1.1% lower than the 2021 result.

The concentration of total aliphatic hydrocarbons (TAH) at station SV5 in 2024 was 29.9 µg/g (dry matter) and was very close to the historic mean for this station (2004-2021). The 2024 result was within 1 standard deviations from the historic mean for data between 2004-2021, indicating that there had been little change. The relative standard deviation between the 3 TAH grab replicates was 7.0% indicating low variation in the sediment composition for TAH. The percentage of UCM in the TAH was similar to the 2018 and 2021 results which were higher than the historic mean result 2004-2021, indicating there continues to be some change to the composition of oil profile.

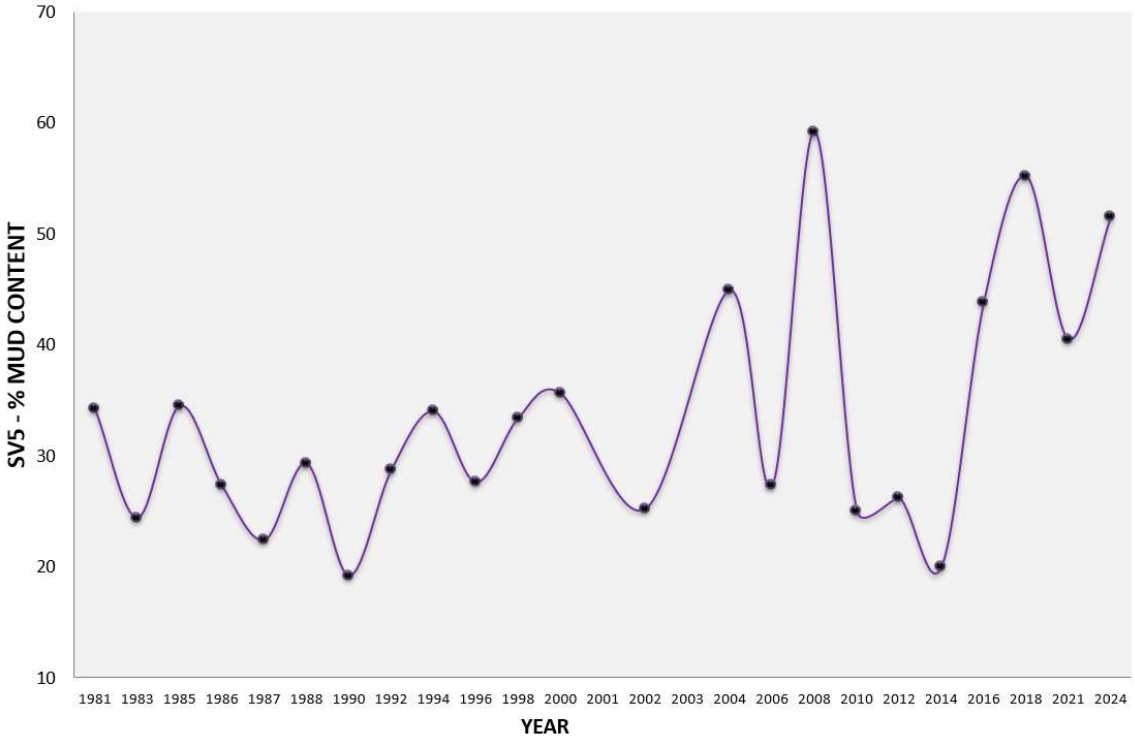

Figure 16 – SV5 Percentage Mud content

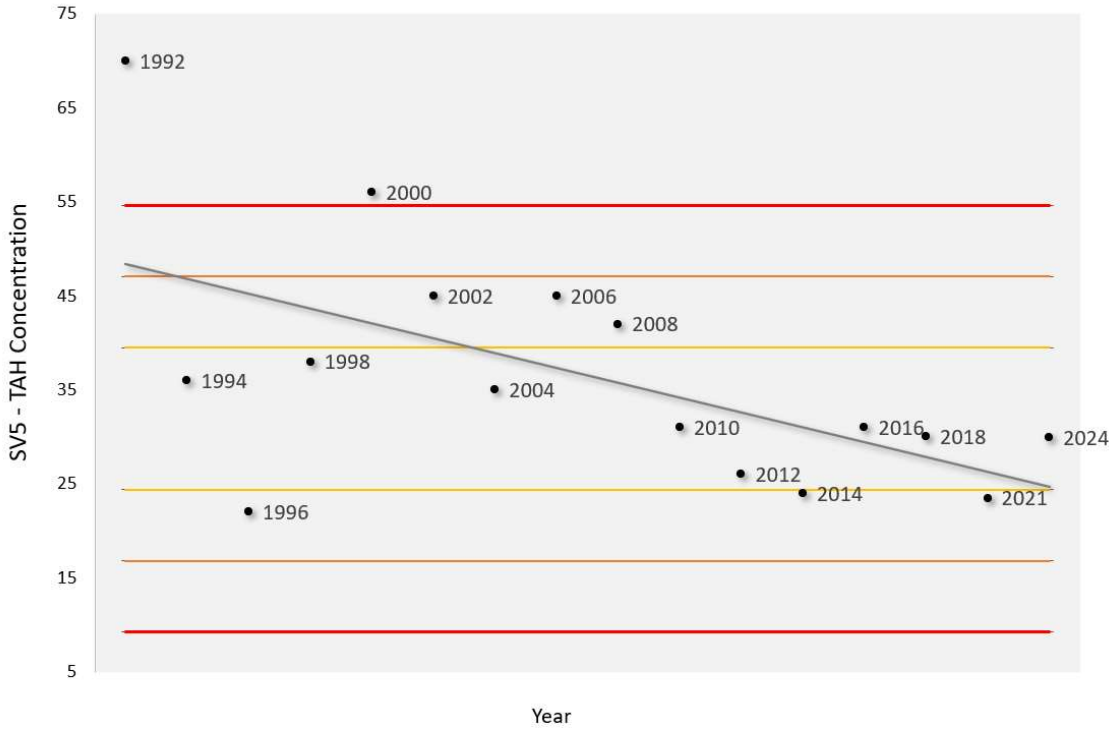

Figure 17 – SV5 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

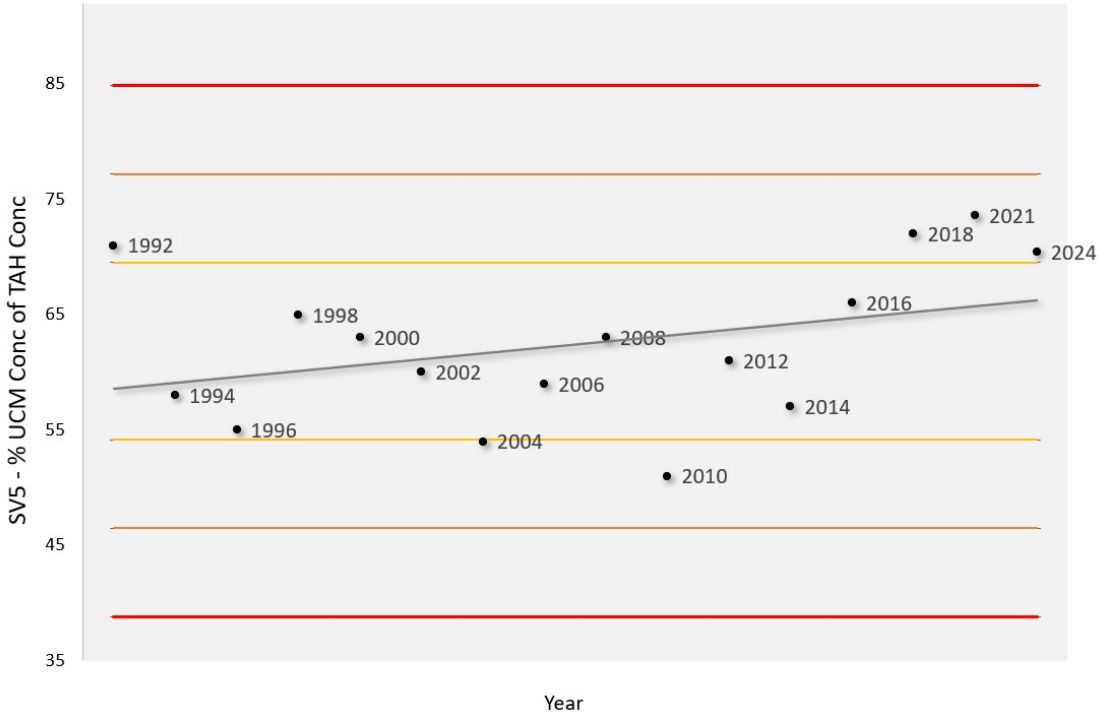

Figure 18 – SV5 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.2 JETTY AREA AND WEST OF CALBECK NESS (STATIONS 7-11 AND 17)

3.4.2.1 Jetty Grid SV7

For station SV7, the mud content in 2024 was 48.1% and 7.4% higher than in 2021. The variation in mud concentration at this site is high across the historic data set. The total organic content in 2024 was 6.3% which was a 0.1% higher than the 2021 result.

The concentration of total aliphatic hydrocarbons (TAH) at station SV7 in 2024 was 48.8 µg/g (dry matter) which was similar to the 2021 result. The 2024 result was within 1 standard deviation from the historic mean which indicates little change from the historic data set 2004-2021. The relative standard deviation between the 3 TAH grab replicates was 16.0% indicating moderate variation in the sediment composition for TAH. The percentage of UCM in the TAH was similar to the 2016 and 2018 results which were higher than the historic mean result 2004-2021, indicating there continues to be some change to the composition of oil profile.

The concentration of 2-6 ring PAH concentration at station SV7 in 2024 was 1893 ng/g which was lower than the concentration in 2021 which was 2240ng/g. The 2024 result was within 1 standard deviation from the historic mean which indicates little change from the historic data set 2004-2021. The percentage of 4-6 ring PAHs of the total PAHs has higher than the 2016-2018 results, however the 2024 result was within 1 standard deviation from the historic data set mean 2004-2021, indicating that there has been little change.

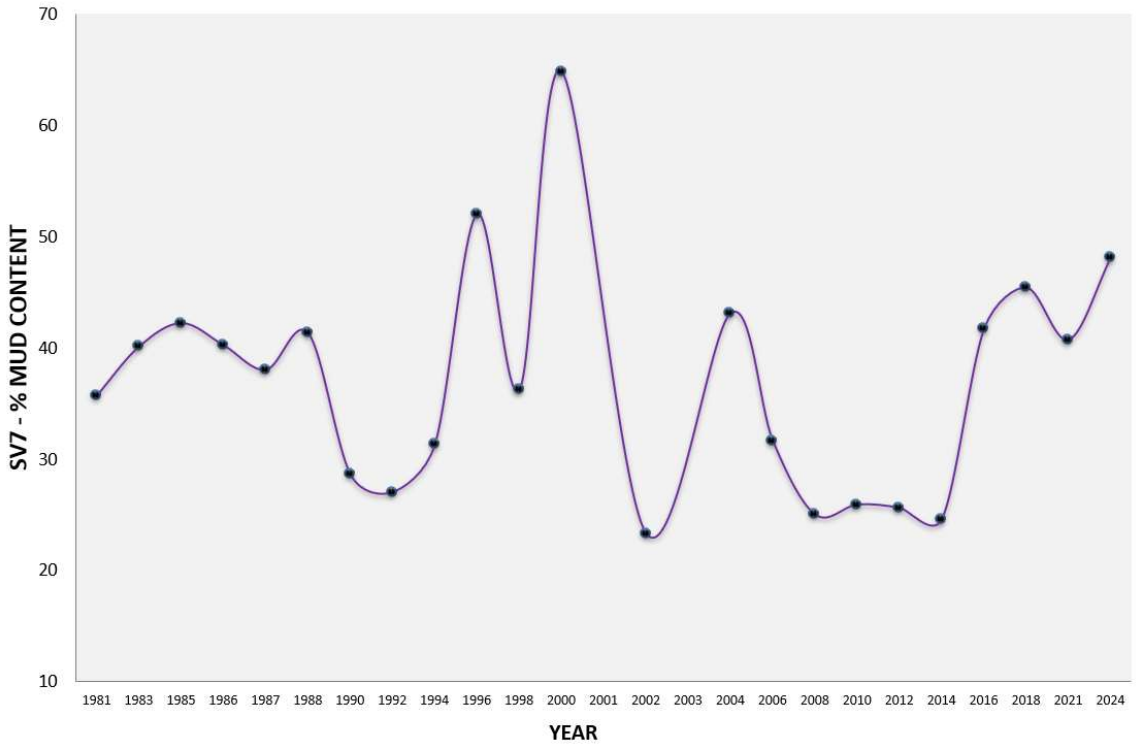

Figure 19 – SV7 Percentage Mud content

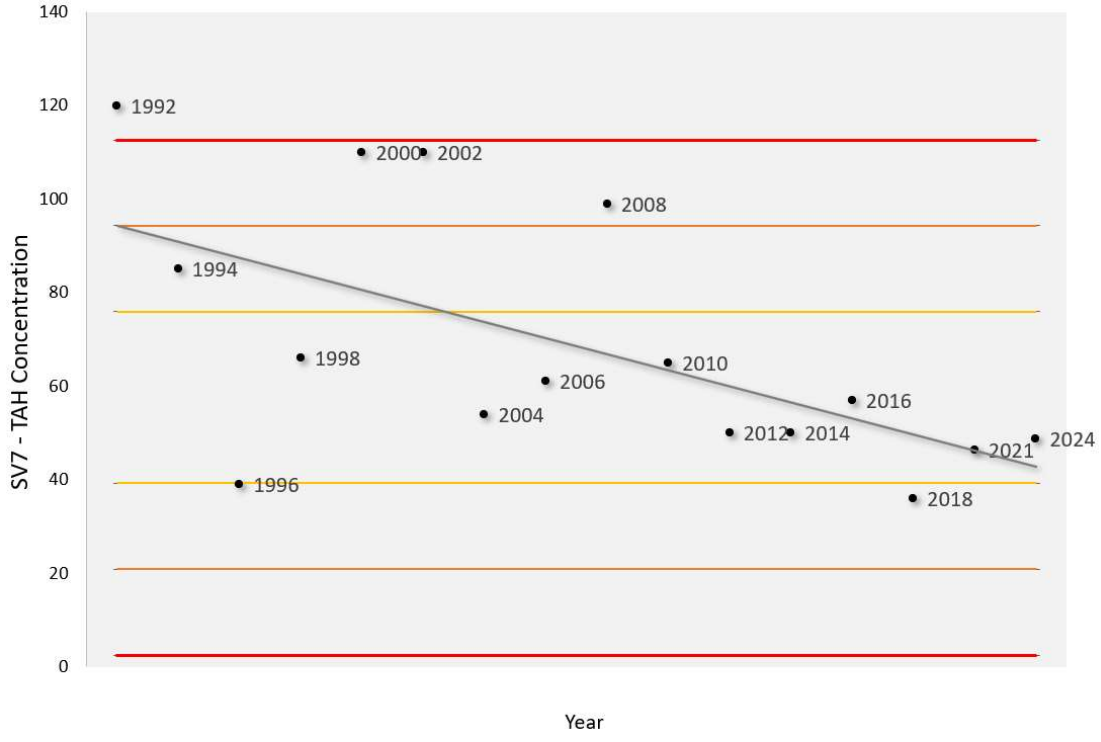

Figure 20 – SV7 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

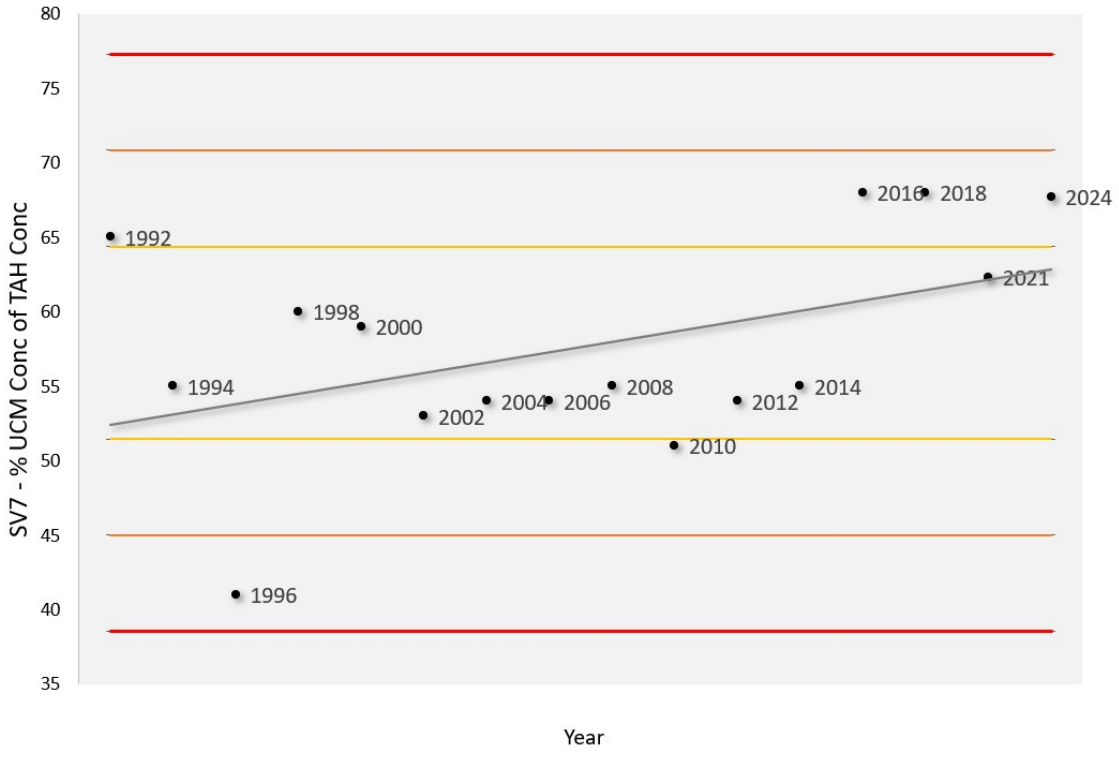

Figure 21 – SV7 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

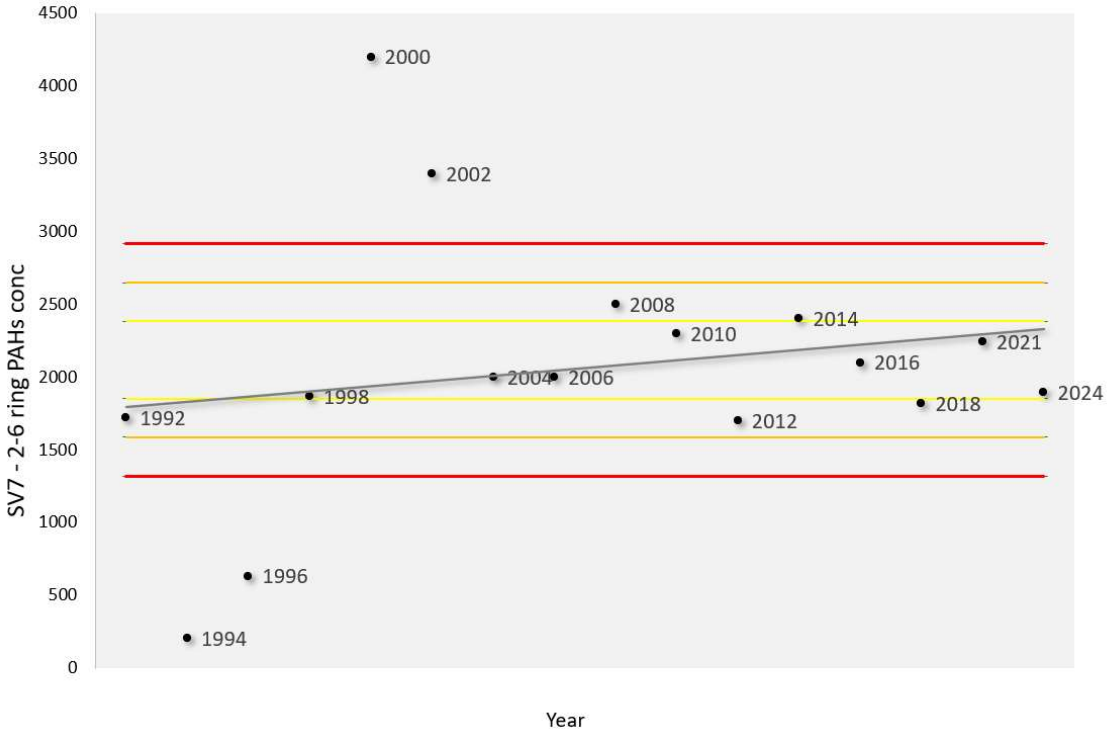

Figure 22 – SV7 2-6 ring PAH concentration (ng.g^{-1} dry sed.)

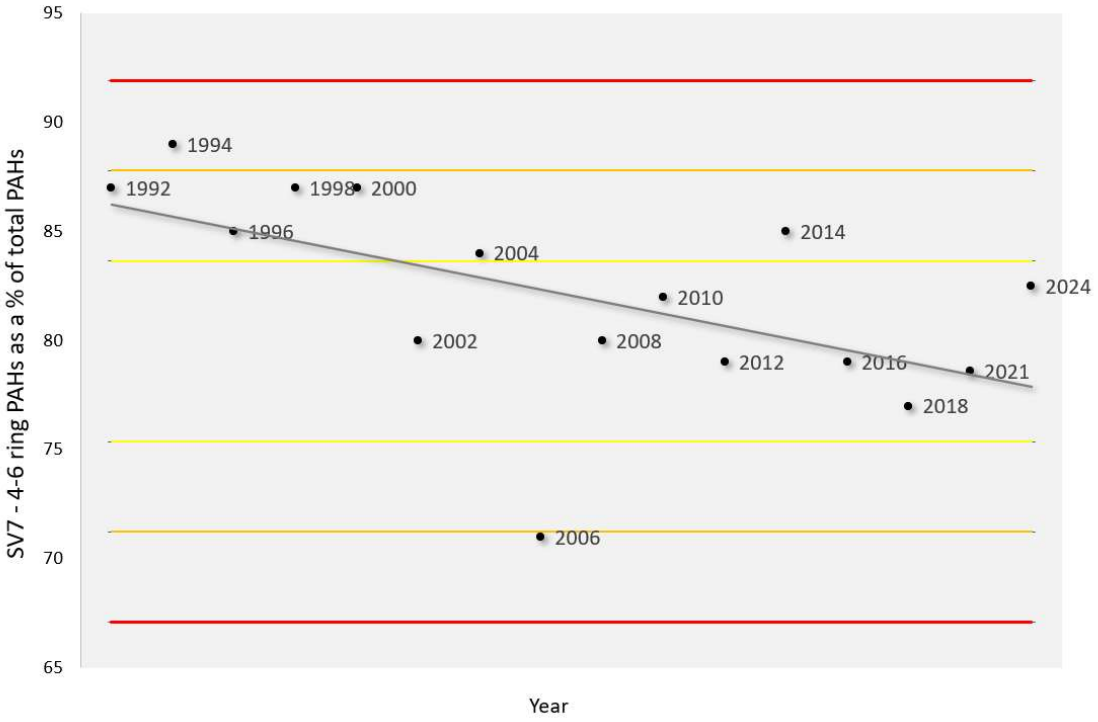

Figure 23 – SV7 4-6 ring PAHs as a percentage of the total PAHs (%)

3.4.2.2 Jetty Grid SV8

For station SV8, the mud content in 2024 was 48.8% which was 13% higher than the 2021 result and the highest result obtained for this station. The total organic content in 2024 was 2.6% which was 1.6% lower than the 2021 result.

The concentration of total aliphatic hydrocarbons (TAH) at station SV8 in 2024 was 18.2 µg/g (dry matter) which was similar to the 2021 result. The 2024 result was within 1 standard deviation from the historic mean 2004-2021, indicating there has been little change. The relative standard deviation between the 3 TAH grab replicates was 10% indicating low variation in the sediment composition for TAH. The percentage of UCM in the TAH is higher than the mean and is <1 standard deviations from the historic mean 2004-2021, indicating there has been little change in the oil profile.

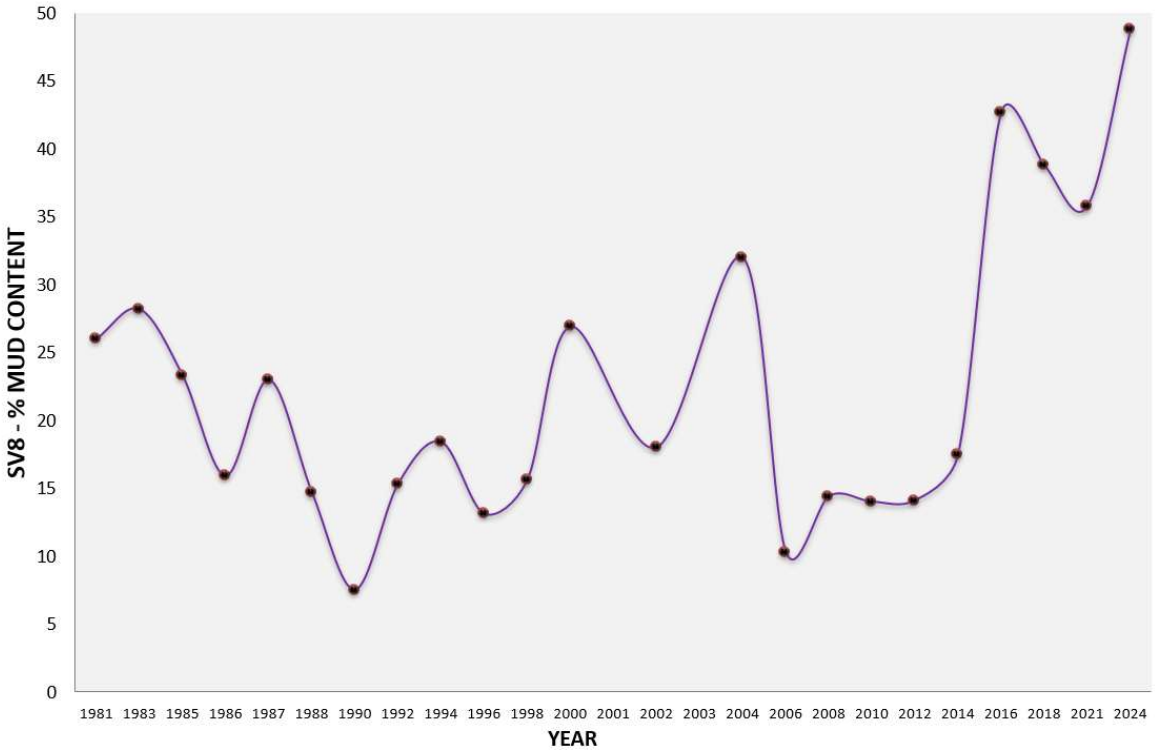

Figure 24 – SV8 Percentage Mud content

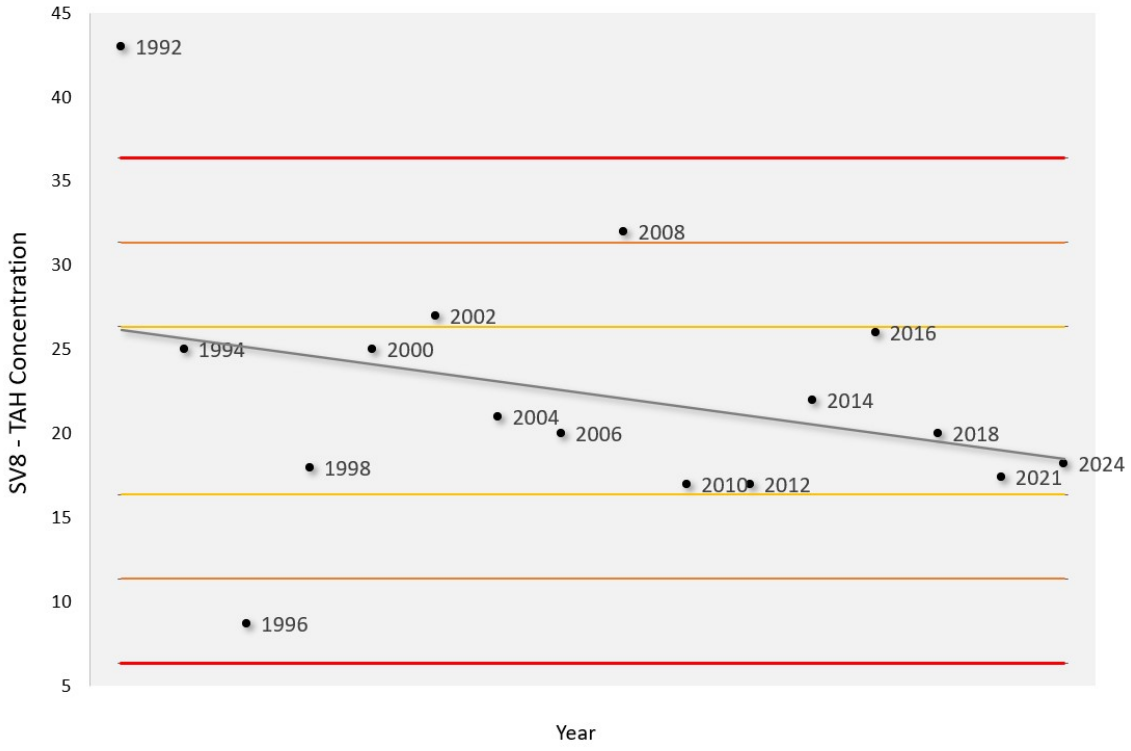

Figure 25 – SV8 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

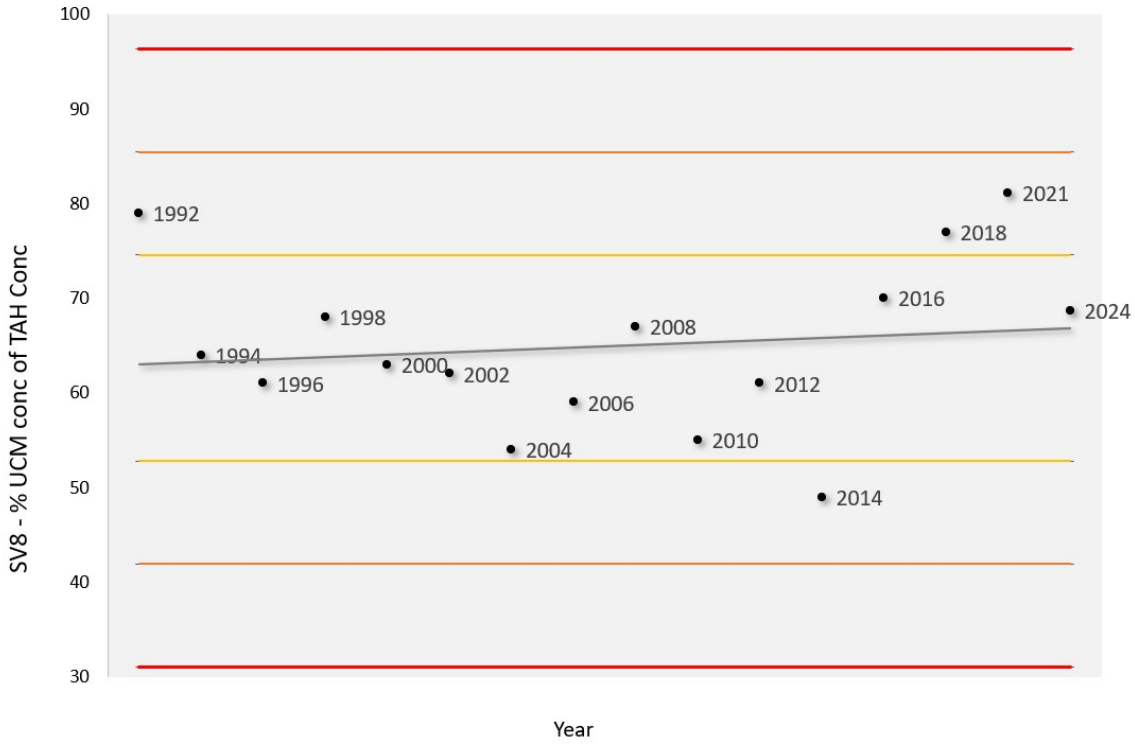

Figure 26 – SV8 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.2.3 Jetty Grid SV8A

For station SV8A, the mud content in 2024 was 40.8% which is 6.0% higher than in 2021 but was in a similar range to the results between 2016-2021. The organic content in 2024 was 1.8%, which was 1.8% lower than the 2021 result.

