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Initial Screening Assessment of BP's UKCS Cuttings Piles

Aquatera Ltd
Stromness Business Centre
Stromness, Orkney, Scotland
KW16 3AW

This study was completed for:

BP
Burnside Road
Farburn Industrial Estate
Dyce
ABERDEEN
AB21 7PB

Contact: Chris Goodman
Tel: 01224 832000
Email: chris.goodman@uk.bp.com

This study was completed by:

Aquatera Ltd
Stromness Business Centre
Stromness
Orkney
KW16 3AW

Contact: David Runciman
Tel: 01856 850 088
Fax: 01856 850 089
Email: dave.runciman@aquatera.co.uk

Revision record
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Revision Number	Issue Date	Revision Details
Rev 0	23/04/07	Initial report submission
Rev 1	08/05/07	Data for Thistle platform added
Rev 2	02/06/07	2006 survey data added and comments addressed

Contents

1 Introduction

BP has a commitment to screen all its cuttings piles for environmental significance prior to June 2008. This report provides an assessment of all of the multi-well installations selected for screening by BP. All major data gaps have been identified and their significance assessed. The assessment criteria utilised for this study were based on those outlined in OSPAR recommendation 2006/5 (see section 2).

The existing geophysical data supplied by BP (primarily Dave Bingham) was used in combination with historical environmental monitoring data to provide the basis of the cuttings pile screening assessment.

2 Background

OSPAR issued recommendations relating to the management of organic-phase drilling fluids (OPF) cuttings piles in June 2006:

> OSPAR Recommendation 2006/5 on a Management Regime for Offshore Cuttings Piles OSPAR 06/23/1-E, Annex 16. Meeting of the Offshore Industry Committee (OIC), Stockholm: 26-30 June 2006

The recommended Cuttings Pile Management Regime is divided into two stages. Stage 1 involves initial screening assessments of all cuttings piles – to be completed before June 2008. Stage 2 involves a BAT / BEP assessment and should occur in the timeframe determined in Stage 1.

This report is concerned with Stage 1 of the process; the key assessment criteria are listed below:

Where water based drilling fluids were used and no other discharges have contaminated the cuttings pile no further investigation is necessary.

Where OPF were used and discharged or other discharges have contaminated the cuttings pile the following process should be completed:

1. Contracting Parties should require that the rate of oil loss and the persistence of the area of seabed contaminated are assessed using existing evidence where sufficient and including relevant research.
2. The rate of oil loss should be assessed on the basis of the quantity of <u>oil lost from the cuttings pile to the water column</u> over time. The unit used should be tonnes per year (te/yr).
3. The persistence should be assessed on the basis of the area of the seabed where the concentration of oil remains above 50mg/kg and the duration that this contamination level remains. The unit used should be square kilometre years (km^2yrs).
4. The results should be compared against the following thresholds:
   i. Rate of oil loss to water column: 10 te/yr
   ii. Persistence of the area of seabed contaminated: $500km^2yr$
5. Where both the rate and persistence are BELOW the thresholds and no other discharges have contaminated the cuttings pile no further action is required and the cuttings pile may be left in situ to degrade naturally.
6. Where either the rate of oil loss or the persistence are ABOVE the thresholds, Stage 2 should be initiated at a time to be agreed with the Contracting Party and should

take into account the rate of oil loss, the persistence of the area of seabed contaminated and the timing of the installation decommissioning.

3 Summary of available data

The following Tables and Figures summarise the relevant survey data BP have collected around their UKCS multi-well installations.

Table 3.1 Summary of available survey data collected around BP's multi-well sites

Installation	Sector	Type	No. Wells	Most recent survey	
				Bathymetry	Environmental
Andrew	CNS	Platform	20	Jul 2004	Jul 2000
Cyrus	CNS	Subsea	3	Jul 2004	-
Cyrus (SWOPS)	CNS	Subsea	2	-	-
ETAP PDR (Marnock)	CNS	Platform	6	May 2006	Jul 2000
Everest North	CNS	Platform	13	May 2005	May 2005
Farragon	CNS	Subsea	2	-	-
Lomond	CNS	Platform	10	Jul 1999	Oct 2006
Machar	CNS	Subsea	9	Feb 2004	Jul 2000
Madoes	CNS	Subsea	3	-	-
Mirren West	CNS	Subsea	2	May 2005	-
Monan	CNS	Subsea	2	Jul 1999	Jul 1999
Mungo	CNS	Platform	17	May 2006	Oct 2006
South Everest	CNS	Subsea	3	-	-
Bruce D	NNS	Platform	25	Aug 2001	Sep 2001
Bruce Phase II (Western Area)	NNS	Subsea	7	Jul 2001	Jul 2000
Don	NNS	Subsea	7	Jul 1999	Jul 1999
Harding	NNS	Platform	28	May 2006	May 2006
NW Hutton	NNS	Platform	52	Aug 1992	Jun 2002
Magnus	NNS	Platform	54	Jul 2000	Aug 1988
Magnus South	NNS	Subsea	2	Dec 2002	Jul 1997
Magnus D3	NNS	Subsea	2	Aug 2002	Jul 1997
Magnus D4	NNS	Subsea	2	-	-
Magnus D8	NNS	Subsea	2	-	-
Magnus Swift, D9/MP5	NNS	Subsea	2	-	-
Magnus Swift	NNS	Subsea	4	-	-
Miller	NNS	Platform	26	Jun 2004	Jun 2004
Thistle	NNS	Platform	54	Sep 2004	Sep 2004
Amethyst A1D	SNS	Platform	6	-	Jul 1992
Amethyst A2D	SNS	Platform	6	Jul 2003	Jul 1992
Amethyst B1D	SNS	Platform	4	Oct 2006	Oct 2006
Amethyst C1D	SNS	Platform	7	Apr 2000	Jul 2000
Cleeton CW	SNS	Platform	7	Jun 2001	Jul 1988
Hyde	SNS	Platform	5	Jul 1999	-
Newsham	SNS	Subsea	2	-	-
Ravenspurn N ST2	SNS	Platform	11	Jun 2001	Mar 1993
Ravenspurn N ST3	SNS	Platform	14	-	Mar 1993
Ravenspurn WT1	SNS	Platform	17	Jun 2001	Mar 1992
Ravenspurn S A	SNS	Platform	7	-	-
Ravenspurn S B	SNS	Platform	11	-	-
Ravenspurn S C	SNS	Platform	5	-	-
West Sole WA	SNS	Platform	7	Dec 1998	-
West Sole WAS	SNS	Platform	6	-	-
West Sole WB	SNS	Platform	6	-	Jul 1988
West Sole WC	SNS	Platform	10	-	Jul 2000
Clair Phase I	WOS	Platform	8	-	-
East Foinaven	WOS	Subsea	4	May 2005	-
Foinaven DC1	WOS	Subsea	18	-	Dec 1998
Foinaven DC2	WOS	Subsea	13	Jun 2005	Dec 1998
Loyal	WOS	Subsea	8	Aug 2003	-
Schiehallion Central	WOS	Subsea	22	Aug 2005	May 2000
Schiehallion Claw	WOS	Subsea	2	May 2006	-
Schiehallion North	WOS	Subsea	3	-	-
Schiehallion Northwest	WOS	Subsea	3	Aug 2005	-
Schiehallion West	WOS	Subsea	14	Aug 2005	-
Installations without suitable survey information				**20**	**24**
Installations with suitable survey information				**34**	**30**

