OCS Study
BOEM 2018-048

Oil-Spill Occurrence Estimators: Fault Tree Analysis for One or More Potential Future Beaufort Sea OCS Lease Sales

US Department of the Interior
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Alaska OCS Region

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Disclaimer

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Report Availability

To download a PDF file of this report, go to the US Department of the Interior, Bureau of Ocean Energy Management Data and Information Systems webpage (http://www.boem.gov/Environmental-Studies-EnvData/) click on the link for the Environmental Studies Program Information System (ESPIS), and search on 2018-048. The report is also available at the National Technical Reports Library (https://ntrl.ntis.gov/NTRL/).

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ABBREVIATIONS AND ACRONYMS

ABS	American Bureau of Shipping
ABSG	ABS Group
bbl	Barrel (42 US gallons, 0.159 kiloliters, 0.159 m^3, or 0.136 metric tonnes)
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CDF	Cumulative Distribution Function
DOI	Department of Interior
E&D	Exploration and Development
GOM	Gulf of Mexico
LOF	Life of Field
LOWC	Loss of Well Control
MMbbl	Million barrels
NEPA	National Environmental Policy Act
OCS	Outer Continental Shelf
PAC	Pacific Ocean

1 INTRODUCTION

1.1 PROJECT OVERVIEW

On 26 September 2017, the Bureau of Ocean Energy Management (BOEM) contracted ABSG Consulting, Inc.(ABSG) in an Indefinite Delivery/Indefinite Quantity contract # M17PC00015 (contract) to perform fault tree analysis to develop oil spill occurrence frequencies for size ranges of crude oil, condensate, and refined petroleum spills for use in environmental analyses related to proposed oil and gas leasing, exploration, development, and production activities in the Alaska Outer Continental Shelf (OCS) Arctic Planning Areas.

The first task order #M17PD00066 (ABSG, 2018) in the contract involved estimation of spill occurrence frequencies. This analysis included:

- Collation of historical US OCS oil spill incident data from a variety of sources
- Calculation of oil spill frequency exposure metrics
- Review of oil spill causal factors
- Calculation of oil spill occurrence frequencies
- Estimation of uncertainty metrics such as confidence intervals

The second task order #140M0118F0007 in the contract, included using the results from the first task order to perform fault tree analysis and Monte Carlo simulation to estimate oil spill occurrence estimators for Beaufort Sea OCS Planning Area. This report documents the approach and results of the fault tree analysis and statistical simulation.

The U.S. Department of the Interior, BOEM, uses oil spill occurrence estimators in National Environmental Policy Act (NEPA) documents for oil and gas lease sales, exploration plans or development and production plans, including production facilities and pipelines that may be developed on the OCS.

1.2 OBJECTIVE

Objective of this study was to develop oil spill occurrence estimators for Beaufort Sea OCS lease sales using fault tree methodology in terms of:

- Oil spill frequency per 1000 years
- Oil spill frequency per billion barrels produced; and
- Oil spill index

.The following specific activities were performed under this task order:

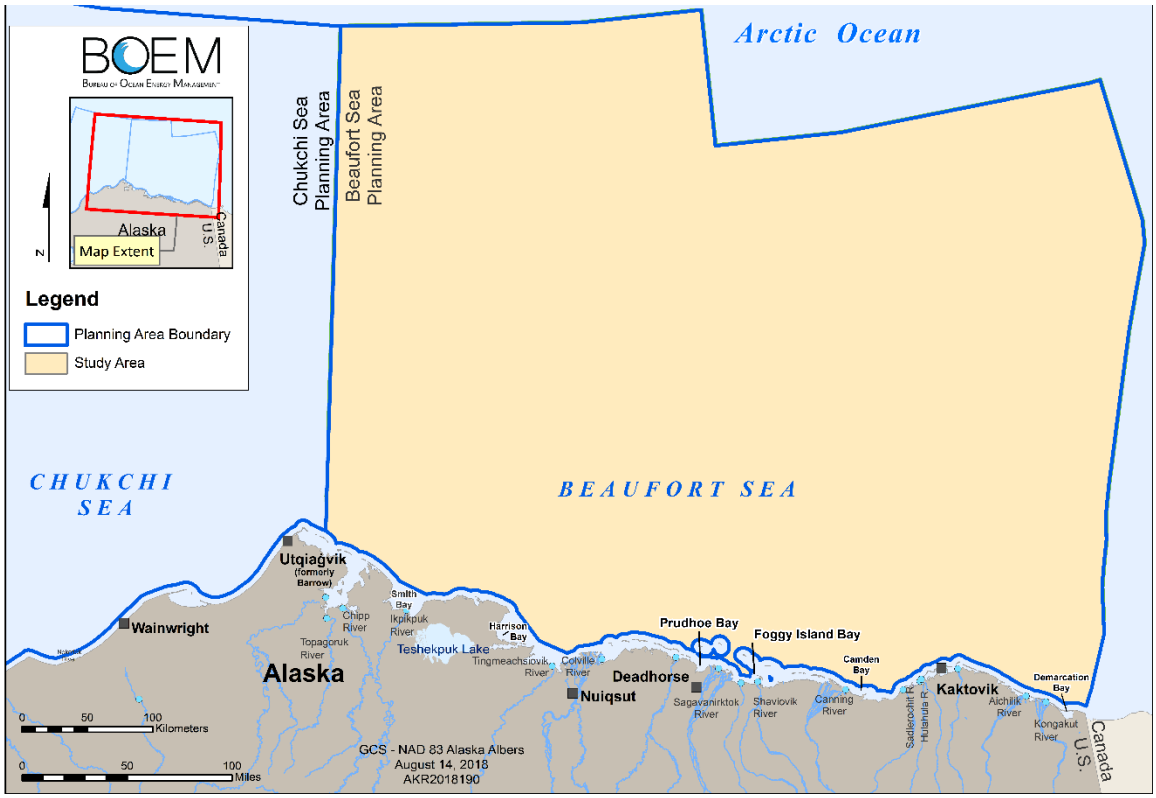
- Development of fault tree models for:
  - Platform oil spill
  - Pipeline oil spill (≤10” in diameter and >10” in diameter)
  - Loss of well control oil spill (during production, exploration, or drilling)

- Developed spill occurrence rates for the size range categories for crude oil, condensate, and diesel spills, as identified by BOEM:
  - Small (S): 50-99 bbl
  - Medium (M): 100-999 bbl
  - Large (L): 1,000-9,999 bbl
  - Huge (H): ≥10,000 bbl
  - Enormous (E): >150,000 bbl (calculated for well oil spills only)
  - Substantial: ≥ 1,000 bbl (includes Large, Huge, and Enormous)

1.3 STUDY AREA

Fault tree analysis and oil spill occurrence estimates presented in this study are specifically developed for the OCS in the US waters of the Beaufort Sea. The analysis is based on an exploration and development scenario that spans 70 years, with a focus on the period of oil exploration and production in years 1 through 54. Figure 1 presents the map of Beaufort Sea Planning Area.

Figure 1: Beaufort Sea Planning Area



1.4 TECHNICAL APPROACH AND REPORT OUTLINE

ABSG has organized this report in a manner consistent with analysis sequence as following in Figure 2:

Figure 2: Analysis Sequence

Section 2 provides the information on historical data, the associated confidence intervals, and deviations from historical data for each oil spill type (i.e. pipeline, platform, and loss of well control). The historical information was taken from the analysis (ABSG, 2018) of historical rates of US OCS oil spill greater than or equal to 50 bbl, which typically have more documentation and details of the causes of oil spills.

Section 3 provides a description and results of the fault tree assessment and statistical simulation.

Section 4 provides an overview of the exploration and development (E&D) scenario for the OCS in the US waters of the Beaufort Sea, for which the analysis was carried out.

The following water depths are considered in this analysis:

- Nearshore (<10 m water depth)
- Inner Shelf (10 m to <25 m water depth)
- Middle Shelf (25 m to <60 m water depth)
- Outer Shelf (≥60 m water depth)

For the purpose of this assessment, ABSG has assumed that the frequency of middle shelf and outer shelf operations are equivalent. Only trawling/fishing net impacts, natural hazards, hurricanes, and loss of well control were seen to have different impacts at deeper water depths. Further, the difference between middle shelf and outer shelf frequencies were seen to be minimal.

Section 5 provides detail on how the oil spill occurrence estimates were calculated. The following oil spill occurrence estimates are presented as follows:

- Spill Frequency per 10^3 years;
- Spill Frequency per 10^9 barrel produced;
- Spill Index (the product of the oil spill size and the oil spill frequency);
- Life of Field Average Spill Frequency;
- Life of Field Average Spill Frequency per 10^9 barrels produced; and
- Life of Field Average Spill Index

Section 6 provides the oil spill occurrence results.

2 US OCS HISTORICAL OIL SPILL DATA

2.1 OIL SPILL DATA OVERVIEW

ABSG collated oil spill data from the following sources to develop incident counts, and associated causal factors to support the fault tree analysis:

- Historical incident tables (1972 to 2010) provided in a prior BOEM report (Bercha Group, 2013)
- Data collected by ABSG (1964 to 2015) from prior spill studies for BOEM and the Bureau of Safety and Environmental Enforcement (BSEE) (ABSG, 2016)
- Spill-related documents (2010 to 2017) provided by BOEM (Crowley, 2017)
- Spill tables (1972 to 2012) provided by BOEM (BSEE, 2013)
- US Outer Continental Shelf Oil Spill Statistics (ABSG, 2018)

For this study, ABSG conducted a review and analysis of historical OCS oil spills ≥ 50 bbl (ABSG, 2016). The review was focused on the oil spill data from 1972 to 2017 as oil spill rates decreased substantially after 1973 (ABSG, 2016), making prior years less relevant for calculating future expected occurrence rates. The rates are calculated as counts of incidents divided by metrics for oil spill exposure (ABSG, 2018).

Additional details on the calculation of historical oil spill data can be found in previous reports (ABSG, 2016) and (ABSG, 2018). The remainder of this section details the distribution of historical data calculated by ABSG and the deviations from historical data assumed by ABSG in completing the Monte Carlo Assessment.

2.2 DATA ANALYSIS

Data collected from various sources were reviewed and arranged into three main categories:

- Pipeline spills
- Platform spills
- Loss of well control

Section 2.3 to 2.5 provides detailed information on data used in this analysis for each spill category, along with information on deviations taken from historical data to account for conditions in Arctic OCS.

For each spill category listed above, spill data was categorized by the following spill sizes with associated cause classifications:

- Small spill
- Medium spill
- Large spill
- Huge spill
- Enormous spill (only for loss of well control)
- Substantial spill (total of large, huge and enormous spills)

2.3 PIPELINE OIL SPILLS

2.3.1 Historical Causal Data of GOM and PAC Pipeline Oil Spills

Table 1 presents the historical data of GOM and PAC pipeline oil spill statistics[1], and the confidence intervals[2] from a previous study (ABSG, 2018), by cause for small and medium pipeline oil spill (50-99 bbl spill). The highest contributors to pipeline oil spills are natural hazards (i.e., storms/hurricanes) at 47% and third-party impacts (i.e., anchor impacts, jack-up rig impacts, trawl/fishing net impacts) at 19.6%.

Table 1: GOM and PAC Pipeline Oil Spill Statistics and Confidence Intervals by Cause - Small and Medium Spill

Cause Classification	# of Spills	Number of Spills						Small and Medium Spills (50-999 bbl)				
		S	M	L	H	SM	LH	Dist %	# Spills	Frequency [per 10^5km-yr]	Min	Max
CORROSION	**4**	**1**	**2**	**1**	**0**	**3**	**1**	**5.9**	**3**	**0.674**	**0.00**	**1.80**
External	1	1	0	0	0	**1**	**0**	2.0	1	0.225	0.00	0.68
Internal	3	0	2	1	0	**2**	**1**	3.9	2	0.450	0.00	1.13
THIRD PARTY IMPACT	**20**	**2**	**8**	**7**	**3**	**10**	**10**	**19.6**	**10**	**2.248**	**1.12**	**3.82**
Anchor Impact	12	2	5	3	2	**7**	**5**	13.7	7	1.573	0.67	3.15
Jack-up Rig or Spud Barge	3	0	2	1	0	**2**	**1**	3.9	2	0.450	0.00	1.13
Trawl/Fishing Net	5	0	1	3	1	**1**	**4**	2.0	**1**	0.225	0.00	0.68
OPERATION IMPACT	**4**	**3**	**0**	**1**	**0**	**3**	**1**	**5.9**	**3**	**0.674**	**0.00**	**1.80**
Rig Anchoring	1	1	0	0	0	**1**	**0**	2.0	1	0.225	0.00	0.68
Work Boat Anchoring	3	2	0	1	0	**2**	**1**	3.9	2	0.450	0.00	1.58
MECHANICAL	**3**	**0**	**3**	**0**	**0**	**3**	**0**	**5.9**	**3**	**0.674**	**0.00**	**1.80**
Connection Failure	2	0	2	0	0	**2**	**0**	3.9	2	0.450	0.00	1.13
Material Failure	1	0	1	0	0	**1**	**0**	2.0	1	0.225	0.00	0.68
NATURAL HAZARD	**28**	**9**	**15**	**4**	**0**	**24**	**4**	**47.0**	**24**	**5.394**	**3.60**	**7.64**
Mud Slide	3	1	1	1	0	**2**	**1**	3.9	2	0.450	0.00	1.13
Storm/Hurricane	25	8	14	3	0	**22**	**3**	43.1	22	4.945	3.15	7.19
ARCTIC	*Calculated as part of Monte Carlo Assessment*											
Ice Gouging												
Strudel Scour												
Upheaval Buckling												
Thaw Settlement												
Other Arctic												
UNKNOWN	**11**	**1**	**7**	**2**	**1**	**8**	**3**	**15.7**	**8**	**1.798**	**0.67**	**3.37**
TOTALS	**70**	**16**	**35**	**15**	**4**	**51**	**19**	**100.0**	**51.0**	**11.463**	**8.77**	**14.61**

[1] Table 9 GOM and PAC pipeline hydrocarbon spill statistics by cause (1972 to 2017) (ABSG, 2018)

[2] Table 13 Confidence intervals for GOM and PAC pipeline hydrocarbon spill statistics by cause (1972 to 2017) (ABSG, 2018)

Table 2 presents the historical data of GOM and PAC pipeline oil spill statistics[1], and the confidence intervals[2], by cause for substantial pipeline oil (≥1,000 bbl spill) from the previous BOEM OCS study (ABSG, 2018). The major contributors to substantial spills are third-party impacts at 52.7% and natural hazards at 21.1%.

Table 2: GOM and PAC Pipeline Oil Spill Statistics and Confidence Intervals by Cause - Substantial Spill

Cause Classification	# of Spills	Number of Spills						Substantial Spills (>=1,000 bbl)				
		S	M	L	H	SM	LH	Dist %	# Spills	Frequency [per 10^5km-yr]	Min	Max
CORROSION	**4**	**1**	**2**	**1**	**0**	**3**	**1**	**5.3**	**1**	**0.225**	**0.00**	**0.68**
External	1	1	0	0	0	**1**	**0**	0.0	0	0.000	0.00	0.23
Internal	3	0	2	1	0	**2**	**1**	5.3	1	0.225	0.00	0.68
THIRD PARTY IMPACT	**20**	**2**	**8**	**7**	**3**	**10**	**10**	**52.7**	**10**	**2.248**	**1.12**	**3.82**
Anchor Impact	12	2	5	3	2	**7**	**5**	26.3	5	1.124	0.22	2.47
Jack-up Rig or Spud Barge	3	0	2	1	0	**2**	**1**	5.3	1	0.225	0.00	0.68
Trawl/Fishing Net	5	0	1	3	1	**1**	**4**	21.1	4	0.899	0.22	2.25
OPERATION IMPACT	**4**	**3**	**0**	**1**	**0**	**3**	**1**	**5.3**	**1**	**0.225**	**0.00**	**0.68**
Rig Anchoring	1	1	0	0	0	**1**	**0**	0.0	0	0.000	0.00	0.23
Work Boat Anchoring	3	2	0	1	0	**2**	**1**	5.3	1	0.225	0.00	0.68
MECHANICAL	**3**	**0**	**3**	**0**	**0**	**3**	**0**	**0.0**	**0**	**0.000**	**0.00**	**0.23**
Connection Failure	2	0	2	0	0	**2**	**0**		0	0.000	0.00	0.23
Material Failure	1	0	1	0	0	**1**	**0**		0	0.000	0.00	0.23
NATURAL HAZARD	**28**	**9**	**15**	**4**	**0**	**24**	**4**	**21.1**	**4**	**0.899**	**0.22**	**2.25**
Mud Slide	3	1	1	1	0	**2**	**1**	5.3	1	0.225	0.00	0.68
Storm/Hurricane	25	8	14	3	0	**22**	**3**	15.8	3	0.674	0.00	1.80
ARCTIC	*Calculated as part of Monte Carlo Assessment*											
Ice Gouging												
Strudel Scour												
Upheaval Buckling												
Thaw Settlement												
Other Arctic												
UNKNOWN	**11**	**1**	**7**	**2**	**1**	**8**	**3**	**15.8**	**3**	**0.674**	**0.00**	**1.80**
TOTALS	**70**	**16**	**35**	**15**	**4**	**51**	**19**	**100.2**	**19.0**	**4.271**	**2.70**	**6.29**

[1] Table 9 GOM and PAC pipeline hydrocarbon spill statistics by cause (1972 to 2017) (ABSG, 2018)

[2] Table 13 Confidence intervals for GOM and PAC pipeline hydrocarbon spill statistics by cause (1972 to 2017) (ABSG, 2018)

2.3.2 Arctic Effects Historical Data on Pipelines

Arctic effects are unique causal effects to pipelines in the Alaska OCS; for example, ice gouging, strudel scour, upheaval buckling, thaw settlement, and other arctic effects:

- Ice gouging occurs when floating sea ice drifts into shallower areas and the keel comes into contact with the seabed. This results in a long, narrow gouge on the seabed. In general, ice gouging occurs at a shallow or medium water depth; therefore, ice gouging effects have not been calculated for deeper water scenarios.
- Strudel scour occurs when river water flow on top of sea ice and drains through a hole in the ice. The resulting vortex creates scours on the seabed. Strudel scour occurs only in the shallow nearshore area.
- Upheaval buckling occurs when a pipeline expands in the axial direction buckles upwards due to thermal expansion. There is no analytical method for calculating the probability of upheaval buckling. For the purpose of this analysis, it has been assumed that upheaval buckling will occur 20% as often as strudel scour. Further, upheaval buckling is independent of water depth; therefore, the same value is used no matter the water depth.
- Thaw settlement occurs when a buried pipeline in permafrost thaws the soil around it and settles as the thawed soil consolidates. As there is no analytical method for calculating thaw settlement rates, it has been assumed that thaw settlement occurs 10% as often as strudel scour.
- Other arctic effects include arctic factors which could lead to an oil spill. It has been assumed that other arctic pipeline effects occur at 10% of the sum of all pipeline arctic effects.

A more detailed description of artic effects, including additional references to scholarly articles, and be found in a previous analysis for the Beaufort Sea[3] (Bercha Group, 2008).