The concentration of total aliphatic hydrocarbons (TAH) at station SV8A in 2024 was similar to the 2021 result. The 2024 result was within 1 standard deviation from the historic mean for data 2004-2021, this indicates there has been little change. The relative standard deviation between the 3 TAH grab replicates was 0.8% indicating low variation in the sediment composition for TAH. In 2024, the percentage of UCM in the TAH was within 1 standard deviations of the historic mean for data set 2004-2021, indicating little change in the oil profile.

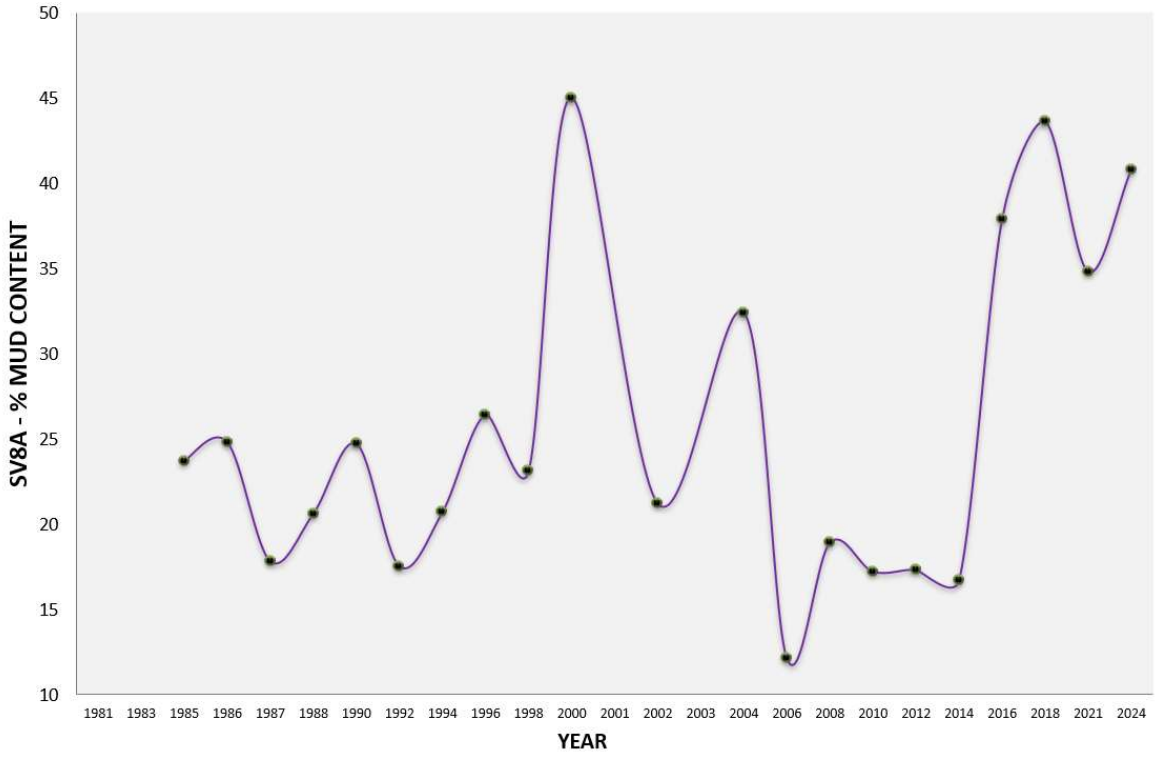

Figure 27 – SV8A Percentage Mud content

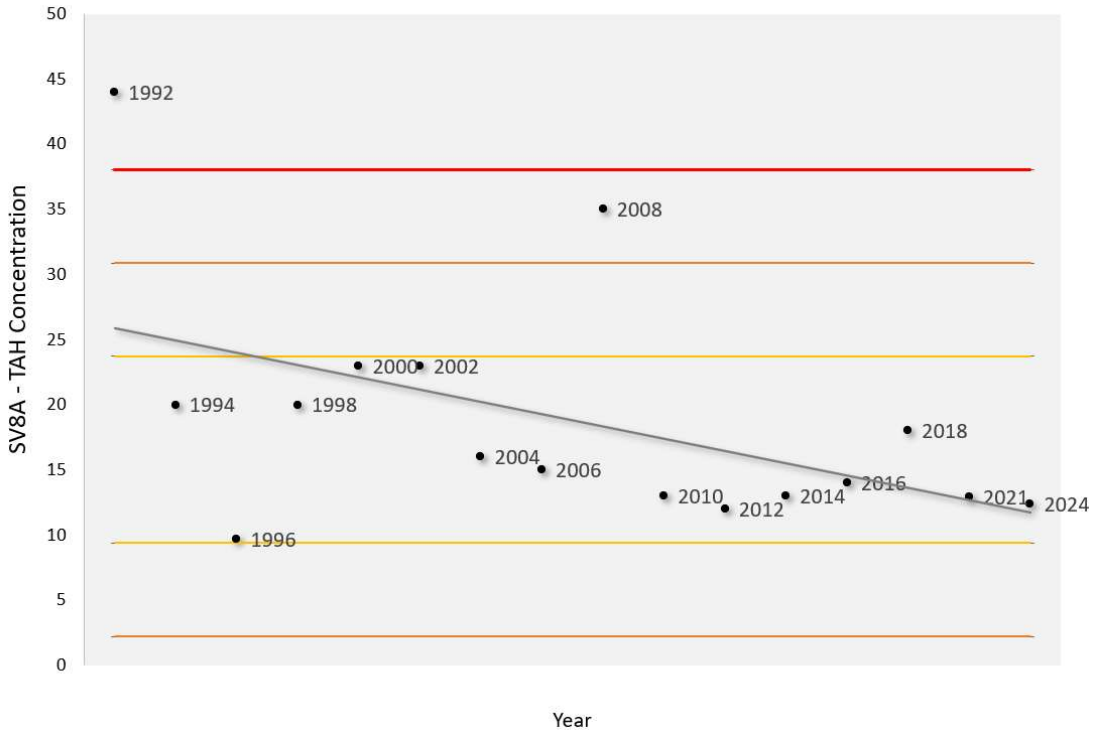

Figure 28 – SV8A Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

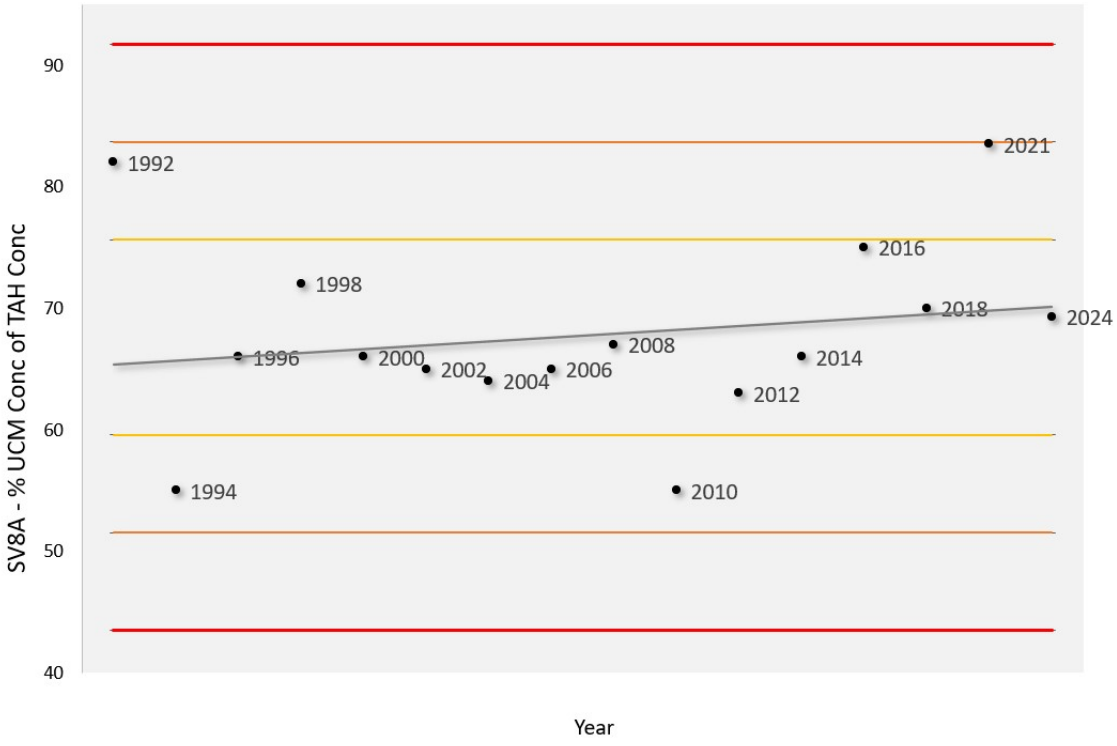

Figure 29 – SV8A Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.2.4 Outer Voe SV9

For station SV9, the mud content in 2024 was 55.1% and 7.3% higher than the 2021 result. The organic content in 2024 was 5.8% which was 1.5% lower than the 2021.

The concentration of total aliphatic hydrocarbons (TAH) at station SV9 in 2024 was 34 ug/g which was higher than the 2021 result, but within 1 standard deviation from the historic mean for the data set 2004-2021, indicating that there had been little change. The relative standard deviation between the 3 TAH grab replicates was 4.8% indicating low variation in the sediment composition for TAH. The percentage of UCM in the TAH was lower than in 2021 but still higher than the historic mean. The 2024 UCM result was within 1 standard deviations from the mean for the historic data set 2004-2021, indicating there has been little change in the oil profile.

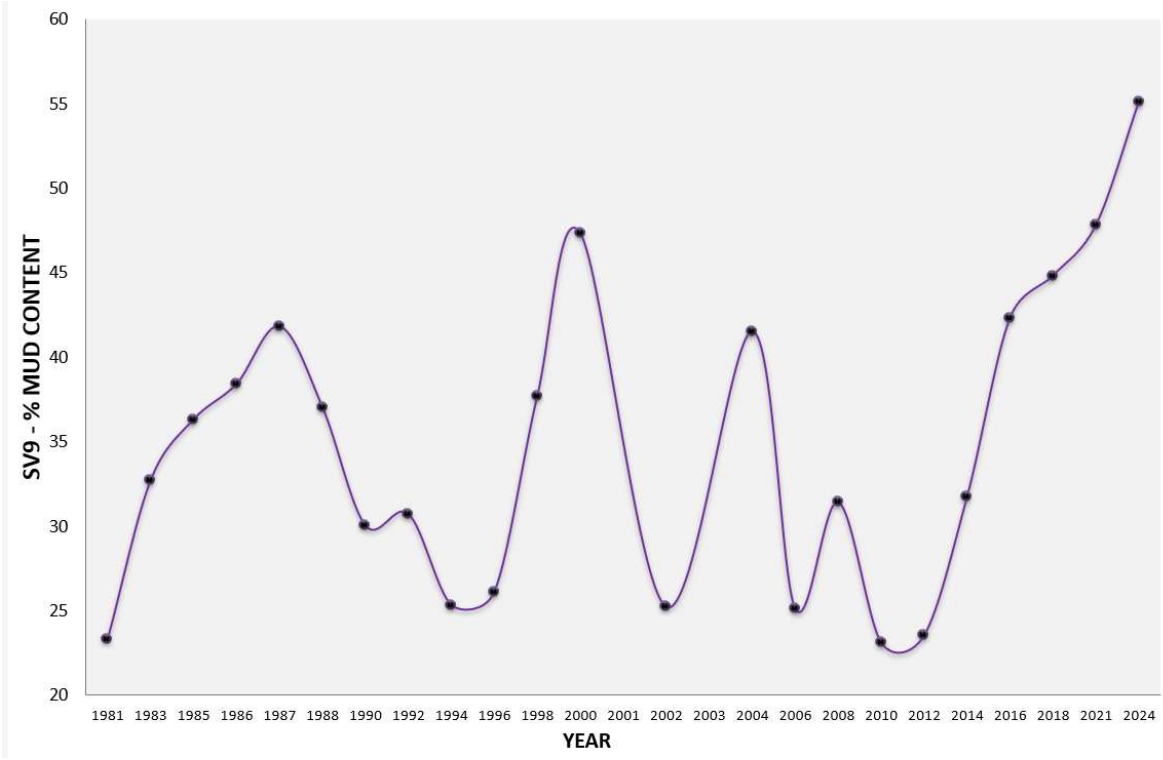

Figure 30 – SV9 Percentage Mud content

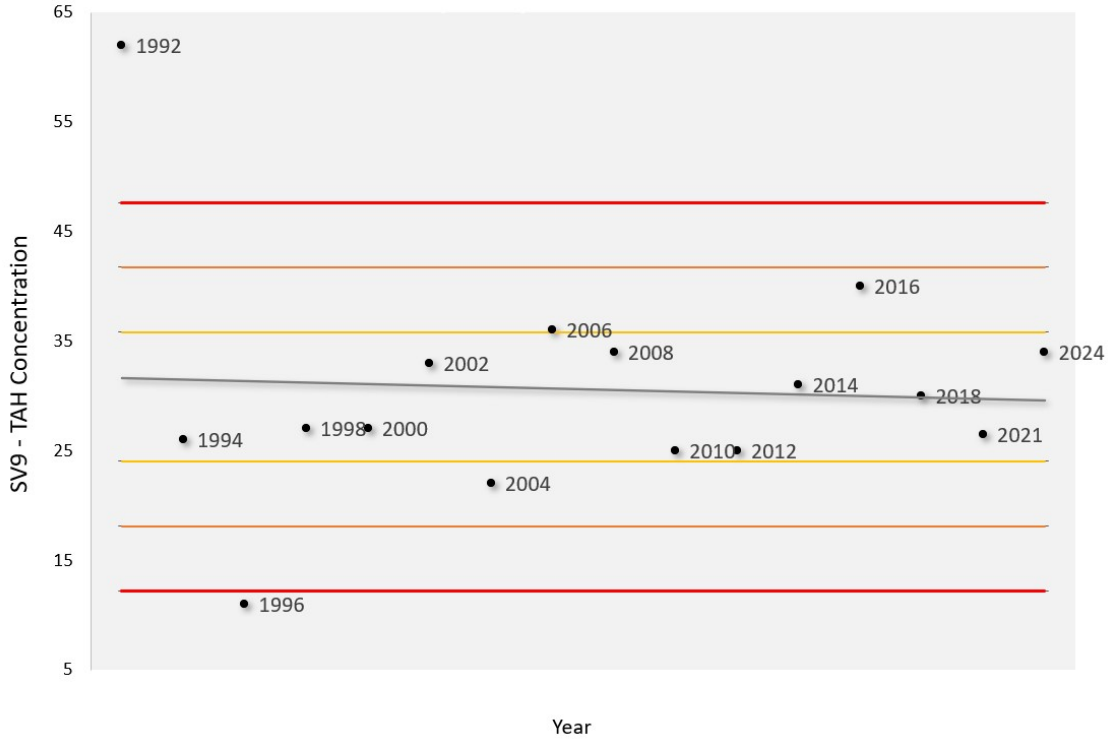

Figure 31 – SV9 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

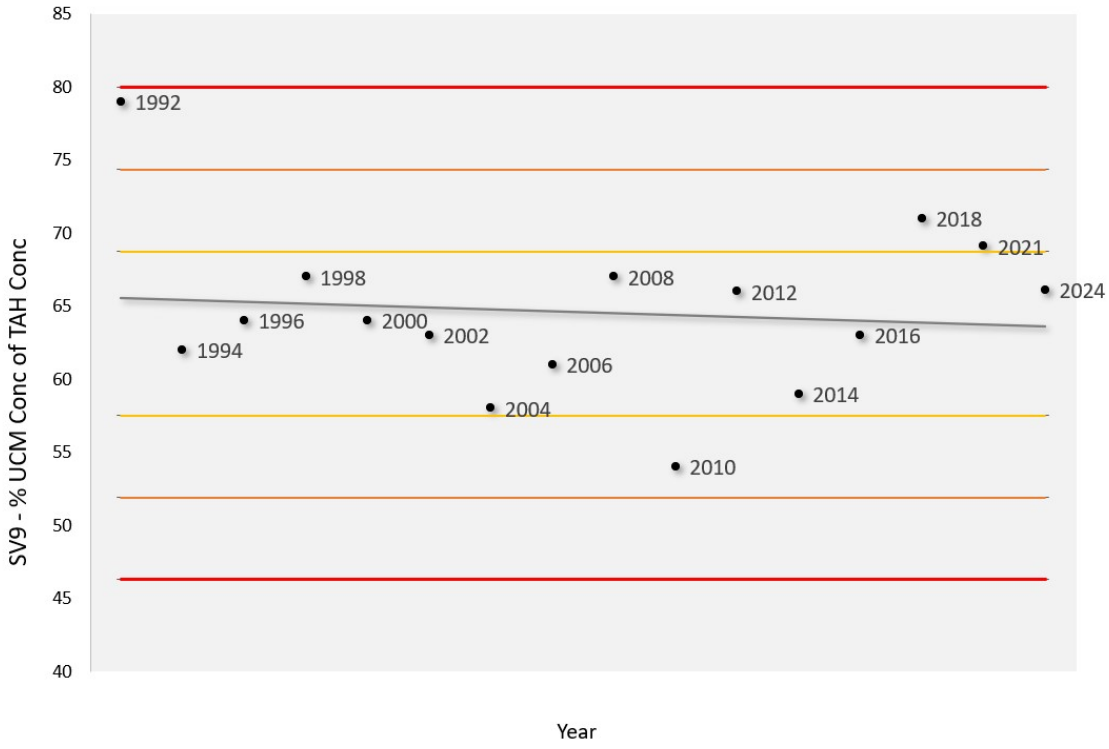

Figure 32 – SV9 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.2.5 Outer Voe SV10

For station SV10, the mud content in 2024 was 58.0% and 5.2% higher than in 2021 and the highest result recorded at this station. The total organic content in 2024 was 3.2% which was 2.0% lower than the 2021 result.

The concentration of total aliphatic hydrocarbons (TAH) at station SV10 in 2024 was higher than the 2018 and 2021 results. The 2024 result was within 1 standard deviation from the historic mean for data set 2004-2021, indicating that there had been little change. The relative standard deviation between the 3 grab samples for TAH was 1.6%, indicating low variation in the sediment composition for TAH. The percentage of UCM in the TAH was lower than in 2021 but similar to the historic mean for data 2004-2021. The 2024 UCM result was within 1 standard deviations from the mean for the historic data set 2004-2021, indicating there has been little change in the oil profile.

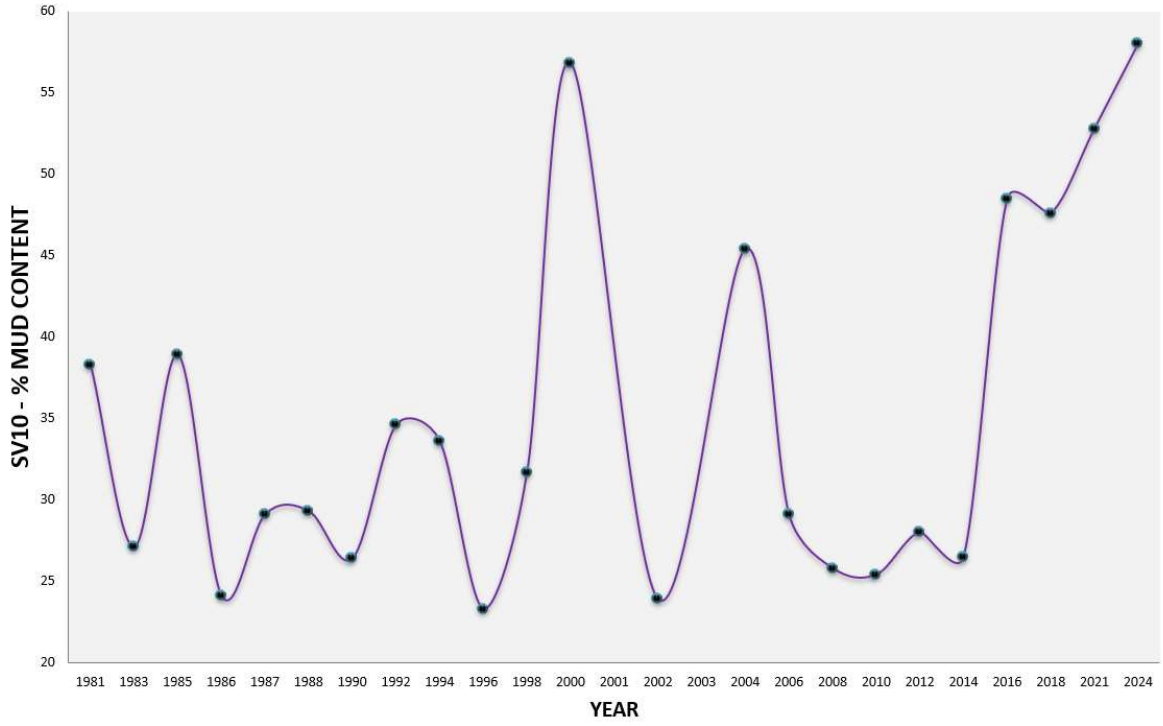

Figure 33 – SV10 Percentage Mud content

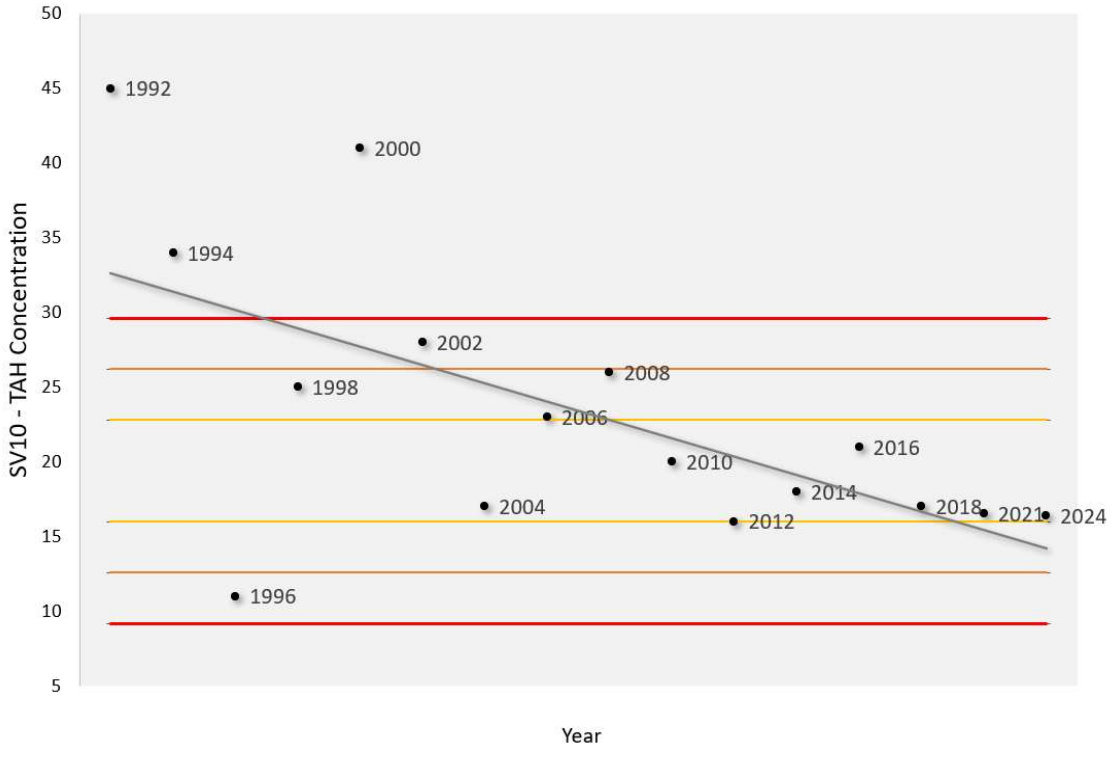

Figure 34 – SV10 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

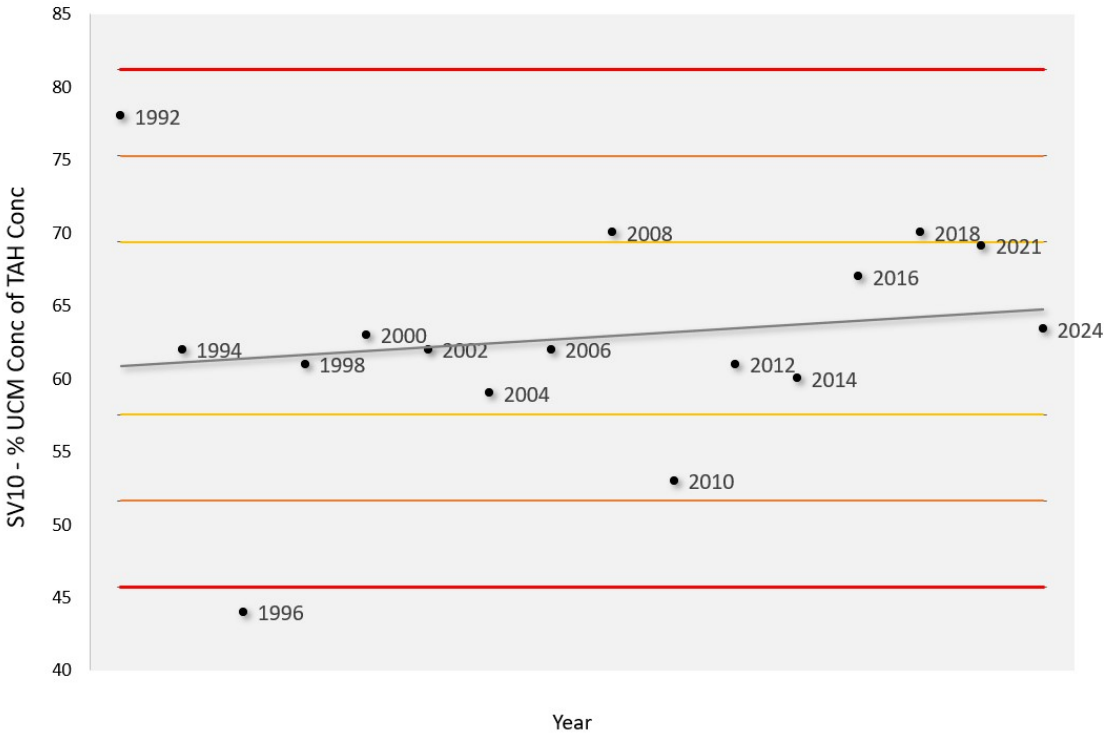

Figure 35 – SV10 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.2.6 Outer Voe SV11

For station SV11, the mud content in 2024 was 61.7% which was 9.9% higher than the 2021 result and the highest recorded result at this station. The organic content in 2024 was 3.3% which was 2.6% lower than in 2021.

The concentration of total aliphatic hydrocarbons (TAH) at station SV11 in 2024 was close to the historic mean for results 2004-2021. The 2024 result was within 1 standard deviation from the historic mean and indicates there has been little change. The relative standard deviation between the 3 TAH grab replicates was 8.6% indicating low variation in the sediment composition for TAH. The percentage of UCM in the TAH was lower than in 2021 but was close to the historic mean for results 2004-2021. The 2021 UCM result was within 1 standard deviations from the historic mean for data 2004-2021 which indicates there has been little change in the oil profile.