Figure 3.2 Information available for BP UKCS multi-well installations

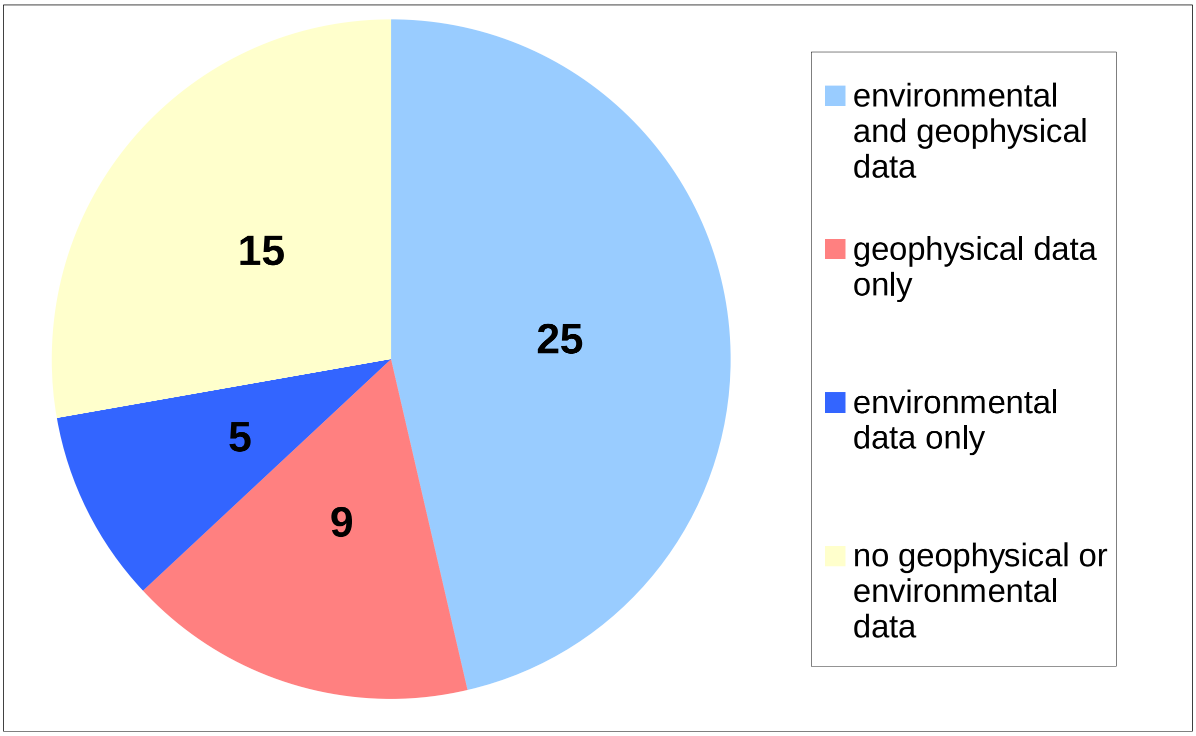


Figure 3.3 Bathymetry survey dates

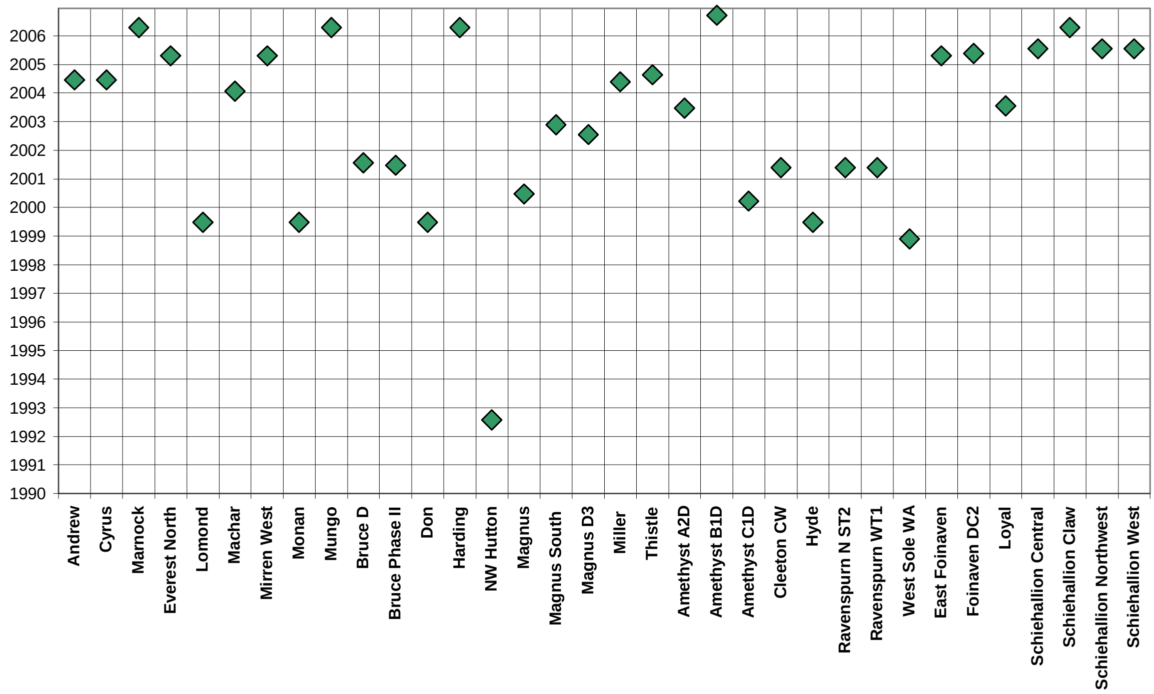
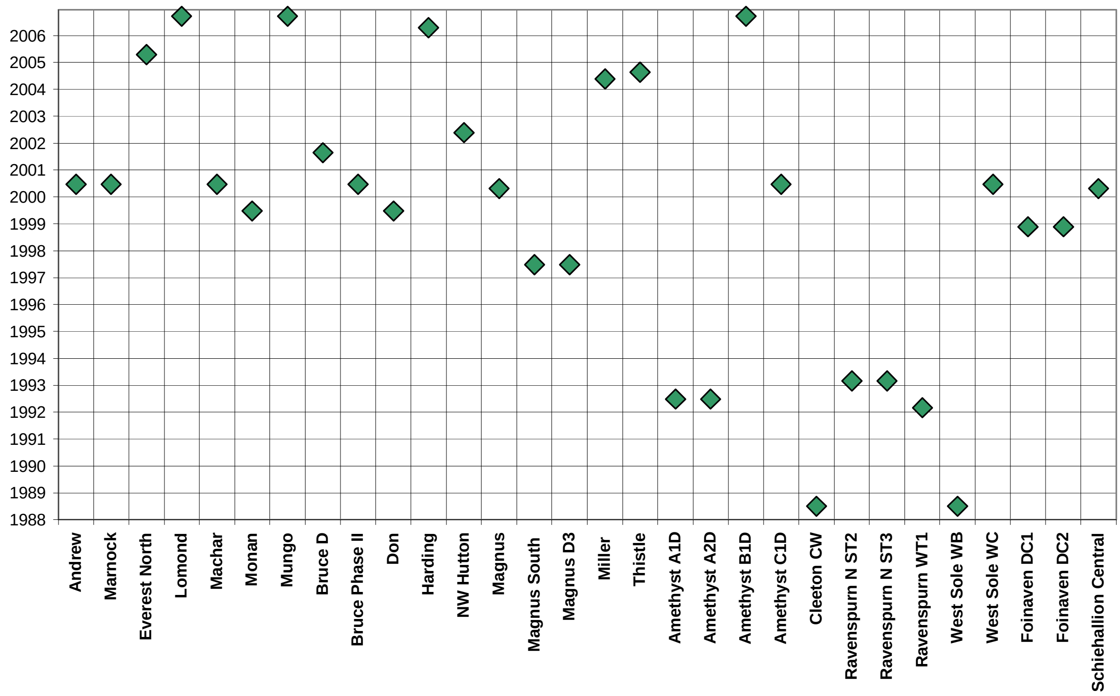


Figure 3.4 Most recent environmental survey dates



Note: Locations where no relevant survey data has been collected have been omitted from the graphs.

4 Assessment of available data

4.1 Geophysical survey data

Two types of geophysical data were used to assess the areal extent and volume of any cuttings present on the seabed.

1. Seabed bathymetry, typically measured using multibeam echo sounder equipment. This information can be used to estimate the physical size of any cuttings pile present. Unfortunately this data can be difficult to interpret accurately if large seabed structures are present in the area being studied (eg platform legs, wellheads, pipelines)

2. Seabed surface texture measured using side scan sonar techniques. This data can be used to detect areas of disturbed seabed or areas of relatively high reflectivity that are indicative of the presence of a surface layer of drill cuttings.

4.1.1 Geophysical data interpretation

Table 4.1 and Figures 4.1 to 4.3 summarise the data obtained at the installations where evidence of cuttings was found. The area of the physical cuttings piles identified from the seabed bathymetry data have either been directly calculated using specialised software or are based on a visual assessment of the maps generated from the raw data. The approximate footprints of the surface cuttings layer identified by side scan sonar have been calculated from a visual assessment of the relevant maps generated from the data.

Significant physical cuttings piles were recorded at thirteen installations, all located in the Northern or Central North Sea (NNS, CNS) sectors in water depths ranging from 85 to 185 m. The relationship between the physical footprint of the piles and intensity of drilling activity is shown in Figure 4.2. The numbers of wells drilled at each site is used to provide an indication of the level of drilling activity. The graph shows that there is a reasonably good linear relationship between the physical pile footprint and the number of wells drilled, even though the amount of cuttings deposited on the seabed from drilling any particular well would be expected to vary significantly from well-to-well (due to variables such as; length of well, mud system utilised, cuttings treatment and discharge configuration, water depth and in some cases, cuttings reinjection may have been utilised). A similar graph was generated for the relationship between dispersed seabed cuttings and wells drilled (Figure 4.3).

The pile volume was only calculated for a relatively small number of installations (Table 4.2), in these cases the volume of the pile was plotted against the number of wells drilled. A quadratic relationship was found, however this correlation should be treated with caution due to the relatively small dataset available (Figure 4.4).

Table 4.3 lists the installations where geophysical survey techniques did not detect the presence of a physical cuttings pile. These installations generally fall into three general categories:

1. NNS and CNS Installations where limited drilling was undertaken. Surface deposits of dispersed cuttings (from side scan sonar data) were evident at some locations.
2. Installations located in the SNS in shallow water. No evidence of dispersed cuttings on the seabed surface in the vicinity of the installations was found, however some seabed scouring and sand build-up probably derived from strong water currents was observed.
3. Installations located West of Shetland (WOS) in deep water. The presence of physical piles at these sites is generally difficult to determine due to the large

numbers of seabed installations present in the development areas. Surface deposits of dispersed cuttings (from side scan sonar data) were evident at most locations.

The Harding platform does not fall into any of the general categories. This installation is composed of a jack-up production unit structure sitting upon a large subsea storage tank sitting on the seabed. The survey work found no evidence of a cuttings pile on the seabed in the vicinity of the platform however there was some evidence to suggest a layer of cuttings lying on the top of the storage tank.

Table 4.1 Cuttings pile footprint areas estimated from bathymetry and side scan sonar data

Installation	No. wells	Depth (m)	Estimated footprint of cuttings pile					
			Bathymetry (physical pile)			Side scan sonar (surface cuttings layer)		
			Assumed shape	Dimensions[1] (m)	Area (m^2)	Assumed shape	Dimensions[1] (m)	Area (m^2)
Andrew	20	115	circular	45	6,359	elliptical	230 x 100	18,055
Cyrus	3	110	circular	35	3,847	irregular ellipse	250 x 70	13,738
Marnock	6	92	patchy/disturbed	na	4,438	patchy/disturbed	na	4,438
Everest North	13	89	elliptical	120 x 60	5,652	-	-	-
Lomond	10	85	circular	50	6,875[a]	elliptical	150 x 100	11,775
Machar	9	83	small/patchy	10 x 10, 10 x 30	<1,000	-	-	-
Monan	2	92	patchy/disturbed	70 x 20, 70 x 50	2,922[a]	-	-	-
Mungo	17	87	elliptical	145 x 80	6,505[a]	elliptical	300 x 100	23,550
Bruce D	25	121	circular	50	7,850	-	-	-
Bruce Phase II	7	119	-	-	-	elliptical	250 x 100	19,625
Don	7	164	circular	35	4,912[a]	elliptical	150x 75	8,831
Harding	28	109	-	-	-	elliptical	250 x 150	29,438
NW Hutton	52	144	circular	70	15,386	elliptical	300 x 150	35,325
Magnus	54	185	circular	60	11,304	-	-	-
Magnus D3	2	186	-	-	-	approx rectangular	150 x 30	4,500
Miller	26	103	elliptical	150 x 100	9,500	-	-	-
Thistle	54	160	circular	70	14,798[a]	-	-	-
East Foinaven	4	370	-	-	-	circular	50	7,850
Foinaven DC2	13	475	not defined[b]	-	-	circular	100	31,400
Loyal	8	467	-	-	-	elliptical	150 x 75	8,831
Schiehallion Central	22	355	not defined[b]	-	-	Irregular[c]		26,667
Schiehallion Claw	2	438	-	-	-	elliptical	200 x 100	15,700
Schiehallion Northwest	3	444	not defined[b]	-	-	circular	50	7,850
Schiehallion West	14	377	not defined[b]	-	-	elliptical	200 x 100	15,700

1 circular = radius, elliptical = major axis x minor axis.
a areas calculated from the raw data using data analysis software
b presence of pile difficult to determine due to the presence of large numbers of seabed installations/infrastructure in the vicinity
c covers approx 2/3 of the seabed in the vicinity of seabed infrastructure (200 m x 200m)

Table 4.2 Cuttings pile volumes estimated from bathymetry data (calculated by surveyors using specialised data analysis software)

Installation	No. wells	depth (m)	Estimated volume of physical pile (m^3)
Everest North	13	89	3,272
Lomond	10	85	2,210
Monan	2	92	764
Mungo	17	87	4,339
Don	7	164	1,335
NW Hutton	52	144	30,500[1]
Miller	26	103	9,535
Thistle	54	160	23,641

1 Value taken from:, Long-term trends in seabed disturbance around the North West Hutton platform, report ENV08, BMT Cordah Ltd., October 2004.