ABSG utilized a previous report for the Beaufort Sea[4] (Bercha Group, 2008), as a starting point for the Monte Carlo assessment. Four water depths have been considered in this analysis: nearshore (i.e., water depths of <10 m), inner shelf (i.e., water depths of 10-24 m), middle shelf (i.e., water depths 25-60 m), and outer shelf (i.e., water depths of > 60 m). For the purpose of this assessment, ABSG has assumed that the frequency of middle shelf and outer shelf operations are equivalent.

[3] Section 2.5 Arctic Effect Historical Data (Bercha Group, 2008)
[4]Table 2.11 Summary of Pipeline Unique Arctic Effect Inputs (Bercha Group, 2008)

Table 3 presents the data for arctic effects utilized for this analysis. The mode of each arctic effect denotes the average frequency increment per 10^5 km-yr while the min and max denote the confidence intervals.

Table 3: Arctic Effects Data for Pipeline Oil Spills[4] (Bercha Group, 2008)

Cause Classification	Spill Size	Frequency Increment per 10^5 km-yr								
		Nearshore			Inner Shelf			Middle/Outer Shelf		
		Min	Mode	Max	Min	Mode	Max	Min	Mode	Max
Ice Gouging	S	0.0087	0.1054	1.2841	0.0108	0.1318	1.6051			
	M	0.0087	0.1054	1.2841	0.0108	0.1318	1.6051			
	L	0.0216	0.2635	3.2103	0.0270	0.3294	4.0128			
	H	0.0043	0.0527	0.6421	0.0054	0.0659	0.8026			
Strudel Scour	S	0.0110	0.0235	0.1381						
	M	0.0110	0.0235	0.1381						
	L	0.0276	0.0587	0.3452						
	H	0.0055	0.0117	0.0690						
Upheaval Buckling	S	0.00221	0.00469	0.02761	0.00221	0.00469	0.02761	0.00221	0.00469	0.02761
	M	0.00221	0.00469	0.02761	0.00221	0.00469	0.02761	0.00221	0.00469	0.02761
	L	0.00552	0.01174	0.06904	0.00552	0.01174	0.06904	0.00552	0.01174	0.06904
	H	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381
Thaw Settlement	S	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381
	M	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381	0.00110	0.00235	0.01381
	L	0.00276	0.00587	0.03452	0.00276	0.00587	0.03452	0.00276	0.00587	0.03452
	H	0.00055	0.00117	0.00690	0.00055	0.00117	0.00690	0.00055	0.00117	0.00690
Other Arctic	S	0.00230	0.01359	0.14636	0.00141	0.01388	0.16466	0.00033	0.00070	0.00414
	M	0.00230	0.01359	0.14636	0.00141	0.01388	0.16466	0.00033	0.00070	0.00414
	L	0.00575	0.03398	0.3659	0.00353	0.03470	0.41164	0.00083	0.00176	0.01036
	H	0.00115	0.00680	0.07318	0.00071	0.00694	0.08233	0.00017	0.00035	0.00207

[4]Table 2.11 Summary of Pipeline Unique Arctic Effect Inputs (Bercha Group, 2008)

2.3.3 Deviations from Historical Data

Occurrence rates were adjusted to account for conditions in the Alaska OCS that reduce the likelihood of oil spills, such as lower vessel traffic, fewer operations, and a lower potential for storms in the arctic region versus the GOM and PAC. Table 4 details the assumptions made for various parameters.

Table 4: Deviations from Historical Causal Data of GOM and PAC Pipeline Oil Spills and Arctic Effects

Cause Classification	Water Depth	Reduction in Variable			Reasoning, Basis for Assumption
		Min	Mode	Max	
Corrosion					
External Corrosion	All	0%	-40%	-20%	Low temperature environment – limited biological and chemical effects are expected.
Internal Corrosion	All	0%	-40%	-20%	Increased inspection expected
Third-Party Impact					
Anchor Impact	All	-90%	-50%	-20%	Low traffic environment
Jack-up Rig or Spud Barge	All	-90%	-50%	-20%	Limited operations in area compared to Gulf of Mexico (GOM)
Trawl/Fishing Net	Nearshore	-90%	-50%	-20%	Low fishing activity
	Inner Shelf	-90%	-60%	-20%	Low fishing activity, less risk at lower depths
	Middle/Outer Shelf	-90%	-70%	-20%	Low fishing activity, less risk at lower depths
Operational Impacts					
Rig Anchoring	All	-50%	-20%	-10%	Ice season will preclude most marine traffic for a portion of the year and limit marine traffic during the open water season compared to the GOM and PAC
Work Boat Anchoring	All	-50%	-20%	-10%	Ice season will preclude most marine traffic for a portion of the year and limit marine traffic during the open water season compared to the GOM and PAC
Mechanical					
Connection Failure	All	--	--	--	No change due to Arctic environment
Material Failure	All	--	--	--	No change due to Arctic environment
Natural Hazards					
Mud Slide	Nearshore	-90%	-60%	-10%	Mud slide potential is low at nearshore and inner shelf depths
	Inner Shelf	-90%	-60%	-10%	
	Middle/Outer Shelf	-90%	-40%	-10%	Mud slide potential increases with depth
Storm/Hurricane	Nearshore	-90%	-80%	-10%	Fewer severe storms
	Inner Shelf	-90%	-80%	-10%	
	Middle/Outer Shelf	-90%	-70%	-10%	Fewer severe storms but effects more intense in deep water
Arctic Effects					
Ice Gouging	All	0%	0%	0%	No reduction assumed; arctic effects are derived variables based on hazards which are unique to the arctic. For additional detail on the derivation of these parameters, see previous report (Bercha Group, 2008)
Strudel Scour	All	0%	0%	0%	
Upheaval Buckling	All	0%	0%	0%	
Thaw Settlement	All	0%	0%	0%	
Other Arctic	All	0%	0%	0%	

2.4 PLATFORM OIL SPILLS

2.4.1 Historical Causal Data of GOM and PAC Platform Oil Spills

Table 5 presents the historical data of GOM and PAC platform oil spill statistics[5] and the confidence intervals[6], by cause for small and medium platform oil spills (50-999 bbl spill) from the previous BOEM OCS study (ABSG, 2018). The major contributors to small and medium platform oil spills are hurricanes (i.e., natural hazards) at 48.9% and equipment failures at 30.5%.

Table 5: GOM and PAC Platform Oil Spill Statistics and Confidence Intervals by Cause - Small and Medium Platform Spill

Cause Classification	# of Spills	Number of Spills						Small and Medium Spills (50-999 bbl)				
		S	M	L	H	SM	LH	Dist %	# Spills	Frequency [per 10^4 well-yr]	Min	Max
EQUIPMENT FAILURE	44	25	18	1	0	43	1	30.5	43	1.56	1.30	2.28
HUMAN ERROR	16	6	10	0	0	16	0	11.3	16	0.58	0.41	1.02
TANK FAILURE	0	0	0	0	0	0	0	0.0	0	0.00	0.00	0.00
SHIP COLLISION	1	0	1	0	0	1	0	0.7	1	0.04	0.04	0.12
WEATHER	7	1	4	2	0	5	2	3.5	5	0.18	2.24	0.45
HURRICANE	73	29	40	4	0	69	4	48.9	69	2.51	0.12	3.46
OTHER	8	1	6	0	1	7	1	5.0	7	0.25	0.12	0.57
ARCTIC	*Calculated as part of Monte Carlo Assessment*											
Ice Force												
Facility Low Temperature												
Other Arctic												
TOTALS	149	62	79	7	1	141	8	100.0	141	5.13	4.97	6.64

[5] Table 5 GOM and PAC OCS platform hydrocarbon spill statistics by cause (1972 to 2017) (ABSG, 2018)

[6] Table 11 Confidence intervals for GOM and PAC OCS platform hydrocarbon spill statistics (1972 to 2017) (ABSG, 2018)

Table 6 presents the historical data of GOM and PAC platform oil spill statistics[5], and the confidence intervals[6], by cause for substantial platform oil spills (≥1,000 bbl spill) from the previous BOEM OCS study (ABSG, 2018). The major causal factor contributors to substantial platform oil spills are hurricanes at 50% and other weather related issues at 25%.

Table 6: GOM and PAC Platform Oil Spill Statistics and Confidence Intervals by Cause - Substantial Platform Spill

Cause Classification	# of Spills	Number of Spills						Substantial Spills (>=1,000 bbl)				
		S	M	L	H	SM	LH	Dist %	# Spills	Frequency [per 10^4 well-yr]	Min	Max
EQUIPMENT FAILURE	44	25	18	1	0	43	1	12.5	1	0.04	0.00	0.12
HUMAN ERROR	16	6	10	0	0	16	0	0.0	0	0.00	0.00	0.04
TANK FAILURE	0	0	0	0	0	0	0	0.0	0	0.00	0.00	0.00
SHIP COLLISION	1	0	1	0	0	1	0	0.0	0	0.00	0.00	0.04
WEATHER	7	1	4	2	0	5	2	25.0	2	0.07	0.00	0.20
HURRICANE	73	29	40	4	0	69	4	50.0	4	0.15	0.04	0.41
OTHER	8	1	6	0	1	7	1	12.5	1	0.04	0.00	0.12
ARCTIC	*Calculated as part of Monte Carlo Assessment*											
Ice Force												
Facility Low Temperature												
Other Arctic												
TOTALS	149	62	79	7	1	141	8	100.0	8.0000	0.29	0.12	0.61

[5] Table 5 GOM and PAC OCS platform hydrocarbon spill statistics by cause (1972 to 2017) (ABSG, 2018)
[6] Table 11 Confidence intervals for GOM and PAC OCS platform hydrocarbon spill statistics (1972 to 2017) (ABSG, 2018)

2.4.2 Arctic Effects Historical Data on Platforms

Arctic effects unique to platforms in the Alaska OCS include ice forces, low facility temperatures;

- The impact of ice forces on a platform in the arctic is approximated by the ice force arctic effect. It has been assumed that platforms are designed for a 10,000 year return period with a reliability level of 96%, in accordance with (ISO, 2006)[11]. Meaning that 4% of the time, the 10,000 year return period ice force can cause an oil spill. It was further assumed that 85% oil spills are small/medium while the remaining 15% are substantial, as per previous analyses[7] (Bercha Group, 2008).
- Facility low temperature is assumed to be a percentage of the historical causal frequencies. It was assumed that facility low temperatures would cause small/medium oil spills 6% of the total historical small/medium oil spill frequency, while facility low temperature would cause substantial spills 3% of the total historical substantial spill frequency, as per previous analyses[7] (Bercha Group, 2008).
- Other arctic effects include arctic factors which could lead to an oil spill. It has been assumed that other arctic platform effects occur at 10% of the sum of all platform arctic effects.

Table 7 presents the data for arctic effects. For arctic effects, ABS Consulting utilized a previous report for the Beaufort Sea report (Bercha Group, 2008) as a starting point for the Monte Carlo assessment.

Table 7: Arctic Effects for Platform Oil Spills[8] (Bercha Group, 2008)

Cause Classification	Spill Size	Frequency Increment per 10^4 well-yr								
		Nearshore			Inner Shelf			Middle/Outer Shelf		
		Min	Mode	Max	Min	Mode	Max	Min	Mode	Max
Ice Force	SM	0.003	0.034	0.34	0.005	0.051	0.510	0.008	0.077	0.765
	LH	0.001	0.006	0.060	0.001	0.009	0.090	0.001	0.014	0.135
Facility Low Temp	SM	0.049	0.099	0.148	0.049	0.099	0.148	0.049	0.099	0.148
	LH	0.008	0.016	0.025	0.008	0.016	0.025	0.008	0.016	0.025
Other Arctic	SM	0.005	0.013	0.049	0.005	0.015	0.066	0.006	0.018	0.091
	LH	0.001	0.002	0.008	0.001	0.003	0.011	0.001	0.003	0.016

[7] Section 2.5.6 Platform Arctic Unique Effects
[8] Table 2.12 Summary of Platform Unique Arctic Effect Inputs (Bercha Group, 2008)
[11] Section 7.2.2.3 WG8, Arctic Structures, Reliability, Chapter 7 (IS)

2.4.3 Deviation from Historical Data

Occurrence rates were adjusted to account for conditions in the Alaska OCS that reduce the likelihood of oil spills, such as lower vessel traffic, fewer operations, and a lower potential for storms in the arctic region versus the GOM and PAC. Table 8 details the assumptions made for various parameters.

Table 8: Deviations from Historical Causal Data of GOM and PAC Platform Oil Spills and Arctic Effects

Cause Classification	Water Depth	Reduction in Variable			Reasoning, Basis for Assumption
		Min	Mode	Max	
Equipment Failure	All	-60%	-30%	-10%	Industry practices are more robust – increased inspection and maintenance
Human Error	All	-60%	-20%	-10%	More qualified personnel for arctic application
Ship Collision	All	-60%	-50%	-10%	Low traffic environment
Weather	All	10%	20%	30%	Cold temperatures, cycling
Hurricane	Nearshore	-90%	-80%	-10%	Fewer severe storms
	Inner Shelf	-90%	-80%	-10%	
	Middle/Outer Shelf	-90%	-70%	-10%	Fewer severe storms but effects more intense in deep water
Other	All	--	--	--	No change due to Arctic environment
Arctic Effects					
Ice Force	All	0%	0%	0%	No reduction assumed; arctic effects are derived variables based on hazards which are unique to the arctic. For additional detail on the derivation of these parameters, see previous report (Bercha Group, 2008)
Facility Low Temperature	All	0%	0%	0%	
Other Arctic	All	0%	0%	0%	

2.5 LOSS OF WELL CONTROL

2.5.1 Historical Data

The scenarios considered under this analysis include exploration wells, development wells, and production wells. Although most of the Loss of Well Control (LOWC) oil spills are small, an additional spill volume category "enormous" is added to indicate oil spill volumes greater than 150,000 bbl. Enormous spills have been included only for wells because other OCS spill sources do not have the potential to reach an enormous spill volume.

Table 9 presents the distribution and frequency of historical oil spills for LOWC events in (Bercha Group, 2008) and (Bercha Group, 2013) . The loss of well control data presented below was used as a starting point for the Monte Carlo assessment.

Table 9: Loss of Well Control Oil Spill Frequencies and Confidence Intervals

Event	Spill Size	Frequency	Min [90% CI]	Max [90% CI]
Production Well [per 10^4 well-years)	Small/Medium	0.147	**0.066**	**0.227**
	Large	1.028	**0.460**	**1.588**
	Huge	0.441	**0.197**	**0.681**
	Enormous	0.294	**0.132**	**0.454**
	Total	1.91	**0.86**	**2.95**
Exploration Well [per 10^4 wells]	Small/Medium	1.966	**0.863**	**4.002**
	Large	13.754	**6.039**	**28.001**
	Huge	5.909	**2.595**	**12.031**
	Enormous	3.421	**1.502**	**6.965**
	Total	25.05	**11.00**	**51.00**
Development Well (Drilling) [per 10^4 wells]	Small/Medium	0.654	**0.286**	**1.151**
	Large	4.570	**1.998**	**8.041**
	Huge	1.963	**0.858**	**3.454**
	Enormous	1.963	**0.858**	**3.454**
	Total	4.00	**9.15**	**16.10**

2.5.2 Deviation from Historical Data

Occurrence rates were adjusted to account for conditions that reduce the likelihood of oil spills, such as advances in technology and increased monitoring. Table 10 details the assumptions made for various parameters.

Table 10: Deviations from Historical Data of Loss of Well Control

Cause Classification	Water Depth	Reduction in Variable			Reasoning, Basis for Assumption
		Min	Mode	Max	
Production Well	Nearshore	-60%	-30%	-10%	State of the art now, high QC, high inspection/maintenance
	Inner Shelf	-40%	-20%	-10%	Qualified drilling contractor, better logistic support in shallower water
	Middle/Outer Shelf	-20%	-10%	-5%	
Exploration Well	Nearshore	-60%	-30%	-10%	State of the art now, high QC, high inspection/maintenance
	Inner Shelf	-40%	-20%	-10%	Qualified drilling contractor, better logistic support in shallower water
	Middle/Outer Shelf	-20%	-10%	-5%	
Development Well (Drilling)	Nearshore	-60%	-30%	-10%	State of the art now, high QC, high inspection/maintenance
	Inner Shelf	-40%	-20%	-10%	Qualified drilling contractor, better logistic support in shallower water
	Middle/Outer Shelf	-20%	-10%	-5%	

2.6 HISTORICAL OIL SPILL SIZE DISTRIBUTIONS

ABS Consulting completed a Monte Carlo assessment for the historical spill size based off the spill range (low, high) and the average ([low + high]/2). The expected spill for each spill range is then estimated from the Monte Carlo assessment. Table 11 details the historical expected oil spill size distribution parameters used for Monte Carlo modeling.

Table 11: Historical Oil Spill Size Distribution Parameters for Modeling

Spill Size	Small Spill (50-99 bbl)			Medium Spill (100-999 bbl)			Large Spill (100-999 bbl)			Huge Spill (>=10,000 bbl)			Enormous Spill (>=150000bbl)		
Spill Expectation	Low	High	Exp	Low	High	Exp	Low	High	Exp	Low	High	Exp	Low	High	Exp
Pipeline Spill	50	99	71	100	999	464	1000	9999	4740	10000	20000	15460			
Platform Spill	50	99	74.7	100	999	531.1	1000	9999	5296.5	10000	20000	15033.5			
LOWC	50	99	75	100	999	538	1000	9999	5318	10000	149999	77369	150000	250000	200359

2.7 ADDITIONAL HISTORICAL DISTRIBUTION ASSUMPTIONS

ABSG also used additional historical distribution assumptions obtained from modeling and other sources. These assumptions are detailed in Table 12.