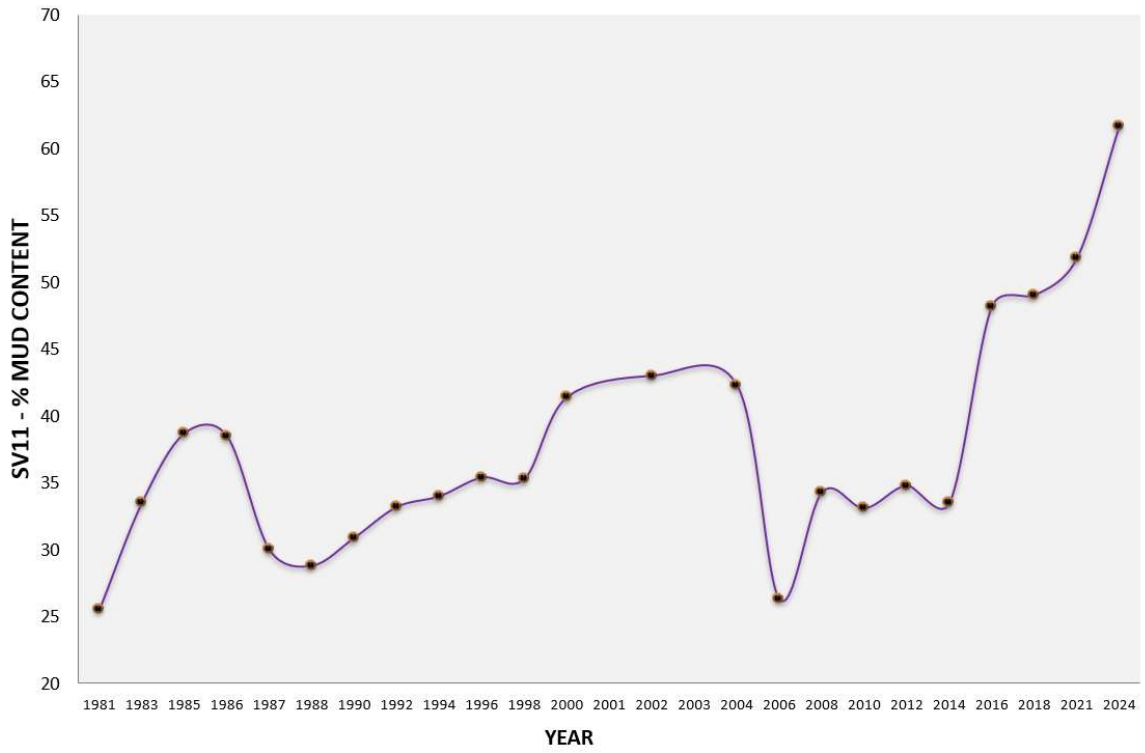

Figure 36 – SV11 Percentage Mud content

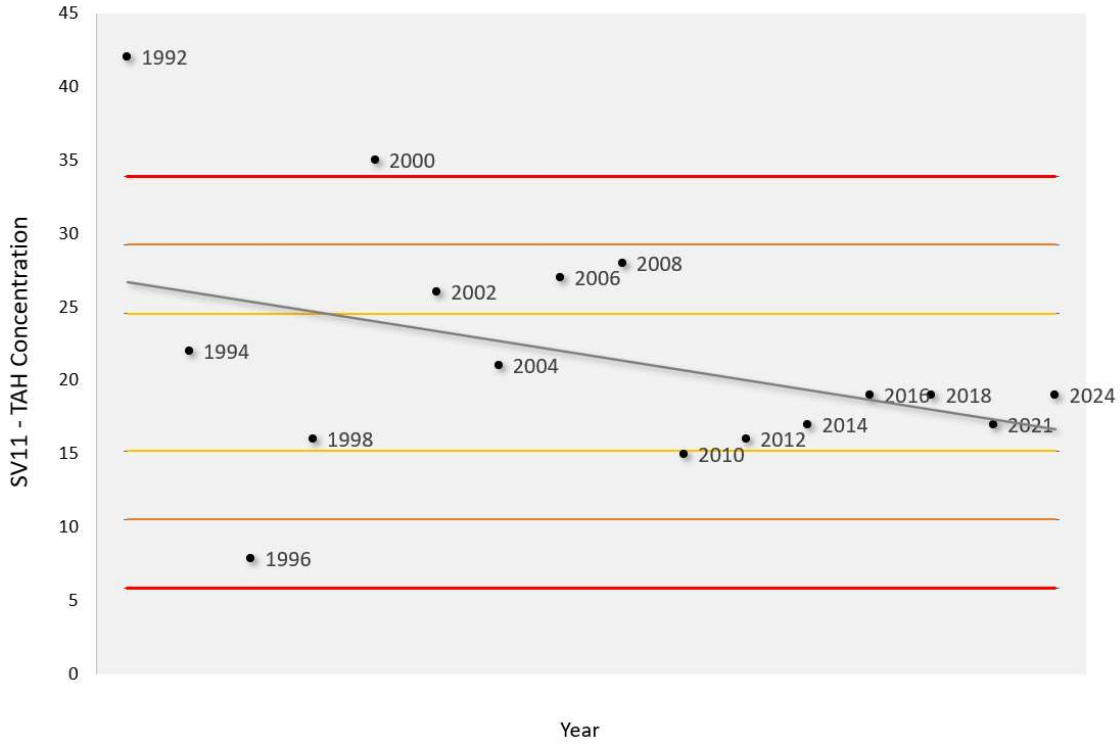

Figure 37 – SV11 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

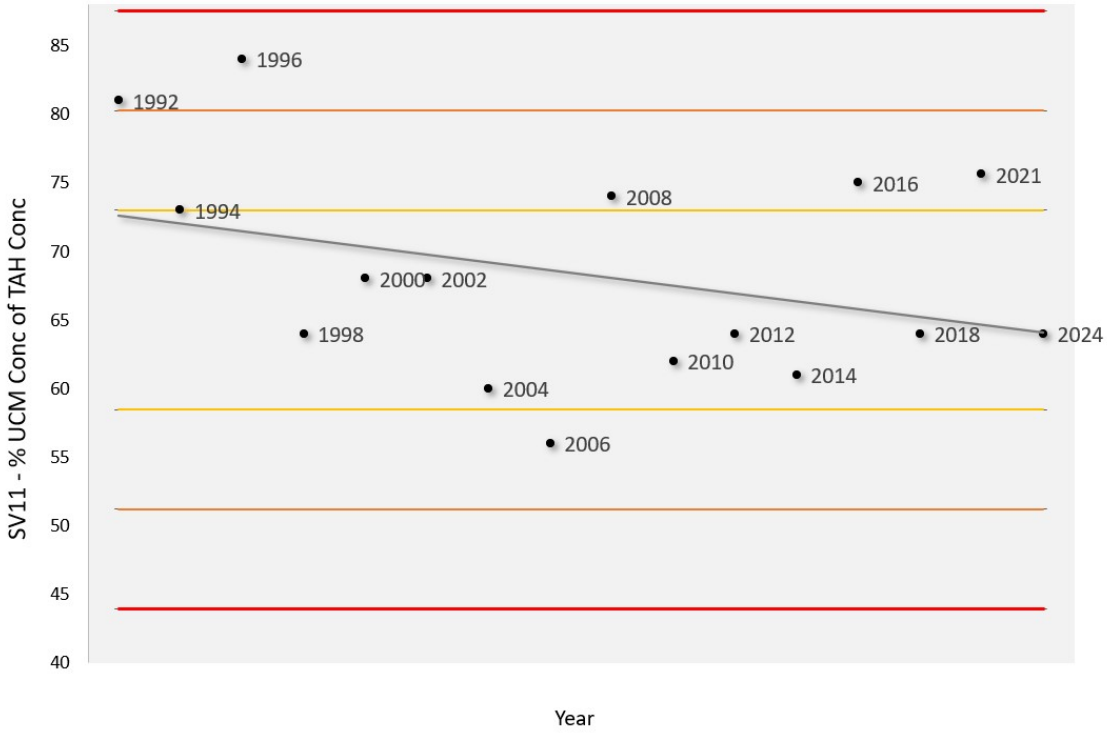

Figure 38 – SV11 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.2.7 Jetty Grid SV17

For station SV17, the mud content in 2024 was 14.4%, which was 19.9% lower than the result in 2021 but in-line with the results from 2014 and 2018. The total organic content in 2024 was 1.8% which was 1.6% lower than the 2021 result.

The concentration of total aliphatic hydrocarbons (TAH) at station SV17 in 2024 was similar to the result in 2021. The 2024 result was within 1 standard deviation from the historic mean for data 2004-2021, indicating that there has been little change. The relative standard deviation between the 3 TAH grab replicates was 4.3% indicating low variation in the sediment composition for TAH. The percentage of UCM in the TAH was similar to the 2021 result. The 2024 result was within 1 standard deviation from the historic mean for data 2004-2021, indicating there has been little change in the oil profile.

The concentration of 2-6 ring PAH concentration at station SV17 in 2024 was 1048 ng/g which was comparable to the concentration in 2021 which was 1090 ng/g. The 2024 result was within 1 standard deviation of the historic mean for data 2004-2021, which indicates there has been little change. The percentage of 4-6 ring PAHs of the total PAHs was similar to the 2021 result and +1.0 standard deviations of the historic mean for data 2004-2021, which indicates there has been little change.

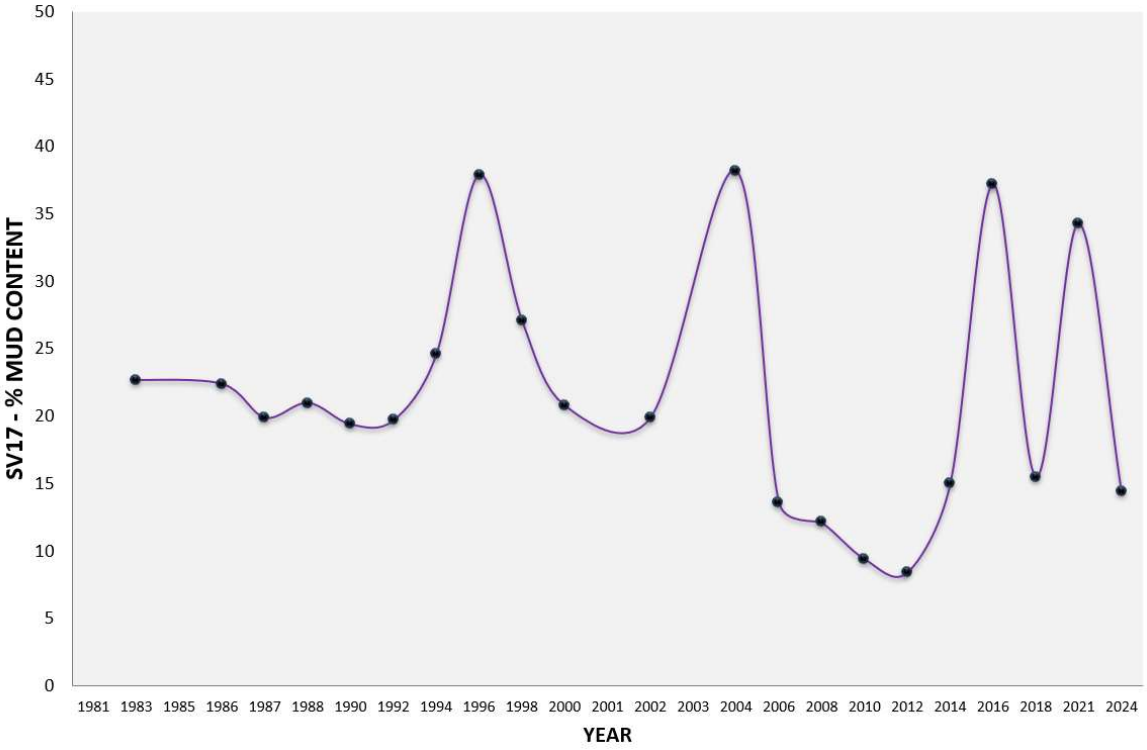

Figure 39 – SV17 Percentage Mud content

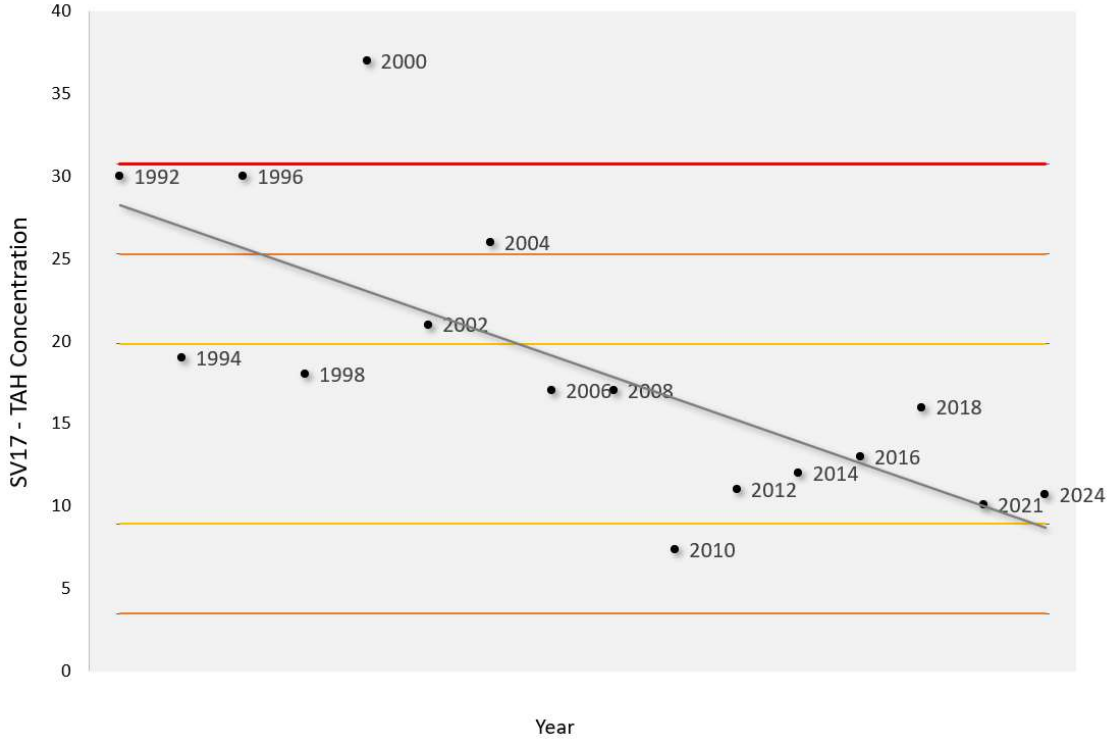

Figure 40 – SV17 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

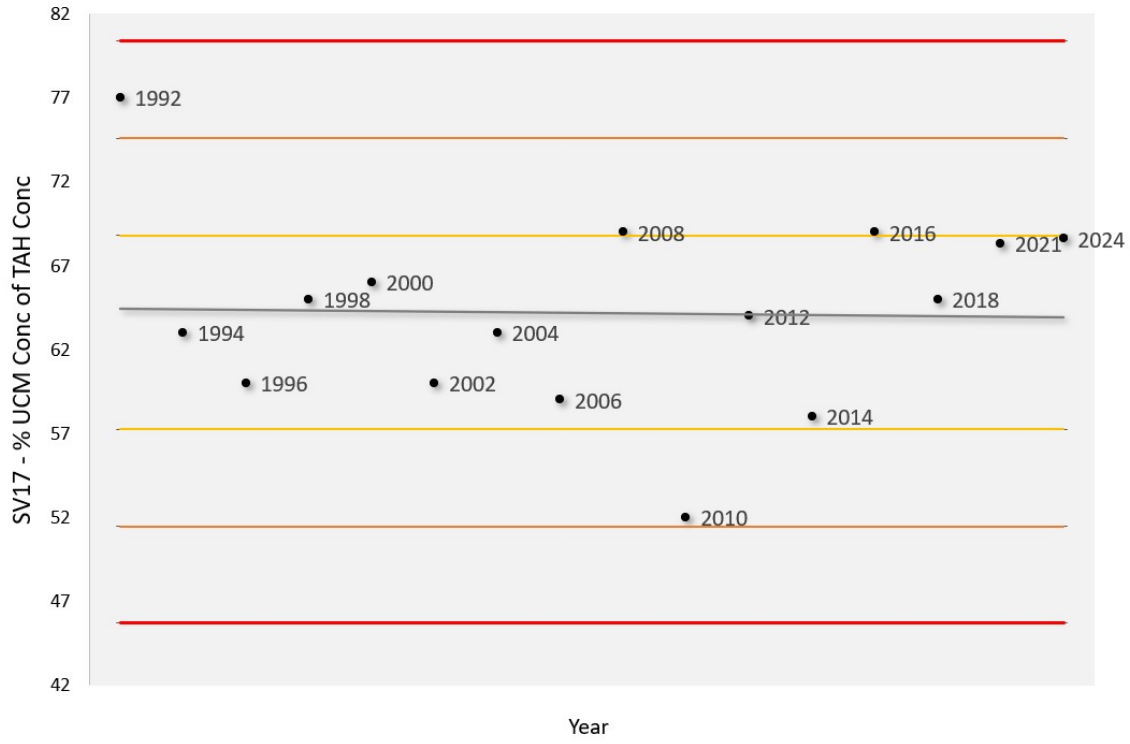

Figure 41 – SV17 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

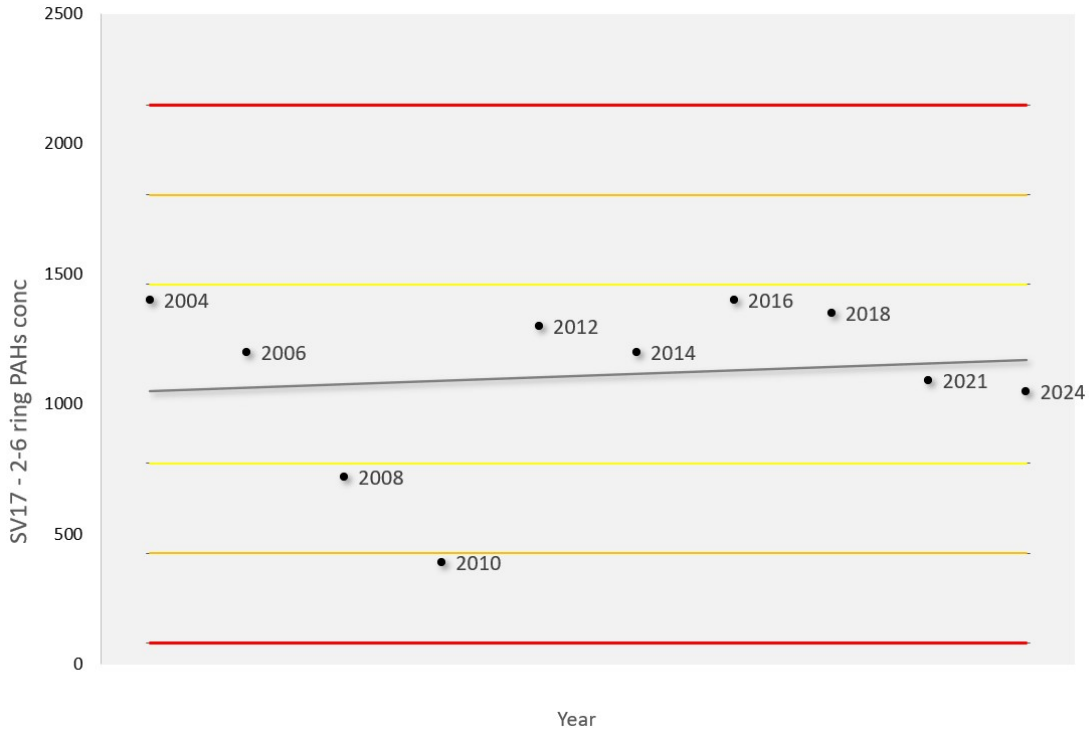

Figure 42 – SV17 2-6 ring PAH concentration (ng.g^{-1} dry sed.)

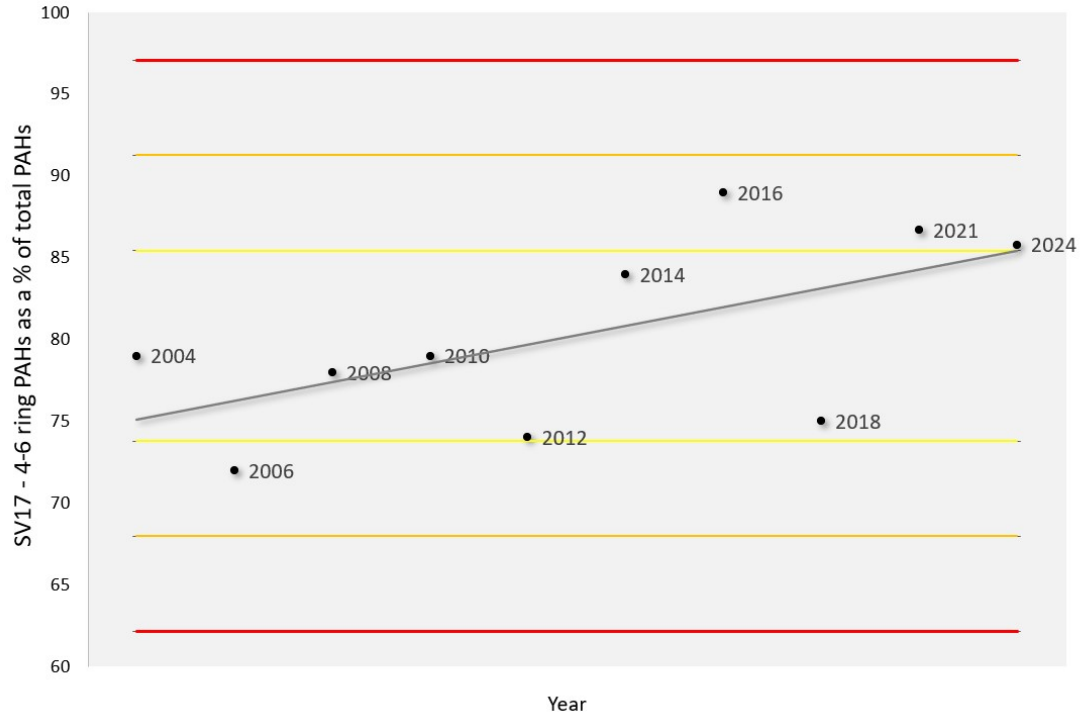

Figure 43 – SV17 4-6 ring PAHs as a percentage of the total PAHs (%)

3.4.3 YELL SOUND AND NORTH OF CALBECK NESS (STATIONS 33 TO 37)

3.4.3.1 Calbeck Ness SV12

For station SV12, the mud content in 2024 was 12.1% which was 4.3% higher than in 2021. The organic content in 2024 was 1.1% which is 2.3% lower than the 2021 result.

The concentration of total aliphatic hydrocarbons (TAH) at station SV12 is generally low (<10µg.g^{-1}) and in 2024 the level was similar to the results 2010, 2012, 2014 and 2018. The 2024 result was within 1 standard deviation from the historic mean for data 2004-2021, indicating there had been little change. The relative standard deviation between the 3 TAH grab replicates was 16.6% indicating moderate variation in the sediment composition for TAH. The percentage of UCM in the TAH in 2014 was similar to 2021 and shows little change from the historic mean for data 2004-2021.

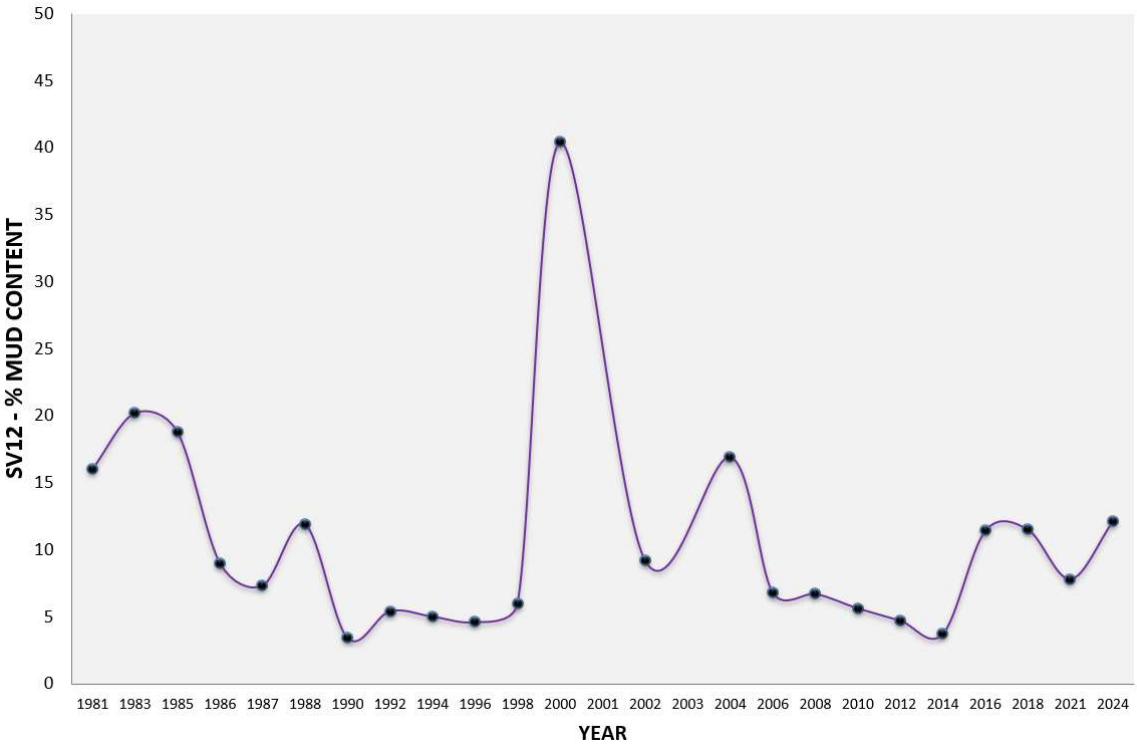

Figure 44 – SV12 Percentage Mud content

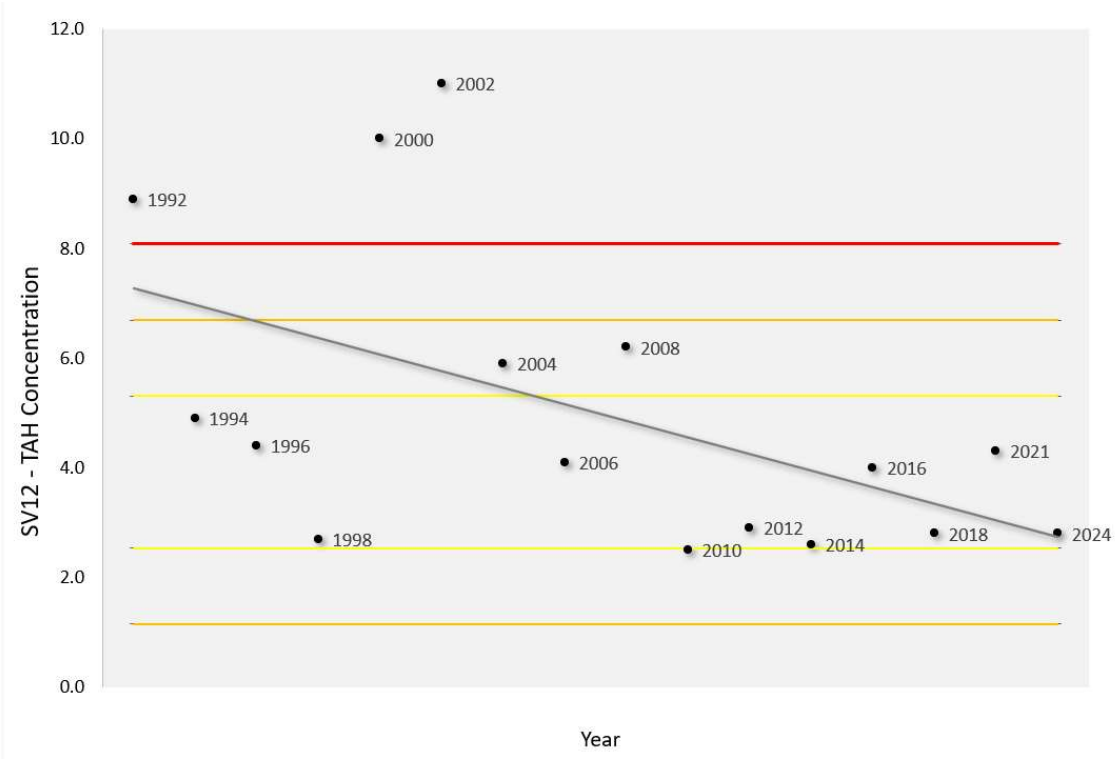

Figure 45 – SV12 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

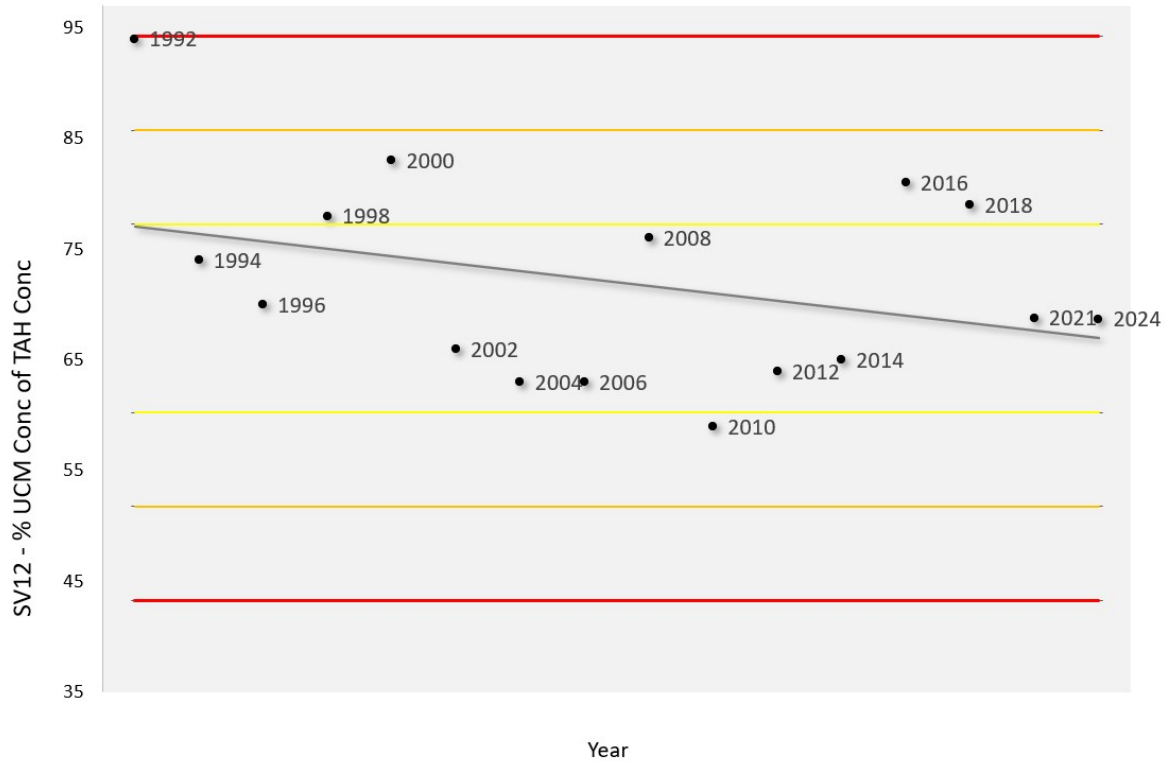

Figure 46 – SV12 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.3.2 Calbeck Ness SV33

For station SV33, the mud content in 2024 was 31.9% and was 0.7% lower than in 2021. The organic content in 2024 was 2.2% which was 1.7% lower than the 2021 result.

The concentration of total aliphatic hydrocarbons (TAH) at station SV33 was 5.3 ug/g which was lower than in 2021 but remains comparable with the results from 2010 to 2014, 2018 to 2021. The 2024 result was -1.3 standard deviation from the historic mean for data 2004-2021, indicating there had been some change, however the range of data used to calculate the mean was varied and the change only appears slight on the chart. The relative standard deviation between the 3 TAH grab replicates was 14.9% indicating low variation in the sediment composition for TAH. The percentage of UCM in the TAH was comparable to the level in 2016-2021 and higher than the historic mean for 2004-2021.