Table 4.3 Installations where no physical cuttings piles were detected by geophysical survey methods

Installation	Sector	No. Wells	Comments
Mirren West	CNS	2	-
Bruce Phase II	NNS	7	Evidence of some surface cuttings from SSS data.
Harding	NNS	28	Evidence of cuttings layer on platform base. Surface cuttings indicated by SSS data.
Magnus South	NNS	2	-
Magnus D3	NNS	2	-
Amethyst A2D	SNS	6	No evidence of any seabed cuttings found.
Amethyst B1D	SNS	4	No evidence of any seabed cuttings found.
Amethyst C1D	SNS	7	No evidence of any seabed cuttings found.
Cleeton CW	SNS	7	No evidence of any seabed cuttings found.
Hyde	SNS	5	No evidence of any seabed cuttings found.
Ravenspurn N ST2	SNS	11	Evidence of seabed scouring in vicinity of the installation and some buildup of sand mounds.
Ravenspurn WT1	SNS	17	Evidence of seabed scouring in vicinity of the installation and some buildup of sand mounds.
West Sole WA	SNS	7	Seabed topography dominated by large sand waves.
East Foinaven	WOS	4	Evidence of some surface cuttings from SSS data.
Foinaven DC2	WOS	13	Evidence of some surface cuttings from SSS data
Loyal	WOS	8	Evidence of some surface cuttings from SSS data.
Schiehallion Central	WOS	22	Evidence of some surface cuttings from SSS data.
Schiehallion Claw	WOS	2	Evidence of some surface cuttings from SSS data.
Schiehallion Northwest	WOS	3	Evidence of some surface cuttings from SSS data.
Schiehallion West	WOS	14	Evidence of some surface cuttings from SSS data.

Figure 4.1 Estimated footprint of physical pile based on geophysical survey data

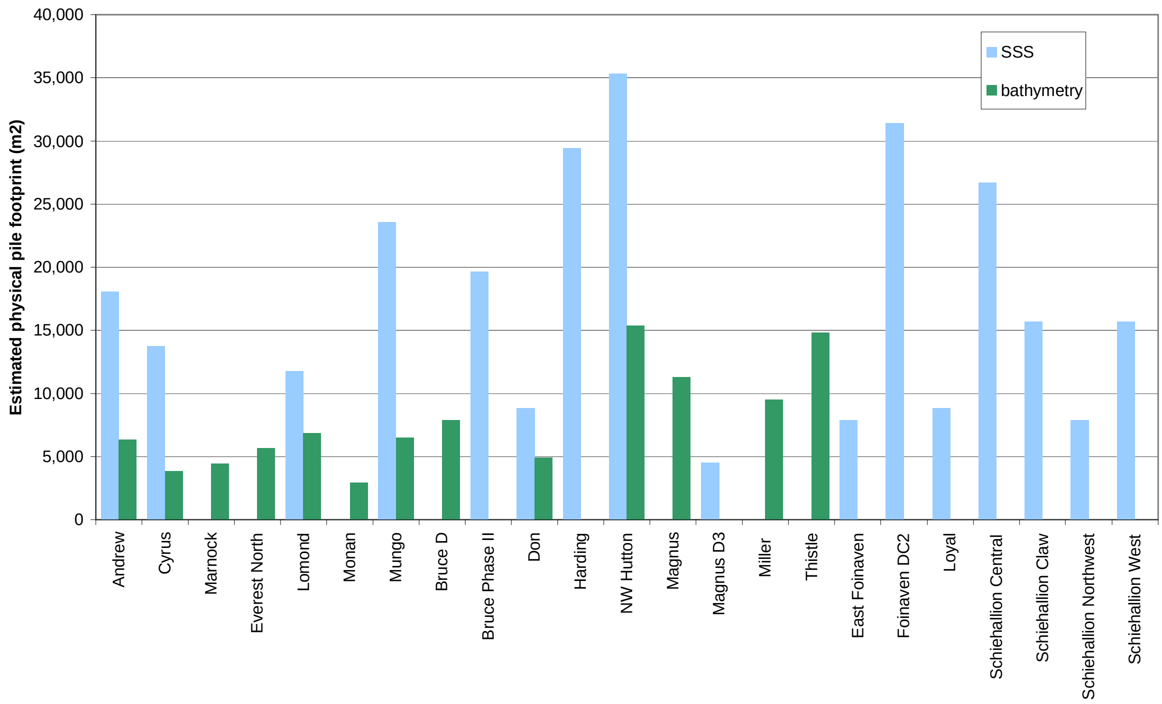


Figure 4.2 Relationship between physical footprint (estimated from seabed bathymetry data) and number of wells drilled

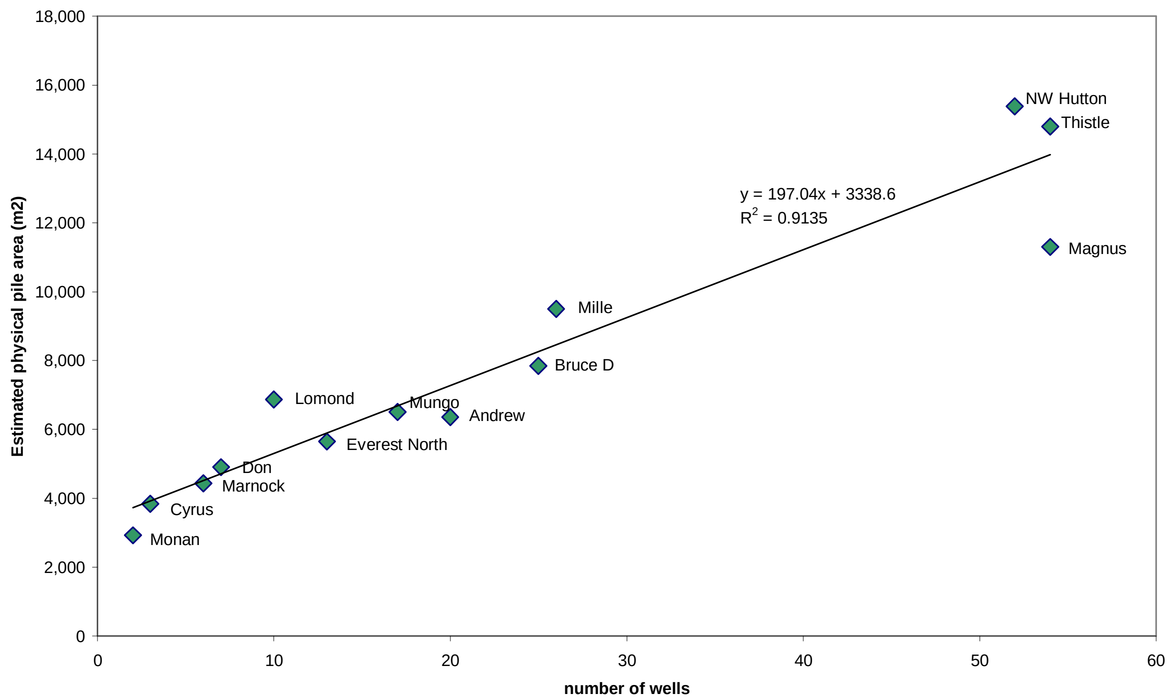


Figure 4.3 Relationship between physical footprint (estimated from side scan sonar data) and number of wells drilled