Table 12: Historical Distribution Assumptions used in Processing Results

Assumption Basis	Assumption
For all platform frequencies, the multiplication factor used to get from Small/medium and Large/huge from previous study[9] (ABSG, 2018), data is based off the distribution of historical data.	Small = Small/medium * 44.0% Medium = Small/medium * 56.0% Large = Large/huge * 87.5% Huge = Large/Huge * 12.5%
For all pipeline frequencies, the distribution of pipelines less than or equal to 10" in diameter and greater than 10" in diameter are based off the historical distribution of oil spill from pipelines ≤10" and >10" from previous study[10] (ABSG, 2018)	Pipeline >10" = 47.1% Pipeline ≤10" = 52.9%
For pipeline frequencies, the factor to get from Small/medium and Large/huge from previous study[10] (ABSG, 2018) data is based off the distribution of Monte Carlo data.	Small =- Small/medium * 32.1% Medium = Small/medium * 67.9% Large = Large/huge * 76.3% Huge = Large/huge * 23.7%

[9] Table 5 GOM and PAC OCS platform hydrocarbon spill statistics (1972 to 2017)
[10] Table 10 GOM and PAC pipeline hydrocarbon spill statistics by spill size and pipeline diameter (1972 to 2017)

3 FAULT TREE ASSESSMENT

3.1 FAULT TREE OVERVIEW

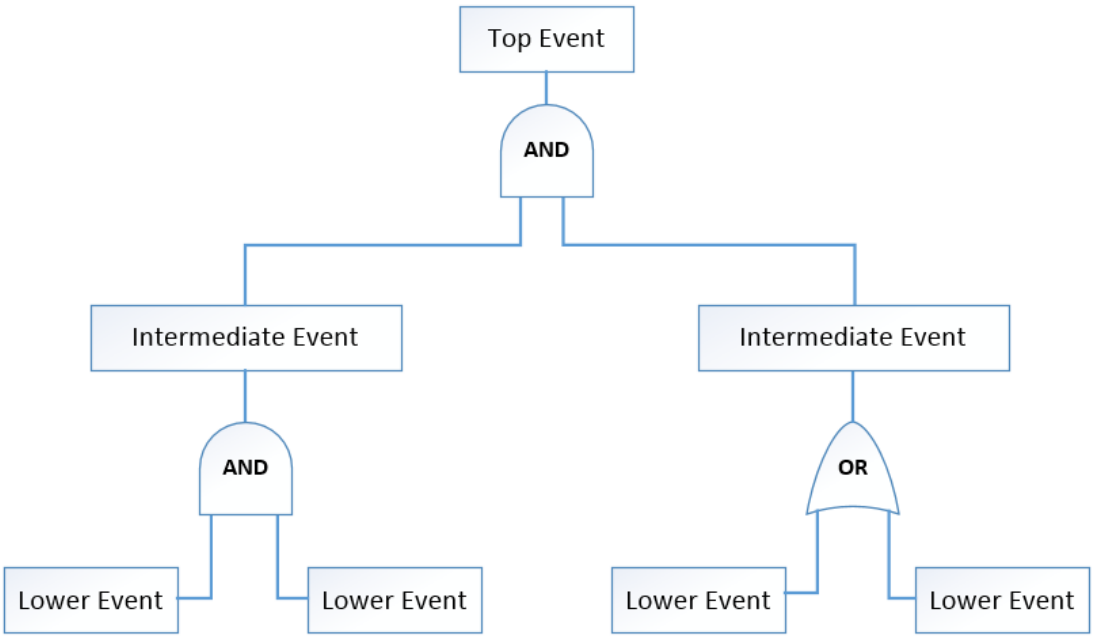
A fault tree analysis is a top down, deductive failure analysis in which an un-desired state, or upset condition of a system is specified and analyzed using Boolean logic to combine a series of lower-level events that can lead to a top or undesired state or upset condition. In other words, a fault tree is a graphical model which shows the various combinations of equipment failures and human errors that can lead to a particular event (e.g. a pipeline spill, platform spill, or loss well control). For example, Table 13 presents the total frequency of small pipeline spills based on water depth (i.e., nearshore, inner shelf, middle/outer shelf) and pipeline diameter (i.e., ≤10" or >10") for all initiating causes which have historically lead to pipeline spills (i.e., corrosion, third party impacts, natural hazards).

Fault trees consist of following objects:

- Top event
- Intermediate event
- Lower event
- "AND gate"
- "OR gate"

"AND" gate and "OR" gates are logic steps which either allows or prevent flow of fault logic to top or intermediate event. Figure 3 provides the basic overview of the fault tee structure.

Figure 3: Basic Fault Tree Structure



Higher-level event results from an AND gate only if all lower events exists simultaneously. The occurrence of a higher-level event from OR gates depends on existence of one or more lower event.

After construction of the fault tree, each input event is assigned a frequency. Following Boolean logic, the AND-gate represents the intersection of the events connected to the AND-gate and requires multiplication of the failure frequency. In simple terms, all events that are attached to AND-gates must exist for the higher-level event to occur.

The OR-gate represents the union of the events connected to the OR-gate and required summation of the failure frequency.

Using the above methodology, faults trees were constructed for the Pipeline, Platform and Loss of well control spill events. For this study, as casual factors are considered independent of each other, only OR gates are used to develop the fault tress.

Based on the data, the analysis depicts causal factors for each spill type are logically represented into the fault tree, for example:

- Pipeline Spills are top event that are caused by either corrosion (external or internal), third party impact (anchor impacts, jack-up rig impacts, or spud barge impacts), operational impacts (rig anchoring or workboat failures), mechanical failures (connection failures or material failures), natural hazards (mud slides or storms/hurricanes), or other events which are unique or novel.
- Platform Spills are events that are caused by either equipment failures, human errors, tank failures, ship collisions, weather related (other than hurricanes), hurricanes, or other events which are unique or novel.
- Loss of Well Control Spills are events which are tied to the type of well drilled (such as production well, exploration well, or development well).

Historical frequencies of root causes (also referred to as an initiating cause) are then used to determine the potential for an oil spill from a pipeline, platform, or well drilling operation. For example, the historical frequency of a small spill from a pipeline less than or equal to 10 inches in diameter due to corrosion is 0.0591 per 10^5 km-yr, which is the sum of external corrosion initiating causes (0.034 per 10^5 km-yr) and internal corrosion initiating causes (0.0251 per 10^5 km-yr).

The sum of all root causes defines the total oil spill frequency for a pipeline, platform, or well drilling operation. For example, the historical frequency of all small spills from a pipeline less than or equal to 10 inches in diameter due to all causes (e.g., corrosion, third party impacts, operational impacts, mechanical impacts, natural hazards, and other hazards) is 1.4193 per 10^5 km-yr, which is the sum of corrosion initiating causes (0.0591 per 10^5 km-yr), third party impact initiating causes (0.3060 per 10^5 km-yr), operational impact initiating causes (0.1020 per 10^5 km-yr), mechanical impact initiating causes (0.1020 per 10^5 km-yr), natural hazard initiating causes (0.5781 per 10^5 km-yr), and other initiating causes (0.2720 per 10^5 km-yr).

Figure 4 through Figure 9 illustrates fault trees developed for this study.

3.2 MONTE CARLO OVERVIEW

ABSG utilized a Monte Carlo assessment to account for the uncertainties in the collected data. Monte Carlo assessments rely on repeated random sampling and a computer algorithm to obtain numerical results.

A triangular distribution was used to calculate the results from each Monte Carlo run. A random number is generated and compared to the ratio of the mean, max, and min to determine if the normalized random number is less than or greater than the mean. The location of the data point along the triangular distribution is then calculated. More specifically, consider the following equations:

$$if\ \ MCRAND\ \leq \frac{Mean\ -\ Min}{Max\ -\ Min} \qquad Min + \sqrt{MCRAND\ *\left(Max\ -\ Min\right)\left(Mean\ -\ Min\right)}$$

$$if\ \ MCRAND\ > \frac{Mean\ -\ Min}{Max\ -\ Min} \qquad Max - \sqrt{\left(1 - MCRAND\ \right)\left(Max\ -\ Min\right)\left(Max\ -\ Mean\right)}$$

Where:

MCRAND	Random number generated by Monte Carlo simulator
Mean	Average value of the dataset
Max	Maximum value of the dataset
Min	Minimum value of the dataset

The maximum and minimum values around the mean are defined by the confidence interval of each frequency which was calculated for each parameter as part of a previous analysis. The results of the Monte Carlo Assessment can be viewed as a cumulative distribution function (CDF) whereby the CDF defines the accuracy or variance of the calculations. ABSG has determined the CDF for each variable and included the results as part of Appendix A – Monte Carlo Results.

3.3 PIPELINE SPILLS

Figure 4 presents the fault tree results for a small pipeline spill (50-99 bbl) while Table 13 presents a tabulated summary of results. Figure 5, Figure 6, and Figure 7 present the results of for a medium pipeline spill (100-999 bbl), a large pipeline spill (1000-9,999 bbl), and a huge pipeline spill (>=10,000 bbl), respectively. Table 14, Table 15, and Table 16 present the tabulated summary of results for medium, large and huge pipeline spills.

Figure 4: Small Pipeline Spill Fault Tree Results

Pipeline, Small Spill: 50 - 99 bbls	All	Dia <=10"	Dia >10"
Hist.	3.0143	1.4193	1.5950
Nearshore	3.4106	1.6059	1.8047
Inner	3.4662	1.6321	1.8341
Middle/Outer	2.8882	1.3600	1.5283

Corrosion	All	Dia <=10"	Dia >10"
Hist.	0.1256	0.0591	0.0665
Nearshore	0.1987	0.0936	0.1052
Inner	0.1987	0.0936	0.1052
Middle/Outer	0.1987	0.0936	0.1052

Third Party Impact	All	Dia <=10"	Dia >10"
Hist.	0.6500	0.3060	0.3439
Nearshore	0.5503	0.2591	0.2912
Inner	0.5488	0.2584	0.2904
Middle/Outer	0.5454	0.2568	0.2886

Operational Impact	All	Dia <=10"	Dia >10"
Hist.	0.2167	0.1020	0.1146
Nearshore	0.2452	0.1154	0.1297
Inner	0.2452	0.1154	0.1297
Middle/Outer	0.2452	0.1154	0.1297

Mechanical	All	Dia <=10"	Dia >10"
Hist.	0.2167	0.1020	0.1146
Nearshore	0.2676	0.1260	0.1416
Inner	0.2676	0.1260	0.1416
Middle/Outer	0.2676	0.1260	0.1416

Natural Hazard	All	Dia <=10"	Dia >10"
Hist.	1.2277	0.5781	0.6496
Nearshore	0.9251	0.4356	0.4895
Inner	0.9324	0.4391	0.4934
Middle/Outer	0.9860	0.4643	0.5217

Other	All	Dia <=10"	Dia >10"
Hist.	0.5778	0.2720	0.3057
Nearshore	0.6260	0.2948	0.3313
Inner	0.6260	0.2948	0.3313
Middle/Outer	0.6260	0.2948	0.3313

Arctic	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.5976	0.2814	0.3162
Inner	0.6473	0.3048	0.3425
Middle/Outer	0.0192	0.0091	0.0102

External Corrosion	All	Dia <=10"	Dia >10"
Hist.	0.0722	0.0340	0.0382
Nearshore	0.0713	0.0336	0.0377
Inner	0.0713	0.0336	0.0377
Middle/Outer	0.0713	0.0336	0.0377

Anchor Impact	All	Dia <=10"	Dia >10"
Hist.	0.5055	0.2380	0.2675
Nearshore	0.3584	0.1687	0.1896
Inner	0.3584	0.1687	0.1896
Middle/Outer	0.3584	0.1687	0.1896

Rig Anchoring	All	Dia <=10"	Dia >10"
Hist.	0.0722	0.0340	0.0382
Nearshore	0.0755	0.0356	0.0400
Inner	0.0755	0.0356	0.0400
Middle/Outer	0.0755	0.0356	0.0400

Connection Failure	All	Dia <=10"	Dia >10"
Hist.	0.1444	0.0680	0.0764
Nearshore	0.1704	0.0802	0.0902
Inner	0.1704	0.0802	0.0902
Middle/Outer	0.1704	0.0802	0.0902

Mud Slide	All	Dia <=10"	Dia >10"
Hist.	0.1444	0.0680	0.0764
Nearshore	0.1258	0.0592	0.0666
Inner	0.1331	0.0627	0.0704
Middle/Outer	0.1374	0.0647	0.0727

Ice Gouging	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.4709	0.2218	0.2492
Inner	0.5694	0.2681	0.3013
Middle/Outer	0.0000	0.0000	0.0000

Internal Corrosion	All	Dia <=10"	Dia >10"
Hist.	0.0534	0.0251	0.0282
Nearshore	0.1275	0.0600	0.0674
Inner	0.1275	0.0600	0.0674
Middle/Outer	0.1275	0.0600	0.0674

Jackup Rig or Spud Barge	All	Dia <=10"	Dia >10"
Hist.	0.1444	0.0680	0.0764
Nearshore	0.1218	0.0574	0.0644
Inner	0.1218	0.0574	0.0644
Middle/Outer	0.1218	0.0574	0.0644

Work Boat Failure	All	Dia <=10"	Dia >10"
Hist.	0.1444	0.0680	0.0764
Nearshore	0.1696	0.0799	0.0898
Inner	0.1696	0.0799	0.0898
Middle/Outer	0.1696	0.0799	0.0898

Material Failure	All	Dia <=10"	Dia >10"
Hist.	0.0722	0.0340	0.0382
Nearshore	0.0972	0.0458	0.0514
Inner	0.0972	0.0458	0.0514
Middle/Outer	0.0972	0.0458	0.0514

Storm/Hurricane	All	Dia <=10"	Dia >10"
Hist.	1.0833	0.5101	0.5732
Nearshore	0.7994	0.3764	0.4230
Inner	0.7994	0.3764	0.4230
Middle/Outer	0.8486	0.3996	0.4490

Strudel Scour	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0569	0.0268	0.0301
Inner	0.0000	0.0000	0.0000
Middle/Outer	0.0000	0.0000	0.0000

Trawl/Fishing Net	All	Dia <=10"	Dia >10"
Hist.	0.0722	0.0340	0.0382
Nearshore	0.0701	0.0330	0.0371
Inner	0.0687	0.0323	0.0363
Middle/Outer	0.0652	0.0307	0.0345

Upheaval Buckling	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0116	0.0055	0.0062
Inner	0.0118	0.0056	0.0062
Middle/Outer	0.0117	0.0055	0.0062

Thaw Settlement	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0057	0.0027	0.0030
Inner	0.0058	0.0028	0.0031
Middle/Outer	0.0058	0.0027	0.0031

Other Arctic	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0523	0.0246	0.0277
Inner	0.0603	0.0284	0.0319
Middle/Outer	0.0017	0.0008	0.0009

Table 13: Summary of Frequency Results for Small Pipeline Spills

Cause	% Dist	Pipeline Diameter <=10"										Pipeline Diameter >10"									
		Freq per 10^5 km-yr	Nearshore			Inner Shelf			Middle/Outer Shelf			Freq per 10^5 km-yr	Nearshore			Inner Shelf			Middle/Outer Shelf		
			Change	MC Freq	MC %	Change	MC Freq	MC %	Change	MC Freq	MC %		Change	MC Freq	MC %	Change	MC Freq	MC %	Change	MC Freq	MC %
Corrosion	**6.8%**	**0.102**	**(0.008)**	**0.094**	**5.8%**	**(0.008)**	**0.094**	**5.7%**	**(0.008)**	**0.094**	**6.9%**	**0.115**	**(0.009)**	**0.105**	**5.8%**	**(0.009)**	**0.105**	**5.7%**	**(0.009)**	**0.105**	**6.9%**
External Corrosion	2.3%	0.034	(0.000)	0.034	2.1%	(0.000)	0.034	2.1%	(0.000)	0.034	2.5%	0.038	(0.000)	0.038	2.1%	(0.000)	0.038	2.1%	(0.000)	0.038	2.5%
Internal Corrosion	4.5%	0.068	(0.008)	0.060	3.7%	(0.008)	0.060	3.7%	(0.008)	0.060	4.4%	0.076	(0.009)	0.067	3.7%	(0.009)	0.067	3.7%	(0.009)	0.067	4.4%
Third Party Impact	**22.7%**	**0.340**	**(0.081)**	**0.259**	**16.1%**	**(0.082)**	**0.258**	**15.8%**	**(0.083)**	**0.257**	**18.9%**	**0.382**	**(0.091)**	**0.291**	**16.1%**	**(0.092)**	**0.290**	**15.8%**	**(0.094)**	**0.289**	**18.9%**
Anchor Impact	15.9%	0.238	(0.069)	0.169	10.5%	(0.069)	0.169	10.3%	(0.069)	0.169	12.4%	0.267	(0.078)	0.190	10.5%	(0.078)	0.190	10.3%	(0.078)	0.190	12.4%
Jackup Rig or Spud Barge	4.5%	0.068	(0.011)	0.057	3.6%	(0.011)	0.057	3.5%	(0.011)	0.057	4.2%	0.076	(0.012)	0.064	3.6%	(0.012)	0.064	3.5%	(0.012)	0.064	4.2%
Trawl/Fishing Net	2.3%	0.034	(0.001)	0.033	2.1%	(0.002)	0.032	2.0%	(0.003)	0.031	2.3%	0.038	(0.001)	0.037	2.1%	(0.002)	0.036	2.0%	(0.004)	0.035	2.3%
Operation Impact	**6.8%**	**0.102**	**0.013**	**0.115**	**7.2%**	**0.013**	**0.115**	**7.1%**	**0.013**	**0.115**	**8.5%**	**0.115**	**0.015**	**0.130**	**7.2%**	**0.015**	**0.130**	**7.1%**	**0.015**	**0.130**	**8.5%**
Rig Anchoring	2.3%	0.034	0.002	0.036	2.2%	0.002	0.036	2.2%	0.002	0.036	2.6%	0.038	0.002	0.040	2.2%	0.002	0.040	2.2%	0.002	0.040	2.6%
Work Boat Connection	4.5%	0.068	0.012	0.080	5.0%	0.012	0.080	4.9%	0.012	0.080	5.9%	0.076	0.013	0.090	5.0%	0.013	0.090	4.9%	0.013	0.090	5.9%
Mechanical	**6.8%**	**0.102**	**0.024**	**0.126**	**7.8%**	**0.024**	**0.126**	**7.7%**	**0.024**	**0.126**	**9.3%**	**0.115**	**0.027**	**0.142**	**7.8%**	**0.027**	**0.142**	**7.7%**	**0.027**	**0.142**	**9.3%**
Connection Failure	4.5%	0.068	0.012	0.080	5.0%	0.012	0.080	4.9%	0.012	0.080	5.9%	0.076	0.014	0.090	5.0%	0.014	0.090	4.9%	0.014	0.090	5.9%
Material Failure	2.3%	0.034	0.012	0.046	2.9%	0.012	0.046	2.8%	0.012	0.046	3.4%	0.038	0.013	0.051	2.9%	0.013	0.051	2.8%	0.013	0.051	3.4%
Natural Hazard	**38.6%**	**0.578**	**(0.142)**	**0.436**	**27.1%**	**(0.139)**	**0.439**	**26.9%**	**(0.114)**	**0.464**	**34.1%**	**0.650**	**(0.160)**	**0.490**	**27.1%**	**(0.156)**	**0.493**	**26.9%**	**(0.128)**	**0.522**	**34.1%**
Mud Slide	4.5%	0.068	(0.009)	0.059	3.7%	(0.005)	0.063	3.8%	(0.003)	0.065	4.8%	0.076	(0.010)	0.067	3.7%	(0.006)	0.070	3.8%	(0.004)	0.073	4.8%
Storm/Hurricane	34.1%	0.510	(0.134)	0.376	23.4%	(0.134)	0.376	23.1%	(0.111)	0.400	29.4%	0.573	(0.150)	0.423	23.4%	(0.150)	0.423	23.1%	(0.124)	0.449	29.4%
Arctic	**0.0%**	**0.000**	**0.281**	**0.281**	**17.5%**	**0.305**	**0.305**	**18.7%**	**0.009**	**0.009**	**0.7%**	**0.000**	**0.316**	**0.316**	**17.5%**	**0.343**	**0.343**	**18.7%**	**0.010**	**0.010**	**0.7%**
Ice Gouging	0.0%	0.000	0.222	0.222	13.8%	0.268	0.268	16.4%	0.000	0.000	0.0%	0.000	0.249	0.249	13.8%	0.301	0.301	16.4%	0.000	0.000	0.0%
Strudel Scour	0.0%	0.000	0.027	0.027	1.7%	0.000	0.000	0.0%	0.000	0.000	0.0%	0.000	0.030	0.030	1.7%	0.000	0.000	0.0%	0.000	0.000	0.0%
Upheaval Buckling	0.0%	0.000	0.005	0.005	0.3%	0.006	0.006	0.3%	0.006	0.006	0.4%	0.000	0.006	0.006	0.3%	0.006	0.006	0.3%	0.006	0.006	0.4%
Thaw Settlement	0.0%	0.000	0.003	0.003	0.2%	0.003	0.003	0.2%	0.003	0.003	0.2%	0.000	0.003	0.003	0.2%	0.003	0.003	0.2%	0.003	0.003	0.2%
Other Arctic	0.0%	0.000	0.025	0.025	1.5%	0.028	0.028	1.7%	0.001	0.001	0.1%	0.000	0.028	0.028	1.5%	0.032	0.032	1.7%	0.001	0.001	0.1%
Other	**18.2%**	**0.272**	**0.023**	**0.295**	**18.4%**	**0.023**	**0.295**	**18.1%**	**0.023**	**0.295**	**21.7%**	**0.306**	**0.026**	**0.331**	**18.4%**	**0.026**	**0.331**	**18.1%**	**0.026**	**0.331**	**21.7%**
Total	**100.0%**	**1.496**	**0.110**	**1.606**	**100.0%**	**0.136**	**1.632**	**100.0%**	**(0.136)**	**1.360**	**100.0%**	**1.681**	**0.123**	**1.805**	**100.0%**	**0.153**	**1.834**	**100.0%**	**(0.153)**	**1.528**	**100.0%**