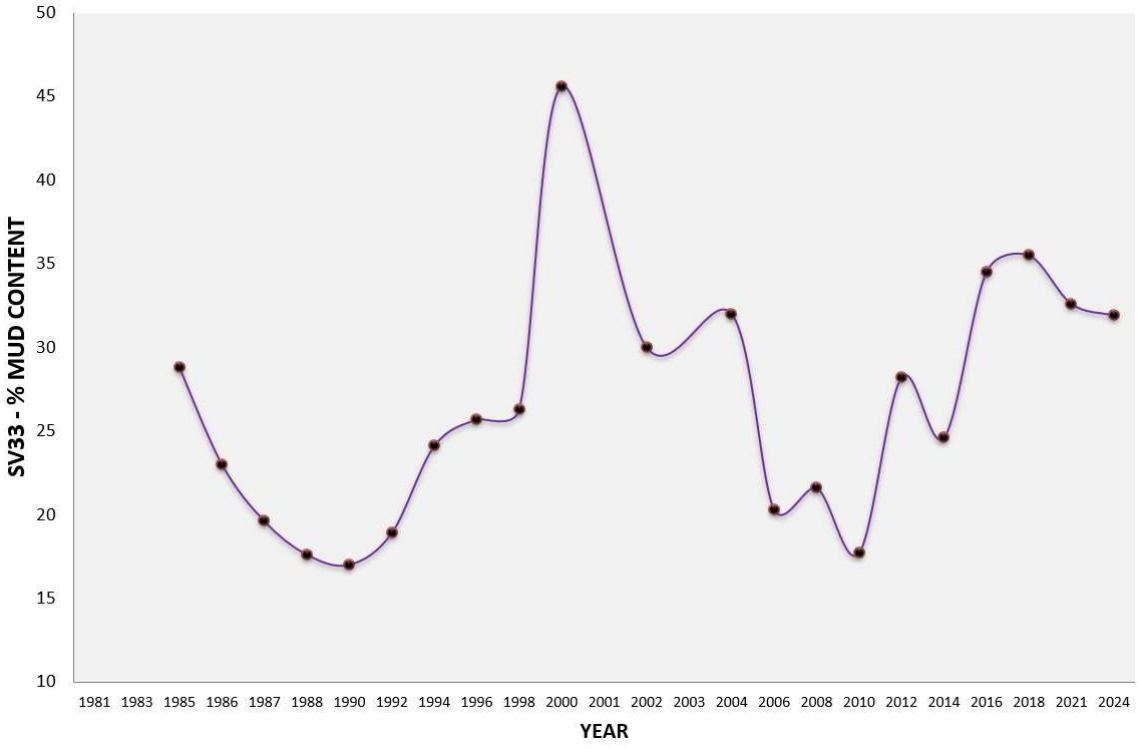

Figure 47 – SV33 Percentage Mud content

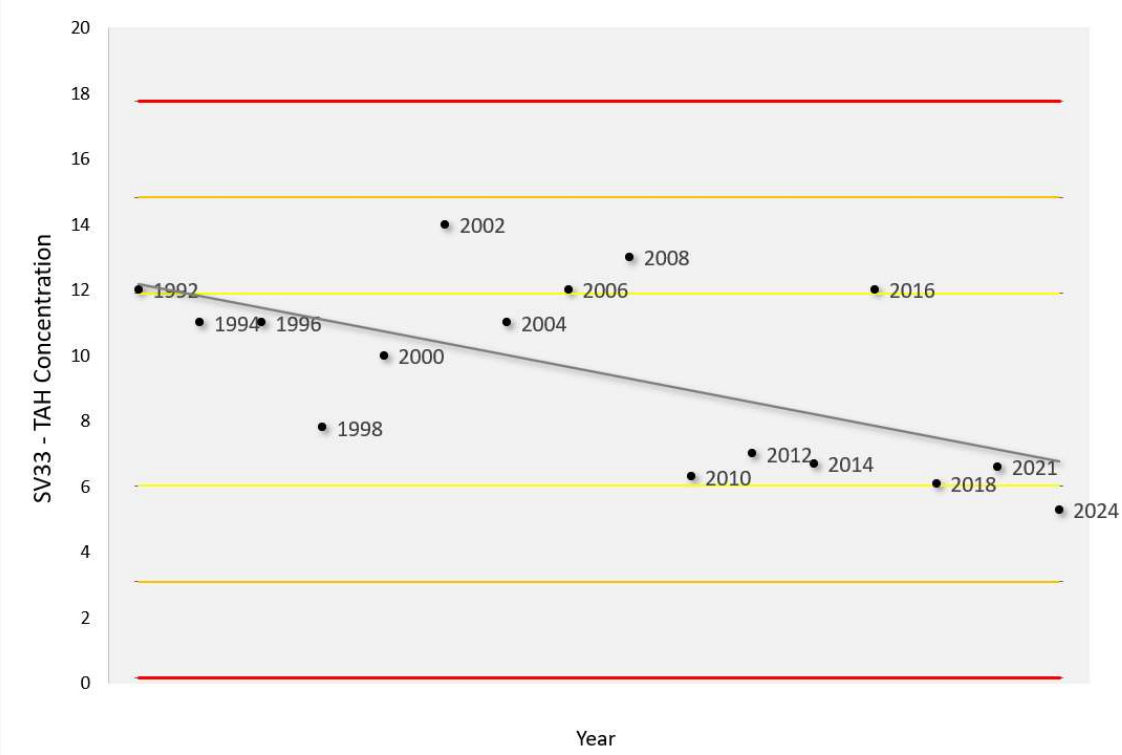

Figure 48 – SV33 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

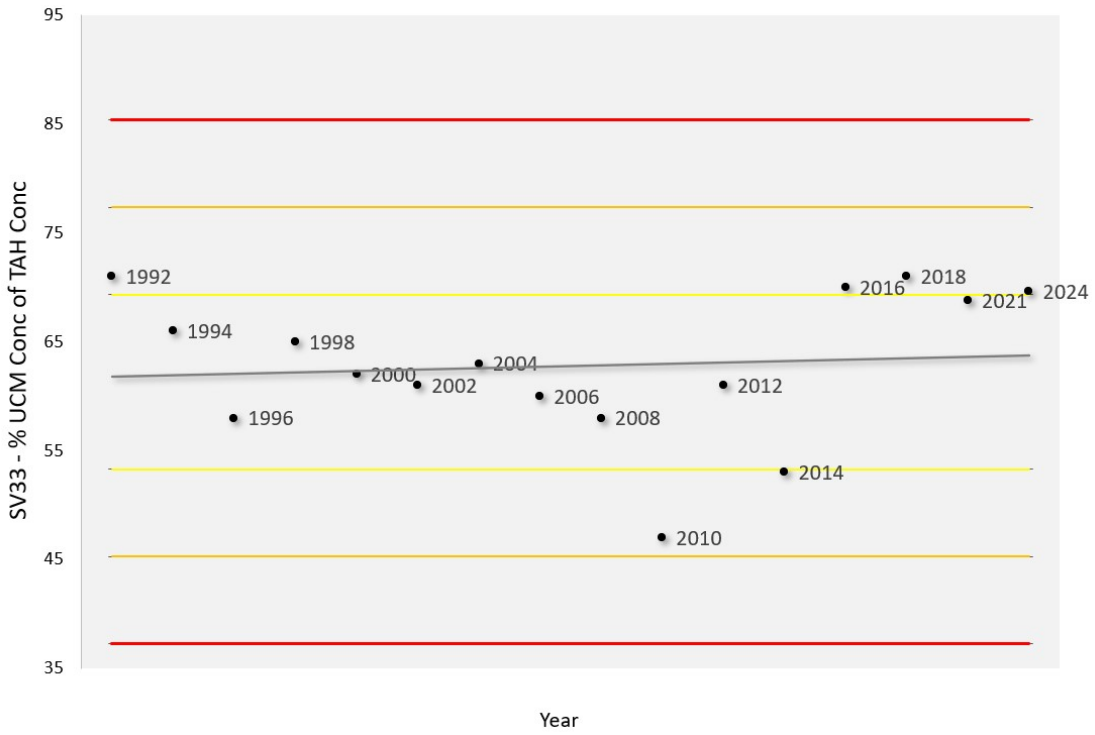

Figure 49 – SV33 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.3.3 Calbeck Ness SV34

For station SV34, the mud content in 2024 was 38.2% and 6.9% higher than the 2021 result and the highest recorded at this station. The total organic content in 2024 was 1.6% which was 2.6% lower than the 2021 result.

The concentration of total aliphatic hydrocarbons (TAH) at station SV34 is generally low (<10µg.g^{-1}), in 2024 the result was 6.4 ug/g and has not changed significantly. The 2024 result was -1.2 standard deviation from the historic mean for 2004-2021 indicating some change. However the data range that has been used to determine the chart limits includes data for 2004-2008 which has skewed the mean and limits, taking the 2024 result in comparison to the 2010-2021 results there has been minimal change. The relative standard deviation between the 3 TAH grab replicates was 9.6 % indicating low variation in the sediment composition for TAH. The percentage of UCM in the TAH was similar to the 2021 result and within 1 standard deviations of the historic mean for 2004-2021, indicating little change in the oil profile.

The concentration of 2-6 ring PAH concentration at station SV34 in 2024 was 168 ng/g which was similar to the results for 2018 (174 ng/g) and 2021 (161 ng/g). The 2024 result was within 1 standard deviation from the historic mean for 2004-2021 and indicates little change. The percentage of 4-6 ring PAHs of the total PAHs has demonstrated little change against the historic mean for 2004-2021.

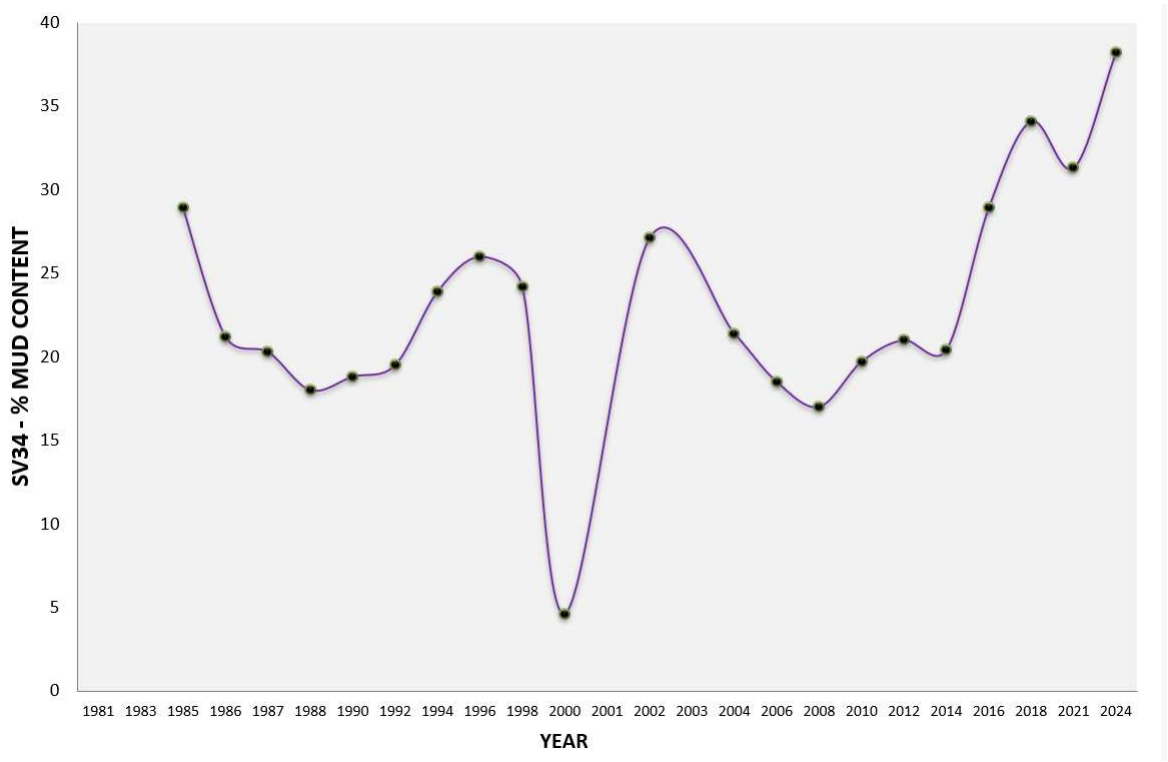

Figure 50 – SV34 Percentage Mud content

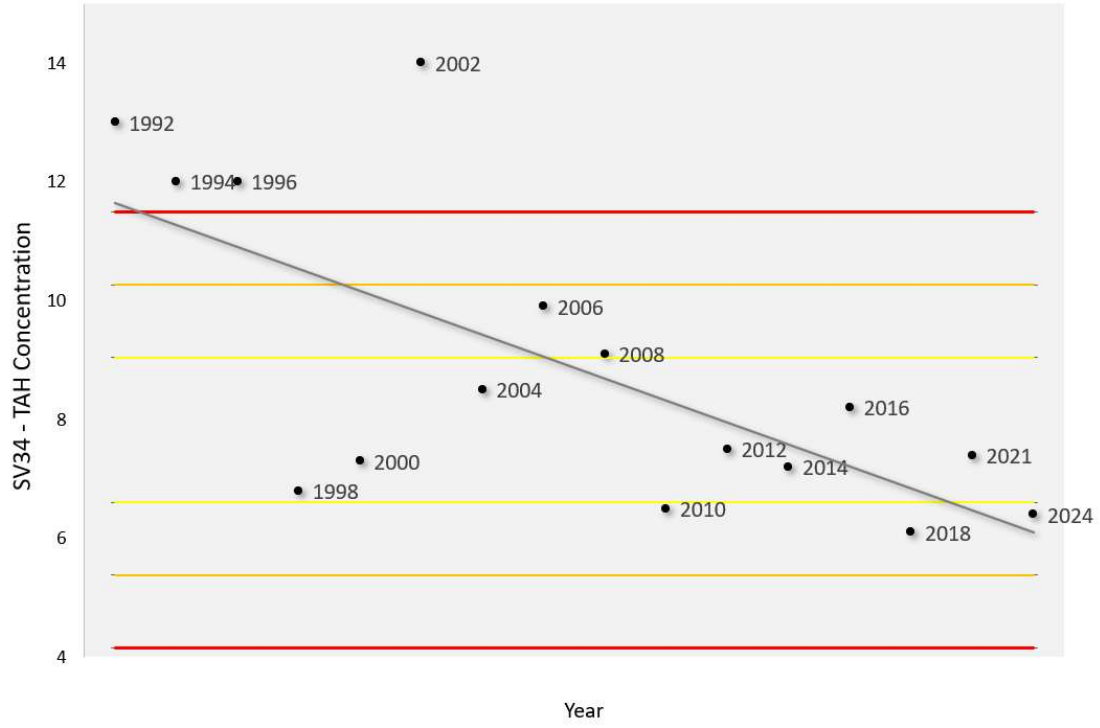

Figure 51 – SV34 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

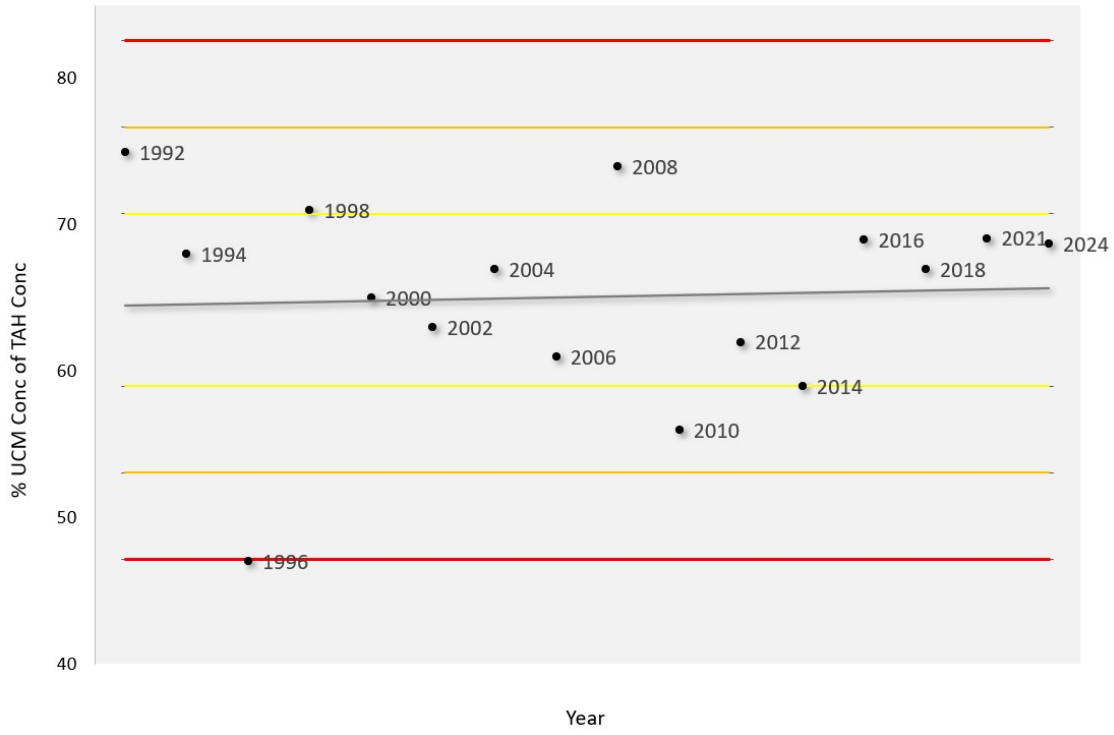

Figure 52 – SV34 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

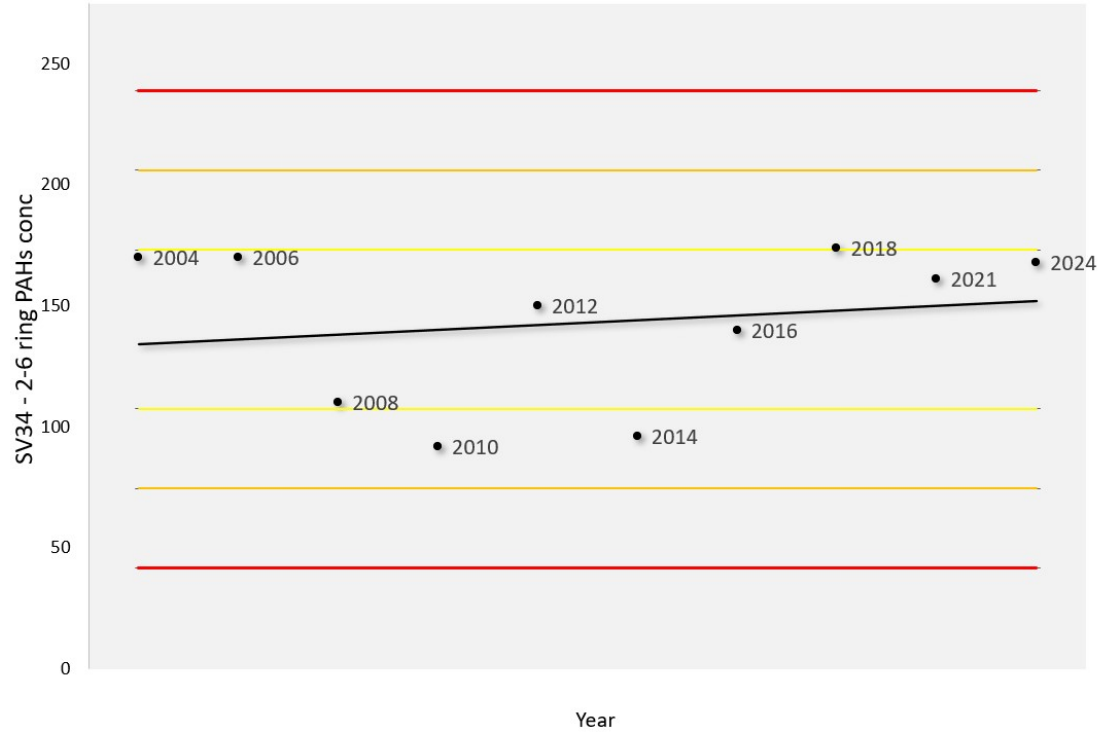

Figure 53 – SV34 2-6 ring PAH concentration (ng.g^{-1} dry sed.)

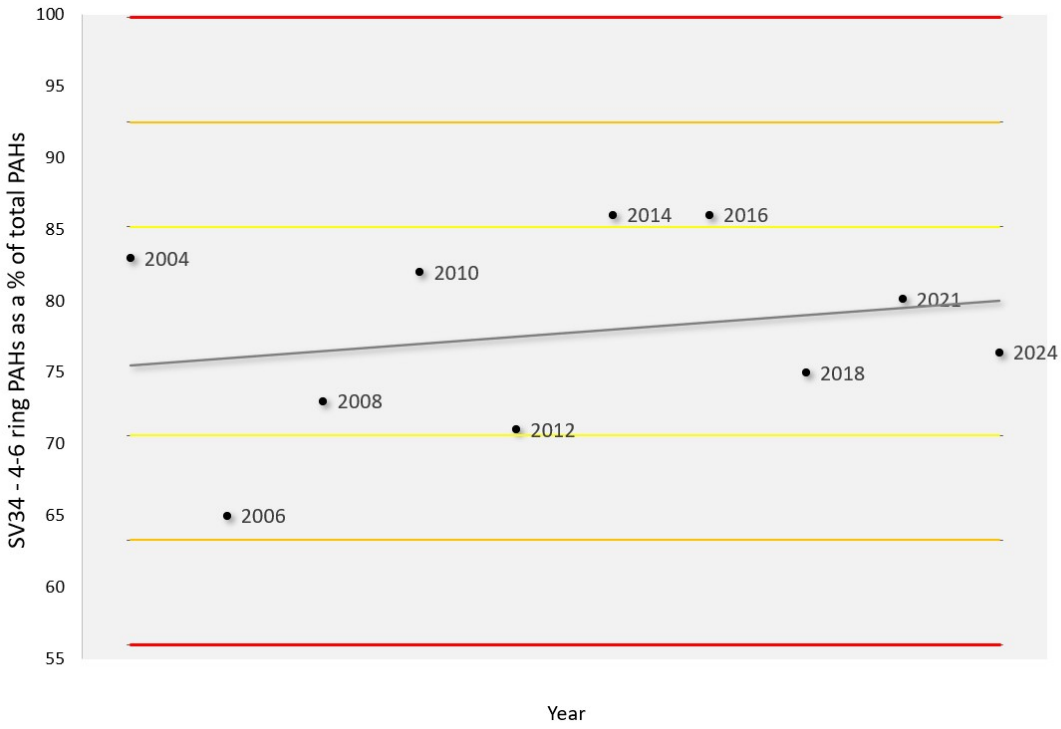

Figure 54 – SV34 4-6 ring PAHs as a percentage of the total PAHs (%)

3.4.3.4 Calbeck Ness SV35

For station SV35, the mud content in 2024 was 14.6% which was 6.3% higher than in 2021 and the highest recorded result for this station. The total organic content in 2024 was 0.7% which was 0.6% lower than the 2021 result.

The concentration of total aliphatic hydrocarbons (TAH) at station SV35 is generally low (<10µg.g^{-1}), in 2024 the result was 2.4 ug/g and has not changed significantly compared with the 2021 result (7.4 ug/g). The 2024 result was within 1 standard deviations from the historic mean for 2004-2021, indicating little change. The relative standard deviation between the 3 TAH grab replicates was 12.1% indicating low variation in the sediment composition for TAH. The percentage of UCM in the TAH is close to the historic mean for 2004-2021 and is with 1 standard deviations from the historic mean, indicating little change to the oil profile.

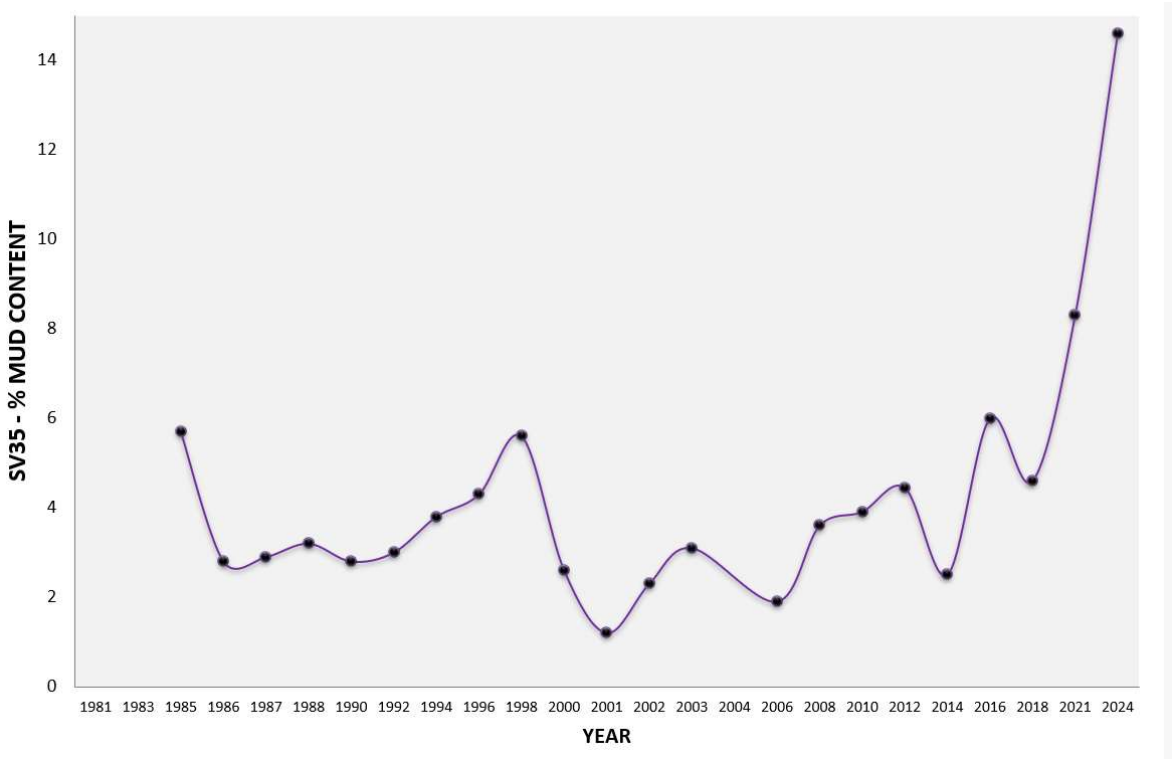

Figure 55 – SV35 Percentage Mud content

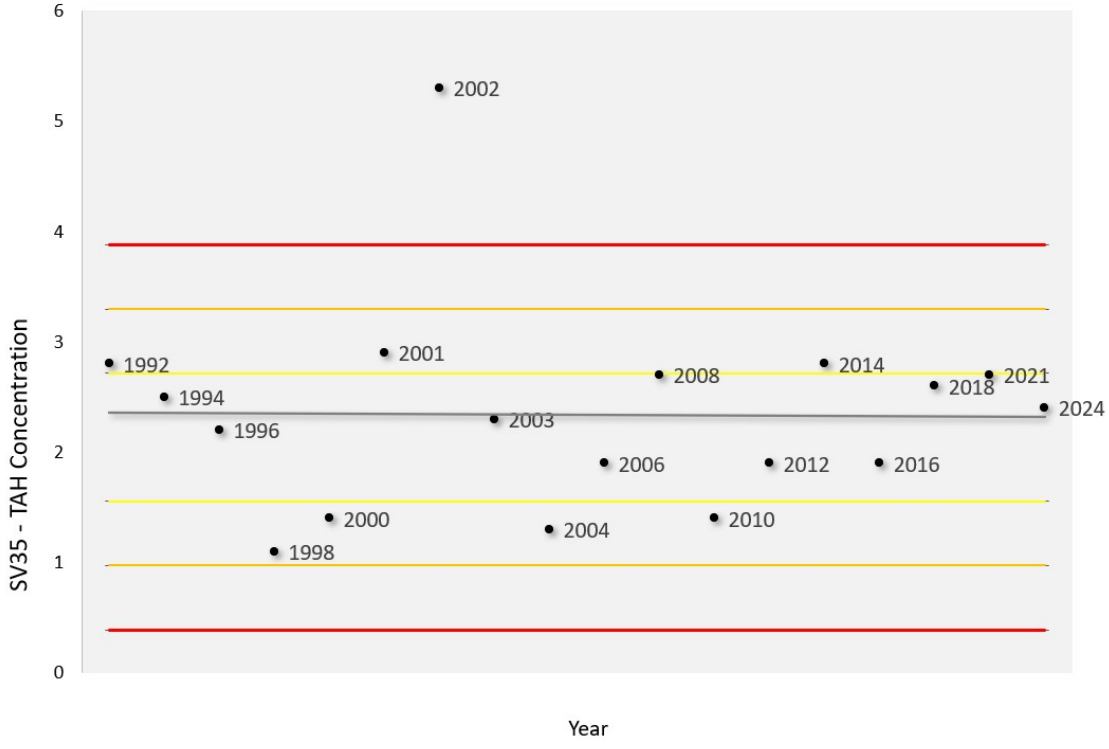

Figure 56 – SV35 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

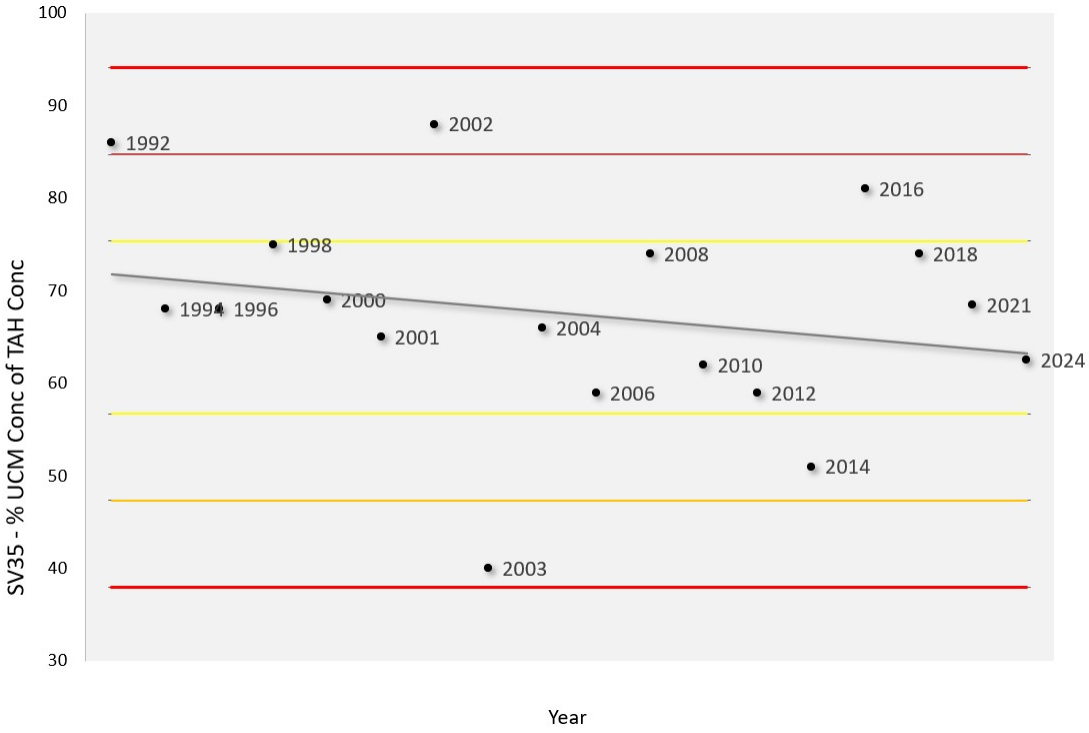

Figure 57 – SV35 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.3.5 Calbeck Ness SV37C

Fresh coordinates for SV37 at Calbeck Ness were identified in 2024, satisfactory grabs were obtained at the revise location although the patch of sediment is not extensive. The TAH concentration at SV37C was 3.0 ug/g which is at low level similar to the other stations in this area. As this is the first survey with results there is no comparison to a historic data set.