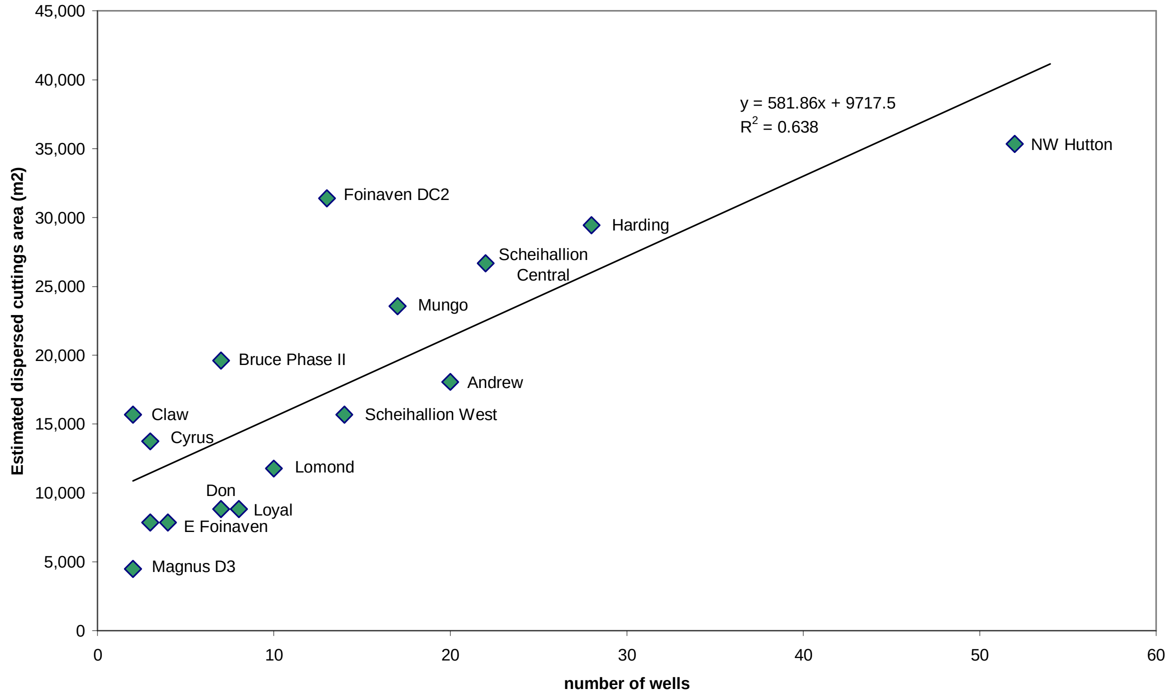
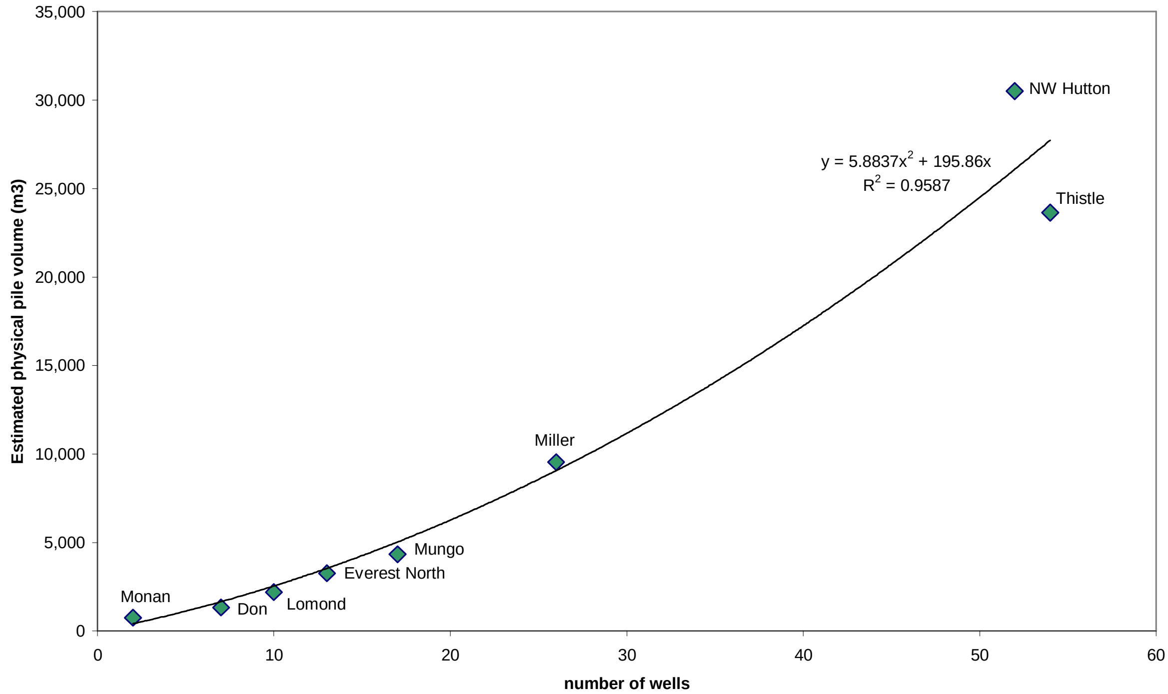


Table 4.4 Relationship between estimated physical pile volume and number of wells drilled



4.2 Environmental survey data (sediment hydrocarbon values)

Data relating to the likely 'ecological effect' footprint associated with the discharged cuttings was assessed using the data obtained from various historic seabed monitoring surveys carried out around the installations. The approximate effect footprint is defined by OSPAR as the area of seabed where surface sediment hydrocarbon concentrations are in excess of 50 ppm ($\mu g g^{-1}$) dry weight (this value is derived from various studies carried out as part of the UKOOA drill cuttings initiative, 1999-2005).

4.2.1 Interpretation of sediment hydrocarbon values

Table 4.4 and Figure 4.4 summarise the data obtained for the installations where environmental survey data was available. There are a number of limitations associated with the available environmental datasets that should be noted:

1. The accuracy of the footprint estimation is heavily dependent on the number, and relative locations, of data points used. In most cases the areas are calculated using data obtained from a very small number of sampling stations (usually less than four and typically one or two). Historically, environmental surveys were not focused on providing a detailed spatial assessment of the pattern of contamination around an installation – they tended to be designed to investigate effect gradients and were based on a single transect or crossed-transect sampling patterns.
2. Sediment hydrocarbon concentration data can not normally be reliably extrapolated or interpolated. The areas calculated here are defined by stations where sediment hydrocarbon levels fall below the 50 ppm threshold. The areas can therefore be considered as providing the 'worst-case scenario'. Using the stations where levels were above the 50 ppm threshold to calculate the footprint could, in some cases, vastly underestimate the area.

The area estimates reported here should therefore be treated with caution and can only be considered as providing a very rough estimate of the effect footprint. In Figure 4.4 the light green bars indicate where the estimations are most tentative – this may be because the estimate is based on old data or where the datasets available did not provide a clear indication of the location of the 50 ppm hydrocarbon threshold.

Figure 4.5 shows that there is no clear relationship between the 50 ppm hydrocarbon footprint area and the number of wells drilled. This observation is not entirely unexpected since the data used to make the estimation is not very precise. In addition it is known that the extent of the 50 ppm footprint is likely to be influenced by the length of time that has elapsed between the completion of drilling activities and the survey.

Table 4.5 Estimated 50 ppm sediment hydrocarbon footprint areas calculated from environmental survey data

Installation	No. wells	Assumed pattern	Dimensions[1] (m)	Estimated area of 50 ppm sediment hydrocarbon footprint (km^2)
Andrew	20	elliptical	1,000 x 330	0.26
Marnock	6	circular	550	0.95[a]
Everest North	13	circular	500	0.79
Lomond	10	elliptical	1000 x 700	0.55
Machar	9	circular	1,000	3.14[a]
Monan	2	circular	500	0.79
Mungo	17	circular	575	1.04
Bruce D	25	elliptical	1,700 x 1,000	1.33
Bruce Phase II	7	circular	500	0.79
Don	7	circular	500	0.79
Harding	28	elliptical	660 x 320	0.17
NW Hutton	52	circular	800	2.01
Magnus	54	circular	500	0.79[b]
Magnus South	2	circular	500	0.79
Magnus D3	2	circular	100	0.03
Miller	26	elliptical	1,000 x 500	0.39
Thistle	54	elliptical	1,500 x 1,000	1.18
Amethyst A1D	6	circular	200	0.13[a]
Amethyst A2D	6	circular	200	0.13
Amethyst B1D	4	circular	200	0.13[a]
Amethyst C1D	7	circular	100	0.03[a]
Cleeton CW	7	No sediment hydrocarbon data reported		
Ravenspurn N ST2	11	circular	800	2.01[b]
Ravenspurn N ST3	14	circular	1,000	3.14[b]
Ravenspurn WT1	17	elliptical	2,000 x 1,600	2.52[b]
West Sole WB	6	No sediment hydrocarbon data reported		
West Sole WC	10	circular	500	0.79[a]
Foinaven DC1	18	circular	200	0.13[a]
Foinaven DC2	13	circular	200	0.13
Schiehallion Central	22	circular	150	0.07[a]

1 circular = radius, elliptical = major axis x minor axis.
a no values over 50 ppm were recorded, area calculation is based on the distance of the innermost station sampled from the installation.
b footprint area calculated using relatively old survey data

Figure 4.4 Estimated 50 ppm sediment hydrocarbon footprints calculated from environmental survey data

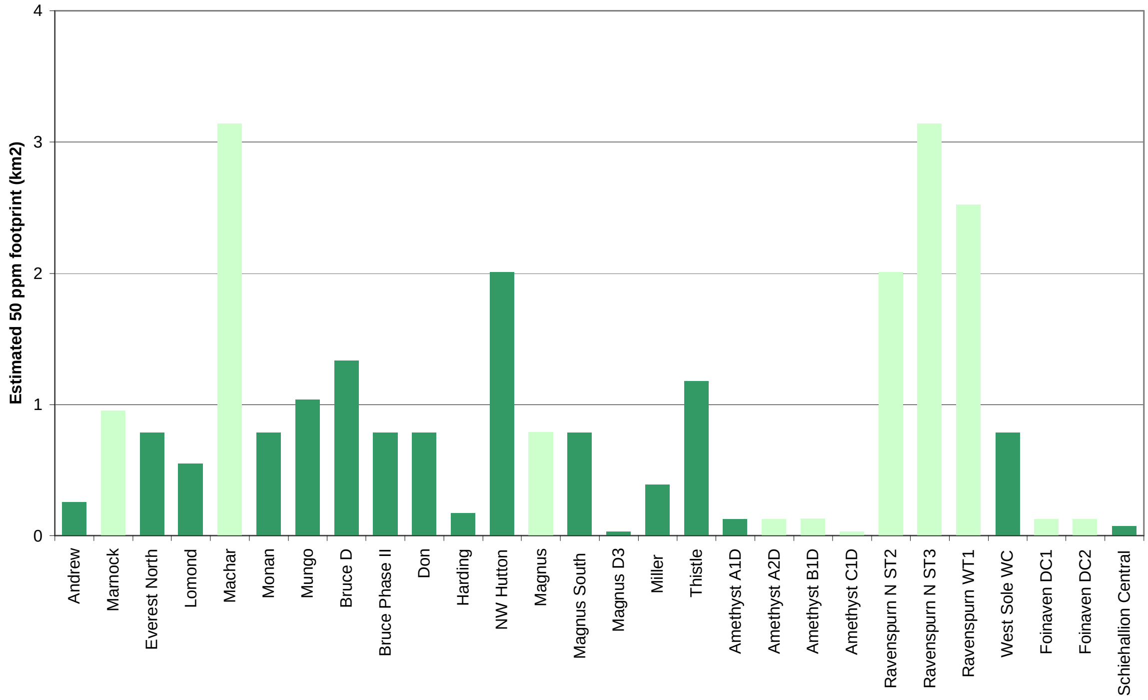
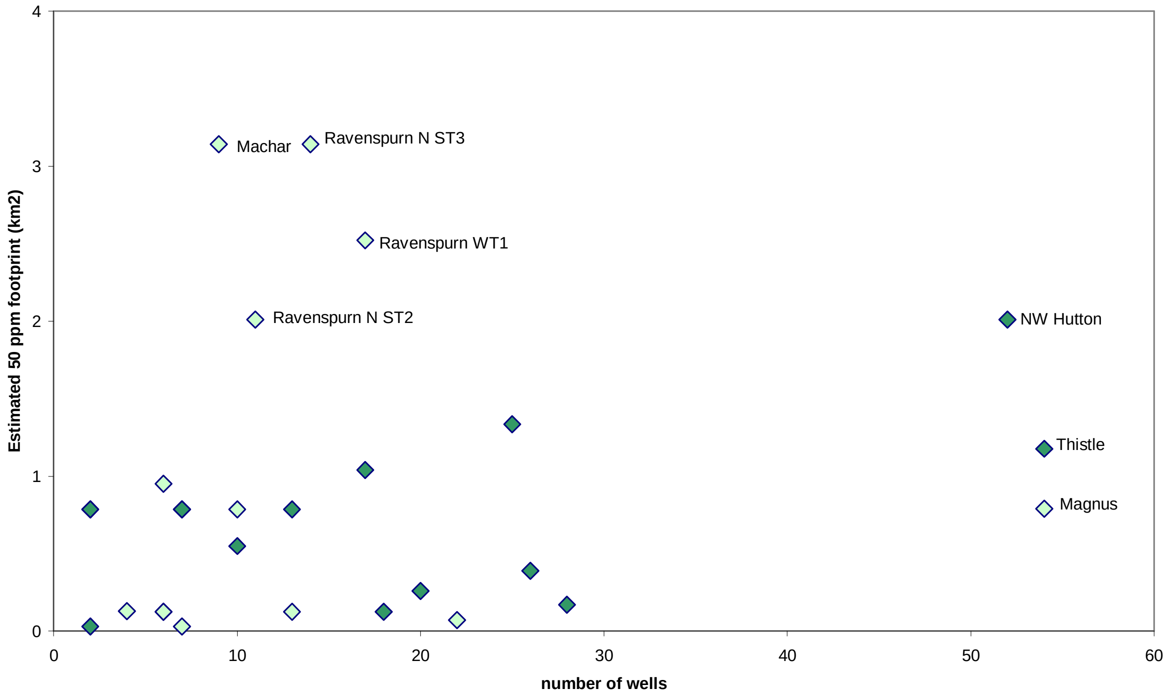