Figure 5: Medium Pipeline Spill Fault Tree Results

Pipeline, Medium Spill: 100-999 bbls	All	Dia <=10"	Dia >10"
Hist.	6.3080	2.9702	3.3378
Nearshore	6.5414	3.0801	3.4613
Inner	6.6160	3.1152	3.5007
Middle/Outer	6.0796	2.8627	3.2169

Corrosion	All	Dia <=10"	Dia >10"
Hist.	0.2060	0.0970	0.1090
Nearshore	0.4198	0.1977	0.2221
Inner	0.4198	0.1977	0.2221
Middle/Outer	0.4198	0.1977	0.2221

Third Party Impact	All	Dia <=10"	Dia >10"
Hist.	1.3729	0.6465	0.7265
Nearshore	1.1624	0.5473	0.6151
Inner	1.1593	0.5459	0.6135
Middle/Outer	1.1521	0.5425	0.6096

Operational Impact	All	Dia <=10"	Dia >10"
Hist.	0.4576	0.2155	0.2422
Nearshore	0.5179	0.2439	0.2740
Inner	0.5179	0.2439	0.2740
Middle/Outer	0.5179	0.2439	0.2740

Mechanical	All	Dia <=10"	Dia >10"
Hist.	0.4576	0.2155	0.2422
Nearshore	0.5653	0.2662	0.2991
Inner	0.5653	0.2662	0.2991
Middle/Outer	0.5653	0.2662	0.2991

Natural Hazard	All	Dia <=10"	Dia >10"
Hist.	2.5933	1.2211	1.3722
Nearshore	1.9542	0.9202	1.0341
Inner	1.9697	0.9274	1.0422
Middle/Outer	2.0828	0.9807	1.1021

Other	All	Dia <=10"	Dia >10"
Hist.	1.2204	0.5747	0.6458
Nearshore	1.3224	0.6227	0.6997
Inner	1.3224	0.6227	0.6997
Middle/Outer	1.3224	0.6227	0.6997

Arctic	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.5992	0.2822	0.3171
Inner	0.6614	0.3114	0.3500
Middle/Outer	0.0192	0.0091	0.0102

External Corrosion	All	Dia <=10"	Dia >10"
Hist.	0.1526	0.0718	0.0807
Nearshore	0.1506	0.0709	0.0797
Inner	0.1506	0.0709	0.0797
Middle/Outer	0.1506	0.0709	0.0797

Anchor Impact	All	Dia <=10"	Dia >10"
Hist.	1.0679	0.5028	0.5650
Nearshore	0.7570	0.3564	0.4006
Inner	0.7570	0.3564	0.4006
Middle/Outer	0.7570	0.3564	0.4006

Rig Anchoring	All	Dia <=10"	Dia >10"
Hist.	0.1526	0.0718	0.0807
Nearshore	0.1596	0.0751	0.0844
Inner	0.1596	0.0751	0.0844
Middle/Outer	0.1596	0.0751	0.0844

Connection Failure	All	Dia <=10"	Dia >10"
Hist.	0.3051	0.1436	0.1614
Nearshore	0.3600	0.1695	0.1905
Inner	0.3600	0.1695	0.1905
Middle/Outer	0.3600	0.1695	0.1905

Mud Slide	All	Dia <=10"	Dia >10"
Hist.	0.3051	0.1436	0.1614
Nearshore	0.2657	0.1251	0.1406
Inner	0.2811	0.1324	0.1487
Middle/Outer	0.2903	0.1367	0.1536

Ice Gouging	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.4684	0.2206	0.2479
Inner	0.5841	0.2750	0.3091
Middle/Outer	0.0000	0.0000	0.0000

Internal Corrosion	All	Dia <=10"	Dia >10"
Hist.	0.0534	0.0251	0.0282
Nearshore	0.2692	0.1268	0.1425
Inner	0.2692	0.1268	0.1425
Middle/Outer	0.2692	0.1268	0.1425

Jackup Rig or Spud Barge	All	Dia <=10"	Dia >10"
Hist.	0.3051	0.1436	0.1614
Nearshore	0.2573	0.1211	0.1361
Inner	0.2573	0.1211	0.1361
Middle/Outer	0.2573	0.1211	0.1361

Work Boat Failure	All	Dia <=10"	Dia >10"
Hist.	0.3051	0.1436	0.1614
Nearshore	0.3583	0.1687	0.1896
Inner	0.3583	0.1687	0.1896
Middle/Outer	0.3583	0.1687	0.1896

Material Failure	All	Dia <=10"	Dia >10"
Hist.	0.1526	0.0718	0.0807
Nearshore	0.2053	0.0967	0.1087
Inner	0.2053	0.0967	0.1087
Middle/Outer	0.2053	0.0967	0.1087

Storm/Hurricane	All	Dia <=10"	Dia >10"
Hist.	2.2882	1.0775	1.2108
Nearshore	1.6885	0.7951	0.8935
Inner	1.6885	0.7951	0.8935
Middle/Outer	1.7925	0.8440	0.9485

Strudel Scour	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0593	0.0279	0.0314
Inner	0.0000	0.0000	0.0000
Middle/Outer	0.0000	0.0000	0.0000

Trawl/Fishing Net	All	Dia <=10"	Dia >10"
Hist.	0.1526	0.0718	0.0807
Nearshore	0.1481	0.0697	0.0784
Inner	0.1451	0.0683	0.0768
Middle/Outer	0.1378	0.0649	0.0729

Upheaval Buckling	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0114	0.0054	0.0060
Inner	0.0115	0.0054	0.0061
Middle/Outer	0.0116	0.0055	0.0061

Thaw Settlement	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0058	0.0027	0.0031
Inner	0.0059	0.0028	0.0031
Middle/Outer	0.0059	0.0028	0.0031

Other Arctic	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0543	0.0256	0.0287
Inner	0.0599	0.0282	0.0317
Middle/Outer	0.0017	0.0008	0.0009

Table 14 Summary of Frequency Results for Medium Pipeline Spills

Cause	% Dist	Pipeline Diameter <=10"										Pipeline Diameter >10"									
		Freq per 10^5 km-yr	Nearshore			Inner Shelf			Middle/Outer Shelf			Freq per 10^5 km-yr	Nearshore			Inner Shelf			Middle/Outer Shelf		
			Change	MC Freq	MC %	Change	MC Freq	MC %	Change	MC Freq	MC %		Change	MC Freq	MC %	Change	MC Freq	MC %	Change	MC Freq	MC %
Corrosion	**6.8%**	**0.215**	**(0.018)**	**0.198**	**6.4%**	**(0.018)**	**0.198**	**6.3%**	**(0.018)**	**0.198**	**6.9%**	**0.242**	**(0.020)**	**0.222**	**6.4%**	**(0.020)**	**0.222**	**6.3%**	**(0.020)**	**0.222**	**6.9%**
External Corrosion	2.3%	0.072	(0.001)	0.071	2.3%	(0.001)	0.071	2.3%	(0.001)	0.071	2.5%	0.081	(0.001)	0.080	2.3%	(0.001)	0.080	2.3%	(0.001)	0.080	2.5%
Internal Corrosion	4.5%	0.144	(0.017)	0.127	4.1%	(0.017)	0.127	4.1%	(0.017)	0.127	4.4%	0.161	(0.019)	0.142	4.1%	(0.019)	0.142	4.1%	(0.019)	0.142	4.4%
Third Party Impact	**22.7%**	**0.718**	**(0.171)**	**0.547**	**17.8%**	**(0.172)**	**0.546**	**17.5%**	**(0.176)**	**0.542**	**18.9%**	**0.807**	**(0.192)**	**0.615**	**17.8%**	**(0.194)**	**0.613**	**17.5%**	**(0.198)**	**0.610**	**18.9%**
Anchor Impact	15.9%	0.503	(0.146)	0.356	11.6%	(0.146)	0.356	11.4%	(0.146)	0.356	12.5%	0.565	(0.164)	0.401	11.6%	(0.164)	0.401	11.4%	(0.164)	0.401	12.5%
Jackup Rig or Spud Barge	4.5%	0.144	(0.023)	0.121	3.9%	(0.023)	0.121	3.9%	(0.023)	0.121	4.2%	0.161	(0.025)	0.136	3.9%	(0.025)	0.136	3.9%	(0.025)	0.136	4.2%
Trawl/Fishing Net	2.3%	0.072	(0.002)	0.070	2.3%	(0.004)	0.068	2.2%	(0.007)	0.065	2.3%	0.081	(0.002)	0.078	2.3%	(0.004)	0.077	2.2%	(0.008)	0.073	2.3%
Operation Impact	**6.8%**	**0.215**	**0.028**	**0.244**	**7.9%**	**0.028**	**0.244**	**7.8%**	**0.028**	**0.244**	**8.5%**	**0.242**	**0.032**	**0.274**	**7.9%**	**0.032**	**0.274**	**7.8%**	**0.032**	**0.274**	**8.5%**
Rig Anchoring	2.3%	0.072	0.003	0.075	2.4%	0.003	0.075	2.4%	0.003	0.075	2.6%	0.081	0.004	0.084	2.4%	0.004	0.084	2.4%	0.004	0.084	2.6%
Work Boat Connection	4.5%	0.144	0.025	0.169	5.5%	0.025	0.169	5.4%	0.025	0.169	5.9%	0.161	0.028	0.190	5.5%	0.028	0.190	5.4%	0.028	0.190	5.9%
Mechanical	**6.8%**	**0.215**	**0.051**	**0.266**	**8.6%**	**0.051**	**0.266**	**8.5%**	**0.051**	**0.266**	**9.3%**	**0.242**	**0.057**	**0.299**	**8.6%**	**0.057**	**0.299**	**8.5%**	**0.057**	**0.299**	**9.3%**
Connection Failure	4.5%	0.144	0.026	0.170	5.5%	0.026	0.170	5.4%	0.026	0.170	5.9%	0.161	0.029	0.190	5.5%	0.029	0.190	5.4%	0.029	0.190	5.9%
Material Failure	2.3%	0.072	0.025	0.097	3.1%	0.025	0.097	3.1%	0.025	0.097	3.4%	0.081	0.028	0.109	3.1%	0.028	0.109	3.1%	0.028	0.109	3.4%
Natural Hazard	**38.6%**	**1.221**	**(0.301)**	**0.920**	**29.9%**	**(0.294)**	**0.927**	**29.8%**	**(0.240)**	**0.981**	**34.3%**	**1.372**	**(0.338)**	**1.034**	**29.9%**	**(0.330)**	**1.042**	**29.8%**	**(0.270)**	**1.102**	**34.3%**
Mud Slide	4.5%	0.144	(0.019)	0.125	4.1%	(0.011)	0.132	4.2%	(0.007)	0.137	4.8%	0.161	(0.021)	0.141	4.1%	(0.013)	0.149	4.2%	(0.008)	0.154	4.8%
Storm/Hurricane	34.1%	1.077	(0.282)	0.795	25.8%	(0.282)	0.795	25.5%	(0.233)	0.844	29.5%	1.211	(0.317)	0.893	25.8%	(0.317)	0.893	25.5%	(0.262)	0.948	29.5%
Arctic	**0.0%**	**0.000**	**0.282**	**0.282**	**9.2%**	**0.311**	**0.311**	**10.0%**	**0.009**	**0.009**	**0.3%**	**0.000**	**0.317**	**0.317**	**9.2%**	**0.350**	**0.350**	**10.0%**	**0.010**	**0.010**	**0.3%**
Ice Gouging	0.0%	0.000	0.221	0.221	7.2%	0.275	0.275	8.8%	0.000	0.000	0.0%	0.000	0.248	0.248	7.2%	0.309	0.309	8.8%	0.000	0.000	0.0%
Strudel Scour	0.0%	0.000	0.028	0.028	0.9%	0.000	0.000	0.0%	0.000	0.000	0.0%	0.000	0.031	0.031	0.9%	0.000	0.000	0.0%	0.000	0.000	0.0%
Upheaval Buckling	0.0%	0.000	0.005	0.005	0.2%	0.005	0.005	0.2%	0.005	0.005	0.2%	0.000	0.006	0.006	0.2%	0.006	0.006	0.2%	0.006	0.006	0.2%
Thaw Settlement	0.0%	0.000	0.003	0.003	0.1%	0.003	0.003	0.1%	0.003	0.003	0.1%	0.000	0.003	0.003	0.1%	0.003	0.003	0.1%	0.003	0.003	0.1%
Other Arctic	0.0%	0.000	0.026	0.026	0.8%	0.028	0.028	0.9%	0.001	0.001	0.0%	0.000	0.029	0.029	0.8%	0.032	0.032	0.9%	0.001	0.001	0.0%
Other	**18.2%**	**0.575**	**0.048**	**0.623**	**20.2%**	**0.048**	**0.623**	**20.0%**	**0.048**	**0.623**	**21.8%**	**0.646**	**0.054**	**0.700**	**20.2%**	**0.054**	**0.700**	**20.0%**	**0.054**	**0.700**	**21.8%**
Total	**100.0%**	**3.161**	**(0.080)**	**3.080**	**100.0%**	**(0.045)**	**3.115**	**100.0%**	**(0.298)**	**2.863**	**100.0%**	**3.552**	**(0.090)**	**3.461**	**100.0%**	**(0.051)**	**3.501**	**100.0%**	**(0.335)**	**3.217**	**100.0%**

Figure 6: Large Pipeline Spill Fault Tree Results

Pipeline, Large Spill: 1,000 to 9,999 bbls			
	All	**Dia <=10"**	**Dia >10"**
Hist.	2.2814	1.0742	1.2072
Nearshore	4.5276	2.1319	2.3957
Inner	4.6737	2.2007	2.4730
Middle/Outer	3.0903	1.4551	1.6352

Corrosion			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.0534	0.0251	0.0282
Nearshore	0.2162	0.1018	0.1144
Inner	0.2162	0.1018	0.1144
Middle/Outer	0.2162	0.1018	0.1144

Third Party Impact			
	All	**Dia <=10"**	**Dia >10"**
Hist.	1.0283	0.4842	0.5441
Nearshore	1.3913	0.6551	0.7362
Inner	1.3682	0.6442	0.7239
Middle/Outer	1.3682	0.6442	0.7239

Operational Impact			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.1714	0.0807	0.0907
Nearshore	0.2303	0.1084	0.1219
Inner	0.2303	0.1084	0.1219
Middle/Outer	0.2303	0.1084	0.1219

Mechanical			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.0000	0.0000	0.0000
Nearshore	0.1177	0.0554	0.0623
Inner	0.1177	0.0554	0.0623
Middle/Outer	0.1177	0.0554	0.0623

Natural Hazard			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.5142	0.2421	0.2721
Nearshore	0.4671	0.2199	0.2471
Inner	0.4788	0.2254	0.2533
Middle/Outer	0.4849	0.2283	0.2566

Other			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.5142	0.2421	0.2721
Nearshore	0.6252	0.2944	0.3308
Inner	0.6252	0.2944	0.3308
Middle/Outer	0.6252	0.2944	0.3308

Arctic			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.0000	0.0000	0.0000
Nearshore	1.4800	0.6969	0.7831
Inner	1.6374	0.7710	0.8664
Middle/Outer	0.0479	0.0226	0.0254

External Corrosion			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0463	0.0218	0.0245
Inner	0.0463	0.0218	0.0245
Middle/Outer	0.0463	0.0218	0.0245

Anchor Impact			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.8569	0.4035	0.4534
Nearshore	0.6479	0.3051	0.3428
Inner	0.6479	0.3051	0.3428
Middle/Outer	0.6479	0.3051	0.3428

Rig Anchoring			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0470	0.0221	0.0249
Inner	0.0470	0.0221	0.0249
Middle/Outer	0.0470	0.0221	0.0249

Connection Failure			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0595	0.0280	0.0315
Inner	0.0595	0.0280	0.0315
Middle/Outer	0.0595	0.0280	0.0315

Mud Slide			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.1714	0.0807	0.0907
Nearshore	0.1746	0.0822	0.0924
Inner	0.1863	0.0877	0.0986
Middle/Outer	0.1863	0.0877	0.0986

Ice Gouging			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.0000	0.0000	0.0000
Nearshore	1.1571	0.5448	0.6123
Inner	1.4435	0.6797	0.7638
Middle/Outer	0.0000	0.0000	0.0000

Internal Corrosion			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.0534	0.0251	0.0282
Nearshore	0.1699	0.0800	0.0899
Inner	0.1699	0.0800	0.0899
Middle/Outer	0.1699	0.0800	0.0899

Jackup Rig or Spud Barge			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.1714	0.0807	0.0907
Nearshore	0.1702	0.0801	0.0900
Inner	0.1702	0.0801	0.0900
Middle/Outer	0.1702	0.0801	0.0900

Work Boat Failure			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.1714	0.0807	0.0907
Nearshore	0.1833	0.0863	0.0970
Inner	0.1833	0.0863	0.0970
Middle/Outer	0.1833	0.0863	0.0970

Material Failure			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0582	0.0274	0.0308
Inner	0.0582	0.0274	0.0308
Middle/Outer	0.0582	0.0274	0.0308

Storm/Hurricane			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.3427	0.1614	0.1814
Nearshore	0.2925	0.1377	0.1548
Inner	0.2925	0.1377	0.1548
Middle/Outer	0.2985	0.1406	0.1580

Strudel Scour			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.0000	0.0000	0.0000
Nearshore	0.1441	0.0679	0.0763
Inner	0.0000	0.0000	0.0000
Middle/Outer	0.0000	0.0000	0.0000

Trawl/Fishing Net			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.6856	0.3228	0.3628
Nearshore	0.5732	0.2699	0.3033
Inner	0.5501	0.2590	0.2911
Middle/Outer	0.5501	0.2590	0.2911

Upheaval Buckling			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0291	0.0137	0.0154
Inner	0.0291	0.0137	0.0154
Middle/Outer	0.0293	0.0138	0.0155

Thaw Settlement			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0143	0.0067	0.0076
Inner	0.0144	0.0068	0.0076
Middle/Outer	0.0143	0.0068	0.0076

Other Arctic			
	All	**Dia <=10"**	**Dia >10"**
Hist.	0.0000	0.0000	0.0000
Nearshore	0.1353	0.0637	0.0716
Inner	0.1503	0.0708	0.0795
Middle/Outer	0.0043	0.0020	0.0023