In 2016 the coordinates for station SV37 were revised as the original coordinates were within a 200m exclusion zone of pipeline assets. Revised coordinates for station SV37B did not yield acceptable grabs in 2018 and 2021 due to the coordinates being very close to the sediment bed edge where the sediment meets the rocky substrate.

3.4.4 GARTHS VOE (STATIONS 6, 6A, 6F TO 32)

3.4.4.1 Garths Voe SV6

For station SV6, the mud content in 2024 was 36.6% which was 5.1% higher than in 2021 and was in a similar range to the 2016-2021 results. The organic content in 2024 was 4.3% which was 0.6% lower than the 2021 result.

The concentration of total aliphatic hydrocarbons (TAH) at station SV34 was comparable to the 2014-2021 results and is within 1 standard deviation of the historic mean for 2004-2021, indicating there has been little change. The relative standard deviation between the 3 TAH grab replicates was 4.8% indicating low variation in the sediment composition for TAH. As in the 2016-2018 surveys, the percentage of UCM in the TAH continues to be higher than the historic mean and is +1.6 standard deviation of the historic mean 2004-2021 indicating some change in the oil profile.

The concentration of 2-6 ring PAH concentration at station SV6 in 2021 was 1025ng/g which was lower than in 2021 (1110ng/g). The 2024 result was within 1 standard deviation of the historic mean 2004-2021, indicating that there had been little change. The percentage of 4-6 ring PAHs of the total PAHs was within 1 standard deviation of the historic mean 2004-2021, indicating there had been little change.

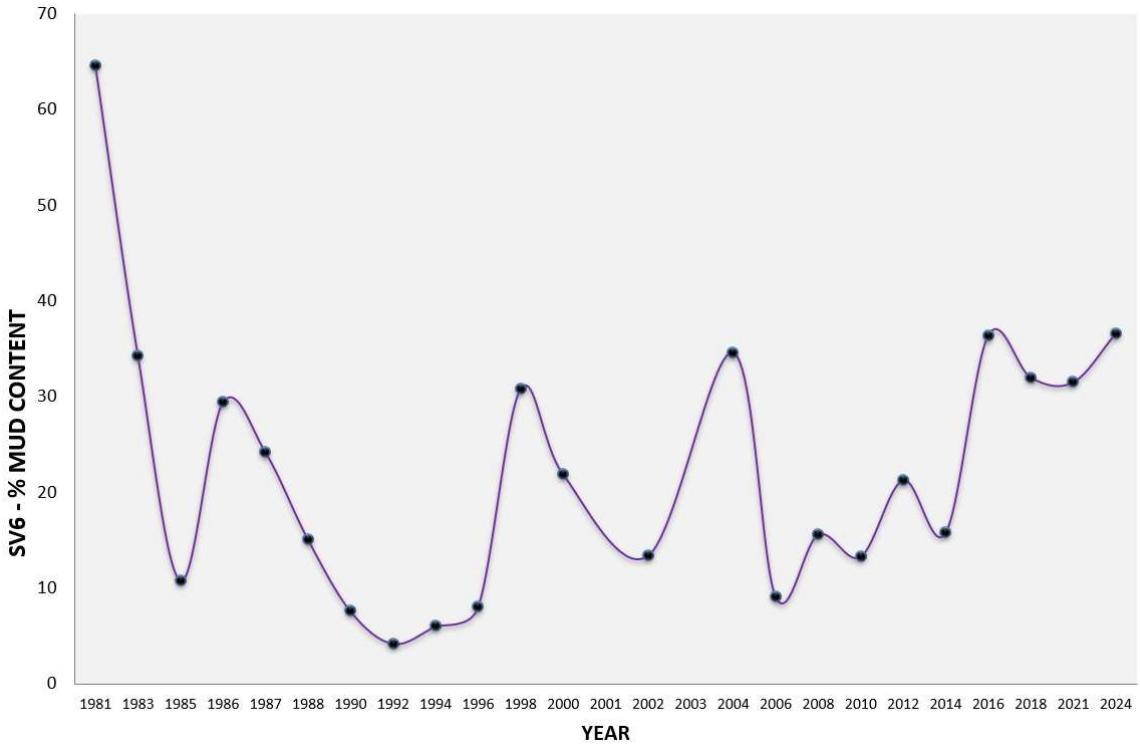

Figure 58 – SV6 Percentage mud content

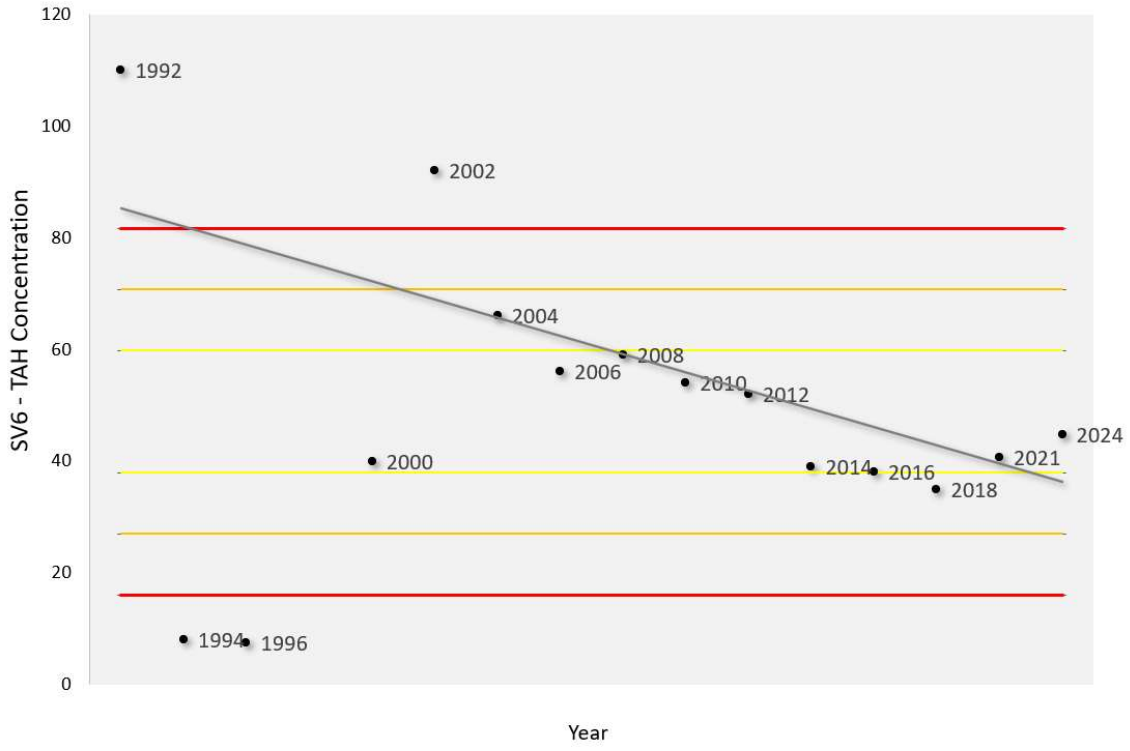

Figure 59 – SV6 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

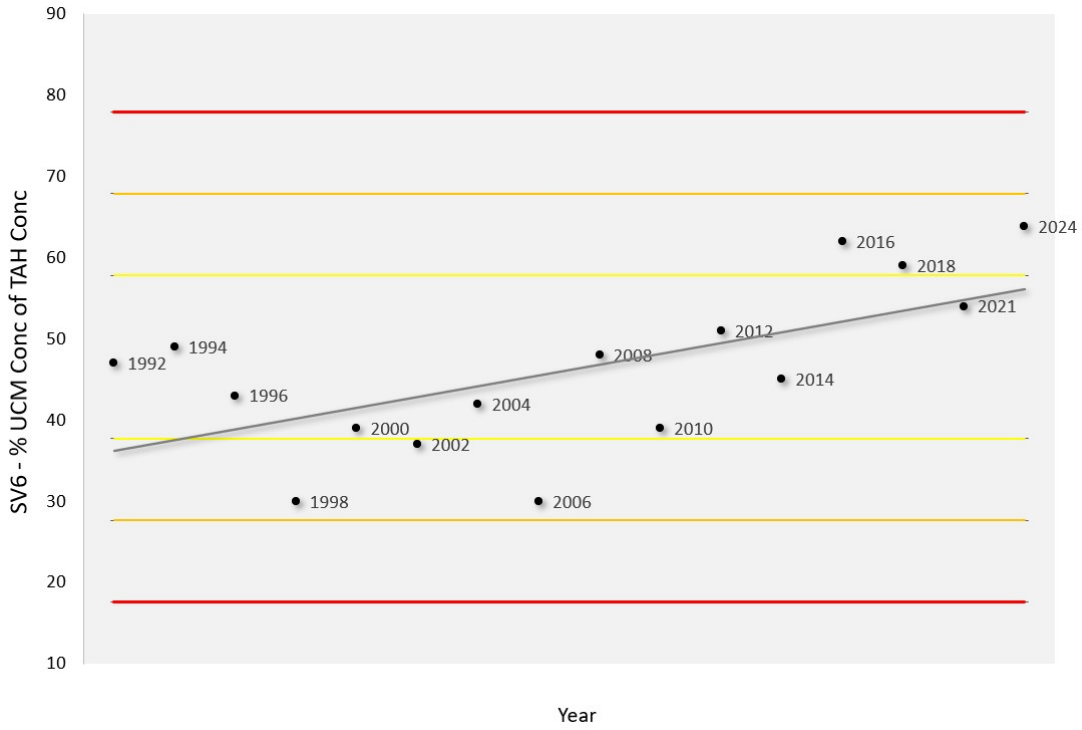

Figure 60 – SV6 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

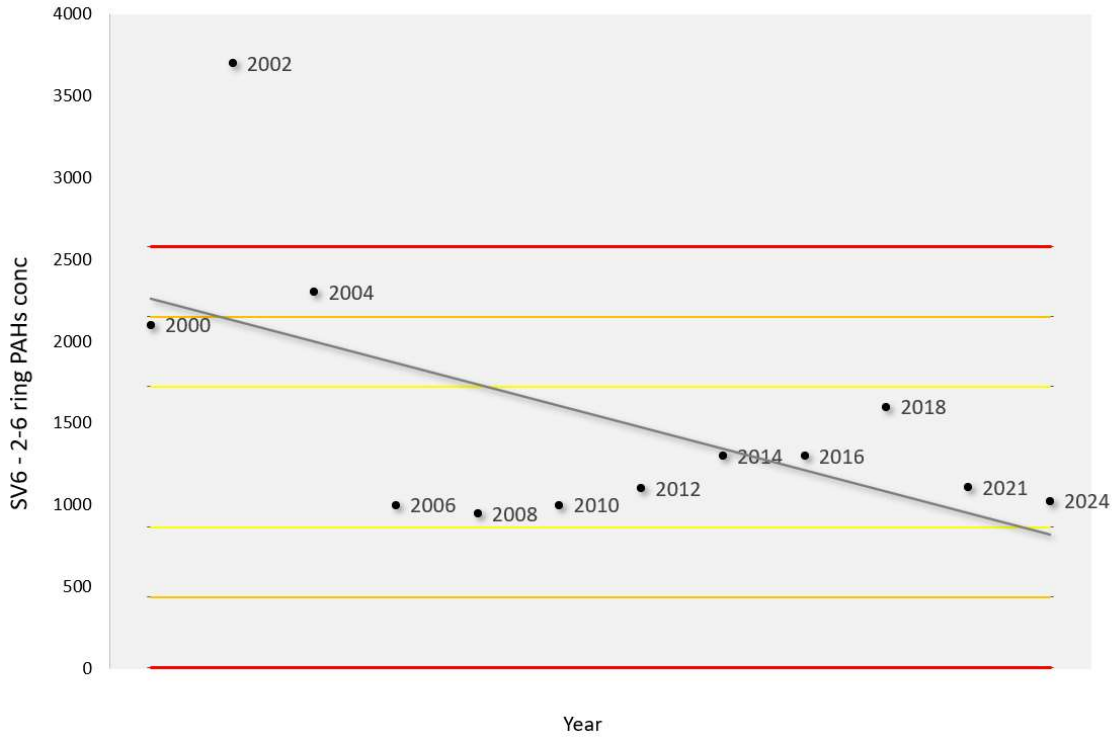

Figure 61 – SV6 2-6 ring PAH concentration (ng/g^{-1} dry sed.)

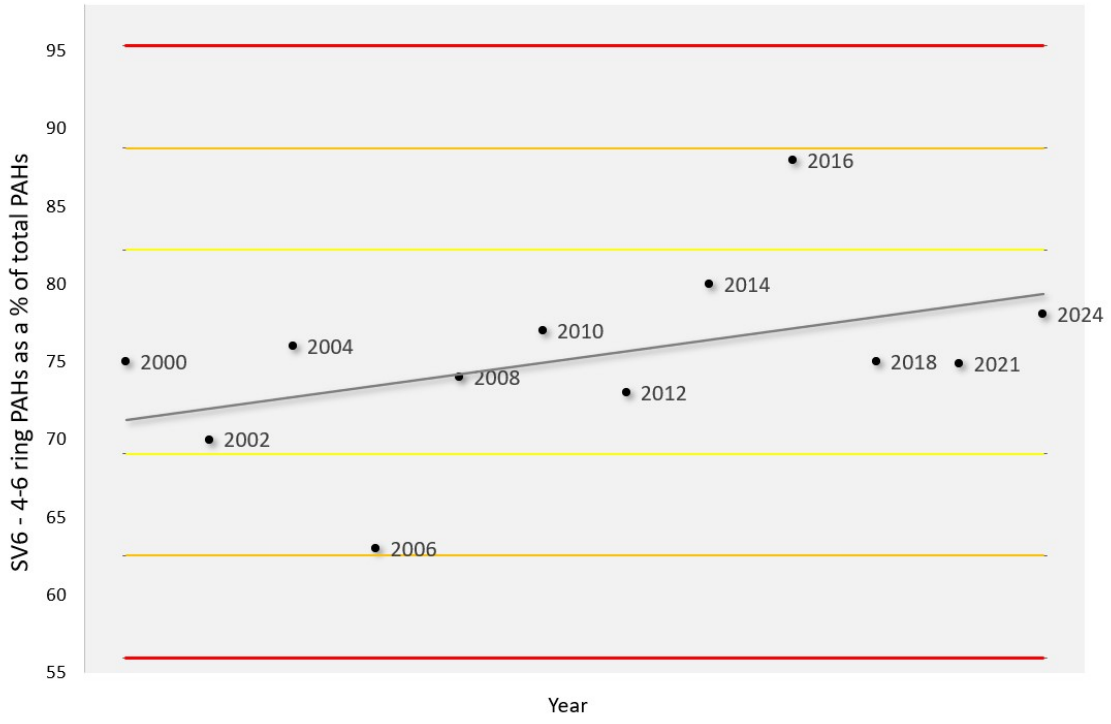

Figure 62 – SV6 4-6 ring PAHs as a percentage of the total PAHs (%)

3.4.4.2 Garths Voe SV6A

For station SV6A, the mud content result in 2024 was 32.4% which was 3.9% higher than in 2021. The organic content in 2024 was 12.2% which was 4.6% higher than the 2021 result.

The concentration of total aliphatic hydrocarbons (TAH) at station SV6A in 2024 was 93.9 ug/g which was higher than in 2021. The 2024 result was within 1 standard deviation from the historic mean for 2004-2021, indicating little change. The relative standard deviation between the 3 TAH grab replicates was 13% indicating moderate variation in the sediment composition for TAH. The percentage of UCM in the TAH is higher than in 2021 but is within 1 standard deviation of the historic mean for 2004-2021, indicating little change in the oil profile.

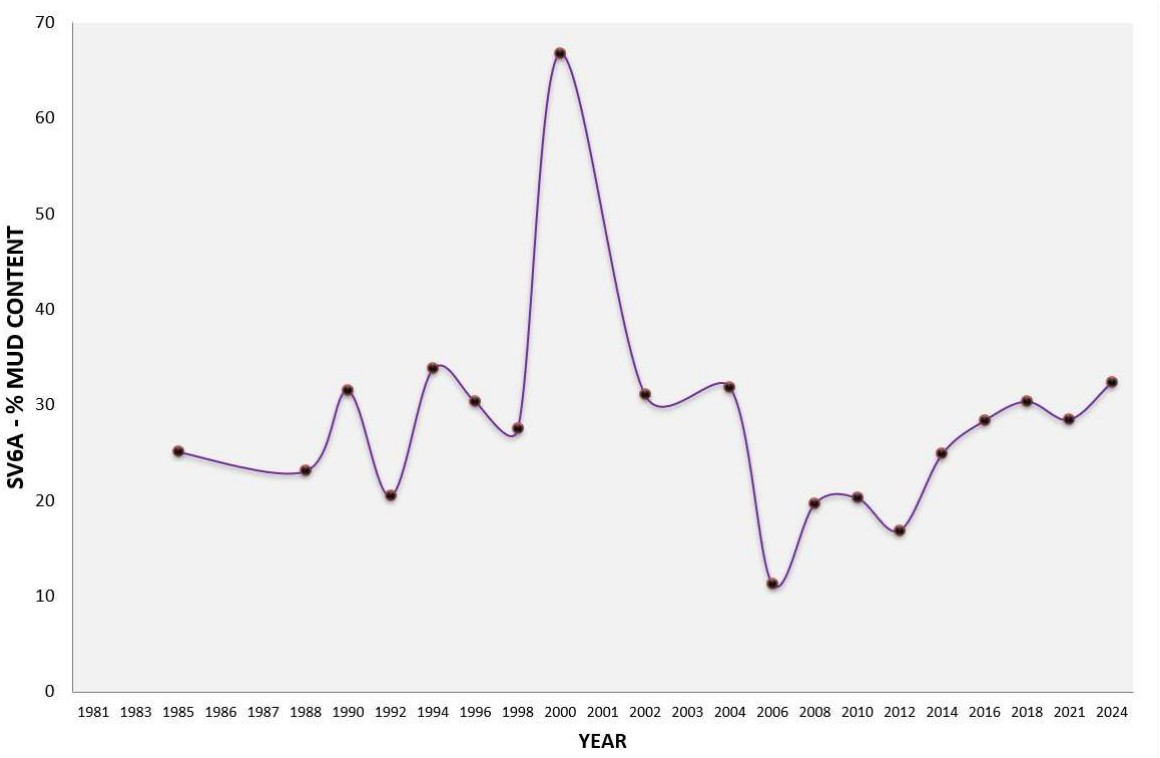

Figure 63 – SV6A Percentage mud content

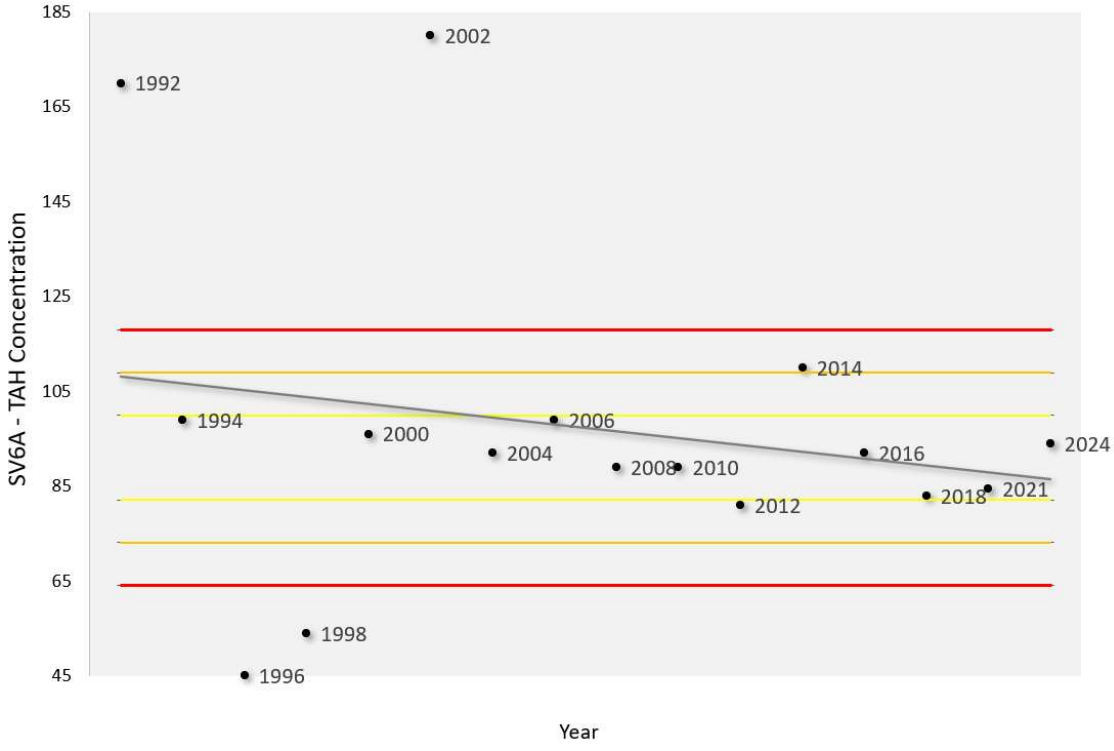

Figure 64 – SV6A Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

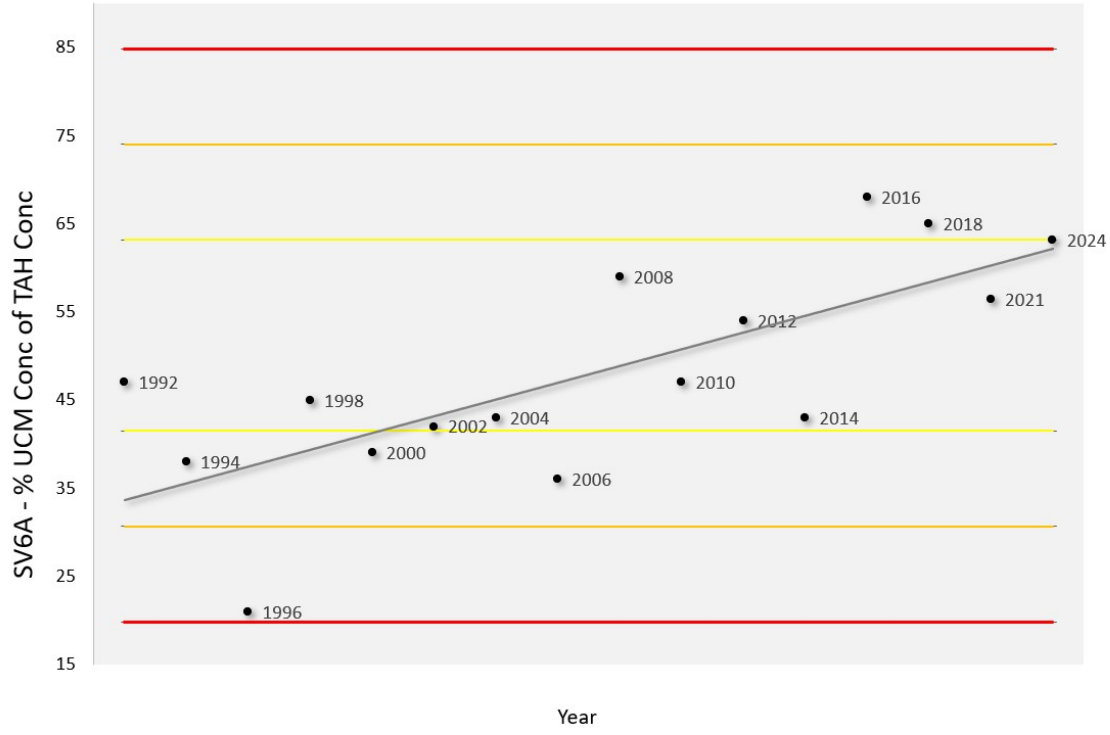

Figure 65 – SV6A Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.4.3 Garths Voe SV6F

For station SV6F, the mud content in 2024 was 34.2% which was 4.1% higher than in 2021. The total organic content in 2024 was 13.2% which was 1.7% lower than in 2021.

The concentration of total aliphatic hydrocarbons (TAH) at station SV6F in 2024 was 126 ug/g which was slightly higher than in 2021. The 2021 result was within 1 standard deviation from the historic mean 2004-2021 indicating little change. The relative standard deviation between the 3 TAH grab replicates was 13.2% indicating low variation in the sediment composition for TAH. The percentage of UCM in the TAH was higher than the 2021 result but is similar to the 2016 and 2018 results, this was +1.2 standard deviation from the historic mean, indicating some change to the oil profile.

The concentration of 2-6 ring PAH concentration at station SV6F in 2024 was 1573 ng/g, which was similar to the 2021 result which was 1640 ng/g but was lower than the historic mean for 2004-2021 of 2050 ng/g. The 2024 result was -1.1 standard deviation from the historic mean indicating some change. The percentage of 4-6 ring PAHs of the total PAHs was within 1 standard deviation from the historic mean, indicating little change.