Figure 4.5 Relationship between the estimated 50 ppm sediment hydrocarbon footprint and the number of wells drilled



Note: Light green bars/point markers indicate where area has been calculated from datasets that did not exceed 50 ppm or where relatively old survey data was used.

4.3 Comparison of physical and chemical footprint areas

Table 4.5 shows the relationships between the various footprints calculated. The data is fairly variable (as indicated by the relatively high % relative standard deviations recorded, 30 to 112%) indicating that there are no strong correlations. However, on average, the physical pile is approximately 45% of the dispersed cuttings area which is in turn accounts for approximately 10% of the 50 ppm sediment hydrocarbon footprint.

Table 4.6 Comparison of the various footprints calculated

Installation	No. wells	depth (m)	bathy/SSS proportion (%)	bathy/50ppm proportion (%)	SSS/50ppm proportion (%)
Andrew	20	115	35.2	2.5	7.0
Marnock	6	92		0.5	
Everest North	13	89		0.7	
Lomond	10	85	58.4	1.3	2.1
Monan	2	92		0.4	
Mungo	17	87	27.6	0.6	2.3
Bruce D	25	121		0.6	
Bruce Phase II	7	119			2.5
Don	7	164	55.6	0.6	1.1
Harding	28	109			17.3
NW Hutton	52	144	43.6	0.8	1.8
Magnus	54	185		1.4	
Magnus D3	2	186			14.3
Miller	26	103		0.8	
Thistle	54	160		1.2	
Foinaven DC2	13	475			24.7
Schiehallion Central	22	355			37.7
		Average	**44.1**	**0.9**	**11.1**
		Relative Standard Deviation (%)	**30**	**61**	**112**

bathy/SSS area of physical pile expressed as a proportion of dispersed surface cuttings area
bathy/50ppm area of physical pile expressed as a proportion of 50 ppm hydrocarbon footprint
SSS/50ppm area of dispersed surface cuttings expressed as a proportion of 50 ppm hydrocarbon footprint

4.4 Drilling locations where no OBM cuttings were discharged

Table 4.7 lists the locations where no oil based fluids were discharged. These sites do not therefore need to be included in the screening exercise.

Table 4.7 locations where no OBM cuttings were discharged

Installation	Sector	Type	No. Wells	Block
Farragon	CNS	Subsea	2	16/28
Madoes	CNS	Subsea	3	22/23
Mirren West	CNS	Subsea	3	22/09
East Foinaven	WOS	Subsea	4	204/25
Schiehallion Claw	WOS	Subsea	2	204/20
Schiehallion Northwest	WOS	Subsea	3	204/20

4.5 Identified data gaps

The data gaps encountered during the assessment process are listed in Tables 4.8 and 4.9.

Table 4.8 Installations currently without post-drilling geophysical data

Installation	Sector	Type	No. Wells	Block
Cyrus (SWOPS)	CNS	Subsea	2	16/28
South Everest	CNS	Subsea	3	22/09
Magnus D4	NNS	Subsea	2	211/12
Magnus D8	NNS	Subsea	2	211/12
Magnus Swift, D9/MP5	NNS	Subsea	2	211/12
Magnus Swift	NNS	Subsea	4	211/12
Amethyst A1D	SNS	Platform	6	47/14
Newsham	SNS	Subsea	2	48/07
Ravenspurn N ST3	SNS	Platform	14	42/30
Ravenspurn S A	SNS	Platform	7	42/30
Ravenspurn S B	SNS	Platform	11	42/30
Ravenspurn S C	SNS	Platform	5	42/30
West Sole WAS	SNS	Platform	6	48/06
West Sole WB	SNS	Platform	6	48/06
West Sole WC	SNS	Platform	10	48/06
Clair Phase I	WOS	Platform	8	206/08
Foinaven DC1	WOS	Subsea	18	204/24
Schiehallion North	WOS	Subsea	3	204/20

Table 4.9 Installations currently without post-drilling environmental survey data

Installation	Sector	Type	No. Wells	Block
Cyrus	CNS	Subsea	3	16/28
Cyrus (SWOPS)	CNS	Subsea	2	16/28
South Everest	CNS	Subsea	3	22/09
Magnus D4	NNS	Subsea	2	211/12
Magnus D8	NNS	Subsea	2	211/12
Magnus Swift, D9/MP5	NNS	Subsea	2	211/12
Magnus Swift	NNS	Subsea	4	211/12
Cleeton CW	SNS	Platform	7	42/29
Hyde	SNS	Platform	5	48/06
Newsham	SNS	Subsea	2	48/07
Ravenspurn S A	SNS	Platform	7	42/30
Ravenspurn S B	SNS	Platform	11	42/30
Ravenspurn S C	SNS	Platform	5	42/30
West Sole WA	SNS	Platform	7	48/06
West Sole WB	SNS	Platform	6	48/06
West Sole WAS	SNS	Platform	6	48/06
Clair Phase I	WOS	Platform	8	206/08
Loyal	WOS	Subsea	8	204/20
Schiehallion North	WOS	Subsea	3	204/20
Schiehallion West	WOS	Subsea	14	204/20

4.6 Assessment of data gaps

An assessment of the likely importance of the current data gaps was undertaken through comparison with the existing results.

4.6.1 Geophysical information gaps

Table 4.8 lists the installations where no geophysical data has been collected. The geographical locations and drilling history of these installations was compared with existing survey data obtained for other similar installations to assess the importance of the data gaps.

Rough estimations of the likely footprint of the physical cuttings piles around the six installations located in the northern and central North Sea (NNS, CNS) sectors can be made using the general wells drilled-seabed area relationship found previously (See Figure 4.2). The theoretical footprint values for these NNS and CNS installations are listed in Table 4.10.

No evidence of physical cuttings piles were recorded at any of the eight southern North Sea installations investigated using geophysical techniques (see Table 4.3). These data generally indicated the presence of a high energy seabed environment with areas of sand waves, scouring and deposition being commonly recorded around the installations. It is therefore considered unlikely that significant physical cuttings depositions would be present in the vicinity of the SNS installations where no geophysical information has been collected to date.

The cuttings distribution at two of the West of Shetland installations can be reasonably assessed using existing data. Foinaven DC1 (18 wells drilled) is likely to be very similar to that observed at the nearby DC2 well centre (13 wells drilled) while the seabed cuttings around Schiehallion North (3 wells) would be expected to be similar to that observed at Schiehallion Northwest (3 wells). Unfortunately there are no other installations located in the vicinity of the Clair phase I installation therefore comparative techniques can not be used to estimate the likely size of the physical pile. However, it should be noted that only one of the eight wells drilled at the Clair platform utilised OBM, therefore it could be considered being as being a single well site and excluded from the screening exercise.

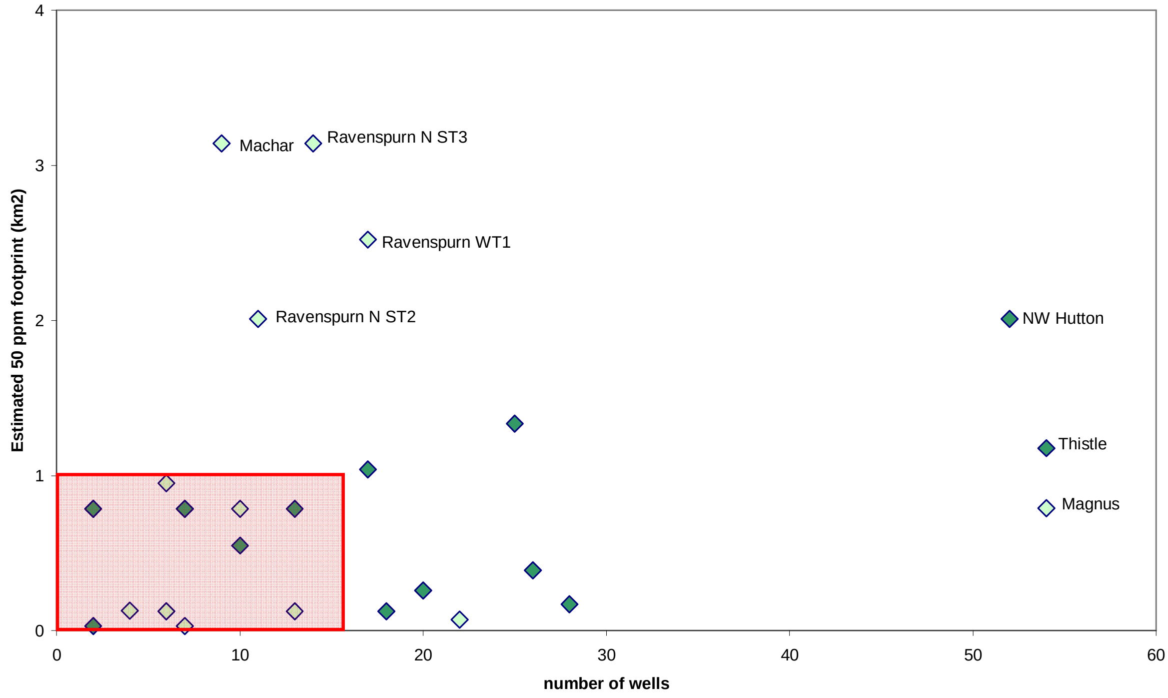
4.6.2 Environmental gaps

There are 26 installations where no suitable environmental data (surface sediment hydrocarbon concentrations) are currently available. Based on a comparison with the available data, these installations would all be expected to fall within the red boxed area drawn in Figure 4.6, eg the ecological effects (50 ppm sediment hydrocarbon) footprint would not be expected to exceed 1 km^2 (a worst-case scenario).