Table 15: Summary of Frequency Results for Large Pipeline Spills

Cause	% Dist	Pipeline Diameter <=10"										Pipeline Diameter >10"									
		Freq per 10^5 km-yr	Nearshore			Inner Shelf			Middle/Outer Shelf			Freq per 10^5 km-yr	Nearshore			Inner Shelf			Middle/Outer Shelf		
			Change	MC Freq	MC %	Change	MC Freq	MC %	Change	MC Freq	MC %		Change	MC Freq	MC %	Change	MC Freq	MC %	Change	MC Freq	MC %
Corrosion	**5.6%**	**0.081**	**0.021**	**0.102**	**4.8%**	**0.021**	**0.102**	**4.6%**	**0.021**	**0.102**	**7.0%**	**0.091**	**0.024**	**0.114**	**4.8%**	**0.024**	**0.114**	**4.6%**	**0.024**	**0.114**	**7.0%**
External Corrosion	0.0%	0.000	0.022	0.022	1.0%	0.022	0.022	1.0%	0.022	0.022	1.5%	0.000	0.025	0.025	1.0%	0.025	0.025	1.0%	0.025	0.025	1.5%
Internal Corrosion	5.6%	0.081	(0.001)	0.080	3.8%	(0.001)	0.080	3.6%	(0.001)	0.080	5.5%	0.091	(0.001)	0.090	3.8%	(0.001)	0.090	3.6%	(0.001)	0.090	5.5%
Third Party Impact	**55.6%**	**0.807**	**(0.152)**	**0.655**	**30.7%**	**(0.163)**	**0.644**	**29.3%**	**(0.163)**	**0.644**	**44.3%**	**0.907**	**(0.171)**	**0.736**	**30.7%**	**(0.183)**	**0.724**	**29.3%**	**(0.183)**	**0.724**	**44.3%**
Anchor Impact	27.8%	0.403	(0.098)	0.305	14.3%	(0.098)	0.305	13.9%	(0.098)	0.305	21.0%	0.453	(0.111)	0.343	14.3%	(0.111)	0.343	13.9%	(0.111)	0.343	21.0%
Jackup Rig or Spud Barge	5.6%	0.081	(0.001)	0.080	3.8%	(0.001)	0.080	3.6%	(0.001)	0.080	5.5%	0.091	(0.001)	0.090	3.8%	(0.001)	0.090	3.6%	(0.001)	0.090	5.5%
Trawl/Fishing Net	22.2%	0.323	(0.053)	0.270	12.7%	(0.064)	0.259	11.8%	(0.064)	0.259	17.8%	0.363	(0.059)	0.303	12.7%	(0.072)	0.291	11.8%	(0.072)	0.291	17.8%
Operation Impact	**5.6%**	**0.081**	**0.028**	**0.108**	**5.1%**	**0.028**	**0.108**	**4.9%**	**0.028**	**0.108**	**7.5%**	**0.091**	**0.031**	**0.122**	**5.1%**	**0.031**	**0.122**	**4.9%**	**0.031**	**0.122**	**7.5%**
Rig Anchoring	0.0%	0.000	0.022	0.022	1.0%	0.022	0.022	1.0%	0.022	0.022	1.5%	0.000	0.025	0.025	1.0%	0.025	0.025	1.0%	0.025	0.025	1.5%
Work Boat Connection	5.6%	0.081	0.006	0.086	4.0%	0.006	0.086	3.9%	0.006	0.086	5.9%	0.091	0.006	0.097	4.0%	0.006	0.097	3.9%	0.006	0.097	5.9%
Mechanical	**0.0%**	**0.000**	**0.055**	**0.055**	**2.6%**	**0.055**	**0.055**	**2.5%**	**0.055**	**0.055**	**3.8%**	**0.000**	**0.062**	**0.062**	**2.6%**	**0.062**	**0.062**	**2.5%**	**0.062**	**0.062**	**3.8%**
Connection Failure	0.0%	0.000	0.028	0.028	1.3%	0.028	0.028	1.3%	0.028	0.028	1.9%	0.000	0.031	0.031	1.3%	0.031	0.031	1.3%	0.031	0.031	1.9%
Material Failure	0.0%	0.000	0.027	0.027	1.3%	0.027	0.027	1.2%	0.027	0.027	1.9%	0.000	0.031	0.031	1.3%	0.031	0.031	1.2%	0.031	0.031	1.9%
Natural Hazard	**16.7%**	**0.242**	**(0.022)**	**0.220**	**10.3%**	**(0.017)**	**0.225**	**10.2%**	**(0.014)**	**0.228**	**15.7%**	**0.272**	**(0.025)**	**0.247**	**10.3%**	**(0.019)**	**0.253**	**10.2%**	**(0.015)**	**0.257**	**15.7%**
Mud Slide	5.6%	0.081	0.001	0.082	3.9%	0.007	0.088	4.0%	0.007	0.088	6.0%	0.091	0.002	0.092	3.9%	0.008	0.099	4.0%	0.008	0.099	6.0%
Storm/Hurricane	11.1%	0.161	(0.024)	0.138	6.5%	(0.024)	0.138	6.3%	(0.021)	0.141	9.7%	0.181	(0.027)	0.155	6.5%	(0.027)	0.155	6.3%	(0.023)	0.158	9.7%
Arctic	**0.0%**	**0.000**	**0.697**	**0.697**	**32.7%**	**0.771**	**0.771**	**35.0%**	**0.023**	**0.023**	**1.6%**	**0.000**	**0.783**	**0.783**	**32.7%**	**0.866**	**0.866**	**35.0%**	**0.025**	**0.025**	**1.6%**
Ice Gouging	0.0%	0.000	0.545	0.545	25.6%	0.680	0.680	30.9%	0.000	0.000	0.0%	0.000	0.612	0.612	25.6%	0.764	0.764	30.9%	0.000	0.000	0.0%
Strudel Scour	0.0%	0.000	0.068	0.068	3.2%	0.000	0.000	0.0%	0.000	0.000	0.0%	0.000	0.076	0.076	3.2%	0.000	0.000	0.0%	0.000	0.000	0.0%
Upheaval Buckling	0.0%	0.000	0.014	0.014	0.6%	0.014	0.014	0.6%	0.014	0.014	0.9%	0.000	0.015	0.015	0.6%	0.015	0.015	0.6%	0.015	0.015	0.9%
Thaw Settlement	0.0%	0.000	0.007	0.007	0.3%	0.007	0.007	0.3%	0.007	0.007	0.5%	0.000	0.008	0.008	0.3%	0.008	0.008	0.3%	0.008	0.008	0.5%
Other Arctic	0.0%	0.000	0.064	0.064	3.0%	0.071	0.071	3.2%	0.002	0.002	0.1%	0.000	0.072	0.072	3.0%	0.080	0.080	3.2%	0.002	0.002	0.1%
Other	**16.7%**	**0.242**	**0.052**	**0.294**	**13.8%**	**0.052**	**0.294**	**13.4%**	**0.052**	**0.294**	**20.2%**	**0.272**	**0.059**	**0.331**	**13.8%**	**0.059**	**0.331**	**13.4%**	**0.059**	**0.331**	**20.2%**
Total	**100.0%**	**1.453**	**0.679**	**2.132**	**100.0%**	**0.748**	**2.201**	**100.0%**	**0.002**	**1.455**	**100.0%**	**1.632**	**0.763**	**2.396**	**100.0%**	**0.841**	**2.473**	**100.0%**	**0.003**	**1.635**	**100.0%**

Figure 7: Huge Pipeline Spill Fault Tree Results

Pipeline, Huge Spill>10,000 bbls	All	Dia <=10"	Dia >10"
Hist.	0.7473	0.3519	0.3954
Nearshore	1.2466	0.5870	0.6596
Inner	1.2745	0.6001	0.6744
Middle/Outer	0.9571	0.4507	0.5064

Corrosion	All	Dia <=10"	Dia >10"
Hist.	0.0534	0.0251	0.0282
Nearshore	0.0673	0.0317	0.0356
Inner	0.0673	0.0317	0.0356
Middle/Outer	0.0673	0.0317	0.0356

Third Party Impact	All	Dia <=10"	Dia >10"
Hist.	0.3203	0.1508	0.1695
Nearshore	0.4333	0.2040	0.2293
Inner	0.4261	0.2007	0.2255
Middle/Outer	0.4261	0.2007	0.2255

Operational Impact	All	Dia <=10"	Dia >10"
Hist.	0.0534	0.0251	0.0282
Nearshore	0.0717	0.0338	0.0380
Inner	0.0717	0.0338	0.0380
Middle/Outer	0.0717	0.0338	0.0380

Mechanical	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0367	0.0173	0.0194
Inner	0.0367	0.0173	0.0194
Middle/Outer	0.0367	0.0173	0.0194

Natural Hazard	All	Dia <=10"	Dia >10"
Hist.	0.1601	0.0754	0.0847
Nearshore	0.1455	0.0685	0.0770
Inner	0.1491	0.0702	0.0789
Middle/Outer	0.1510	0.0711	0.0799

Other	All	Dia <=10"	Dia >10"
Hist.	0.1601	0.0754	0.0847
Nearshore	0.1947	0.0917	0.1030
Inner	0.1947	0.0917	0.1030
Middle/Outer	0.1947	0.0917	0.1030

Arctic	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.2974	0.1400	0.1574
Inner	0.3288	0.1548	0.1740
Middle/Outer	0.0095	0.0045	0.0050

External Corrosion	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0144	0.0068	0.0076
Inner	0.0144	0.0068	0.0076
Middle/Outer	0.0144	0.0068	0.0076

Anchor Impact	All	Dia <=10"	Dia >10"
Hist.	0.2669	0.1257	0.1412
Nearshore	0.2018	0.0950	0.1068
Inner	0.2018	0.0950	0.1068
Middle/Outer	0.2018	0.0950	0.1068

Rig Anchoring	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0146	0.0069	0.0077
Inner	0.0146	0.0069	0.0077
Middle/Outer	0.0146	0.0069	0.0077

Connection Failure	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0185	0.0087	0.0098
Inner	0.0185	0.0087	0.0098
Middle/Outer	0.0185	0.0087	0.0098

Mud Slide	All	Dia <=10"	Dia >10"
Hist.	0.0534	0.0251	0.0282
Nearshore	0.0544	0.0256	0.0288
Inner	0.0580	0.0273	0.0307
Middle/Outer	0.0580	0.0273	0.0307

Ice Gouging	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.2329	0.1097	0.1233
Inner	0.2897	0.1364	0.1533
Middle/Outer	0.0000	0.0000	0.0000

Internal Corrosion	All	Dia <=10"	Dia >10"
Hist.	0.0534	0.0251	0.0282
Nearshore	0.0529	0.0249	0.0280
Inner	0.0529	0.0249	0.0280
Middle/Outer	0.0529	0.0249	0.0280

Jackup Rig or Spud Barge	All	Dia <=10"	Dia >10"
Hist.	0.0534	0.0251	0.0282
Nearshore	0.0530	0.0250	0.0280
Inner	0.0530	0.0250	0.0280
Middle/Outer	0.0530	0.0250	0.0280

Work Boat Failure	All	Dia <=10"	Dia >10"
Hist.	0.0534	0.0251	0.0282
Nearshore	0.0571	0.0269	0.0302
Inner	0.0571	0.0269	0.0302
Middle/Outer	0.0571	0.0269	0.0302

Material Failure	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0181	0.0085	0.0096
Inner	0.0181	0.0085	0.0096
Middle/Outer	0.0181	0.0085	0.0096

Storm/Hurricane	All	Dia <=10"	Dia >10"
Hist.	0.1068	0.0503	0.0565
Nearshore	0.0911	0.0429	0.0482
Inner	0.0911	0.0429	0.0482
Middle/Outer	0.0930	0.0438	0.0492

Strudel Scour	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0289	0.0136	0.0153
Inner	0.0000	0.0000	0.0000
Middle/Outer	0.0000	0.0000	0.0000

Trawl/Fishing Net	All	Dia <=10"	Dia >10"
Hist.	0.2135	0.1005	0.1130
Nearshore	0.1785	0.0841	0.0945
Inner	0.1713	0.0807	0.0907
Middle/Outer	0.1713	0.0807	0.0907

Upheaval Buckling	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0057	0.0027	0.0030
Inner	0.0057	0.0027	0.0030
Middle/Outer	0.0057	0.0027	0.0030

Thaw Settlement	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0029	0.0013	0.0015
Inner	0.0029	0.0014	0.0015
Middle/Outer	0.0029	0.0014	0.0015

Other Arctic	All	Dia <=10"	Dia >10"
Hist.	0.0000	0.0000	0.0000
Nearshore	0.0270	0.0127	0.0143
Inner	0.0304	0.0143	0.0161
Middle/Outer	0.0009	0.0004	0.0005

Table 16: Summary of Frequency Results for Huge Pipeline Spills

Cause	% Dist	Pipeline Diameter <=10"										Pipeline Diameter >10"									
		Freq per 10^5 km-yr	Nearshore			Inner Shelf			Middle/Outer Shelf			Freq per 10^5 km-yr	Nearshore			Inner Shelf			Middle/Outer Shelf		
			Change	MC Freq	MC %	Change	MC Freq	MC %	Change	MC Freq	MC %		Change	MC Freq	MC %	Change	MC Freq	MC %	Change	MC Freq	MC %
Corrosion	**5.6%**	**0.025**	**0.007**	**0.032**	**5.4%**	**0.007**	**0.032**	**5.3%**	**0.007**	**0.032**	**7.0%**	**0.028**	**0.007**	**0.036**	**5.4%**	**0.007**	**0.036**	**5.3%**	**0.007**	**0.036**	**7.0%**
External Corrosion	0.0%	0.000	0.007	0.007	1.2%	0.007	0.007	1.1%	0.007	0.007	1.5%	0.000	0.008	0.008	1.2%	0.008	0.008	1.1%	0.008	0.008	1.5%
Internal Corrosion	5.6%	0.025	(0.000)	0.025	4.2%	(0.000)	0.025	4.2%	(0.000)	0.025	5.5%	0.028	(0.000)	0.028	4.2%	(0.000)	0.028	4.2%	(0.000)	0.028	5.5%
Third Party Impact	**55.6%**	**0.251**	**(0.047)**	**0.204**	**34.8%**	**(0.051)**	**0.201**	**33.4%**	**(0.051)**	**0.201**	**44.5%**	**0.282**	**(0.053)**	**0.229**	**34.8%**	**(0.057)**	**0.225**	**33.4%**	**(0.057)**	**0.225**	**44.5%**
Anchor Impact	27.8%	0.126	(0.031)	0.095	16.2%	(0.031)	0.095	15.8%	(0.031)	0.095	21.1%	0.141	(0.034)	0.107	16.2%	(0.034)	0.107	15.8%	(0.034)	0.107	21.1%
Jackup Rig or Spud Barge	5.6%	0.025	(0.000)	0.025	4.3%	(0.000)	0.025	4.2%	(0.000)	0.025	5.5%	0.028	(0.000)	0.028	4.3%	(0.000)	0.028	4.2%	(0.000)	0.028	5.5%
Trawl/Fishing Net	22.2%	0.101	(0.016)	0.084	14.3%	(0.020)	0.081	13.4%	(0.020)	0.081	17.9%	0.113	(0.019)	0.094	14.3%	(0.022)	0.091	13.4%	(0.022)	0.091	17.9%
Operation Impact	**5.6%**	**0.025**	**0.009**	**0.034**	**5.8%**	**0.009**	**0.034**	**5.6%**	**0.009**	**0.034**	**7.5%**	**0.028**	**0.010**	**0.038**	**5.8%**	**0.010**	**0.038**	**5.6%**	**0.010**	**0.038**	**7.5%**
Rig Anchoring	0.0%	0.000	0.007	0.007	1.2%	0.007	0.007	1.1%	0.007	0.007	1.5%	0.000	0.008	0.008	1.2%	0.008	0.008	1.1%	0.008	0.008	1.5%
Work Boat Connection	5.6%	0.025	0.002	0.027	4.6%	0.002	0.027	4.5%	0.002	0.027	6.0%	0.028	0.002	0.030	4.6%	0.002	0.030	4.5%	0.002	0.030	6.0%
Mechanical	**0.0%**	**0.000**	**0.017**	**0.017**	**2.9%**	**0.017**	**0.017**	**2.9%**	**0.017**	**0.017**	**3.8%**	**0.000**	**0.019**	**0.019**	**2.9%**	**0.019**	**0.019**	**2.9%**	**0.019**	**0.019**	**3.8%**
Connection Failure	0.0%	0.000	0.009	0.009	1.5%	0.009	0.009	1.5%	0.009	0.009	1.9%	0.000	0.010	0.010	1.5%	0.010	0.010	1.5%	0.010	0.010	1.9%
Material Failure	0.0%	0.000	0.009	0.009	1.5%	0.009	0.009	1.4%	0.009	0.009	1.9%	0.000	0.010	0.010	1.5%	0.010	0.010	1.4%	0.010	0.010	1.9%
Natural Hazard	**16.7%**	**0.075**	**(0.007)**	**0.069**	**11.7%**	**(0.005)**	**0.070**	**11.7%**	**(0.004)**	**0.071**	**15.8%**	**0.085**	**(0.008)**	**0.077**	**11.7%**	**(0.006)**	**0.079**	**11.7%**	**(0.005)**	**0.080**	**15.8%**
Mud Slide	5.6%	0.025	0.000	0.026	4.4%	0.002	0.027	4.6%	0.002	0.027	6.1%	0.028	0.001	0.029	4.4%	0.002	0.031	4.6%	0.002	0.031	6.1%
Storm/Hurricane	11.1%	0.050	(0.007)	0.043	7.3%	(0.007)	0.043	7.1%	(0.006)	0.044	9.7%	0.056	(0.008)	0.048	7.3%	(0.008)	0.048	7.1%	(0.007)	0.049	9.7%
Arctic	**0.0%**	**0.000**	**0.140**	**0.140**	**23.9%**	**0.155**	**0.155**	**25.8%**	**0.004**	**0.004**	**1.0%**	**0.000**	**0.157**	**0.157**	**23.9%**	**0.174**	**0.174**	**25.8%**	**0.005**	**0.005**	**1.0%**
Ice Gouging	0.0%	0.000	0.110	0.110	18.7%	0.136	0.136	22.7%	0.000	0.000	0.0%	0.000	0.123	0.123	18.7%	0.153	0.153	22.7%	0.000	0.000	0.0%
Strudel Scour	0.0%	0.000	0.014	0.014	2.3%	0.000	0.000	0.0%	0.000	0.000	0.0%	0.000	0.015	0.015	2.3%	0.000	0.000	0.0%	0.000	0.000	0.0%
Upheaval Buckling	0.0%	0.000	0.003	0.003	0.5%	0.003	0.003	0.5%	0.003	0.003	0.6%	0.000	0.003	0.003	0.5%	0.003	0.003	0.5%	0.003	0.003	0.6%
Thaw Settlement	0.0%	0.000	0.001	0.001	0.2%	0.001	0.001	0.2%	0.001	0.001	0.3%	0.000	0.002	0.002	0.2%	0.002	0.002	0.2%	0.002	0.002	0.3%
Other Arctic	0.0%	0.000	0.013	0.013	2.2%	0.014	0.014	2.4%	0.000	0.000	0.1%	0.000	0.014	0.014	2.2%	0.016	0.016	2.4%	0.000	0.000	0.1%
Other	**16.7%**	**0.075**	**0.016**	**0.092**	**15.6%**	**0.016**	**0.092**	**15.3%**	**0.016**	**0.092**	**20.3%**	**0.085**	**0.018**	**0.103**	**15.6%**	**0.018**	**0.103**	**15.3%**	**0.018**	**0.103**	**20.3%**
Total	**100.0%**	**0.452**	**0.135**	**0.587**	**100.0%**	**0.148**	**0.600**	**100.0%**	**(0.002)**	**0.451**	**100.0%**	**0.508**	**0.151**	**0.660**	**100.0%**	**0.166**	**0.674**	**100.0%**	**(0.002)**	**0.506**	**100.0%**

3.4 PLATFORM SPILLS

Figure 8 presents the fault tree results for a platform spill while Table 17 presents a tabulated summary of results.