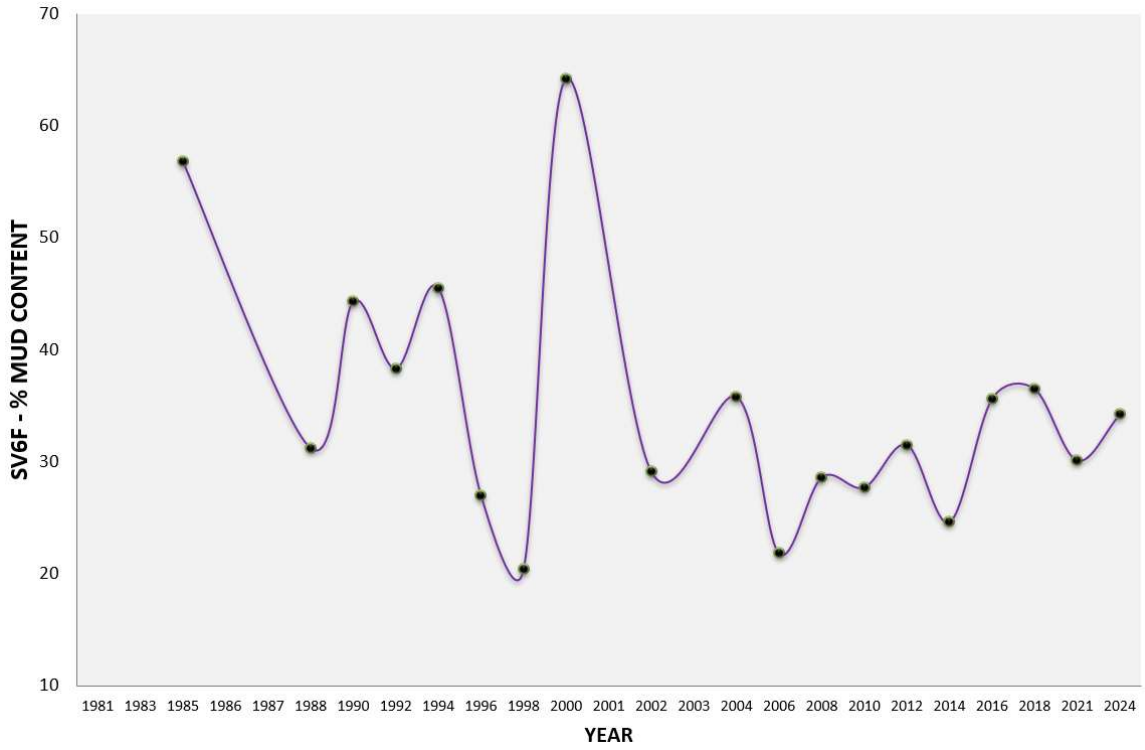

Figure 66 – SV6F Percentage mud content

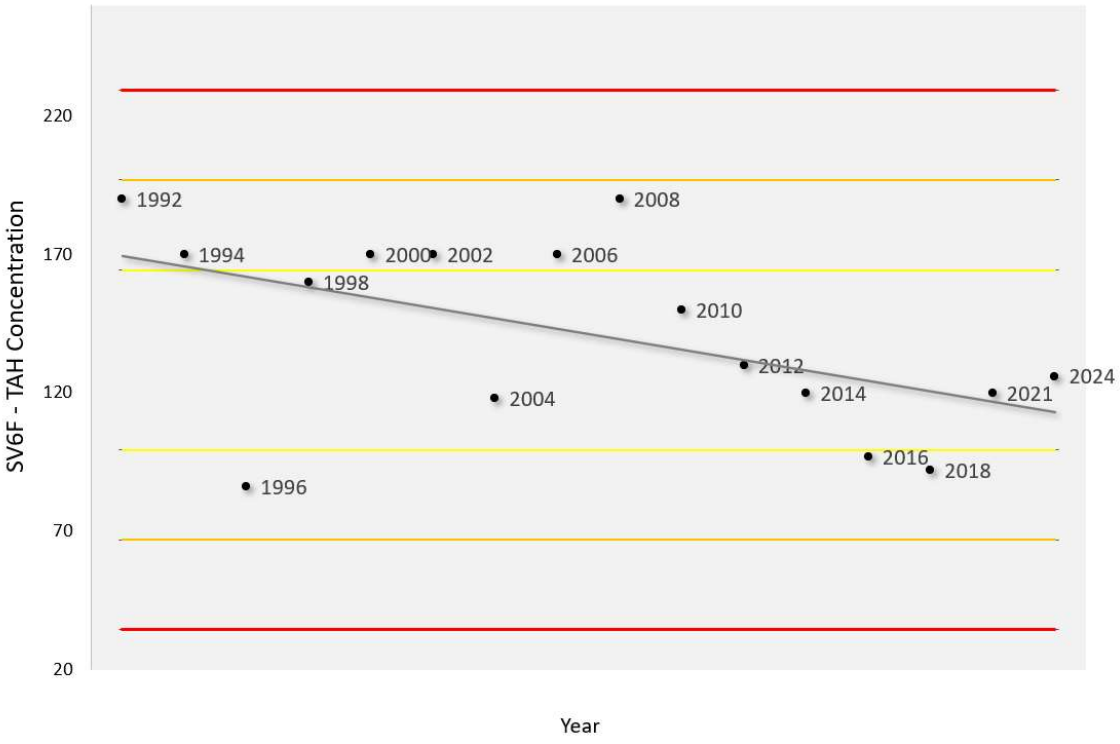

Figure 67 – SV6F Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

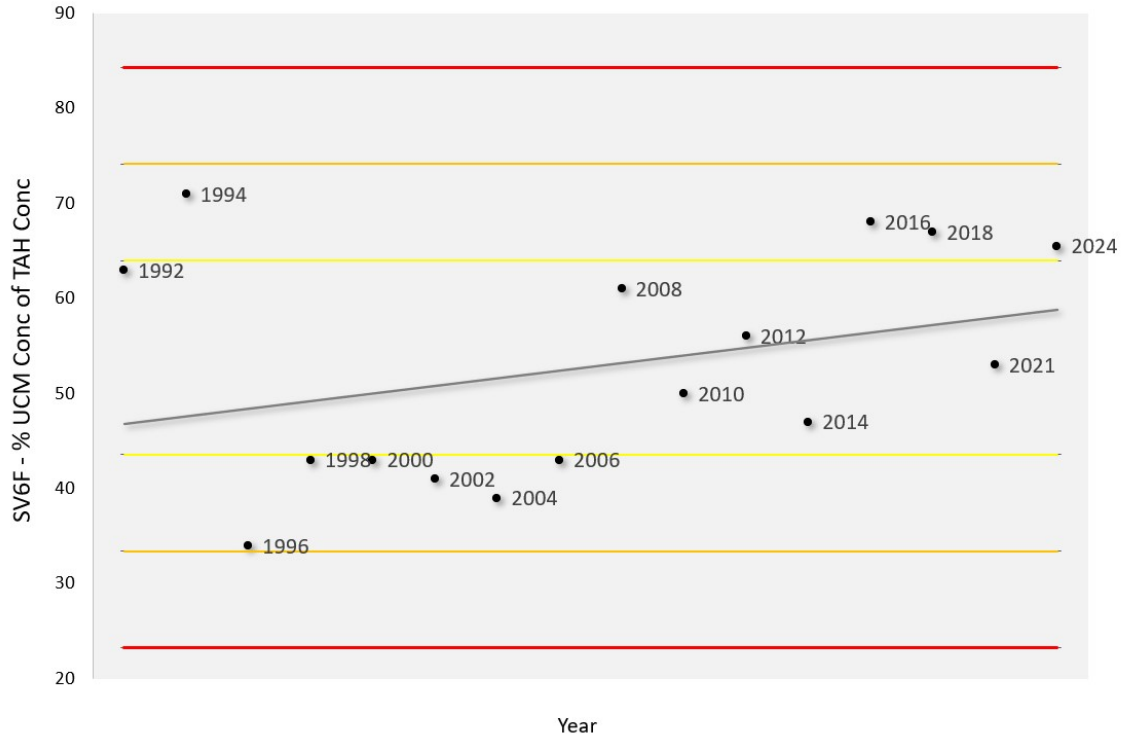

Figure 68 – SV6F Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

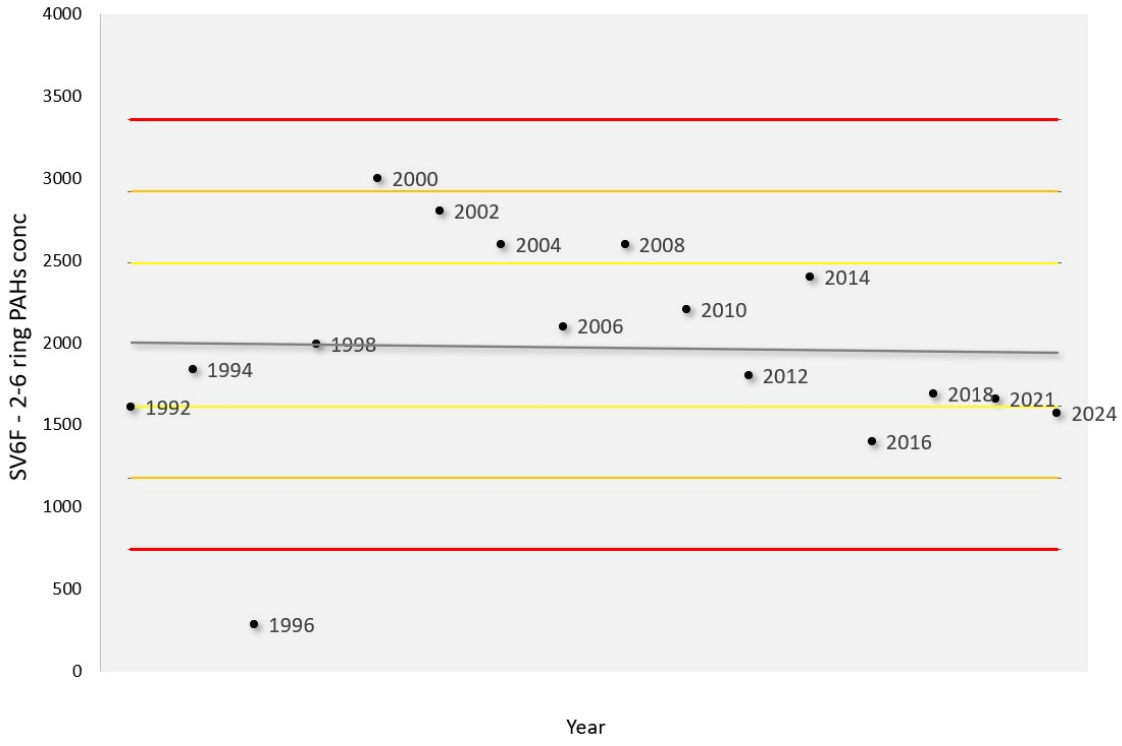

Figure 69 – SV6F 2-6 ring PAH concentration (ng.g^{-1} dry sed.)

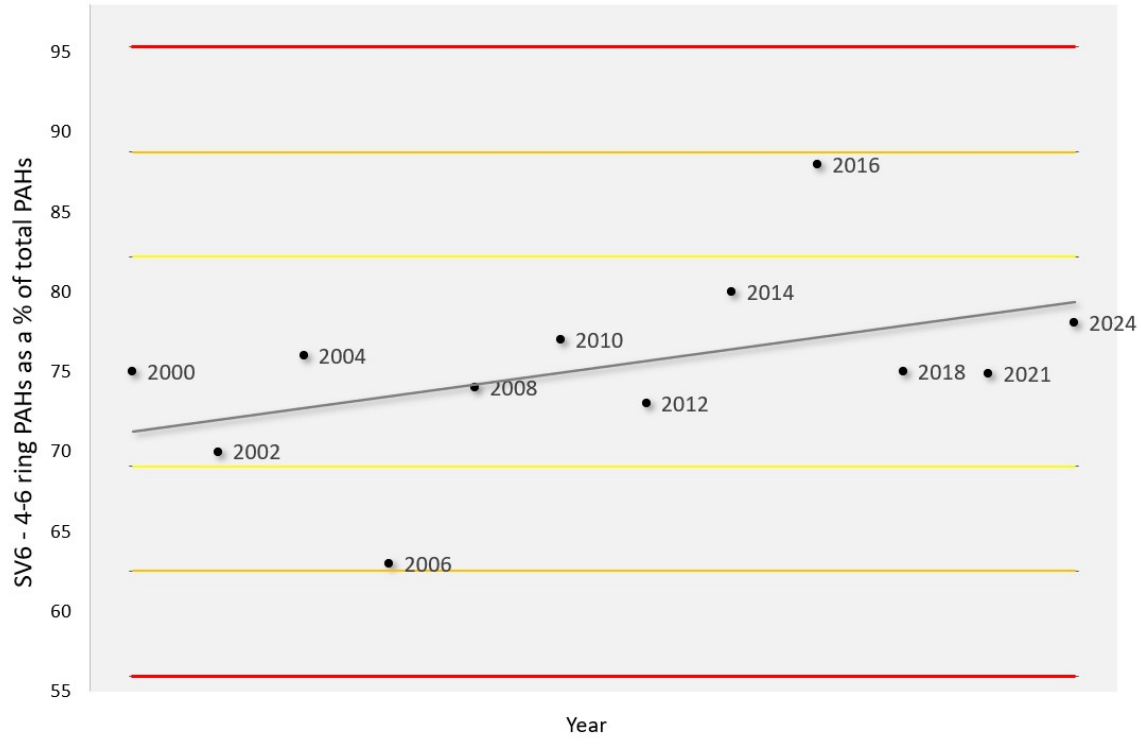

Figure 70 – SV6F 4-6 ring PAHs as a percentage of the total PAHs (%)

3.4.4.4 Garths Voe SV32

For station SV32, the mud content in 2024 was 45.4% with was 3.8% higher than in 2021. The total organic content in 2024 was 10.5% which is 1.1% lower than the 2021 result.

The concentration of total aliphatic hydrocarbons (TAH) at station SV32 in 2024 was 109 ug/g which was lower than the 2021 result. The 2024 result was within 1 standard deviation from the historic mean for 2004-2021 and indicates little change. The relative standard deviation for the TAH was 6.4% for the three grab samples analysed indicating low variation in the sediment composition for TAH. The percentage of UCM in the TAH was higher than in 2021 and was +2.8 standard deviation from the historic mean, indicating that there had been change in the oil profile.

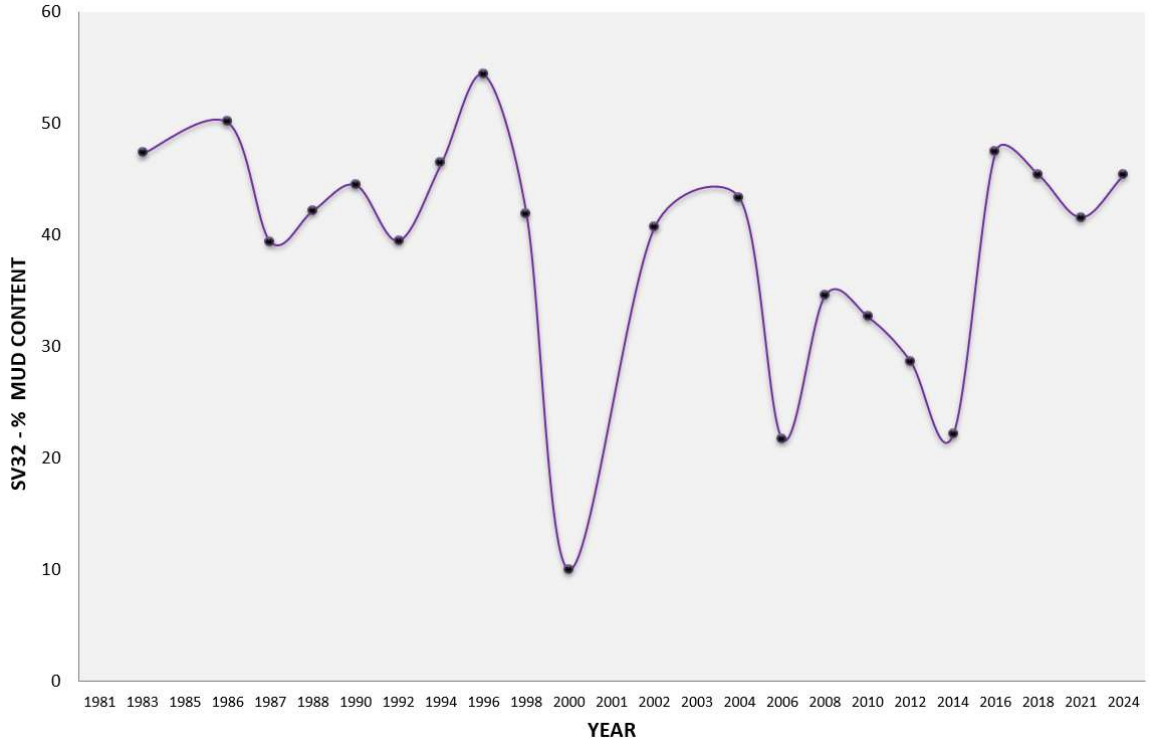

Figure 71 – SV32 Percentage mud content

Figure 72 – SV32 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

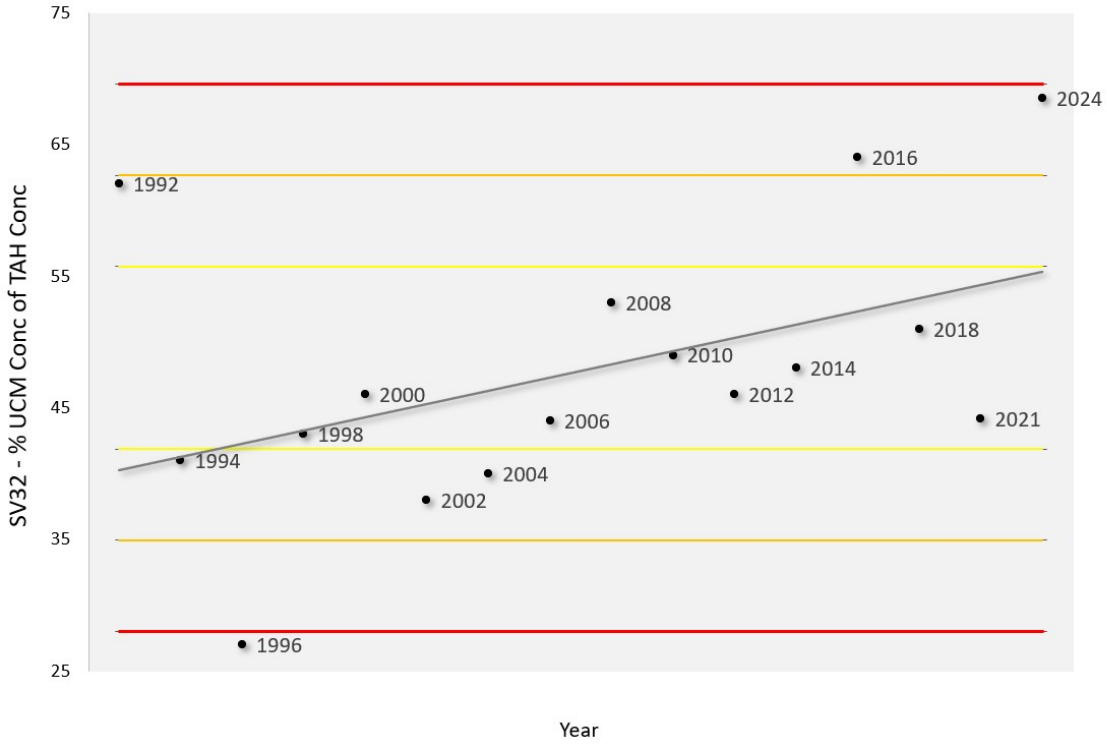

Figure 73 – SV32 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.5 GLUSS VOE (STATIONS GV1 TO GV3)

The proportions of mud at all three Gluss Voe stations ranged between 6.3% and 12% (GV1 6.3%, GV2 12% and GV3 8.4%) which was higher than in 2021 (GV1 2.3%, GV2 2.5% and GV3 3.0%). The portion of gravel had decreased at all Gluss Voe stations since 2021, with subsequent increase in sand and mud portions. At GV1 the mud content was 4% higher in 2024 than in 2021 (2.3%) and the textural group classification changed from Sandy Gravel to Muddy Sandy Gravel. At GV2 the mud content in 2024 was 9.5% higher than in 2021 (2.5%) and the textural group classification changed from Sandy Gravel to Gravelly Muddy Sand. At GV3 the mud content was 5.4% higher in 2024 than in 2021, textural group classification changed from Sandy Gravel to Muddy Sandy Gravel.

In previous reports the current and historic particle size distribution analysis was not included in tabulated format and has not been expressed in chart format in this section.

As in previous surveys, the total organic contents remained low in these stations, with values ranging from 0.1% to 0.3%, compared with 0.52% to 0.8% in 2021 and 0.4% to 0.83% in 2018.

3.4.5.1 Gluss Voe GV1

The concentration of total aliphatic hydrocarbons (TAH) at station GV1 is typically low (<10µg.g^{-1}) the 2024 result has not changed significantly against the historic mean. The 2024 result was 2.6 ug/g which was within 1 standard deviation from the historic mean for 2004-2021, indicating little change has occurred. The percentage of UCM in the TAH is historically very varied at this station. The percentage of UCM in the TAH for 2024 is within 1 standard deviation of the historic mean, indicating there has been little change. The relative standard deviation for the TAH result between the three grab samples was 10.9%.

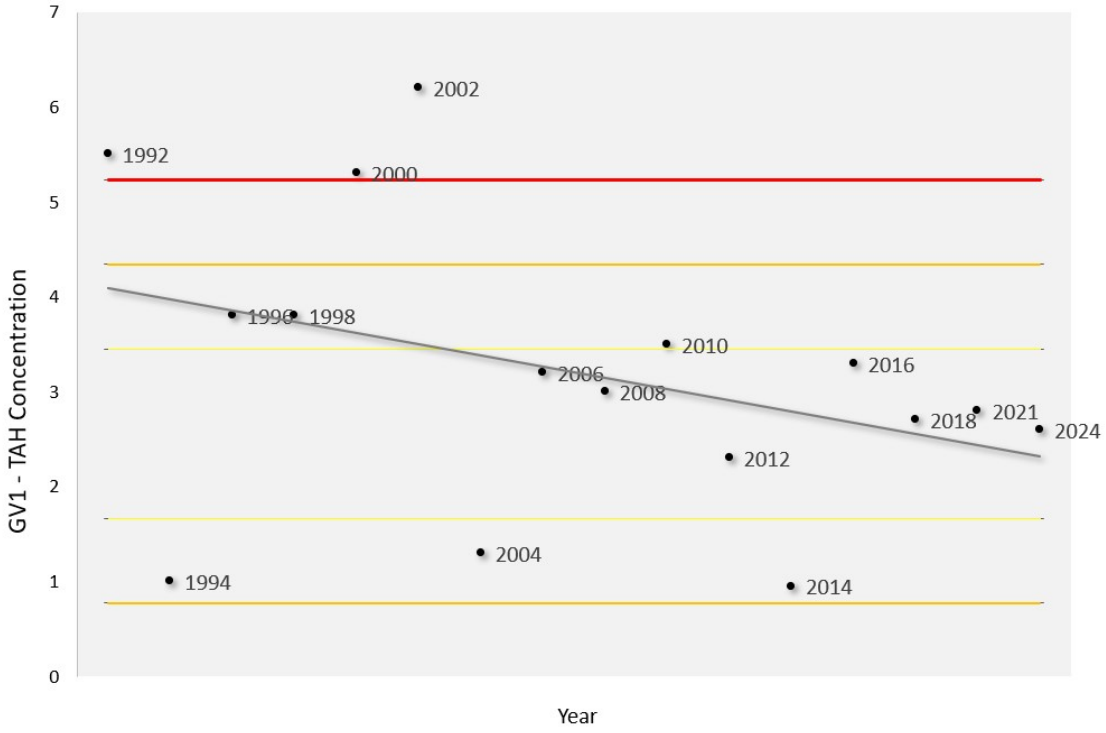

Figure 74 – GV1 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

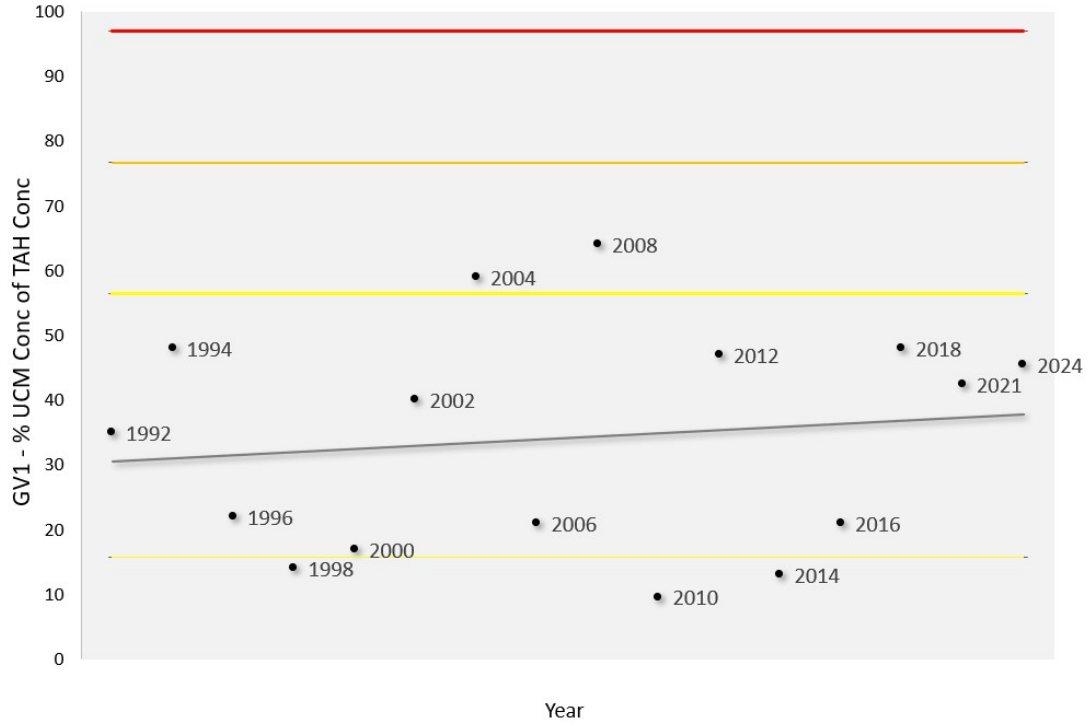

Figure 75 – GV1 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.5.2 Gluss Voe GV2

The concentration of total aliphatic hydrocarbons (TAH) at station GV2 is typically low (<10µg.g^{-1}) the 2024 result was 1.7 ug/g which has not changed significantly against the 2021 result, but there continues to be a trend of lower concentrations when compared to the historic mean 2004-2021. The 2024 result was -1.0 standard deviations from the historic mean for 2004-2021, indicating there had been little change. The percentage of UCM in the TAH is historically very varied at this station, the percentage of UCM in the TAH result for 2024 was lower than in 2016-2021 but was comparable to the historic mean 2004-2021. The 2024 result is within 1 standard deviation from the historic mean for 2004-2021, indicating little change. The relative standard deviation for the TAH results for the three grab samples was 10.5%.

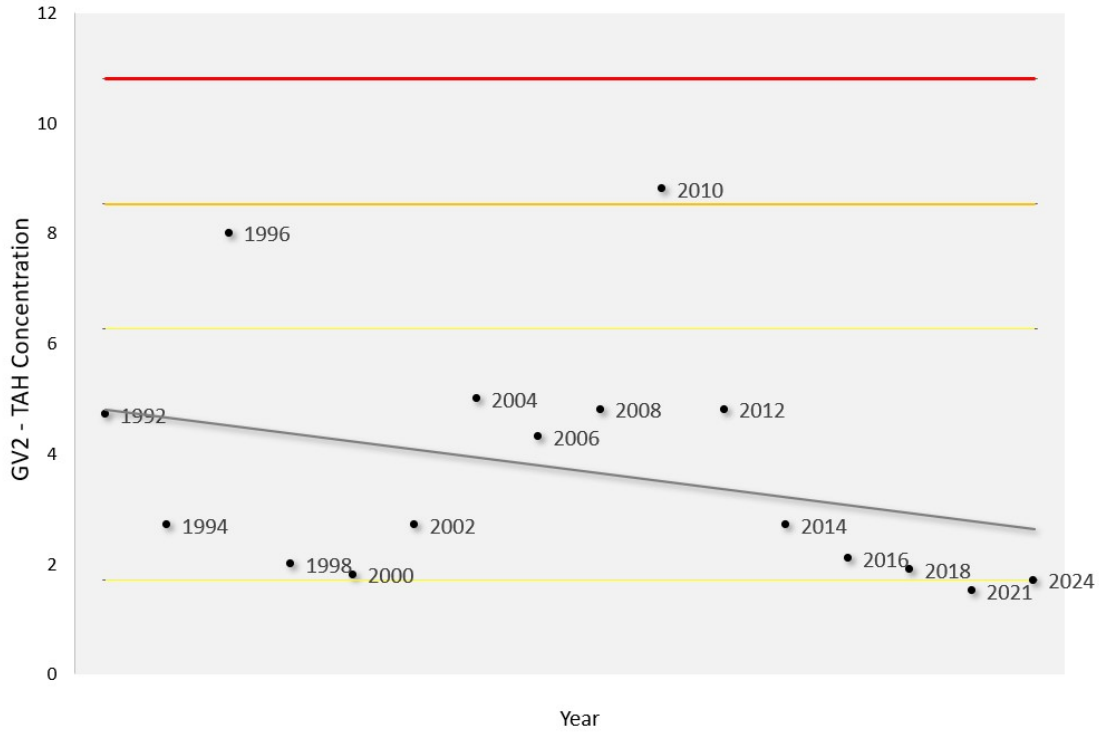

Figure 76 – GV2 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

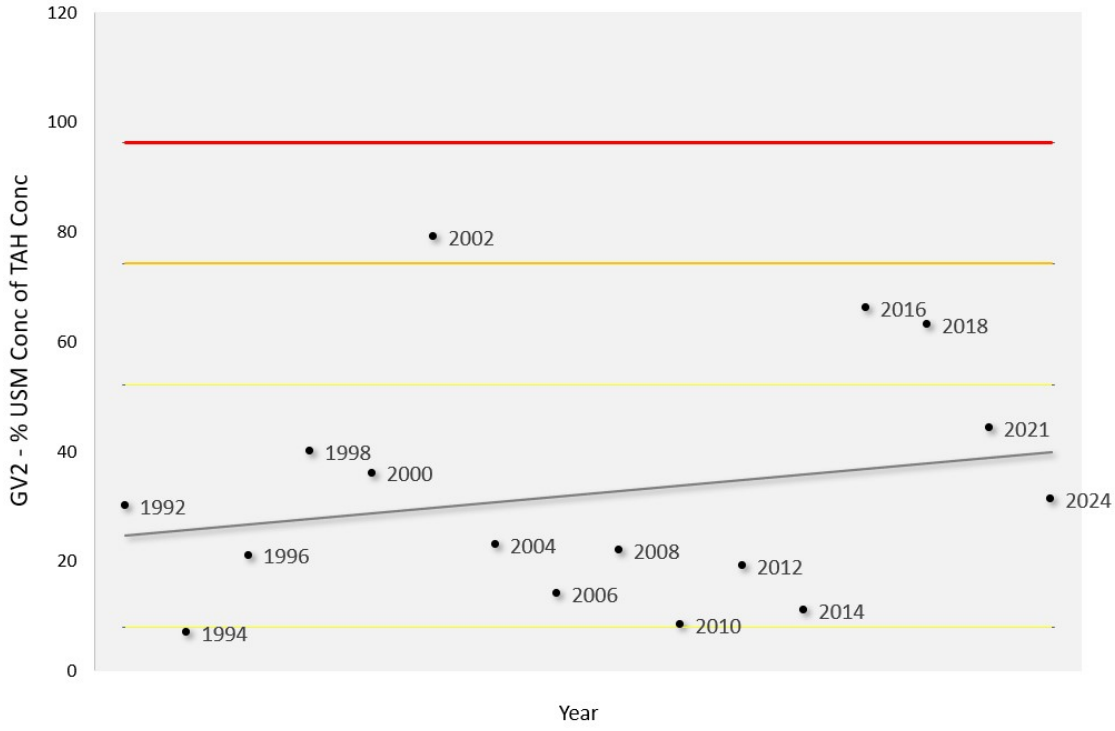

Figure 77 – GV2 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.5.3 Gluss Voe GV3

The concentration of total aliphatic hydrocarbons (TAH) at station GV3 is typically low (<10µg.g^{-1}) the 2024 result was 2.2 ug/g which was similar to the 2021 result. The 2024 result was within 1 standard deviation from the historic mean 2004-2021 indicating there had been little change. The percentage of UCM in the TAH is historically very varied at this station. The percentage of UCM in the TAH result for 2024 is higher than the 2021 result. The 2024 result was +1.3 standard deviations from the historic mean, indicating some change against the historic mean. The relative standard deviation for the TAH results for the three grab samples was 14.9%.