Table 4.10 Estimated cuttings pile physical footprints based on data obtained from other installations

Installation	Sector	No. Wells	Theoretical cuttings pile footprint area (m^2)
Cyrus (SWOPS)	CNS	2	3,700
South Everest	CNS	3	3,900
Magnus D4	NNS	2	3,700
Magnus D8	NNS	2	3,700
Magnus Swift, D9/MP5	NNS	2	3,700
Magnus Swift	NNS	4	4,100

Figure 4.6 Likely limit of the 50 ppm sediment hydrocarbon footprint for installations with environmental data-gaps



4.7 Results of screening process

The key results obtained from the review of the available data are:

- Of the 54 installations identified for screening, thirteen were found to have discrete physical cuttings piles – all located in the central and northern North Sea sectors.
- The physical extent and volume of the cuttings pile appears to be strongly related to the intensity of drilling activity at the installation (approximated by the number of wells drilled).
- Surface layers of dispersed cuttings appear to be present at the vast majority of sites surveyed. The main exceptions being installations located in the southern North Sea sector where water depths of less than 50 m are normally encountered.
- The majority of the geophysical survey data gaps identified are not expected to be particularly critical since, based on drilling history and the other existing data, it is unlikely that large physical cuttings piles would be present at these locations.
- An approximate ecological effect footprint, as defined by the 50 ppm sediment hydrocarbon concentration, can be estimated for 28 of the installations.
- The datasets used for the hydrocarbon concentration footprint calculation tend to be very limited and subject to high levels of uncertainty, therefore the reported areas can only be considered as very approximate estimations.
- Environmental survey data gaps prevented the estimation of ecological effect footprints for 26 installations from actual data, however, based on the results obtained at the other BP sites, none of the installations in question would be expected to have a footprint exceeding 1 km^2.

5 Comparison with OSPAR thresholds values

5.1 OSPAR assessment criteria

As outlined in Section 2, OSPAR have identified two key criteria to assess the environmental significance of OPF cuttings piles:

i.	Rate of oil loss to water column:	10 te/yr
ii.	Persistence of the area of seabed contaminated:	500km^{2}yr

These criteria were suggested by the outcome of the UKOOA Cuttings Initiative and they are focused on two of the most important environmental interactions related to seabed cuttings piles. Unfortunately, due to the lack of a detailed understanding of the relatively complex mechanisms involved in these processes, neither the *rate of loss of oil* or the *persistence* are easily determined.

5.2 Issues relating to the determination of the assessment criteria

5.2.1 Rate of oil loss to water column

The *rate of loss of oil to water column* may be interpreted in two ways:

1. The oil lost from the cuttings pile via leaching processes, or
2. The oil lost from the cuttings pile via leaching <u>and</u> losses of oil contaminated solids due to erosion processes.

In this study it is assumed that oil loss is solely made up of leached hydrocarbons. Cuttings material released through erosion would not be expected to release significant proportions of the hydrocarbons present into the water column (the oil present would remain predominantly associated with the solid phase – most hydrocarbons are not soluble in water to a great extent). In any case, the hydrocarbons associated with any eroded material would be expected to rapidly re-settle on the seabed therefore any environmental impacts associated with cuttings pile erosion would be observed in the sediment phase not the water column.

Accurate in-situ measurements of hydrocarbon leaching rates from cuttings piles are very difficult to obtain therefore oil leaching rates have generally be investigated using laboratory-based experiments (for example UKOOA JIP phases II and III). These studies indicate that potential for leaching of hydrocarbons from cuttings solids into seawater is low, in fact in many of the tests no hydrocarbons could be detected in the water phase.

The only readily applicable value obtained from the UKOOA studies was the estimated surface hydrocarbon leaching rate calculated from data obtained from a mesocosm experiment undertaken on Beryl cuttings (UKOOA phase II, task 3, RF, 2002) - 521 mg/m^2/day. The results obtained from leaching tests carried out in Phase III of the cuttings initiative were not suitable for the estimation of actual leaching rates.

It has been assumed that significant hydrocarbon leaching will only occur if a discrete surface layer of cuttings material was present on the seabed, not in cases where sediment is contaminated with cuttings derived components. Two types of geophysical survey data were used to estimate the area of the surface cuttings layer at the installations:

1. The footprint of the physical cuttings pile identified by sonar investigations.
2. The footprint of disturbed/reflective seabed identified by side scan sonar.

The physical footprint value may slightly underestimate the size of the pile since the technique is not sensitive enough to detect the gradual tailing-off of cuttings around the periphery of the pile. The side scan sonar technique is able to differentiate areas of relatively shallow cuttings deposition from unaffected seabed.

5.2.2 Persistence of the area of seabed contaminated

The accurate determination of this value requires two pieces of information:

1. The total area of seabed where surface sediment hydrocarbon concentrations exceed the 50 ppm threshold.

   Unfortunately the available datasets tend to be unsuitable for the accurate determination of the contamination footprint. Offshore environmental survey designs have tended to be designed to focus on the determination of effect gradients rather than the detailed spatial assessment of contamination.

2. Knowledge of how the spatial extent of the contamination footprint varies with time.

   A number of studies have investigated the long-term recovery of areas of contaminated seabed around offshore installations where OPF cuttings have been discharged (eg DNV, 2004, Daan & Mulder, 1996). The data suggests that the areas impacted by hydrocarbon contamination tend to decrease over time (via processes such as biodegradation), however it should be noted that the majority of the studies are based on very limited datasets (see point 1 above) and therefore the results obtained should only be considered as being very approximate estimations. In addition, the data analysis technique used in the Norwegian study (DNV, 2004) was not suitable for the interpretation of the available datasets.

Table 5.1 Calculated area (km^2) contaminated with THC >50 mg/kg at Norwegian installations (DNV,2004)

Year	1990	1991	1992	1993	1994	1996	1998	1999	2001	2002	%
Statfjord A	4.0	3.4	4.6	3.4		3.4		2.5		1.8	60%
Statfjord B	6.8	3.1	0.0	1.3		2.7		0.5		1.2	82%
Statfjord C	4.0	3.4	4.6	3.4		3.4		2.5		1.8	60%
Gullfaks A	6.5	2.5	1.7	0.2		3.1		0.2		0.2	97%
Gullfaks B	3.2	2.8	1.4	0.5		0.6		0.2		0.2	93%
Gullfaks C	2.5	8.1	2.0	2.4	1.2	1.0		2.4		0.3	88%
Brage			0.6	5.3	5.9		2.4		0.2		96%
Oseberg F		"24"	4.6	1.1	0.6		1.3		2.0		56%
Oseberg C			2.5	"42.1"	1.3		3.5		0.3		91%
Valhall						8.8/4.4		0.6/3.8		3.5/2.7	60%

NOTE: The data presented in this table should be treated with caution and the values quoted should not be used for quantitative purposes.

A mathematical model (taking into account the likely decreasing trend in the contamination footprint) was developed to assess the loss of oil and persistence of five selected cuttings piles as part of phase III of the UKOOA Drill Cuttings Initiative (UKOOA, 2005). It is not practical to run the model to analyse all the installations covered by this review therefore an average correction factor, obtained from the model output for the five installations initially studied, was calculated to convert the 50 ppm footprint areas into persistence values.

Table 5.2 Footprint-persistence conversion factor obtained from BMT model developed for UKOOA phase III.

Installation	Estimated 50 ppm footprint area (km^2)	Persistence calculated by model (km^2.year)	Conversion factor
Clyde	0.785	48.0	61.1
Miller	0.393	29.8	75.8
Beryl A	0.687	46.9	68.3
Brent A	0.876	55.3	63.1
Brent S	0.196	16.7	85.2
		Average factor	**70.7**

5.3 Calculation of OSPAR screening criteria values for BP installations

5.3.1 Rate of oil loss to water column.

The values obtained for the installations where suitable information was available are presented in Table 5.2 and Figure 5.1. The following calculation was used:

Rate of loss of oil to water column (metric tonnes/year) =

$$\frac{\text{Area of cuttings pile } (m^2) \times \text{leaching rate } (mg/m^2/day) \times 365}{1{,}000{,}000{,}000}$$

- Area of cuttings pile: estimated from geophysical survey results (results have been calculated for physical pile and total dispersed surface cuttings).
- The leaching rate used was the 521 mg/m^2/day value obtained from the UKOOA mesocosm study.

5.3.2 Persistence of the area of seabed contaminated.

The values recorded for the installations where suitable information was available are presented in Table 5.3 and Figure 5.2. The following calculation was used:

Persistence (km^2.years) =

Area of 50 ppm sediment hydrocarbon footprint (km2) x conversion factor (70.7)

- Area of 50 ppm footprint pile: estimated from environmental survey results.
- Conversion factor calculated using the output of the model developed for phase III of the UKOOA Drill Cuttings Initiative.

5.3.3 Number of years required to breach threshold - worst-case-scenario - assuming no reduction on the contamination footprint over time.