Figure 8: Platform Spill Fault Tree Results

Platform Spill		
	Small/Medium	Large/Huge
Hist.	5.1317	0.2912
Nearshore	3.8577	0.4153
Inner Shelf	3.9279	0.4274
Middle/Outer Shelf	4.0663	0.4504

Equipment Failure		
	Small/Medium	Large/Huge
Hist.	1.5650	0.0364
Nearshore	1.2191	0.0444
Inner Shelf	1.2191	0.0444
Middle/Outer Shelf	1.2191	0.0444

Human Error		
	Small/Medium	Large/Huge
Hist.	0.5823	0.0000
Nearshore	0.5229	0.0120
Inner Shelf	0.5229	0.0120
Middle/Outer Shelf	0.5229	0.0120

Ship Collision		
	Small/Medium	Large/Huge
Hist.	0.0364	0.0000
Nearshore	0.0420	0.0124
Inner Shelf	0.0420	0.0124
Middle/Outer Shelf	0.0420	0.0124

Weather		
	Small/Medium	Large/Huge
Hist.	0.1820	0.0728
Nearshore	0.2815	0.1165
Inner Shelf	0.2815	0.1165
Middle/Outer Shelf	0.2815	0.1165

Hurricane		
	Small/Medium	Large/Huge
Hist.	2.5112	0.1456
Nearshore	1.2277	0.1346
Inner Shelf	1.2277	0.1346
Middle/Outer Shelf	1.2670	0.1384

Other Hazards		
	Small/Medium	Large/Huge
Hist.	0.2548	0.0364
Nearshore	0.3166	0.0525
Inner Shelf	0.3166	0.0525
Middle/Outer Shelf	0.3166	0.0525

Arctic		
	Small/Medium	Large/Huge
Hist.	0.0000	0.0000
Nearshore	0.2478	0.0428
Inner Shelf	0.3180	0.0549
Middle/Outer Shelf	0.4172	0.0741

Ice Force		
	Small/Medium	Large/Huge
Hist.	0.0000	0.0000
Nearshore	0.1272	0.0228
Inner Shelf	0.1902	0.0337
Middle/Outer Shelf	0.2805	0.0513

Facility Low Temperature		
	Small/Medium	Large/Huge
Hist.	0.0000	0.0000
Nearshore	0.0983	0.0163
Inner Shelf	0.0989	0.0163
Middle/Outer Shelf	0.0987	0.0163

Other Arctic		
	Small/Medium	Large/Huge
Hist.	0.0000	0.0000
Nearshore	0.0224	0.0037
Inner Shelf	0.0289	0.0050
Middle/Outer Shelf	0.0381	0.0065

Table 17: Summary of Frequency Results for Platform Spills

Cause	% Dist	Small, Medium										Large, Huge									
		Freq per	Nearshore			Inner Shelf			Middle/Outer Shelf			Freq per	Nearshore			Inner Shelf			Middle/Outer Shelf		
		10^5 km-yr	Change	MC Freq	MC %	Change	MC Freq	MC %	Change	MC Freq	MC %	10^5 km-yr	Change	MC Freq	MC %	Change	MC Freq	MC %	Change	MC Freq	MC %
Equipment Failure	**29.7%**	**1.565**	**(0.346)**	**1.219**	**0.316**	**(0.346)**	**1.219**	**0.310**	**(0.346)**	**1.219**	**0.300**	**0.036**	**0.008**	**0.044**	**0.107**	**0.008**	**0.044**	**0.104**	**0.008**	**0.044**	**0.099**
Human Error	**11.0%**	**0.582**	**(0.059)**	**0.523**	**0.136**	**(0.059)**	**0.523**	**0.133**	**(0.059)**	**0.523**	**0.129**	**0.000**	**0.012**	**0.012**	**0.029**	**0.012**	**0.012**	**0.028**	**0.012**	**0.012**	**0.027**
Ship Collision	**0.7%**	**0.036**	**0.006**	**0.042**	**0.011**	**0.006**	**0.042**	**0.011**	**0.006**	**0.042**	**0.010**	**0.000**	**0.012**	**0.012**	**0.030**	**0.012**	**0.012**	**0.029**	**0.012**	**0.012**	**0.028**
Weather	**3.4%**	**0.182**	**0.100**	**0.282**	**0.073**	**0.100**	**0.282**	**0.072**	**0.100**	**0.282**	**0.069**	**0.073**	**0.044**	**0.116**	**0.280**	**0.044**	**0.116**	**0.272**	**0.044**	**0.116**	**0.259**
Hurricane	**47.6%**	**2.511**	**(1.283)**	**1.228**	**0.318**	**(1.283)**	**1.228**	**0.313**	**(1.244)**	**1.267**	**0.312**	**0.146**	**(0.011)**	**0.135**	**0.324**	**(0.011)**	**0.135**	**0.315**	**(0.007)**	**0.138**	**0.307**
Arctic	**2.8%**	**0.146**	**0.102**	**0.248**	**0.064**	**0.172**	**0.318**	**0.081**	**0.271**	**0.417**	**0.103**	**0.024**	**0.019**	**0.043**	**0.103**	**0.031**	**0.055**	**0.129**	**0.050**	**0.074**	**0.165**
Ice Force	**0.6%**	0.034	0.093	0.127	**0.033**	0.156	0.190	**0.048**	0.246	0.280	**0.069**	0.006	0.017	0.023	**0.055**	0.028	0.034	**0.079**	0.045	0.051	**0.114**
Facility Low Temperature	**1.9%**	0.099	(0.001)	0.098	**0.025**	(0.000)	0.099	**0.025**	(0.000)	0.099	**0.024**	0.016	0.000	0.016	**0.039**	0.000	0.016	**0.038**	0.000	0.016	**0.036**
Other Arctic	**0.2%**	0.013	0.009	0.022	**0.006**	0.016	0.029	**0.007**	0.025	0.038	**0.009**	0.002	0.002	0.004	**0.009**	0.003	0.005	**0.012**	0.005	0.007	**0.014**
Other	**4.8%**	**0.255**	**0.062**	**0.317**	**0.082**	**0.062**	**0.317**	**0.081**	**0.062**	**0.317**	**0.078**	**0.036**	**0.016**	**0.053**	**0.126**	**0.016**	**0.053**	**0.123**	**0.016**	**0.053**	**0.117**
Total	**100.0%**	**5.278**	**(1.420)**	**3.858**	**1.000**	**(1.350)**	**3.928**	**1.000**	**(1.211)**	**4.066**	**1.000**	**0.315**	**0.100**	**0.415**	**1.000**	**0.112**	**0.427**	**1.000**	**0.135**	**0.450**	**1.000**

3.5 LOSS OF WELL CONTROL

Figure 9 presents the fault tree results for a platform spill, while Table 18 presents a tabulated summary of results.

Figure 9: Loss of Well Control Spill Fault Tree Results

Loss of Well Control, Production [per 10^4 well-year]						
	Small	Medium	Large	Huge	Enormous	Total
Hist.	0.069	0.081	1.030	0.440	0.290	1.910
Nearshore	0.010	0.011	0.008	0.005	0.004	0.038
Inner Shelf	0.010	0.011	0.008	0.005	0.004	0.038
Middle/Outer Shelf	0.010	0.011	0.008	0.005	0.004	0.038

Loss of Well Control, Exploration [per 10^4 wells]						
	Small	Medium	Large	Huge	Enormous	Total
Hist.	0.910	1.060	13.750	5.910	3.420	25.050
Nearshore	0.558	0.650	0.483	0.315	0.197	2.203
Inner Shelf	0.590	0.686	0.528	0.336	0.208	2.349
Middle/Outer Shelf	0.654	0.762	0.569	0.371	0.230	2.587

Loss of Well Control, Development [per 10^4 wells]						
	Small	Medium	Large	Huge	Enormous	Total
Hist.	0.300	0.350	4.570	1.960	1.960	9.140
Nearshore	0.108	0.126	0.094	0.061	0.038	0.426
Inner Shelf	0.115	0.133	0.101	0.066	0.041	0.456
Middle/Outer Shelf	0.127	0.148	0.112	0.072	0.045	0.505

Table 18: Summary of Frequency Results for Loss of Well Control

LOWC Type	Cause	% Dist	Historical Frequency	Nearshore			Inner Shelf			Middle/Outer Shelf		
				Change	MC Freq	MC %	Change	MC Freq	MC %	Change	MC Freq	MC %
Production [per 10^4 well-year]	Small	3.6%	0.069	(0.060)	0.010	25.6%	(0.060)	0.010	25.7%	(0.060)	0.010	25.9%
	Medium	4.2%	0.081	(0.069)	0.011	29.8%	(0.069)	0.011	30.0%	(0.069)	0.011	30.2%
	Large	53.9%	1.030	(1.022)	0.008	20.8%	(1.022)	0.008	20.6%	(1.022)	0.008	20.4%
	Huge	23.0%	0.440	(0.435)	0.005	14.3%	(0.435)	0.005	14.1%	(0.435)	0.005	14.1%
	Enormous	15.2%	0.290	(0.286)	0.004	9.5%	(0.286)	0.004	9.5%	(0.286)	0.004	9.4%
	Total	**100.0%**	**1.910**	**(1.872)**	**0.038**	**100.0%**	**(1.872)**	**0.038**	**100.0%**	**(1.872)**	**0.038**	**100.0%**
Exploration [per 10^4 wells]	Small	3.6%	0.910	(0.352)	0.558	25.3%	(0.321)	0.590	25.1%	(0.256)	0.654	25.3%
	Medium	4.2%	1.060	(0.410)	0.650	29.5%	(0.373)	0.686	29.2%	(0.298)	0.762	29.5%
	Large	54.9%	13.750	(13.267)	0.483	21.9%	(13.222)	0.528	22.5%	(13.181)	0.569	22.0%
	Huge	23.6%	5.910	(5.595)	0.315	14.3%	(5.574)	0.336	14.3%	(5.539)	0.371	14.3%
	Enormous	13.7%	3.420	(3.223)	0.197	8.9%	(3.212)	0.208	8.9%	(3.190)	0.230	8.9%
	Total	**100.0%**	**25.050**	**(22.847)**	**2.203**	**100.0%**	**(22.701)**	**2.349**	**100.0%**	**(22.463)**	**2.587**	**100.0%**
Development [per 10^4 wells]	Small	3.3%	0.300	(0.192)	0.108	25.4%	(0.186)	0.115	25.1%	(0.173)	0.127	25.2%
	Medium	3.8%	0.350	(0.224)	0.126	29.6%	(0.216)	0.133	29.3%	(0.201)	0.148	29.4%
	Large	50.0%	4.570	(4.476)	0.094	22.0%	(4.469)	0.101	22.1%	(4.458)	0.112	22.2%
	Huge	21.4%	1.960	(1.899)	0.061	14.3%	(1.894)	0.066	14.6%	(1.888)	0.072	14.3%
	Enormous	21.4%	1.960	(1.922)	0.038	8.8%	(1.919)	0.041	8.9%	(1.915)	0.045	8.9%
	Total	**100.0%**	**9.140**	**(8.714)**	**0.426**	**100.0%**	**(8.684)**	**0.456**	**100.0%**	**(8.635)**	**0.505**	**100.0%**

3.6 EXPECTED SPILL VOLUME

Table 19 presents the expected spill volume in barrels for each spill type and spill size category. The spill index describes the potential oil spill size concerning total production. Spill index is the product of oil spill frequency per billion barrels produced and the associated expected oil spill size (in barrels).

Table 19: Historical Distribution Assumptions used in Processing Results

Spill Type	Spill Size Category	Low	Mode	High	Expected
Pipeline – All	Small (50-99 bbl)	50	65	99	71
	Medium (100-999 bbl)	100	309	999	464
	Large (1000-9,999 bbl)	1,000	3,347	9,999	4,740
	Huge (>=10000 bbl)	10,000	16,496	20,000	15,460
Platform	Small/medium (50-999 bbl)	50	171	999	407
	Large/huge (>=1000 bbl)	1,000	3,565	20,000	8,193
Loss of Well Control - All	Small (50-99 bbl)	50	75	99	75
	Medium (100-999 bbl)	100	500	999	538
	Large (1000-9999 bbl)	1,000	5,000	9,999	5,318
	Huge (10000-149999 bbl)	10,000	75,000	149,999	77,369
	Enormous (>=150000 bbl)	150,000	200,000	250,000	200,359

4 EXPLORATION AND DEVELOPMENT SCENARIOS

As a basis for this analysis the number and variation of pipelines (>10" or ≤10"), platforms (oil or gas), and wells (exploration, production, or development) for nearshore, inner shelf, middle shelf and outer shelf water depths were provided by BOEM in tabular format. The life of field extends from year 1 through the end of oil production in year 54 and final decommissioning in year 69. A summary of the hazard scenario assessed is included in Appendix B – Exploration and Development Data.

The following water depths are considered in this analysis:

- Nearshore (<10 m water depth)
- Inner Shelf (10 m to <25 m water depth)
- Middle Shelf (25 m to <60 m water depth)
- Outer Shelf (≥60 m water depth)

For the purpose of this assessment, ABSG has assumed that the frequency of middle shelf and outer shelf operations are equivalent. Only trawling/fishing net impacts, natural hazards, hurricanes, and loss of well control were seen to have different impacts at deeper water depths. Further, the difference between middle shelf and outer shelf frequencies were seen to be minimal.

5 OIL SPILL OCCURRENCE

5.1 DEFINITION OF OIL SPILL OCCURRENCE ESTIMATES

Six oil spill occurrence estimates were calculated as part of this analysis:

- Frequency in spills per 10^3 years
- Frequency in spills per 10^9 barrels produced
- Spill Index, which is the product of the spill frequency per billion barrels produced and the associated expected spill size (or volume)
- Life of field frequency in spills per 10^3 years
- Life of field frequency in spills per 10^9 barrels produced
- Life of field spill index

The spill indicators defined above were also subdivided into the following categories:

- By facility type (e.g., pipeline, loss of well control)
- By pipeline diameter (e.g., >10" or ≤10")
- By type of loss of well control (e.g., during production, exploration, drilling)
- By spill size: small, medium, large, huge, enormous, or substantial (which is the sum of all spills ≥ 1,000 bbl or the total of large, huge and enormous).

5.2 CALCULATION OF OIL SPILL OCCURRENCE ESTIMATES

Oil spill occurrence estimates were calculated from facility data detailed in Table 20.

Table 20: Assumed Facility Frequencies for Oil Spill Occurrence Calculations

Facility Type	Assumed Depth	Frequency Unit	Small	Medium	Large	Huge	Enormous
Platform	Middle/Outer Shelf	[per 10^4 well-yr]	1.789	2.277	0.394	0.056	--
Pipeline, ≤10"	Inner Shelf	[per 10^5 km-yr]	1.632	3.115	2.201	0.600	--
Pipeline, >10"	Inner Shelf	[per 10^5 km-yr]	1.834	3.501	2.473	0.674	--
LOWC, Prod.	Middle/Outer Shelf	[per 10^4 well-yr]	0.010	0.011	0.008	0.005	0.004
LOWC, Expl.	Middle/Outer Shelf	[per 10^4 well]	0.654	0.762	0.569	0.371	0.230
LOWC, Devel.	Middle/Outer Shelf	[per 10^4 well]	0.127	0.148	0.112	0.072	0.045

Note that the frequency unit varies for each facility type and becomes essential in ensuring that the proper spill frequency units are calculated. For example, the spill frequency per thousand years is calculated with the following formula:

$$f_{spill} = f_{PL} * D_{\leq 10"} * L_{PL,\leq 10"} + f_{PL} * D_{>10"} * L_{PL,>10"} + f_{Plat} * PW + f_{LOWC,P} * PW + f_{LOWC,E} * EW + f_{LOWC,D} * DW$$

Where:

f_{spill}	Spill frequency [per 10^3 years]
f_{PL}	Pipeline spill frequency [per 10^5 km-yrs]
$D_{<10"}$, $D_{>10"}$	Percent of pipeline spill which are ≤10" in diameter (52.9%) or >10" in diameter (47.1%)
$L_{PL,\leq 10"}$, $L_{PL,>10"}$	Length of pipeline which are ≤10" in diameter or >10" in diameter [km] in a given year
f_{Plat}	Platform spill frequency [per 10^4 well-yrs]
$f_{LOWC,P}$	Loss of well control frequency for producing wells [per 10^4 well-year]
$f_{LOWC,E}$	Loss of well control frequency for exploration wells [per 10^4 wells]
$f_{LOWC,D}$	Loss of well control frequency for development (drilling) wells [per 10^4 wells]
PW, EW, DW	Number of production wells, exploration wells, and development wells in a given year

For any given year, the spill frequency per 10^9 barrels produced is calculated with the following formula:

$$f_{spill\ per\ billion\ barrels\ produced} = \frac{f_{spill}\ [per\ 10^3\ years]}{Oil\ production\ in\ MMbbls}$$

Finally, the spill index is calculated with the following formula (spill index is represented in 10^{-7} by scaling the Spill index by 10^{-2}):

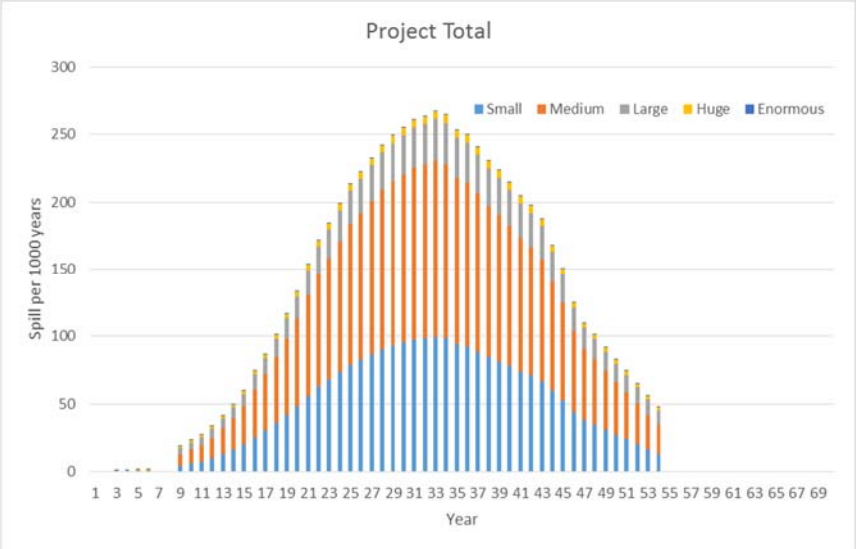
$$Spill\ Index = f_{spill\ per\ barrel} * Expected\ Spill\ Size$$

6 RESULTS

The following section provides results based on the methodology and data provided in Sections 2-5. Additional data on spill indicators such as function facility type and additional summary tables can be found in Appendix C – Oil Spill Indicators Results.