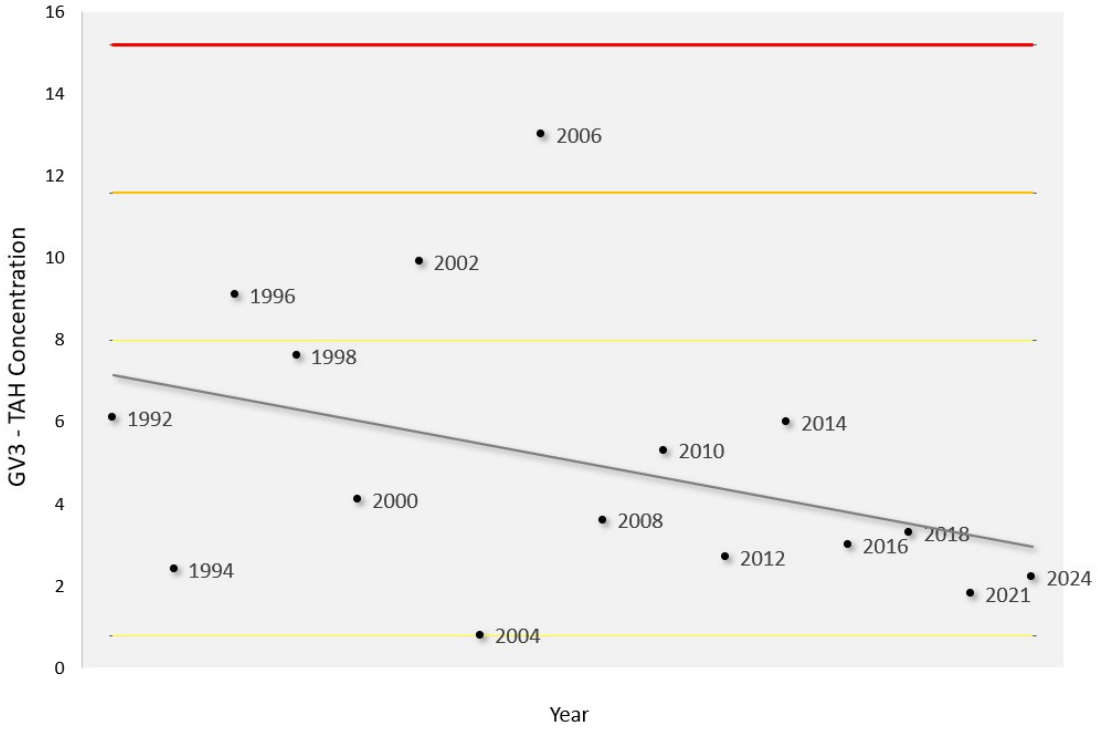

Figure 78 – GV3 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

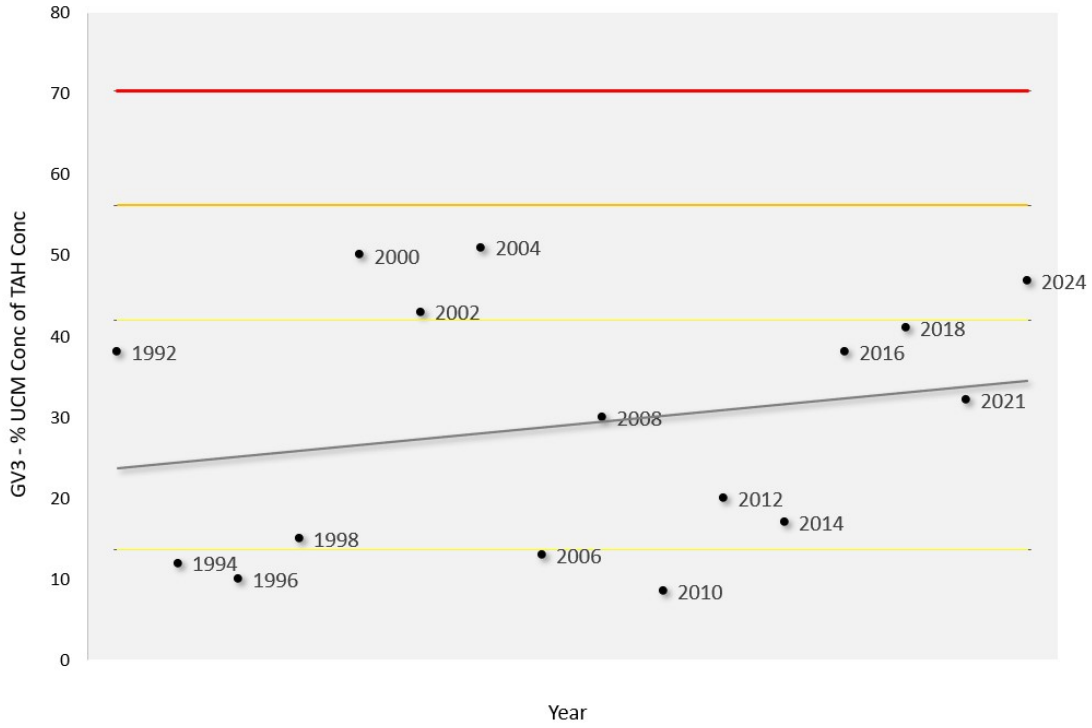

Figure 79 – GV3 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.6 HOUB OF SCATSTA (STATIONS HS1 TO HS3)

The proportions of mud at all three Houb Of Scatsa stations ranged between 3.6% and 9.7% (HS1 3.6%, HS2 11.3% and HS3 9.7%) which was higher than in 2021 (HS1 1.7%, HS2 5.6% and HS3 4.7%).

As in 2021 and 2018, the HS1 classification in 2024 was assigned as Sandy Gravel, the mud content had increased slightly from 1.7% in 2021 to 3.6% in 2024. At HS2 the 2024 classification was assigned as Muddy Sand, the mud content had increased from 5.6% in 2021 to 11.3% in 2024. At HS3 the 2024 classification was assigned as Gravelly Muddy Sand, the mud content had risen slightly from 4.7% in 2021 to 9.7% in 2024.

In previous reports the current and historic particle size distribution analysis was not included in tabulated format and has not been expressed in chart format in this section.

As in previous surveys, the organic contents remained low in these stations, with values ranging from 0.1% to 0.5%, compared with 1.46% to 2.30% in 2021 and 1.22% to 1.95% in 2018.

3.4.6.1 Houb of Scatsta HS1

The concentration of total aliphatic hydrocarbons (TAH) at station HS1 is generally low (<10µg.g^{-1}). The 2024 result was 3.1 ug/g which has not changed significantly against the 2016-2021 results or the historic mean. The 2021 result was within 1 standard deviation from the historic mean 2004-2018, indicating little change. The percentage of UCM in the TAH is historically very varied at this station. The percentage of UCM in the TAH is within 1 standard deviation of the historic mean and indicates there has been little change against the historic mean. The relative standard deviation for the TAH results for the three grab samples was 10.2%.

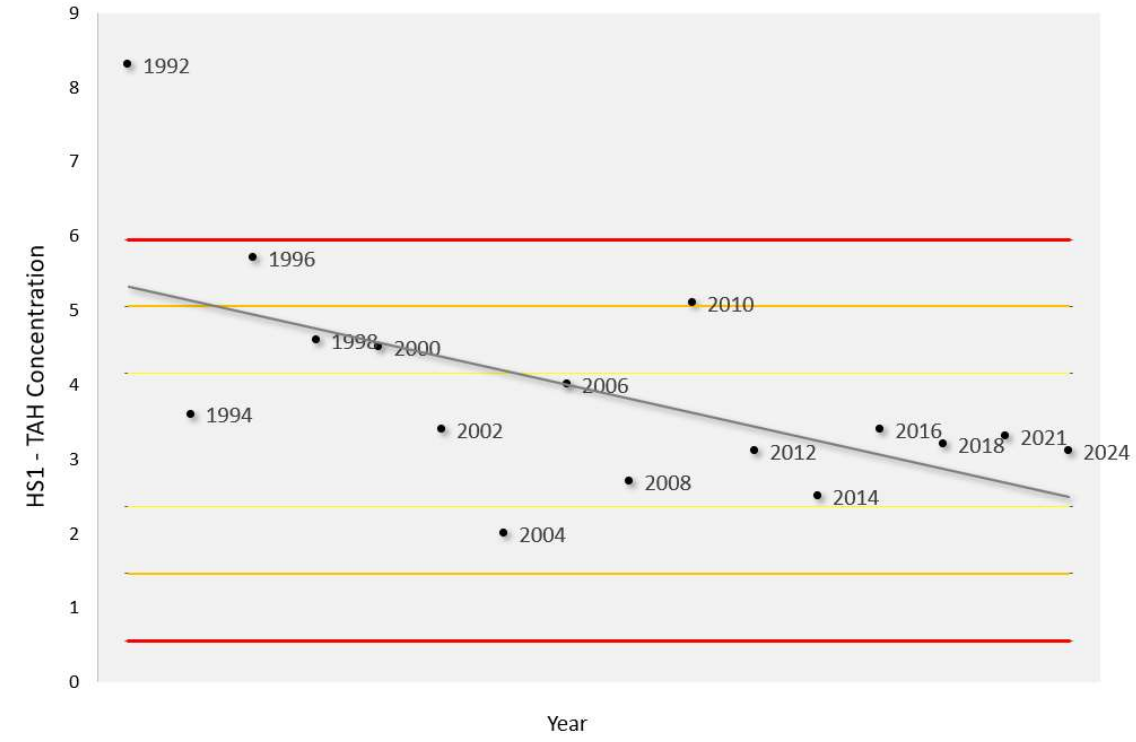

Figure 80 – HS1 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

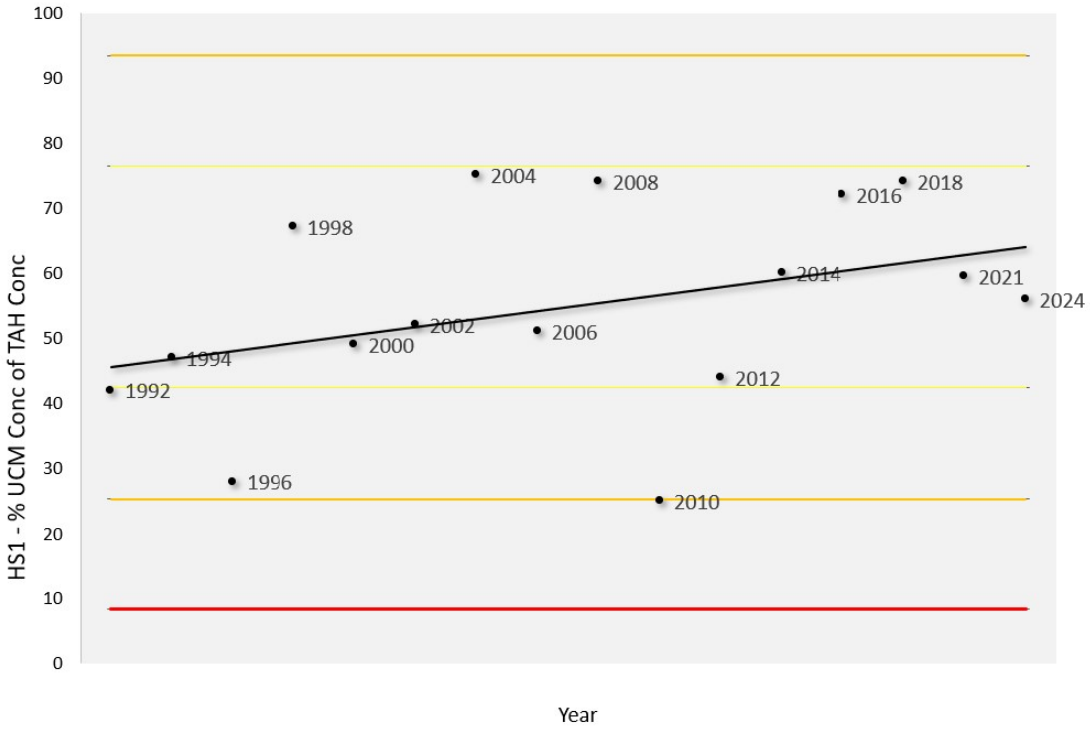

Figure 81 – HS1 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.6.2 Houb of Scatsta HS2

The concentration of total aliphatic hydrocarbons (TAH) at station HS2 is generally low (<10µg.g^{-1}) the 2024 result was 6.0 ug/g which was higher than the 2021 result but comparable with recent results since 2012 and the historic mean 2004-2021. The 2024 result was within 1 standard deviations from the mean indicating little change. The percentage of UCM in the TAH result for 2024 is comparable with the 2021 result. The 2024 result is within 1 standard deviation from the historic mean 2004-2021, indicating little change against the mean. The relative standard deviation for the TAH results for the three grab samples was 15.4%.

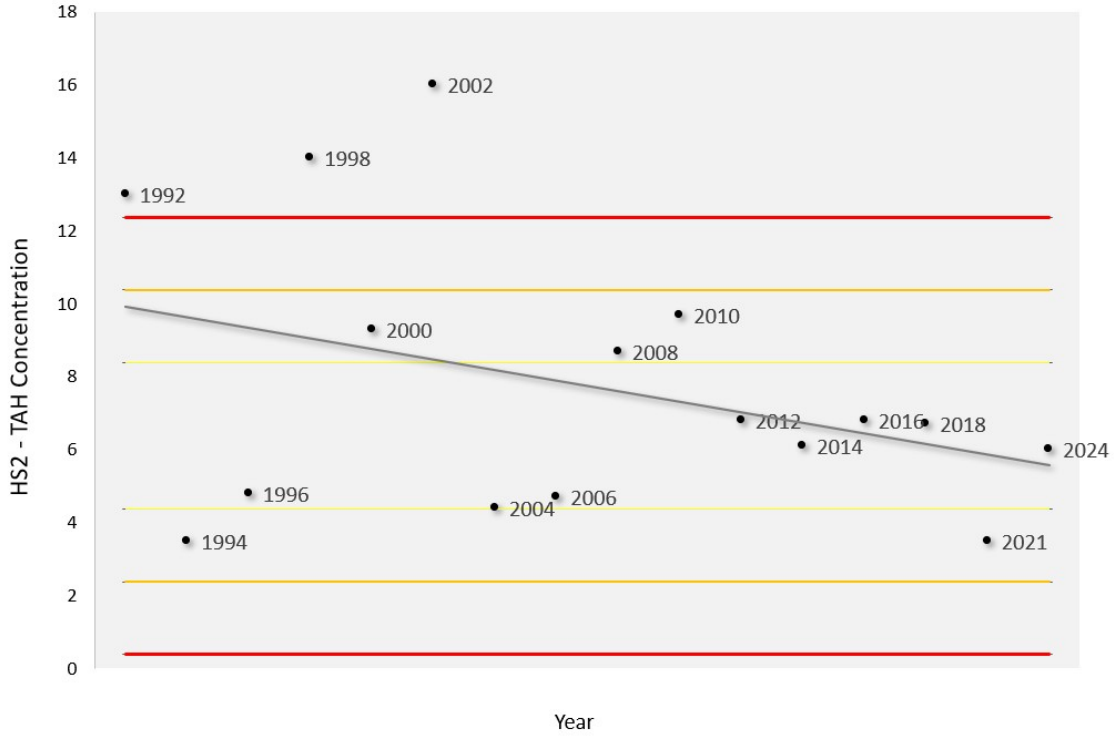

Figure 82 – HS2 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

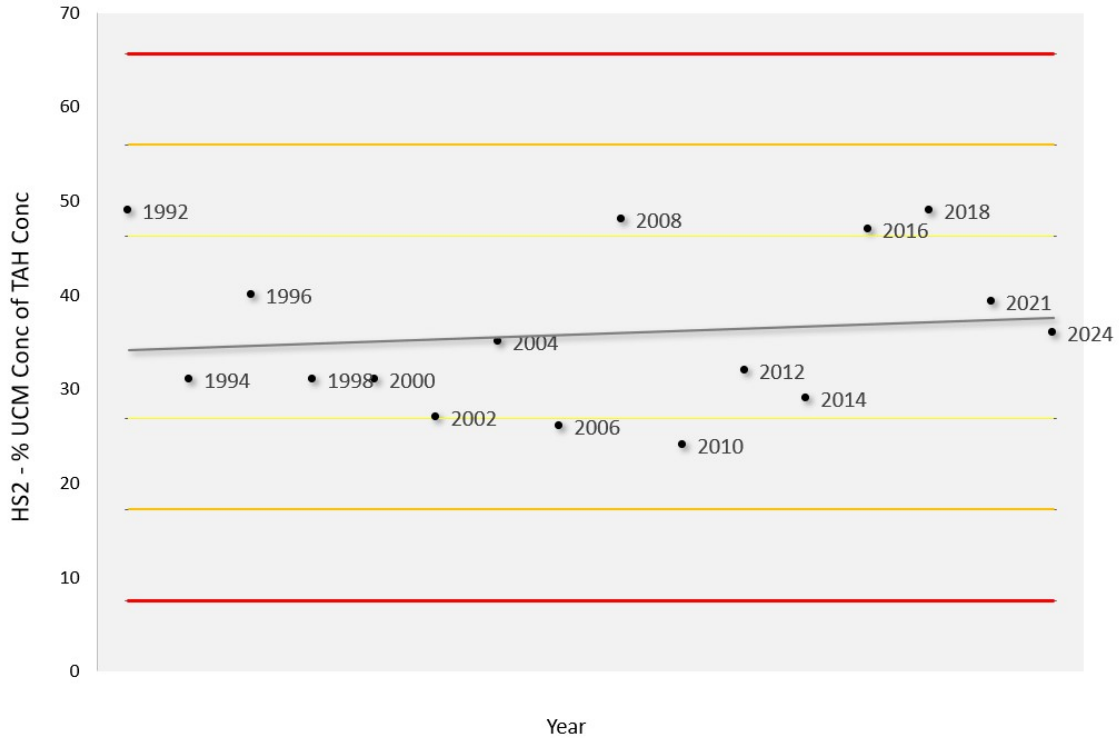

Figure 83 – HS2 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.6.3 Houb of Scatsta HS3

The concentration of total aliphatic hydrocarbons (TAH) at station HS3 is generally low (<20µg.g^{-1}) the 2024 result was 5.5 ug/g which has not changed significantly against the results since 2016 or the historic mean 2004-2021. The 2024 result was within 1 standard deviation from the historic mean 2004-2021, indicating little change. The percentage of UCM in the TAH is historically very varied at this station. The percentage of UCM in the TAH result for 2024 is close to the historic mean. The 2024 result was within 1 standard deviation from the historic mean, indicating little change. The relative standard deviation for the TAH results for the three grab samples was 15.4%.

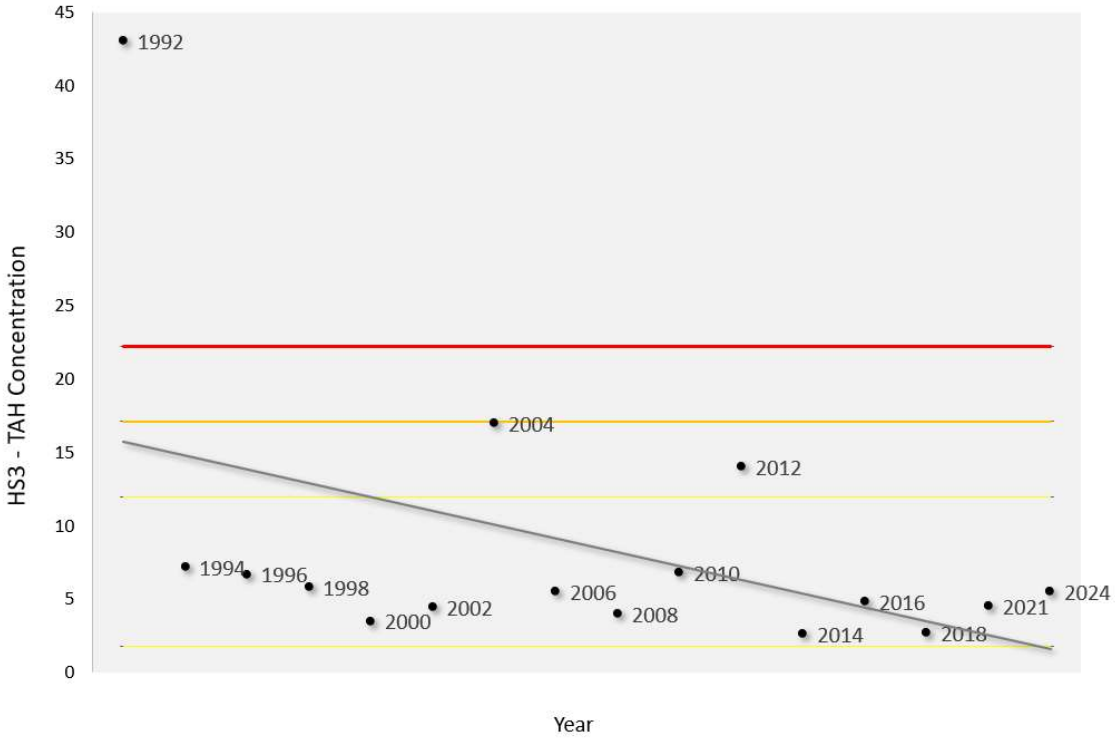

Figure 84 – HS3 Total Aliphatic Hydrocarbon concentration (µg.g^{-1} dry wt. sed.)

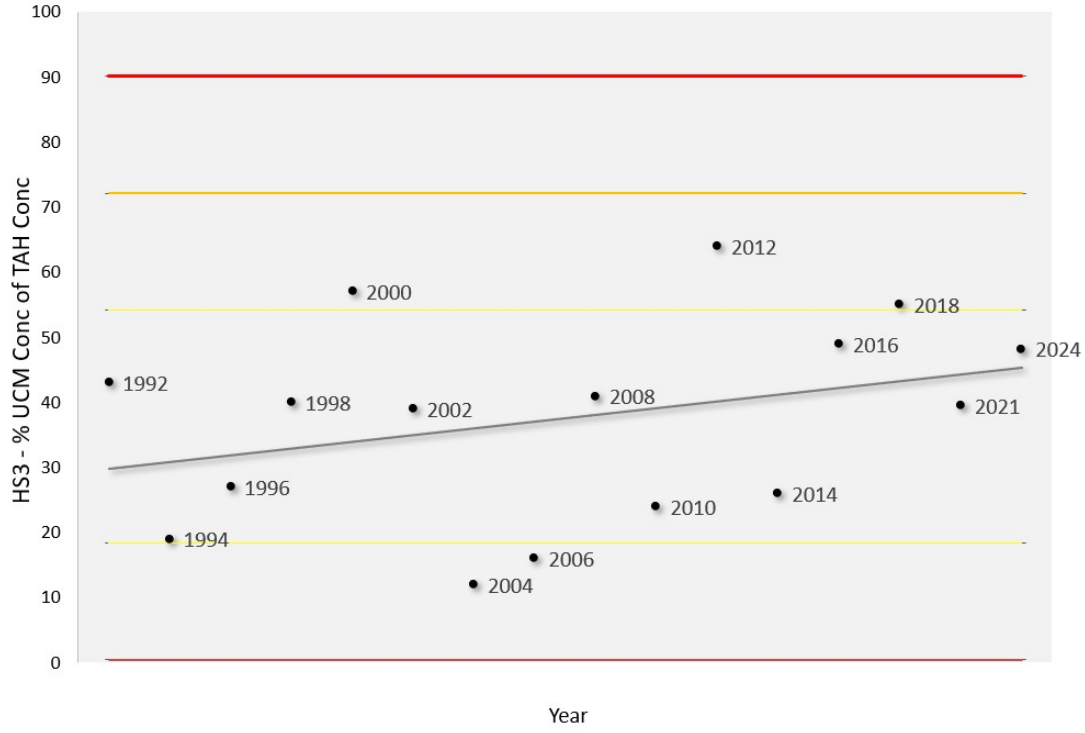

Figure 85 – HS3 Percentage UCM concentration of Total Aliphatic Hydrocarbon concentration (%)

3.4.7 ORKA VOE (STATIONS OV2B TO OV5B)

The revised coordinates at Orka Voe are situated close the edge of the sediment bed with the rocky substrate. Historically 5 stations have been monitored at Orka Voe but following re-situating the stations in 2016, the revised OV1B station did not yield satisfactory grab samples in 2018 and 2021 and subsequently was removed from the survey in 2024. The re-situation of the Orka Voe stations was due to access restrictions (200m exclusion zone) along the pipeline assets as they arrive at the terminal.

In 2024 acceptable grabs were obtained at the 4 Orka Voe stations OV2B-OV5B, enabling Macrobenthic, TAH, PAH, PSA and TOC analysis to be performed.

In 2021 a significant change was observed in the total aliphatic hydrocarbon concentrations compared to 2018. In 2024 the TAH concentration was similar to the levels observed in 2021 and the range of TAH concentration was similar at all the Orka Voe stations, see table 4.

Given the relocation of the site and the observed difference in the seabed at the station no comparison has been made to the historic data.

4 CONCLUSIONS

4.1 SEDIMENTS

The sediment in the Sullom Voe is dominated by sand and mud, with some areas also having a significant amount of gravel within the matrix. Across all subtidal stations the amount of mud present was in the range 3.7-61.7%, the amount of sand present was in the range 37.2-81.5% and the amount of gravel was in the range 0-39.7%. The mean mud content for all subtidal station in 2024 was 37.3%, sand was 56.8% and gravel was 5.9%, compared to 30.9%, 61.7% and 7.4% respectively for the equivalent stations in 2021.

When reviewing the difference between the 2024 mud concentrations and the 2021 mud concentrations, the average mud concentration across all subtidal stations was 4.9% higher than in 2021, ranging from a difference of -19.9% at Jetty station SV17 to +13% at station SV8 in the area to the west of Calbeck Ness. The 2024 mud concentrations are also higher than the historic mean for results 2004-2021, ranging from a difference of -21% at SV17 to +24% at SV8. At 7 of the 24 sub-tidal station, the highest mud content results since 1981 were recorded in 2024. The 7 sites are to the area west of Calbeck Ness and towards the Outer Voe, including SV4, SV8, SV9, SV10, SV11, SV34 and SV35.

The particle size of the sediments has been classified using the Folk classification system (Folk 1954). The most common classification for the 2024 Sullom Voe sediments is “Slightly Gravelly Muddy Sand” followed by “Gravelly Muddy Sand” and “Gravelly Mud”. Only 7 stations from the inter-tidal and sub-tidal maintained the same Folk classification in 2024 when compared to the classification in 2021. These stations were from across the Sullom Voe (HS2, SV10, SV35, SV37, SV6, SV8A, SV9), the variation seen at the other stations was not significant and within the typical variation seen between surveys. For the mud content at 23 of the 24 intertidal stations was within 15% of the 2021 result.

The Jetty station SV17 was the only station which demonstrated a notable change against the 2021 results, with 31% more mud observed in 2024 than in 2021.This area is a mixed sediment area which may see disturbance from the marine traffic at the loading Jetties.

The methodology for the particle size analysis and mud content analysis changed in 2016 to the NMBAQC protocols and higher levels of mud are likely to be observed due to differences between the gravimetric and volumetric measurements.

The total organic matter content at the majority of the sediments in 2024 was lower than the results from the 2018-2021 surveys. The mean total organic content at all stations except SV37 and the Orka Voe stations was 4.2% in 2024, compared to 4.7% in 2021 and 5.7% in 2018. As is normally observed, the highest content of organic matter was observed at station SV1.

4.2 HYDROCARBONS

The total aliphatic hydrocarbon concentrations (TAH) for the Sullom Voe station in 2024 ranged between 1.7-177 ug/g, the range for the sub-tidal stations was 2.4-177 ug/g and for the inter-tidal stations was 1.7-6.0 ug/g. The mean TAH concentration across all stations (except OV2B-OV5B) for 2024 was 32.1 ug/g, in 2021 this was 28.4 ug/g and the historic mean for results 2004-2021 was 35.6 ug/g. The 2024 TAH results for individual stations (except SV1) are within 10 ug/g of the equivalent 2021 TAH results and within 15 ug/g of the historic mean for TAH results between 2004-2021 For stations with TAH concentrations <10 ug/g the 2024 TAH results are within 3 ug/g of the 2021 results.

The station at SV1 continues to have the highest TAH concentration of the Sullom Voe stations. The 2024 TAH result at SV1 (177 ug/g) was observed to be 55 ug/g higher than it was in 2021 (124 ug/g), however the 2024 result was comparable to the results between 2012 to 2018 and close to the historic mean for data between 2004-2021 (180 ug/g). The 2024 TAH result at SV1 was -0.1 standard deviations from the historic mean for results between 2004-2021, indicating there had been little change. The 2021 result of 124 ug/g does not appear to conform to the recent levels of TAH observed at SV1.

The concentration of unresolved complex mixture (UCM) in the total aliphatic hydrocarbon was broadly aligned with the 2021 results, at some stations it was higher and others lower. The average UCM concentration across all stations (excluding the Orka Voe stations) in 2024 was 21.6 ug/g , which was slightly higher than in 2021 (17.0 ug/g), this correlates with the slightly higher TAH concentration results observed in 2024. The UCM as a percentage of the TAH had not changed significantly in 2024 when compared to 2021. The average percentage UCM of the TAH across all stations was 64.6% in 2024 compared to 60.8% in 2021, the 2018 average result was 65.4%, and the average historic mean for period 2004-2014 was 53.9%, the average historic mean for period 2004-2021 was 54.7%.

The 2024 TAH results in Orka Voe correlated with the 2021 TAH results which had been a significant step change compared to 2018. In 2024 the range of TAH results at Orka Voe was in the range 4.8-5.8 ug/g, in 2021 this was 5.1-5.6 µg/g. On average in 2021 for OV2-OV5 stations the total aliphatic hydrocarbon (TAH) levels were 14 µg/g lower than in 2018.

The relative standard deviations for the TAH results from the 3 replicate Grab samples were within the estimate of uncertainty for the test method.

The gas chromatograms for the solvent extracts of the 2024 sediments did not show evidence of fresh input of hydrocarbons, including crude oil or marine fuel. The oil profiles were very similar to those observed in 2021 and in recent surveys.

Overall, there was a slight increase in the TAH concentrations across the stations in 2024, however this was not a significant increase and within the analytical method uncertainties and typical natural variation.

GC-MS analyses of aromatic hydrocarbons reveal the presence of poly aromatic hydrocarbons (PAHs) derived from petrogenic and pyrolytic (combustion) sources in the sediments, although as on previous surveys those from pyrolytic sources predominate (i.e. 4-6 ring PAHs, with parent compounds dominant over the alkylated derivatives).

The 2-6 ring PAHs for the Sullom Voe station in 2024 ranged between 168-1893 ng/g, compared to 161-2240 ng/g in 2021. The highest levels of 2-6 ring PAHs were observed were at stations SV7, SV1 and SV6F. The average 2-6 ring PAHS across all stations was 1137 ng/g in 2024, which was lower than the 1203 ng/g observed in 2021. The 2024 2-6 ring PAH results, expressed as number of relative standard deviations of the historic data set 2004-2021, was in the range -1.1 to +0.8, showing that the 2024 results had little changed when compared to the historic data set.

As in previous surveys, stations 34 (168 ng/g) and OV5B (90.1 ng/g) had much lower concentrations of 2-6 ring PAHs compared to the rest of the stations. This is due to the high energy environment and relatively coarse sediments.

The portion of 4-6 ring PAHs as a percentage of the total PAHs had not changed significantly since 2021. The average for the 4-6 ring PAHs as a percentage of the total PAHs in 2024 was 81.2% compared with 79.8% in 2021. This again indicates there has been little change in the oil profile in the Sullom Voe sediments in 2024.