The values recorded for the installations where suitable information was available are presented in Table 5.3 and Figure 5.3. The following calculation was used:

Number of years required =

$$\frac{\text{Threshold value: } 500\ km^2.\text{years}}{\text{Area of 50 ppm footprint } (km^2)}$$

Table 5.3 Rate of oil loss values calculated from survey data

Installation	No. wells	Depth (m)	Rate of oil loss (Te/year)	
			Physical pile	Dispersed surface cuttings
Andrew	20	115	1.21	3.43
Cyrus	3	110	0.73	2.61
Marnock	6	92	0.84	-
Everest North	13	89	1.07	-
Lomond	10	85	1.31	2.24
Monan	2	92	0.56	-
Mungo	17	87	1.24	4.48
Bruce D	25	121	1.49	-
Bruce Phase II	7	119	-	3.73
Don	7	164	0.93	1.68
Harding	28	109	-	5.60
NW Hutton	52	144	2.93	6.72
Magnus	54	185	2.15	-
Magnus D3	2	186	-	0.86
Miller	26	103	1.81	-
Thistle	54	160	2.81	-
Foinaven DC2	13	475	-	5.97
Loyal	8	467	-	1.68
Schiehallion Central	22	355	-	5.07
Schiehallion West	14	377	-	2.99
OSPAR threshold value			**10**	

Table 5.4 Persistence of contamination values calculated from survey data

Installation	No. wells	Estimated area of 50 ppm sediment hydrocarbon footprint (km^2)	Survey year	Persistence (km^2.year)	Years required to breach 500 km^2.year threshold
Andrew	20	0.26	2000	18	1,930
Marnock	6	0.95	2000	66	526
Everest North	13	0.79	2005	55	637
Lomond	10	0.55	2006	38	910
Machar	9	3.14	2000	220	159
Monan	2	0.79	1999	55	637
Mungo	17	1.04	2006	73	482
Bruce D	25	1.33	2001	93	375
Bruce Phase II	7	0.79	2000	55	637
Don	7	0.79	1999	55	637
Harding	28	0.17	2006	12	2,941
NW Hutton	52	2.01	2002	141	249
Magnus	54	0.79	1988	55	633
Magnus South	2	0.79	1997	55	637
Magnus D3	2	0.03	1997	2	15,924
Miller	26	0.39	2004	27	1,282
Thistle	54	1.18	2004	82	425
Amethyst A1D	6	0.13	1992	9	3,981
Amethyst A2D	6	0.13	1992	9	3,981
Amethyst B1D	4	0.13	2006	9	3,846
Amethyst C1D	7	0.03	2000	2	15,924
Ravenspurn N ST2	11	2.01	1993	141	249
Ravenspurn N ST3	14	3.14	1993	220	159
Ravenspurn WT1	17	2.52	1992	176	198
West Sole WC	10	0.79	2000	55	637
Foinaven DC1	18	0.13	1998	9	3,981
Foinaven DC2	13	0.13	1998	9	3,981
Schiehallion Central	22	0.07	2000	5	7,077
			OSPAR threshold value	**500**	

Table 5.5 Rate of loss and persistence of contamination values for all BP installations where OBM has been discharged

Installation	Sector	No. Wells	Rate of Loss (Te/year)		Area of 50 ppm footprint	
			Physical pile	Dispersed surface cuttings	Area (km^2)	Persistence (km^2.year)
Andrew	CNS	20	**1.21**	**3.43**	**0.26**	**18**
Cyrus	CNS	3	**0.73**	**2.61**	*<1*	*<71*
Cyrus (SWOPS)	CNS	2	*0.71*	*2.07*	*<1*	*<71*
ETAP PDR (Marnock)	CNS	6	**0.84**	*2.51*	**0.95**	**66**
Everest North	CNS	13	*1.07*	*3.29*	**0.79**	**55**
Lomond	CNS	10	**1.31**	**2.24**	**0.55**	**38**
Machar	CNS	9	**0.97**	*2.84*	**3.14**	**220**
Monan	CNS	2	**0.56**	*2.07*	**0.79**	**55**
Mungo	CNS	17	**1.24**	**4.48**	**1.04**	**73**
South Everest	CNS	3	*0.75*	*2.18*	*<1*	*<71*
Bruce D	NNS	25	**1.49**	*4.61*	**1.33**	**93**
Bruce Phase II	NNS	7	-*	**3.73**	**0.79**	**55**
Don	NNS	7	**0.93**	**1.68**	**0.79**	**55**
Harding	NNS	28	-*	**5.60**	**0.17**	**12**
NW Hutton	NNS	52	**2.93**	**6.72**	**2.01**	**141**
Magnus	NNS	54	**2.15**	*7.82*	**0.79**	**55**
Magnus South	NNS	2	*0.71*	*2.07*	**0.79**	**55**
Magnus D3	NNS	2	-*	**0.86**	**0.03**	**2**
Magnus D4	NNS	2	*0.71*	*2.07*	*<1*	*<71*
Magnus D8	NNS	2	*0.71*	*2.07*	*<1*	*<71*
Magnus Swift, D9/MP5	NNS	2	*0.71*	*2.07*	*<1*	*<71*
Magnus Swift	NNS	4	*0.78*	*2.29*	*<1*	*<71*
Miller	NNS	26	**1.81**	*4.73*	**0.39**	**27**
Thistle	NNS	54	**2.81**	*7.82*	**1.18**	**82**
Amethyst A1D	SNS	6	*Significant accumulations of seabed cuttings are considered to be unlikely due to shallow water depths/high energy seabed environment present in the Southern North Sea sector.*		**0.13**	**9**
Amethyst A2D	SNS	6			**0.13**	**9**
Amethyst B1D	SNS	4			**0.13**	**9**
Amethyst C1D	SNS	7			**0.03**	**2**
Cleeton CW	SNS	7			*<1*	*<71*
Hyde	SNS	5			*<1*	*<71*
Newsham	SNS	2			*<1*	*<71*
Ravenspurn N ST2	SNS	11			**2.01**	**141**
Ravenspurn N ST3	SNS	14			**3.14**	**220**
Ravenspurn WT1	SNS	17			**2.52**	**176**
Ravenspurn S A	SNS	7			*<1*	*<71*
Ravenspurn S B	SNS	11			*<1*	*<71*
Ravenspurn S C	SNS	5			*<1*	*<71*
West Sole WA	SNS	7			*<1*	*<71*
West Sole WAS	SNS	6			*<1*	*<71*
West Sole WB	SNS	6			*<1*	*<71*
West Sole WC	SNS	10			**0.79**	**55**
Foinaven DC1	WOS	18	-	*3.84*	**0.13**	**9**
Foinaven DC2	WOS	13	-*	**5.97**	**0.13**	**9**
Loyal	WOS	8	-*	**1.68**	*<1*	*<71*
Schiehallion Central	WOS	22	-*	**5.07**	**0.07**	**5**
Schiehallion North	WOS	3	-	*2.18*	*<1*	*<71*
Schiehallion West	WOS	14	-*	**2.99**	*<1*	*<71*
OSPAR threshold value			**10**	**10**	**-**	**500**

NOTE: The values in italics have been estimated using relationships between the number of wells drilled and the available geophysical and environmental datasets.

* No physical pile detected by geophysical survey.

Figure 5.1 Estimated *Rate of loss of oil into the water column*, based upon physical pile (bathymetry) and dispersed cuttings (side scan sonar) areas, BP UKCS installations