The spill frequency as a function of time is illustrated in Figure 10. Note that the expected spill frequency increases with increasing production and decreases to zero once the project life is reached and wells are decommissioned. The two most likely oil spill events are small spills (50-99 bbl) and medium spills (100-999 bbl).

Figure 10: Spill Frequency per 10^3 Years as a Function of Time



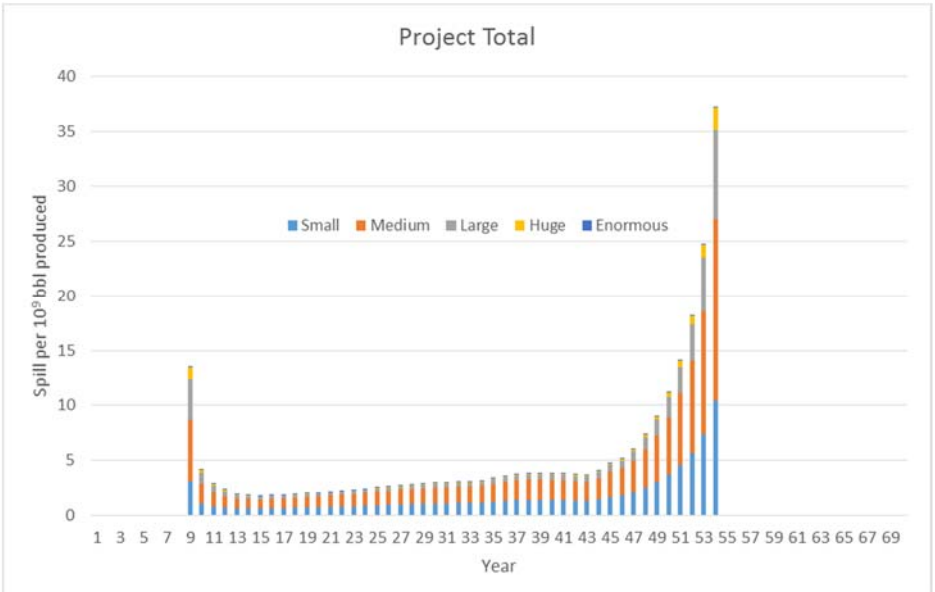
Over the life of the field, the total spill frequency is 130.2 spills per 10^3 years of which small and medium spills make up 84% of all potential spills while substantial spills (e.g., large, huge, and enormous) make up the remaining 16% as provided in Table 21.

Table 21: Life of Field Average Spill Frequency per 10^3 years

Spill Size	LOF Average - Frequency, Spill per 10^3 years									
	Spill Source									
	Pipeline		Platforms		Wells		Platforms and Wells		All	
Small spills 50-99 bbl	5.29	21.62%	41.12	39.61%	0.50	25.56%	41.62	39.36%	46.91	36.02%
Medium spills 100-999 bbl	10.10	41.26%	52.33	50.42%	0.56	29.01%	52.89	50.02%	62.99	48.37%
Small and Medium Spills 50-999 bbl	15.39	62.87%	93.45	90.03%	1.06	54.64%	94.51	89.38%	109.90	84.40%
Large spills 1000-9999 bbl	7.14	29.15%	9.06	8.72%	0.42	21.55%	9.48	8.97%	16.62	12.76%
Huge spills =>10000 bbl	1.95	7.95%	1.29	1.24%	0.27	13.70%	1.56	1.48%	3.51	2.70%
Enormous spills =>150,000 bbl	0.00	0.00%	0.00	0.00%	0.19	9.59%	0.19	0.18%	0.19	0.14%
Substantial spills =>1000 bbl	9.09	37.13%	10.35	9.97%	0.88	45.36%	11.23	10.62%	20.32	15.60%
All spills	**24.48**	**100%**	**103.80**	**100%**	**1.94**	**100%**	**105.74**	**100%**	**130.22**	**100%**

The spill frequency per 10^9 barrels as a function of time is illustrated in Figure 11. Note that the spill frequency shows an increase at the beginning of the facility life and at the end. This is due to the lower production rates at the beginning and end of the facility life. The two most likely oil spill events are small spills (50-99 bbl) and medium spills (100-999 bbl).

Figure 11: Spill Frequency per 10^9 barrels produced as a Function of Time



Over the life of the field, the total spill frequency is 3.07 spills per 10^9 barrels produced of which small and medium spills make up 84% of all potential spills while substantial spills (e.g., large, huge, and enormous) make up the remaining 16% as shown in Table 22.

Table 22: Life of Field Average Spill Frequency per 10^9 barrels produced

Spill Size	LOF Average - Frequency, Spill per 10^9 bbl produced									
	Spill Source									
	Pipeline		Platforms		Wells		Platforms and Wells		All	
Small spills 50-99 bbl	0.12	21.54%	0.97	39.62%	0.01	29.26%	0.98	39.36%	1.10	35.83%
Medium spills 100-999 bbl	0.24	41.11%	1.24	50.43%	0.01	33.22%	1.25	50.20%	1.49	48.53%
Small and Medium Spills 50-999 bbl	0.36	62.07%	2.21	90.20%	0.02	50.00%	2.23	89.56%	2.59	84.36%
Large spills 1000-9999 bbl	0.17	29.04%	0.21	8.73%	0.01	24.67%	0.22	8.84%	0.39	12.70%
Huge spills =>10000 bbl	0.05	7.92%	0.03	1.24%	0.01	15.68%	0.04	1.61%	0.09	2.93%
Enormous =>150,000 bbl	0.00	0.00%	0.00	0.00%	0.00	10.98%	0.00	0.00%	0.00	0.00%
Substantial spills =>1000 bbl	0.22	37.93%	0.24	9.80%	0.02	50.00%	0.26	10.44%	0.48	15.64%
All spills	**0.58**	**100%**	**2.45**	**100%**	**0.04**	**100%**	**2.49**	**100%**	**3.07**	**100%**

The spill index as a function of time is illustrates in Figure 12. The spill index describes the potential spill size with respect to total production. As expected, the highest spill potential lies at the beginning and end of field life; however, this is weighted heavily on the increase of production at the beginning of field life and decrease of production at the end of field life.

Figure 12: Spill Index as a Function of Time

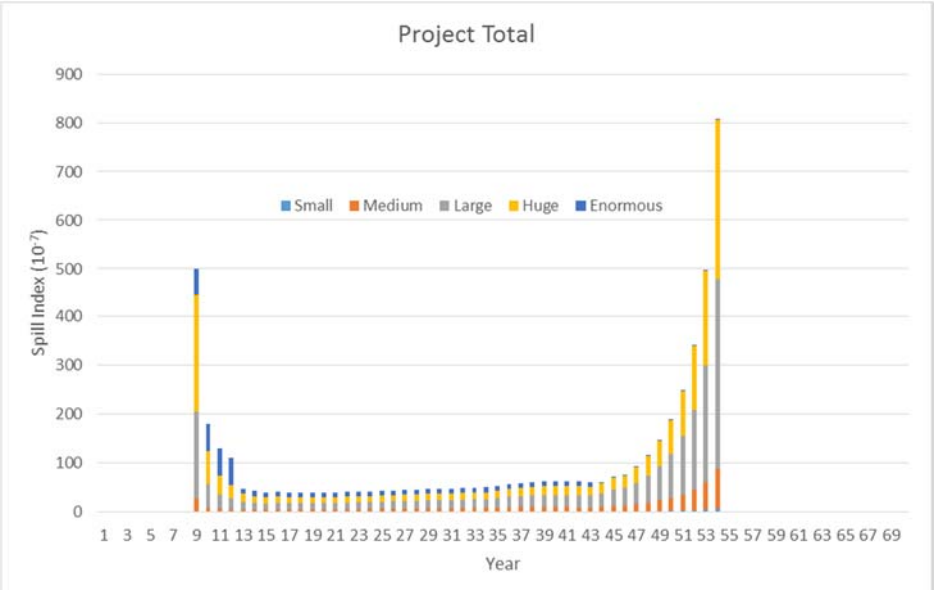


Table 23 presents the life of field average spill index as a function of spill size and facility type.

Table 23: Life of Field Average Spill Index

Spill Size	LOF Average - Spill index, 10^{-7}									
	Spill Source									
	Pipeline		Platforms		Wells		Platforms and Wells		All	
Small spills 50-99 bbl	0.28	0.54%	0.81	3.13%	0.01	0.07%	0.83	1.91%	1.10	1.17%
Medium spills 100-999 bbl	3.46	6.80%	7.36	28.31%	0.10	0.55%	7.46	17.22%	10.92	11.59%
Small and Medium Spills 50-999 bbl	3.74	7.34%	8.17	31.41%	0.11	0.64%	8.29	19.13%	12.02	12.75%
Large spills 1000-9999 bbl	24.98	49.05%	12.71	48.86%	0.71	4.07%	13.41	30.95%	38.40	40.74%
Huge spills =>10000 bbl	22.20	43.61%	5.13	19.71%	6.56	37.87%	11.69	26.97%	33.89	35.96%
Enormous =>150,000 bbl	0.00	0.00%	0.00	0.00%	9.94	57.39%	9.94	22.94%	9.94	10.55%
Substantial spills =>1000 bbl	47.18	92.66%	17.84	68.59%	17.21	99.36%	35.04	80.87%	82.23	87.25%
All spills	**50.92**	**100%**	**26.01**	**100%**	**17.32**	**100%**	**43.33**	**100%**	**94.25**	**100%**

The cumulative distribution function (CDF) is a means to illustrate the variance of the data and the confidence intervals for each parameter. Table 24 presents an example calculation for the CDF in year 31; remaining years as part of this assessment will follow a similar trend. Finally, Figure 13 and Figure 14 illustrate the CDF as a function of spill frequency, spill size, and spill index for the year 31.

Table 24: Cumulative Distribution Functions for Oil Spill Indicators – Year 31

Year 31	Frequency Spills per 10^3 years							Frequency Spills per 10^9 bbl Produced							Spill Index [10^{-7}]						
	Small	Medium	Large	Huge	Enromous	Substantial	All	Small	Medium	Large	Huge	Enromous	Substantial	All	Small	Medium	Large	Huge	Enormous	Substantial	All
Mean	86.00	112.74	23.49	3.19	47.04	73.73	272.47	0.96	1.26	0.26	0.04	0.53	0.82	3.04	0.72	6.60	13.51	8.94	484.36	506.81	2.03
Std. Deviation	14.31	18.26	4.11	0.59	8.42	13.11	45.68	0.16	0.20	0.05	0.01	0.09	0.15	0.51	0.12	1.08	2.42	1.14	158.77	162.32	0.36
Minimum	44.80	60.88	11.00	1.65	1.65	37.11	142.79	0.50	0.68	0.12	0.02	0.27	0.41	1.60	0.37	3.53	6.30	5.96	145.42	157.68	161.58
5%	62.33	82.35	16.73	2.23	33.13	52.09	197.19	0.70	0.92	0.19	0.02	0.37	0.58	2.20	0.52	4.83	9.53	7.06	223.10	239.60	244.91
10%	67.65	89.16	18.22	2.44	36.24	56.91	213.81	0.76	1.00	0.20	0.03	0.40	0.64	2.39	0.56	5.21	10.41	7.47	280.32	298.75	303.97
15%	71.17	93.79	19.24	2.58	38.31	60.13	225.12	0.80	1.05	0.21	0.03	0.43	0.67	2.52	0.59	5.48	11.01	7.75	319.74	338.54	344.38
20%	73.96	97.33	20.03	2.70	39.95	62.68	233.95	0.83	1.09	0.22	0.03	0.45	0.70	2.61	0.62	5.69	11.48	7.97	350.58	370.18	376.48
25%	76.35	100.41	20.72	2.79	41.35	64.83	241.62	0.85	1.12	0.23	0.03	0.46	0.72	2.70	0.64	5.87	11.87	8.16	376.94	397.07	403.58
30%	78.49	103.17	21.33	2.88	42.62	66.84	248.46	0.88	1.15	0.24	0.03	0.48	0.75	2.78	0.65	6.04	12.24	8.34	401.01	421.64	428.34
35%	80.48	105.69	21.91	2.97	43.77	68.65	254.83	0.90	1.18	0.24	0.03	0.49	0.77	2.85	0.67	6.18	12.58	8.50	423.11	444.18	451.06
40%	82.37	108.12	22.45	3.04	44.90	70.39	260.88	0.92	1.21	0.25	0.03	0.50	0.79	2.91	0.69	6.33	12.89	8.65	444.08	465.27	472.32
45%	84.19	110.44	22.97	3.12	45.98	72.07	266.66	0.94	1.23	0.26	0.03	0.51	0.81	2.98	0.70	6.47	13.21	8.79	464.39	486.39	493.54
50%	85.96	112.72	23.49	3.19	47.04	73.71	272.45	0.96	1.26	0.26	0.04	0.53	0.82	3.04	0.72	6.60	13.51	8.94	484.32	506.52	513.88
55%	87.79	115.04	24.00	3.27	48.09	75.37	278.17	0.98	1.29	0.27	0.04	0.54	0.84	3.11	0.73	6.74	13.81	9.08	504.20	527.11	534.61
60%	89.62	117.36	24.53	3.34	49.17	77.03	284.04	1.00	1.31	0.27	0.04	0.55	0.86	3.17	0.75	6.88	14.12	9.23	524.43	547.85	555.49
65%	91.49	119.78	25.07	3.42	50.29	78.78	290.07	1.02	1.34	0.28	0.04	0.56	0.88	3.24	0.76	7.02	14.44	9.38	545.41	569.27	577.04
70%	93.50	122.31	25.64	3.50	51.46	80.60	296.37	1.04	1.37	0.29	0.04	0.57	0.90	3.31	0.78	7.17	14.78	9.53	567.59	591.90	599.84
75%	95.64	125.06	26.26	3.59	52.72	82.56	303.17	1.07	1.40	0.29	0.04	0.59	0.92	3.39	0.80	7.33	15.14	9.70	591.08	615.91	624.40
80%	98.04	128.09	26.94	3.69	54.13	84.74	310.91	1.10	1.43	0.30	0.04	0.60	0.95	3.47	0.82	7.51	15.54	9.90	617.95	643.31	651.61
85%	100.80	131.67	27.73	3.80	55.75	87.30	319.80	1.13	1.47	0.31	0.04	0.62	0.98	3.57	0.84	7.72	16.01	10.12	648.79	674.97	683.48
90%	104.27	136.08	28.73	3.94	57.82	90.45	330.89	1.16	1.52	0.32	0.04	0.65	1.01	3.70	0.87	7.99	16.60	10.40	687.23	714.59	723.33
95%	109.51	142.76	30.23	4.16	60.86	95.29	347.52	1.22	1.59	0.34	0.05	0.68	1.06	3.88	0.91	8.37	17.48	10.82	745.48	773.62	782.84
Maximum	136.99	179.05	37.60	5.21	76.23	119.04	435.08	1.53	2.00	0.42	0.06	0.85	1.33	4.86	1.14	10.51	21.81	13.30	899.37	934.47	946.12

Figure 13: Cumulative Distribution of Spill Frequency per 10^3 years and Spill Frequency per 10^9 barrels produced – Year 31

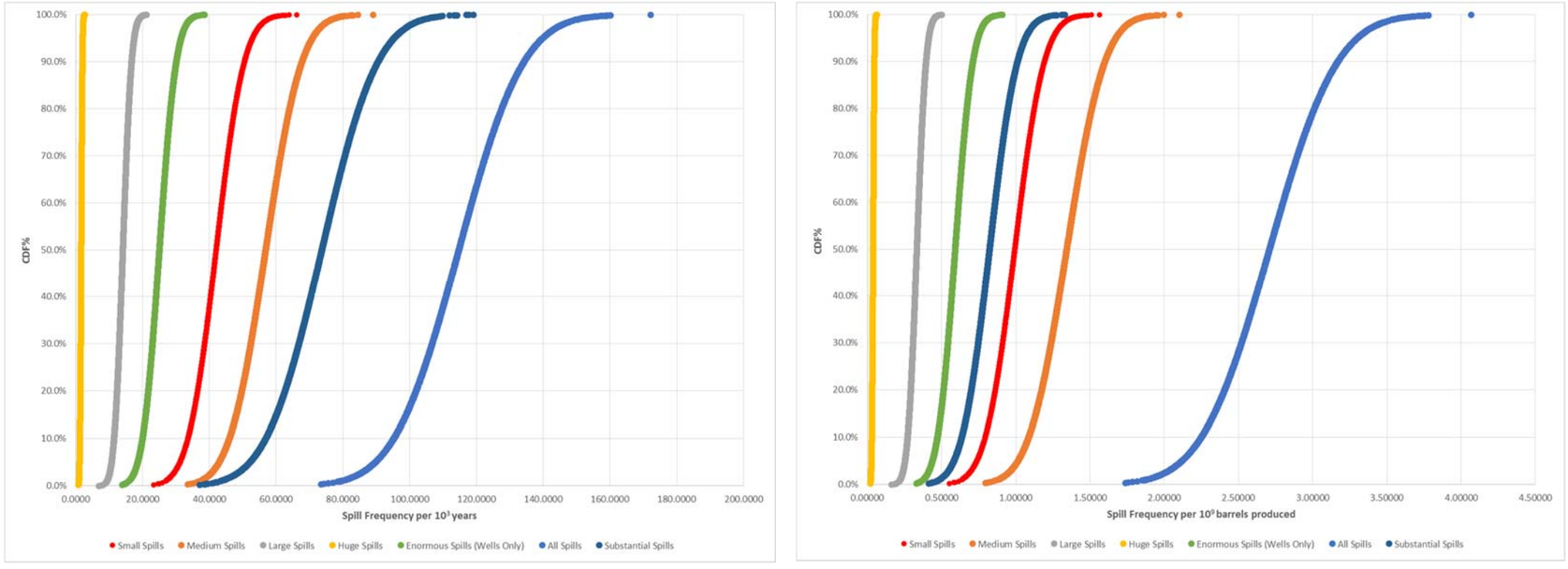


Figure 14: Spill Index [10^{-7}] – Year 31

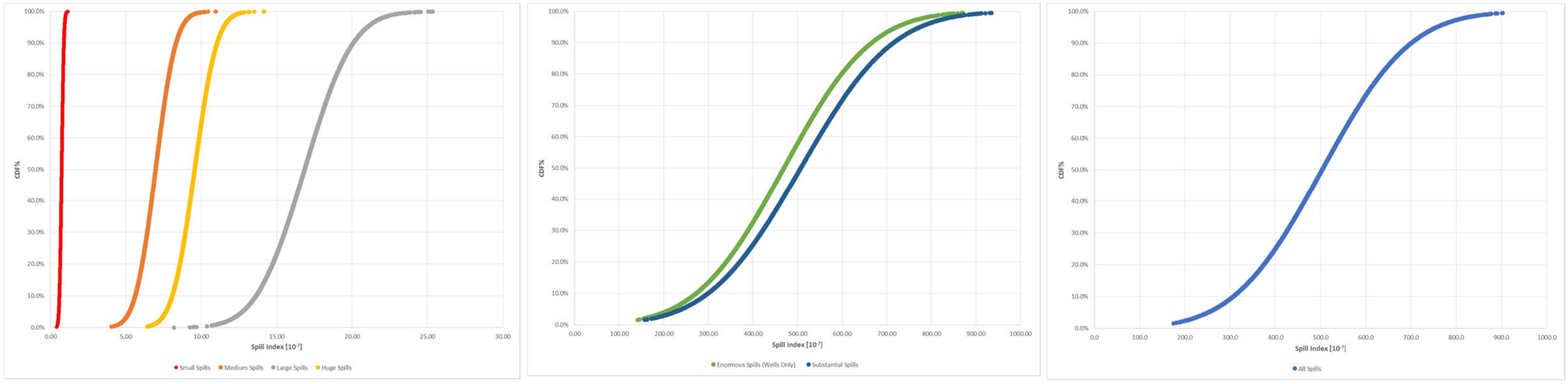


Table 25 presents the CDF for the life of field (LOF) while Figure 15 and Figure 16 illustrate the CDF as a function of spill frequency, spill size, and spill index for the LOF. The CDF for the LOF has been calculated to quantify the variance of the LOF oil spill occurrence estimates.