5 REFERENCES

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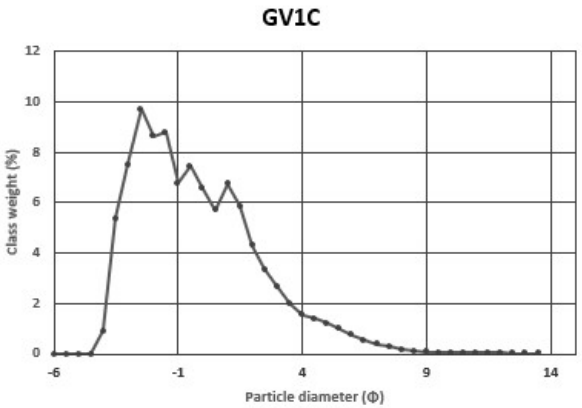
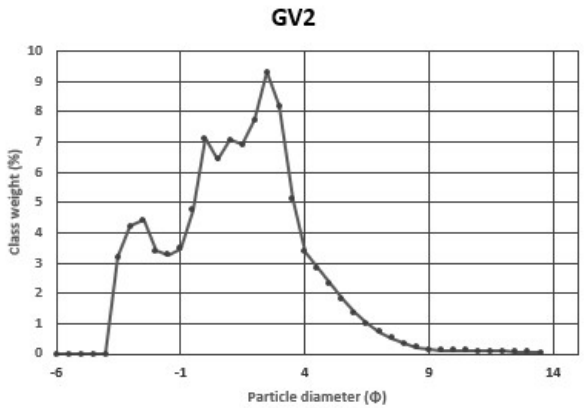
6 APPENDICES

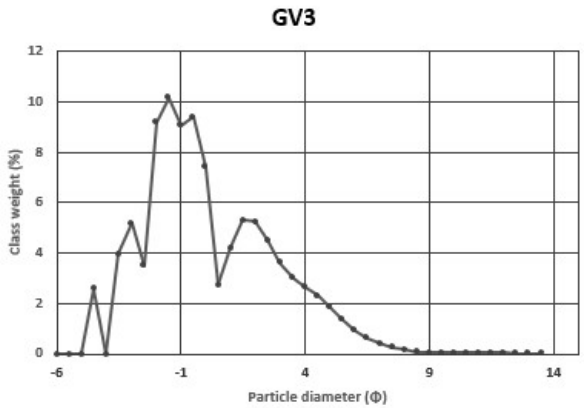
Appendix 1 – Particle Size Analysis Summary for sediment samples from June 2024.

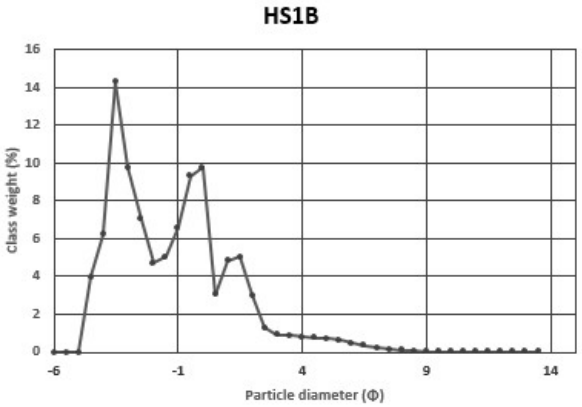
Station	Treatment	Textural Group Classification	Mean phi	Skewness	Kurtosis	Major Sediment Fractions			2024 Textural Group Classification
						% Mud	% Sand	% Gravel	
GV1C	Sediment	msG: Muddy Sandy Gravel	-0.578	0.236	0.950	6.3%	46.1%	47.6%	msG: Muddy Sandy Gravel
GV2	Sediment	gmS: Gravelly Muddy Sand	0.921	-0.085	1.062	12.0%	66.0%	22.0%	gmS: Gravelly Muddy Sand
GV3	Sediment	msG: Muddy Sandy Gravel	-0.121	0.294	0.939	8.4%	48.0%	43.6%	msG: Muddy Sandy Gravel
HS1B	Sediment	sG: Sandy Gravel	-1.474	0.163	0.920	3.6%	38.8%	57.5%	sG: Sandy Gravel
HS2	Sediment	mS: Muddy Sand	2.318	0.143	1.292	11.3%	88.7%	0.0%	mS: Muddy Sand
HS3	Sediment	gmS: Gravelly Muddy Sand	1.963	0.049	1.969	9.7%	85.1%	5.2%	gmS: Gravelly Muddy Sand
OV2B	Sediment	(g)mS: Slightly Gravelly Muddy Sand	3.803	0.371	1.181	34.0%	64.5%	1.5%	(g)mS: Slightly Gravelly Muddy Sand
OV3B	Sediment	(g)mS: Slightly Gravelly Muddy Sand	3.656	0.284	1.349	32.2%	66.9%	0.9%	(g)mS: Slightly Gravelly Muddy Sand
OV4B	Sediment	(g)mS: Slightly Gravelly Muddy Sand	3.549	0.251	1.284	31.5%	68.0%	0.5%	(g)mS: Slightly Gravelly Muddy Sand
OV5B	Sediment	(g)mS: Slightly Gravelly Muddy Sand	3.384	0.209	1.277	29.7%	70.1%	0.2%	(g)mS: Slightly Gravelly Muddy Sand
SV1	Sediment	(g)mS: Slightly Gravelly Muddy Sand	3.518	0.125	0.872	40.1%	59.6%	0.3%	(g)mS: Slightly Gravelly Muddy Sand
SV10	Sediment	(g)sM: Slightly Gravelly Sandy Mud	4.744	0.196	0.978	58.0%	39.9%	2.1%	(g)sM: Slightly Gravelly Sandy Mud
SV11	Sediment	(g)sM: Slightly Gravelly Sandy Mud	4.882	0.265	0.898	61.7%	37.2%	1.1%	(g)sM: Slightly Gravelly Sandy Mud
SV12	Sediment	gmS: Gravelly Muddy Sand	1.796	0.025	1.528	12.1%	81.5%	6.3%	gmS: Gravelly Muddy Sand
SV17	Sediment	msG: Muddy Sandy Gravel	-0.459	0.163	1.181	14.4%	46.0%	39.7%	msG: Muddy Sandy Gravel
SV3	Sediment	gM: Gravelly Mud	3.323	-0.209	1.129	47.3%	45.6%	7.1%	gM: Gravelly Mud
SV32	Sediment	(g)mS: Slightly Gravelly Muddy Sand	3.898	0.076	1.058	45.4%	52.4%	2.2%	(g)mS: Slightly Gravelly Muddy Sand
SV33	Sediment	gmS: Gravelly Muddy Sand	3.624	0.034	2.201	31.9%	58.9%	9.2%	gmS: Gravelly Muddy Sand
SV34	Sediment	(g)mS: Slightly Gravelly Muddy Sand	3.882	0.306	1.160	38.2%	61.4%	0.5%	(g)mS: Slightly Gravelly Muddy Sand
SV35	Sediment	gmS: Gravelly Muddy Sand	1.399	0.115	1.211	14.6%	70.3%	15.0%	gmS: Gravelly Muddy Sand
SV37b	Sediment	gS: Gravelly Sand	0.532	0.056	1.047	3.7%	86.8%	9.6%	gS: Gravelly Sand
SV4	Sediment	gM: Gravelly Mud	4.244	-0.091	1.443	54.0%	38.9%	7.1%	gM: Gravelly Mud
SV5	Sediment	gM: Gravelly Mud	3.623	-0.188	1.154	51.5%	41.9%	6.6%	gM: Gravelly Mud
SV6	Sediment	gmS: Gravelly Muddy Sand	3.224	-0.052	1.144	36.6%	56.9%	6.5%	gmS: Gravelly Muddy Sand
SV6A	Sediment	(g)mS: Slightly Gravelly Muddy Sand	3.158	0.050	1.011	32.4%	64.8%	2.8%	(g)mS: Slightly Gravelly Muddy Sand
SV6F	Sediment	mS: Muddy Sand	3.286	0.063	1.053	34.2%	65.8%	0.0%	mS: Muddy Sand
SV7	Sediment	gM: Gravelly Mud	3.639	-0.160	1.274	48.1%	43.1%	8.8%	gM: Gravelly Mud
SV8	Sediment	(g)sM: Slightly Gravelly Sandy Mud	3.757	-0.057	0.928	48.8%	47.6%	3.6%	(g)sM: Slightly Gravelly Sandy Mud
SV8A	Sediment	(g)mS: Slightly Gravelly Muddy Sand	3.835	0.138	1.150	40.8%	55.3%	3.9%	(g)mS: Slightly Gravelly Muddy Sand
SV9	Sediment	gM: Gravelly Mud	4.109	-0.143	1.277	55.1%	39.3%	5.6%	gM: Gravelly Mud

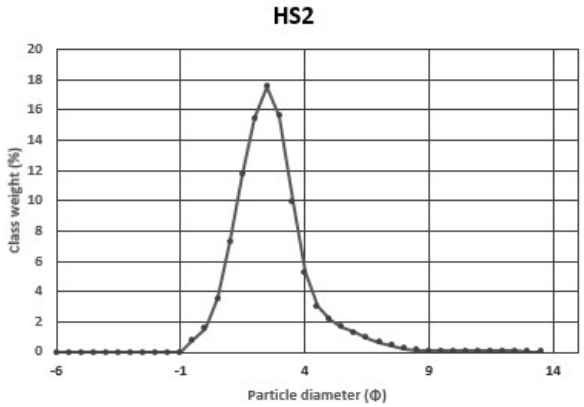
Appendix 2 – Particle Size Analysis Charts for sediment samples from June 2024.

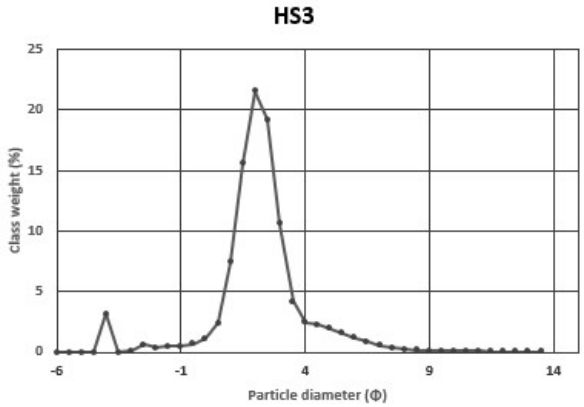


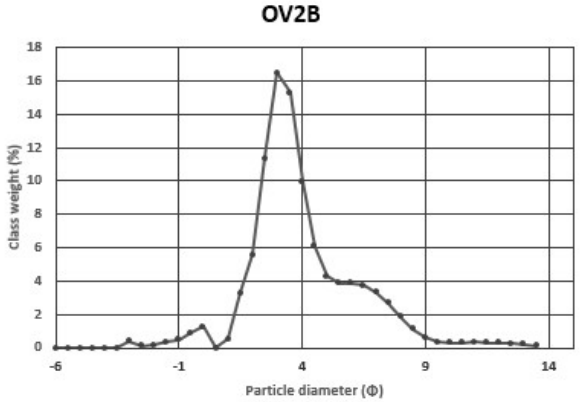


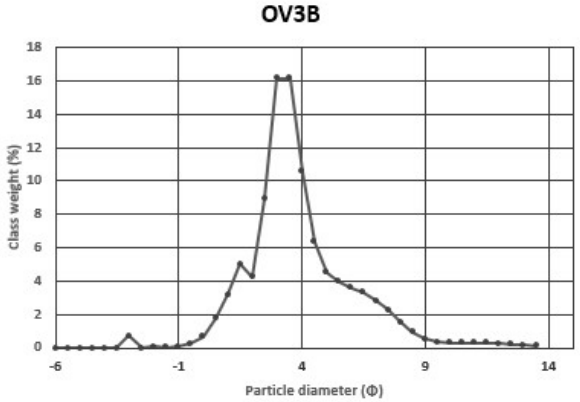









OV2B
Class weight (%)
Particle diameter (Φ)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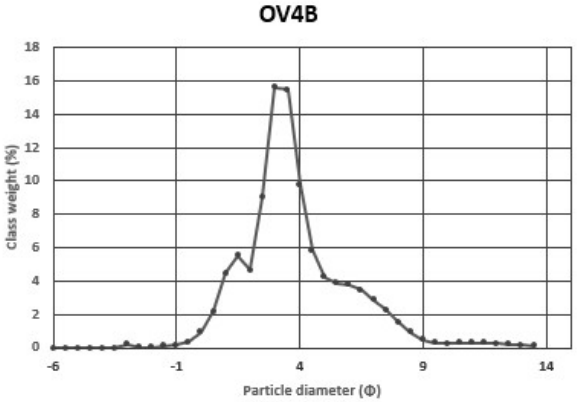
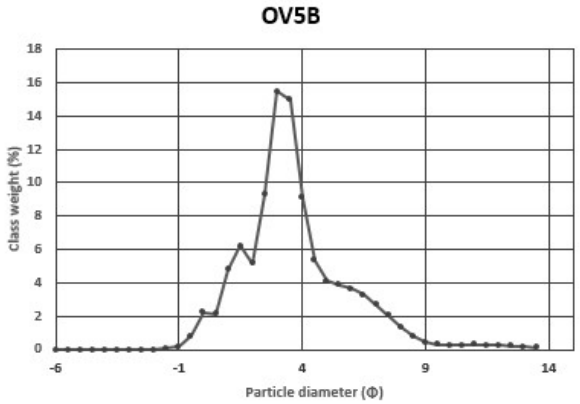
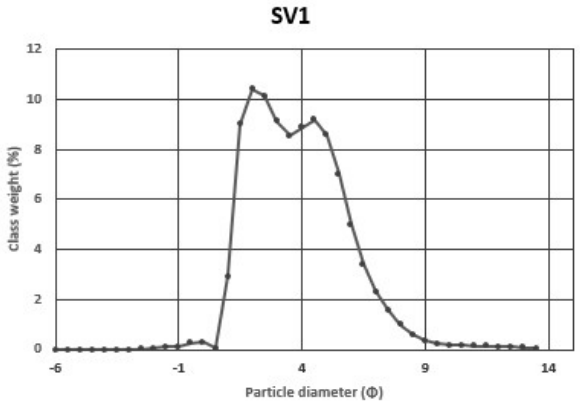
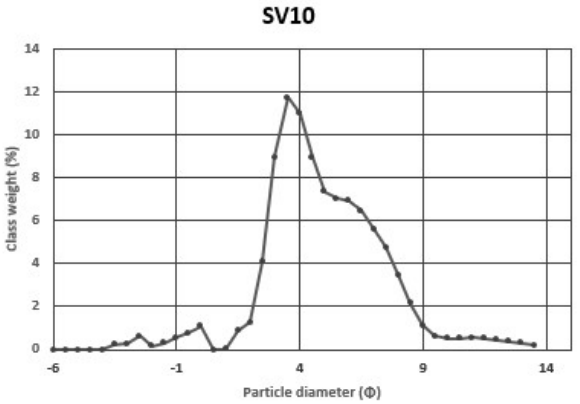
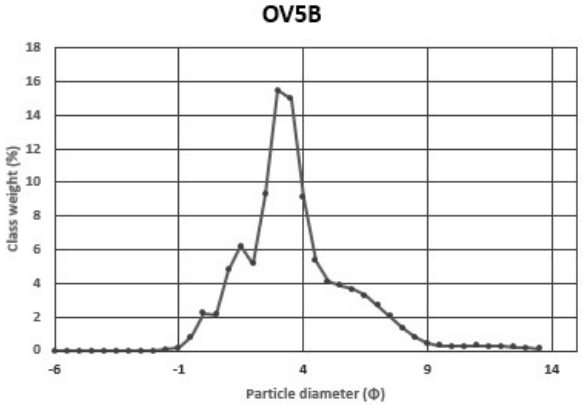
Particle diameter (Φ)


OV4B
Class weight (%)
Particle diameter (Φ)


OV5B
Class weight (%)
Particle diameter (Φ)


SV1
Class weight (%)
Particle diameter (Φ)


SV10
Class weight (%)
Particle diameter (Φ)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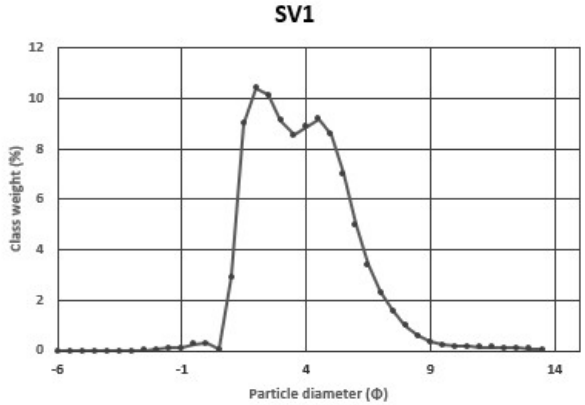
Particle diameter (Φ)


SV1
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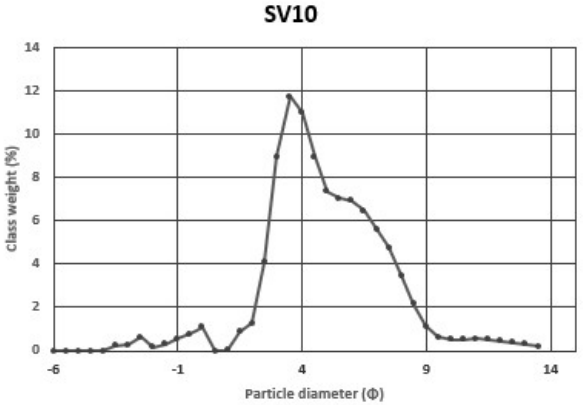
Particle diameter (Φ)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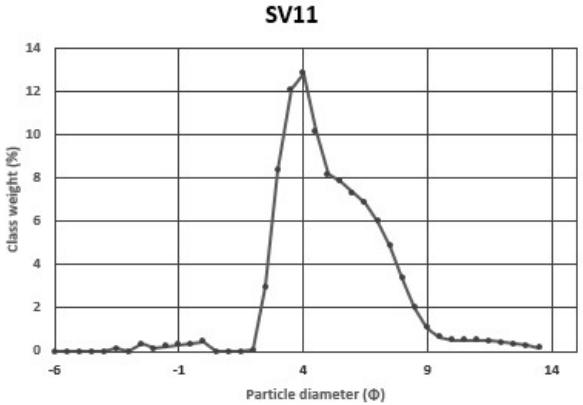
Particle diameter (Φ)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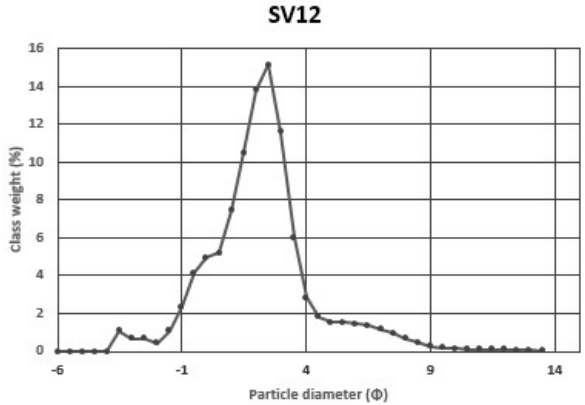
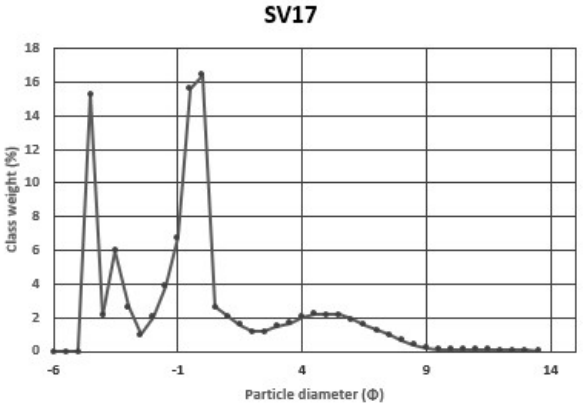
Particle diameter (Φ)


SV12
Class weight (%)
Particle diameter (Φ)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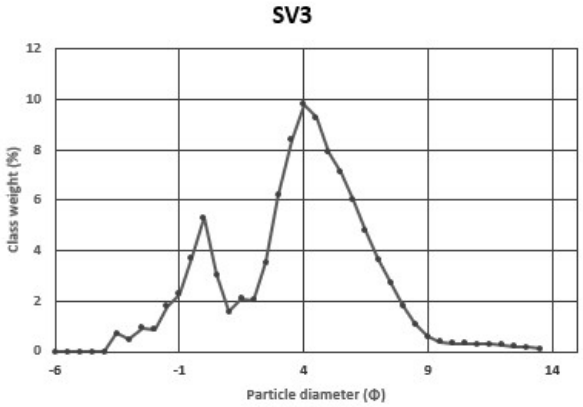
Particle diameter (Φ)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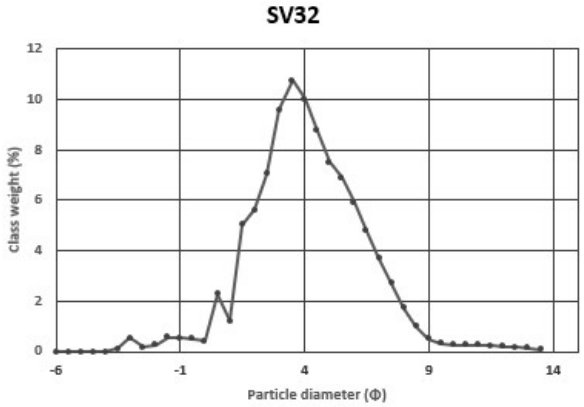
Particle diameter (Φ)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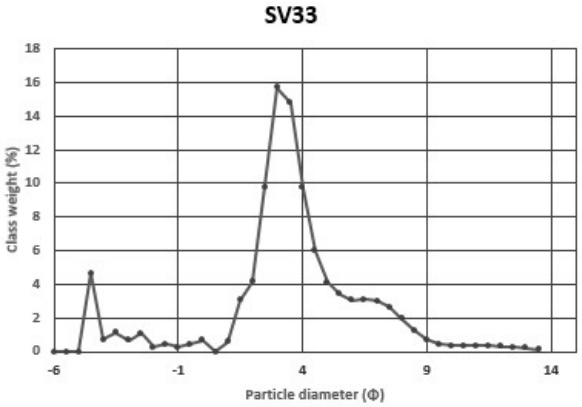
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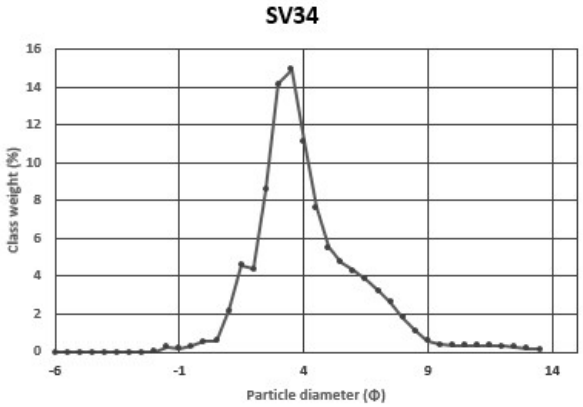
Particle diameter (Φ)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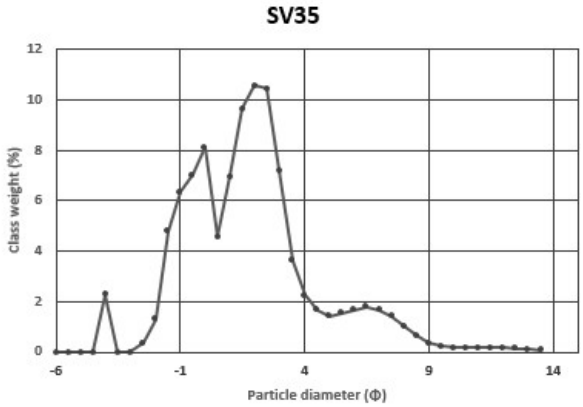
Particle diameter (Φ)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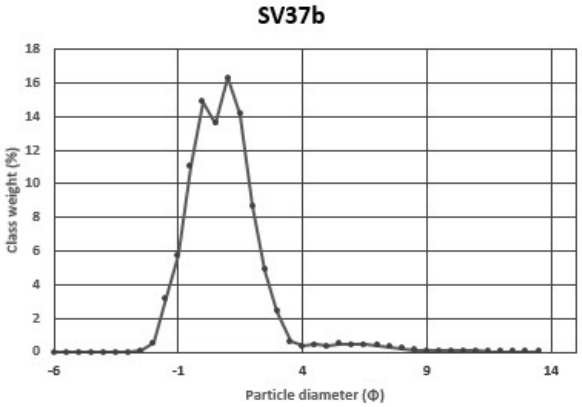
Particle diameter (Φ)


SV37b
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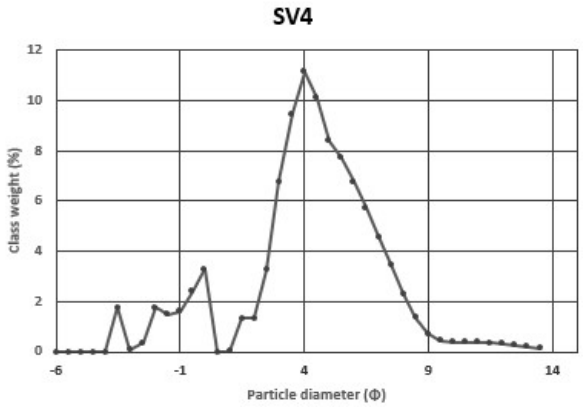
Particle diameter (Φ)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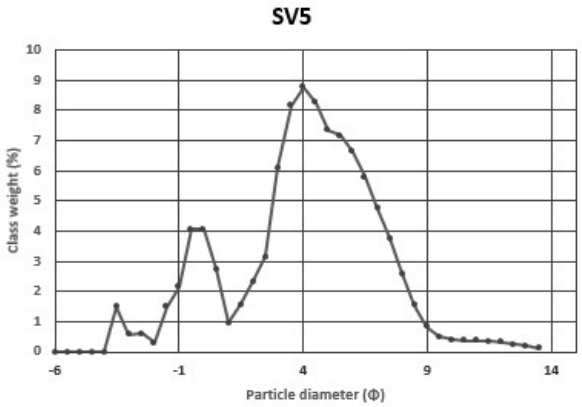
Particle diameter (Φ)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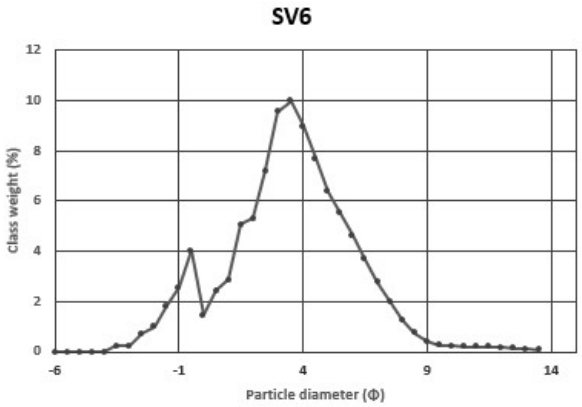
Particle diameter (Φ)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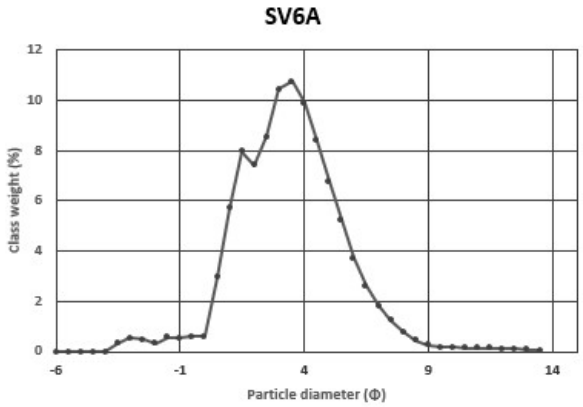
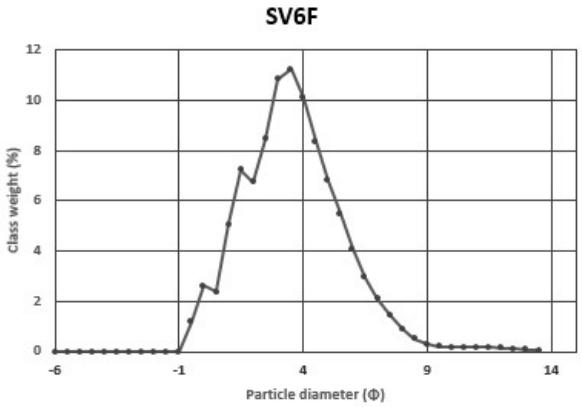
Particle diameter (Φ)


SV6A
Class weight (%)
Particle diameter (Φ)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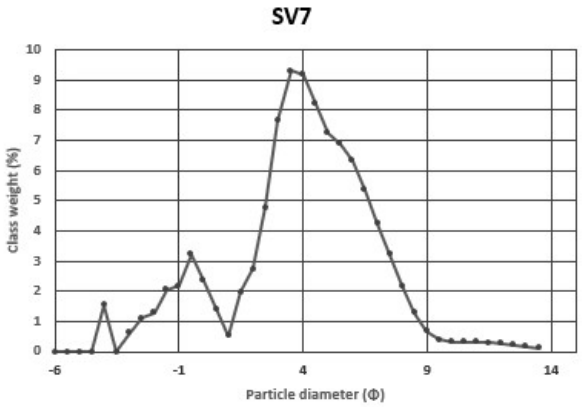
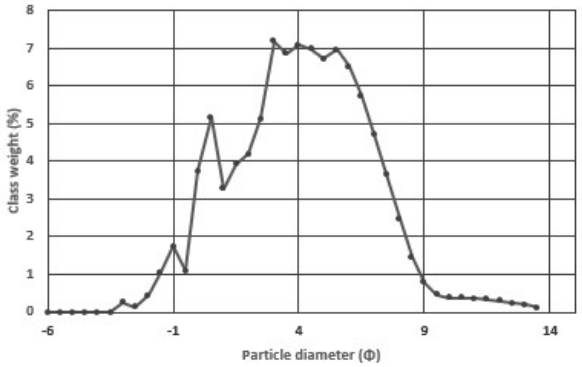
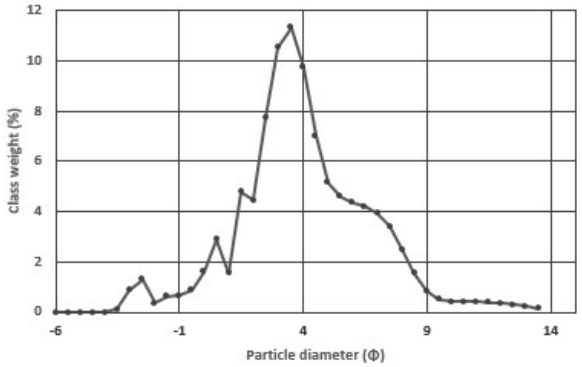
Particle diameter (Φ)


SV7
Class weight (%)
Particle diameter (Φ)

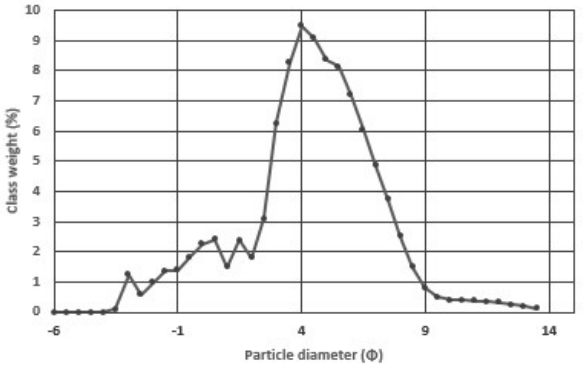
SV8



SV8A



SV9



End of Report