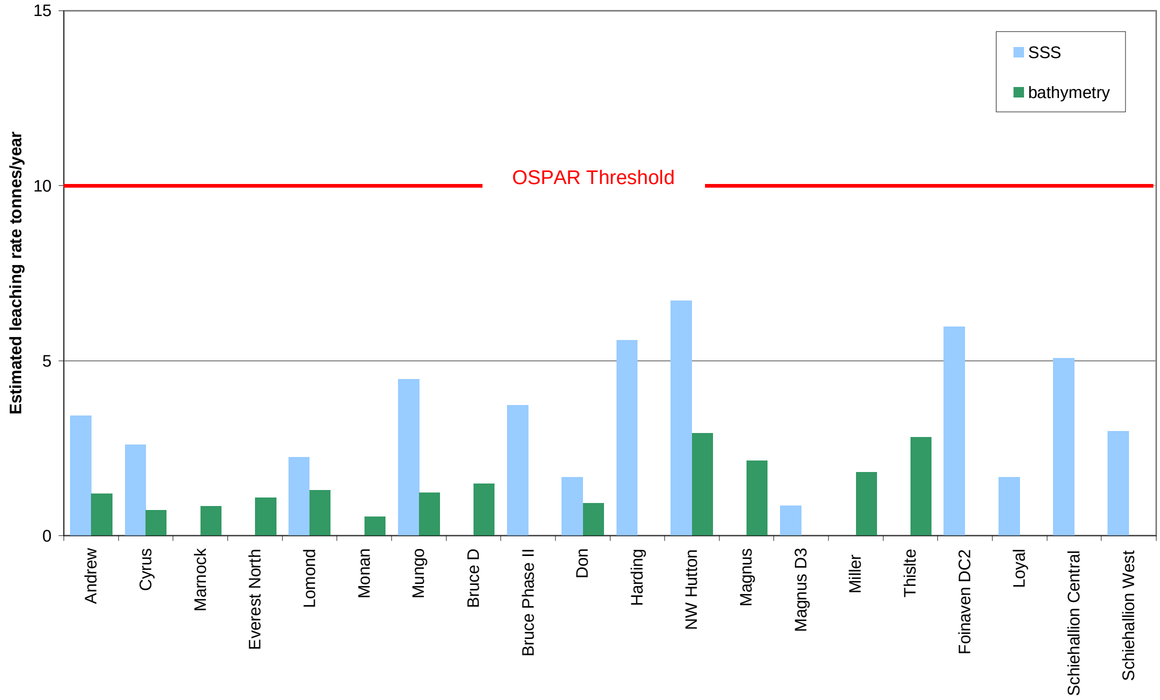
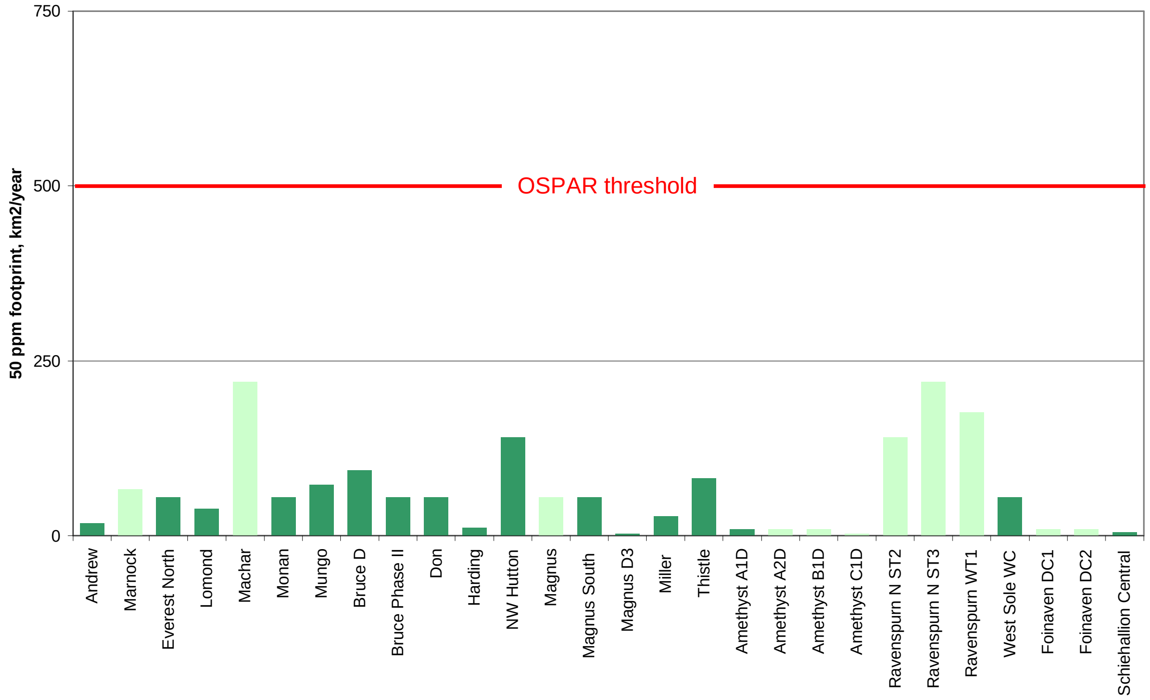
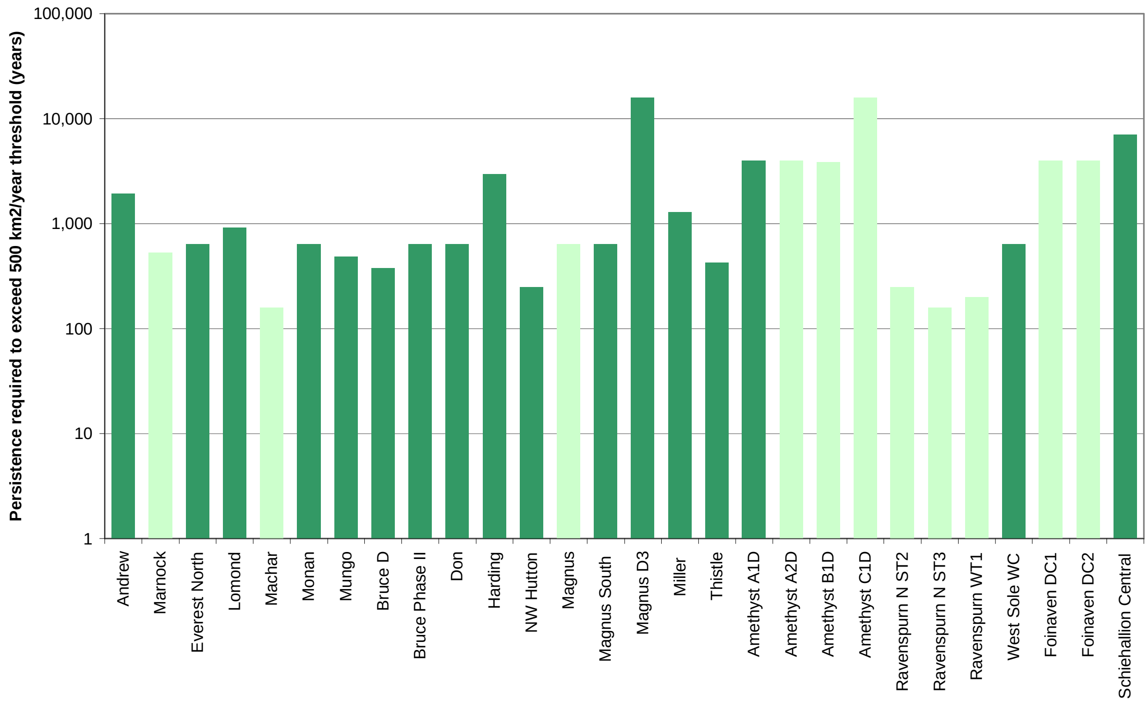


Figure 5.2 Estimated *Persistence of the area of seabed contaminated*, based upon 50 ppm hydrocarbon footprint areas and the expected seabed recovery rate predicted by the model used in UKOOA Drill Cuttings Initiative, phase III.



Note: Light green bars indicate where area has been calculated from datasets that did not exceed 50 ppm or where relatively old survey data was utilised.

Figure 5.3 Sediment hydrocarbon footprint time-spans required to exceed 500 km^2.years threshold (assuming no reduction in footprint over time – 'worst case scenario')



Note: Light green bars indicate where area has been calculated from datasets that did not exceed 50 ppm or where relatively old survey data was utilised.

5.4 Discussion of results

The data obtained from this study indicated that the OSPAR *oil loss* threshold would not be breached at any of the BP installations where cuttings piles were detected. This rate is proportional to the area of the cuttings pile present which in turn appears to be strongly related to the number of wells drilled at the installation. There was no evidence to indicate the presence of seabed cuttings piles at any of the southern North Sea installations where geophysical data was available, probably due to the relatively high potential for dispersion derived from the strong water currents encountered in this shallow water area.

The ecological impact at NW Hutton appears to have the highest potential for long-term *persistence* (141 km^2.years) – although it is still well below the OSPAR threshold. It should be noted that the other sites exceeding 100 km^2.years persistence (Machar and the Ravenspurn installations) are all derived from unreliable data (calculated from either old or very limited datasets) and the actual persistence is likely to be much lower than indicated by the calculated values.

As detailed in previous sections, the *oil loss* and *persistence* values reported in this study are based on a combination of a number of general assumptions and some very approximate estimated data. The values reported provide a mechanism of comparing the probable environmental impacts associated with the various installations studied, however they should not be considered as being suitable for detailed quantitative analysis.

6 Conclusions and recommendations

6.1 Conclusions

The available geophysical and environmental data for the BP installations has been used to calculate the two key assessment parameters defined by OSPAR – *oil loss to water column* and *persistence*. A number of important assumptions and estimations were associated with the calculations and these have been described in previous sections.

All of the calculated values fell below the threshold limits specified by OSPAR. The (reliable) data suggested that cuttings pile at the NW Hutton platform appeared to be the most environmentally significant. Data gaps exist for approximately 40% of BP's installations, however, the majority of these gaps are not considered as being critical since information obtained at the other sites can be used to estimate the likely cuttings distribution and effect footprints.

6.2 Recommendations

6.2.1 BP installation cuttings piles- critical data gaps

As mentioned in Section 6.1, there are some data gaps relating to the assessment of the cuttings piles at BP's UKCS installations. It is recommended that consideration should be given to collecting appropriate data to close the following gaps (in order of importance):

Magnus platform (high priority)

Based on drilling history and the limited available data, a relatively large cuttings pile and associated impact footprint would be expected at this location – potentially BP's most significant pile on the UKCS. The data used in this assessment was not ideal and neither the physical cuttings pile or the environmental footprint have been studied in detail in recent times.

Ravenspurn installations (medium priority)

The environmental data collected around the Ravenspurn North sites in the early 1990s indicate the presence of a relatively large hydrocarbon footprint around the installations. BP should consider collecting some up-to-date information to determine the current extent of the any footprint(s) present (likely to be much smaller).

Machar installation (low priority)

The environmental data collected around the Machar installation does not provide the information required to assess the 50 ppm hydrocarbon footprint. The data obtained at other similar sites suggest that the actual footprint is likely to be considerably less than the maximum value obtained from the assessment of the limited dataset (1 km radius). BP could consider collecting samples closer to the installation to allow a more accurate estimation of the footprint.

6.2.2 General notes

The processes associated with the current OSPAR screening criteria (*oil loss* and *persistence*) are both very complex and relatively poorly understood. This means that any assessments based on these criteria will include a large element of uncertainty.

There are two options available to increase the reliability of the cuttings pile environmental screening process:

1 Collect detailed information relating to the processes involved, thus improving the accuracy of the calculated values.

The research areas that would require further detailed investigation would be:

i) Determination of reliable oil leaching rates from a range of cuttings piles – ideally using in-situ experiments.
ii) Determination of the rates of erosion and its environmental impact in the water column and on the seabed following resettlement.
iii) Investigation of the long-term recovery (eg reduction in surface sediment hydrocarbon content) of the seabed environment around abandoned cuttings piles. Surveys should be specifically focused on determining the overall spatial distribution of the contamination present rather than just transect-based concentration gradients.

These investigations would require extensive financial resources and would require significant amount of time to generate the data required (most notably the long-term recovery investigation).

It may therefore be more appropriate to:

2 Select revised screening criteria that are more easily defined and measured.

This simplified type of approach has been adopted by the Norwegian oil industry. The cuttings pile screening criteria recommended in the 2003 guidelines for the characterisation of offshore cuttings piles (OLF, 2003) are not based upon *oil loss* or *persistence*. The requirement to undertake a detailed physical and chemical investigation at an installation is triggered when:

The sediment total hydrocarbon level at 250m distance from the installation is >50 mg/kg.

7 References

Daan R & Mulder M (1996). Long term effects of OBM cutting discharges at 12 locations on the Dutch continental shelf. NIOZ report 1996-6.

DNV (2004). OLF Technical Note. Cuttings piles – area contaminated with THC. Report to Oljeindustriens Landsforening. DNV Report No. 2004-0492, revision no. 01.

OLF (2003). OLF guidelines for characterisation of offshore drill cuttings piles. Final Report May 2003.

RF (2003). UKOOA phase II – Task 3. Joint report on factors determining future pile characteristics. Report to DNV for UKOOA drill cuttings initiative phase II. Rogaland Research report RF-2001/220.

UKOOA (2005). UKOOA JIP 2004 Drill Cuttings Initiative Phase III: final report. Report for submission to DTI. Report number 20132900, 26 January 2005.