Table 25: Cumulative Distribution Functions for Oil Spill Estimates – LOF[12]

LOF	Frequency Spills per 10^3 years							Frequency Spills per 10^9 bbl Produced							Spill Index [10^{-7}]						
	Small	Medium	Large	Huge	Enormous	Substantial	All	Small	Medium	Large	Huge	Enormous	Substantial	All	Small	Medium	Large	Huge	Enormous	Substantial	All
Mean	55.03	73.92	19.47	4.09	0.21	23.77	152.72	1.76	2.52	0.92	0.22	0.01	1.14	5.42	1.29	12.82	45.06	39.78	11.67	96.52	110.63
Std. Deviation	31.63	40.84	8.30	1.48	0.12	9.90	82.35	1.89	2.97	1.45	0.38	0.01	1.84	6.68	1.38	14.61	70.11	63.44	14.32	146.07	161.96
Minimum	4.38	7.80	5.16	1.49	0.02	6.67	18.90	0.59	0.83	0.25	0.05	0.00	0.31	1.73	0.40	4.30	12.80	11.70	0.80	25.20	29.95
5%	3.00	6.74	5.82	1.66	0.01	7.50	17.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10%	14.49	21.58	8.83	2.20	0.06	11.09	47.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15%	22.25	31.59	10.87	2.56	0.09	13.52	67.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20%	28.41	39.54	12.49	2.85	0.11	15.44	83.42	0.17	0.03	0.00	0.00	0.00	0.00	0.00	0.13	0.52	0.00	0.00	0.00	0.00	0.00
25%	33.70	46.37	13.87	3.09	0.13	17.10	97.18	0.48	0.52	0.00	0.00	0.00	0.00	0.91	0.37	2.97	0.00	0.00	2.01	0.00	1.39
30%	38.44	52.50	15.12	3.32	0.15	18.58	109.54	0.77	0.97	0.15	0.02	0.00	0.18	1.92	0.57	5.16	8.30	6.52	4.16	19.92	25.70
35%	42.84	58.18	16.27	3.52	0.16	19.96	121.00	1.03	1.38	0.36	0.07	0.00	0.43	2.85	0.76	7.19	18.05	15.34	6.15	40.23	48.22
40%	47.02	63.57	17.37	3.72	0.18	21.26	131.86	1.28	1.77	0.55	0.12	0.00	0.67	3.73	0.95	9.12	27.30	23.71	8.04	59.51	69.60
45%	51.06	68.79	18.43	3.90	0.19	22.53	142.38	1.52	2.15	0.73	0.17	0.00	0.91	4.58	1.12	10.98	36.25	31.81	9.87	78.16	90.28
50%	55.03	73.92	19.47	4.09	0.21	23.77	152.72	1.76	2.52	0.92	0.22	0.01	1.14	5.42	1.29	12.82	45.06	39.78	11.67	96.52	110.63
55%	59.01	79.05	20.52	4.28	0.22	25.02	163.07	1.99	2.90	1.10	0.27	0.01	1.37	6.26	1.47	14.66	53.87	47.75	13.47	114.87	130.98
60%	63.05	84.27	21.58	4.46	0.24	26.28	173.59	2.23	3.28	1.28	0.31	0.01	1.61	7.11	1.64	16.52	62.83	55.85	15.30	133.52	151.66
65%	67.22	89.66	22.67	4.66	0.25	27.58	184.45	2.48	3.67	1.48	0.36	0.01	1.85	7.99	1.83	18.45	72.08	64.23	17.19	152.80	173.04
70%	71.62	95.34	23.83	4.86	0.27	28.96	195.91	2.75	4.08	1.68	0.42	0.01	2.10	8.92	2.02	20.48	81.83	73.05	19.18	173.12	195.56
75%	76.37	101.47	25.07	5.09	0.29	30.45	208.27	3.03	4.52	1.90	0.47	0.01	2.38	9.93	2.22	22.67	92.35	82.57	21.33	195.04	219.87
80%	81.66	108.29	26.46	5.33	0.31	32.10	222.03	3.35	5.02	2.14	0.53	0.01	2.69	11.04	2.45	25.12	104.07	93.17	23.72	219.45	246.94
85%	87.82	116.25	28.08	5.62	0.33	34.03	238.07	3.71	5.60	2.42	0.61	0.01	3.04	12.34	2.72	27.96	117.73	105.53	26.51	247.91	278.49
90%	95.57	126.26	30.11	5.98	0.36	36.45	258.25	4.18	6.32	2.78	0.70	0.01	3.49	13.98	3.06	31.54	134.91	121.08	30.02	283.71	318.19
95%	107.07	141.10	33.13	6.52	0.40	40.05	288.17	4.86	7.40	3.31	0.84	0.02	4.16	16.41	3.56	36.85	160.38	144.13	35.23	336.78	377.03
Maximum	99.57	131.13	30.60	6.10	0.40	37.00	267.70	10.40	16.50	8.10	2.10	0.03	10.20	37.10	7.60	81.20	389.80	326.90	55.90	772.60	806.30

[12] Note: The data with negative values are truncated at zero.

Figure 15: Cumulative Distribution of Spill Frequency per 10^3 years and Spill Frequency per 10^9 barrels produced – LOF

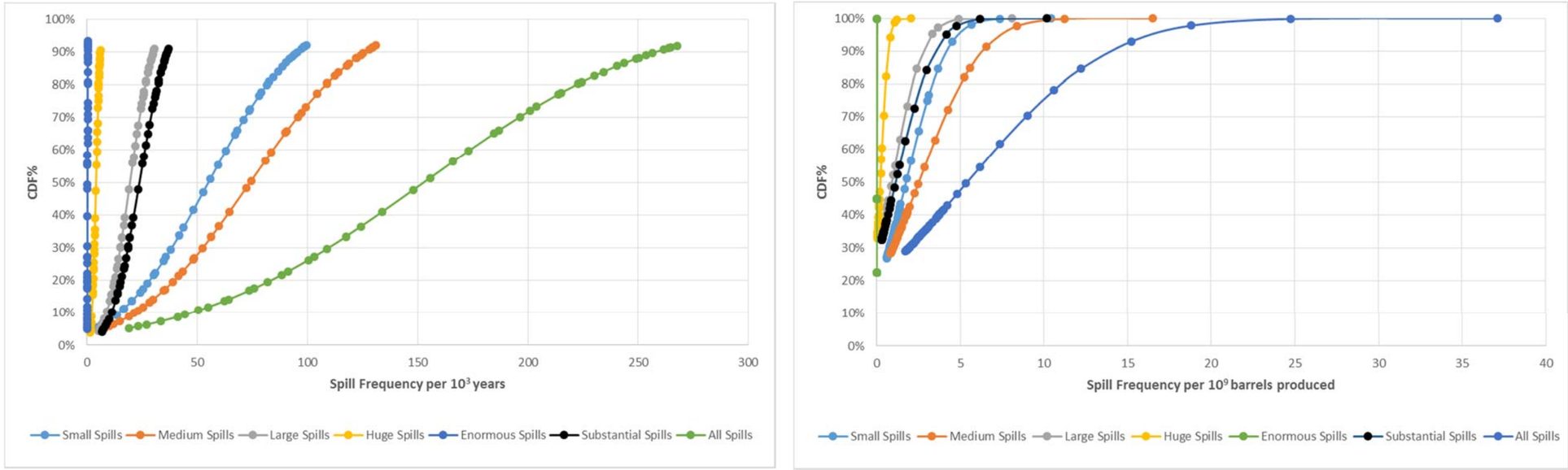
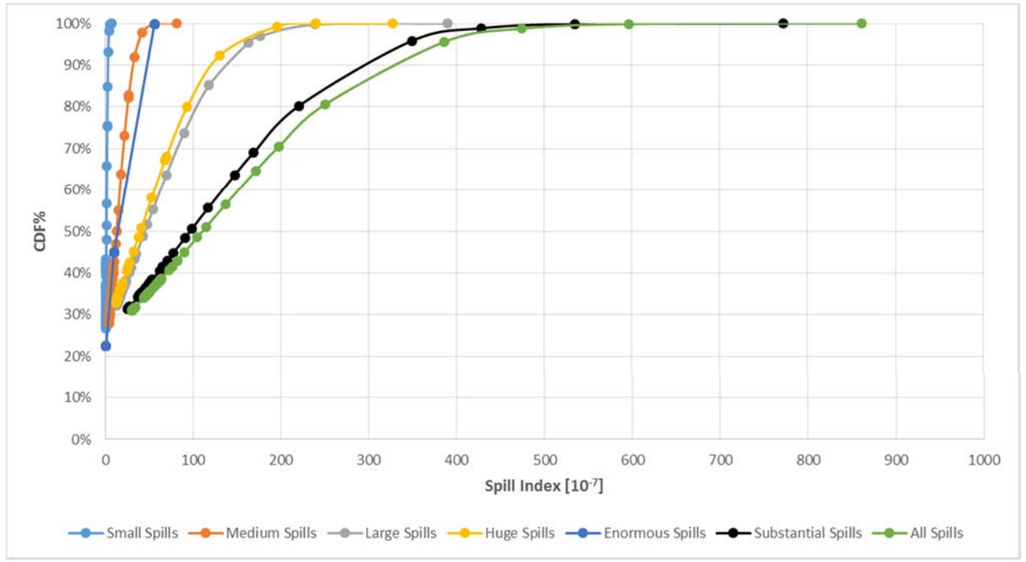


Figure 16: Spill Index [10^{-7}] – LOF



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APPENDIX A – MONTE CARLO RESULTS

Table A-1 through Table A-5 presents the cumulative distribution functions of Monte Carlo modeling for pipelines, platforms, and loss of well control (e.g., production, exploration, drilling). Note that the pipeline frequency can be broken down into >10" and ≤10" by applying the assumed multiplication factor.

Table A-1: Frequency of Pipeline Spills CDF

Pipeline		Frequency Spills per 10^5 km-years				
All		Small	Medium	Large	Huge	All
Mean		3.28	6.47	4.12	0.22	15.04
Std. Deviation		0.47	0.96	0.64	0.08	1.61
Minimum		1.883	3.807	2.261	0.038	9.527
5%		2.496	4.892	3.069	0.093	12.392
10%		2.673	5.244	3.304	0.121	12.974
15%		2.789	5.477	3.459	0.140	13.371
20%		2.882	5.665	3.585	0.155	13.682
25%		2.960	5.824	3.693	0.167	13.952
30%		3.031	5.963	3.788	0.179	14.191
35%		3.096	6.100	3.878	0.190	14.416
40%		3.159	6.226	3.960	0.200	14.630
45%		3.218	6.348	4.044	0.209	14.834
50%		3.278	6.468	4.124	0.219	15.035
55%		3.337	6.588	4.205	0.229	15.237
60%		3.397	6.710	4.287	0.238	15.443
65%		3.459	6.837	4.371	0.248	15.656
70%		3.524	6.968	4.458	0.259	15.876
75%		3.595	7.112	4.556	0.270	16.114
80%		3.674	7.272	4.663	0.283	16.389
85%		3.765	7.457	4.788	0.298	16.701
90%		3.880	7.691	4.941	0.317	17.088
95%		4.052	8.039	5.175	0.345	17.668
Maximum		5.101	10.081	6.460	0.488	20.212

Table A-2: Frequency of Platform Spills CDF

Platform		Frequency Spills per 10^4 well-years				
All		Small	Medium	Large	Huge	All
Mean		1.74	2.21	0.38	0.05	4.38
Std. Deviation		0.29	0.36	0.08	0.01	0.66
Minimum		0.918	1.168	0.169	0.024	2.519
5%		1.267	1.612	0.245	0.035	3.299
10%		1.371	1.745	0.274	0.039	3.540
15%		1.441	1.834	0.294	0.042	3.702
20%		1.497	1.905	0.310	0.044	3.830
25%		1.545	1.966	0.323	0.046	3.938
30%		1.588	2.021	0.335	0.048	4.038
35%		1.628	2.072	0.346	0.049	4.129
40%		1.665	2.120	0.357	0.051	4.216
45%		1.701	2.166	0.367	0.052	4.299
50%		1.737	2.210	0.377	0.054	4.381
55%		1.774	2.258	0.387	0.055	4.463
60%		1.811	2.305	0.397	0.057	4.547
65%		1.849	2.353	0.408	0.058	4.633
70%		1.888	2.403	0.419	0.060	4.724
75%		1.931	2.457	0.431	0.062	4.821
80%		1.979	2.519	0.445	0.064	4.933
85%		2.035	2.590	0.460	0.066	5.061
90%		2.105	2.679	0.480	0.069	5.220
95%		2.209	2.811	0.509	0.073	5.458
Maximum		2.762	3.515	0.658	0.094	6.642

Table A-3: Frequency of Loss of Control from Production Wells CDF

LOWC		Frequency Spills per 10^4 well-years					
Production		Small	Medium	Large	Huge	Enromous	All
Mean		0.01	0.01	0.01	0.00	0.43	0.46
Std. Deviation		0.00	0.00	0.00	0.00	0.14	0.15
Minimum		0.004	0.004	0.003	0.002	0.126	0.139
5%		0.007	0.006	0.005	0.003	0.195	0.215
10%		0.007	0.007	0.005	0.004	0.246	0.269
15%		0.008	0.007	0.006	0.004	0.281	0.305
20%		0.008	0.007	0.006	0.004	0.309	0.334
25%		0.008	0.008	0.006	0.004	0.332	0.358
30%		0.009	0.008	0.006	0.004	0.354	0.380
35%		0.009	0.008	0.006	0.004	0.373	0.401
40%		0.009	0.008	0.007	0.005	0.392	0.421
45%		0.009	0.009	0.007	0.005	0.410	0.439
50%		0.010	0.009	0.007	0.005	0.427	0.458
55%		0.010	0.009	0.007	0.005	0.445	0.476
60%		0.010	0.009	0.007	0.005	0.464	0.495
65%		0.010	0.010	0.007	0.005	0.482	0.514
70%		0.011	0.010	0.008	0.005	0.502	0.535
75%		0.011	0.010	0.008	0.005	0.523	0.557
80%		0.011	0.010	0.008	0.006	0.547	0.582
85%		0.012	0.011	0.008	0.006	0.574	0.611
90%		0.012	0.011	0.009	0.006	0.608	0.647
95%		0.013	0.012	0.009	0.006	0.660	0.700
Maximum		0.015	0.015	0.012	0.007	0.798	0.848

Table A-4: Frequency of Loss of Control from Exploration Wells CDF

LOWC		Frequency Spills per 10^4 well-years					
Exploration		Small	Medium	Large	Huge	Enormous	All
Mean		0.60	0.70	0.53	0.34	0.21	2.38
Std. Deviation		0.12	0.14	0.11	0.07	0.04	0.47
Minimum		0.267	0.311	0.253	0.141	0.097	1.070
5%		0.406	0.472	0.353	0.230	0.143	1.604
10%		0.448	0.522	0.392	0.254	0.158	1.775
15%		0.478	0.556	0.417	0.271	0.168	1.891
20%		0.501	0.583	0.438	0.284	0.177	1.982
25%		0.521	0.606	0.456	0.295	0.184	2.062
30%		0.538	0.627	0.471	0.306	0.190	2.132
35%		0.555	0.646	0.486	0.315	0.196	2.198
40%		0.571	0.664	0.500	0.324	0.201	2.260
45%		0.586	0.682	0.513	0.332	0.207	2.320
50%		0.600	0.699	0.527	0.341	0.212	2.379
55%		0.615	0.717	0.540	0.349	0.217	2.438
60%		0.631	0.734	0.553	0.358	0.222	2.498
65%		0.646	0.753	0.567	0.367	0.228	2.561
70%		0.662	0.771	0.582	0.376	0.234	2.626
75%		0.681	0.792	0.598	0.386	0.240	2.697
80%		0.700	0.815	0.615	0.397	0.247	2.774
85%		0.723	0.842	0.635	0.410	0.255	2.867
90%		0.752	0.876	0.662	0.427	0.265	2.982
95%		0.795	0.926	0.699	0.451	0.281	3.153
Maximum		0.990	1.153	0.891	0.583	0.349	3.965

Table A-5: Frequency of Loss of Control from Development Wells CDF

LOWC		Frequency Spills per 10^4 well-years					
Drilling		Small	Medium	Large	Huge	Enormous	All
Mean		0.12	0.14	0.10	0.07	0.04	0.46
Std. Deviation		0.02	0.02	0.02	0.01	0.01	0.05
Minimum		0.052	0.061	0.047	0.030	0.016	0.279
5%		0.082	0.096	0.072	0.047	0.029	0.377
10%		0.090	0.105	0.079	0.051	0.031	0.396
15%		0.095	0.111	0.083	0.054	0.033	0.409
20%		0.099	0.115	0.087	0.056	0.035	0.419
25%		0.103	0.119	0.090	0.058	0.036	0.427
30%		0.106	0.123	0.093	0.060	0.037	0.435
35%		0.109	0.126	0.095	0.062	0.038	0.442
40%		0.111	0.130	0.098	0.064	0.039	0.449
45%		0.114	0.133	0.100	0.065	0.040	0.456
50%		0.117	0.136	0.102	0.067	0.041	0.462
55%		0.119	0.139	0.105	0.068	0.042	0.469
60%		0.122	0.142	0.107	0.070	0.043	0.475
65%		0.125	0.145	0.109	0.071	0.044	0.482
70%		0.128	0.149	0.112	0.073	0.045	0.489
75%		0.131	0.152	0.115	0.075	0.046	0.497
80%		0.134	0.156	0.118	0.077	0.047	0.506
85%		0.138	0.161	0.121	0.079	0.049	0.516
90%		0.143	0.167	0.126	0.082	0.050	0.529
95%		0.151	0.176	0.132	0.086	0.053	0.547
Maximum		0.182	0.212	0.174	0.109	0.067	0.637

APPENDIX B – EXPLORATION AND DEVELOPMENT DATA

Year	Water depth		Exploration well	Oil production wells	Service wells	Exploration Rig	Production platforms									In-use pipeline length (miles)									Oil Production MMbbl
							Wells			Oil Production Wells Only			Platform			Sum <= 10"			Sum >10"			Sum all			
							incr	Decom	cumul	incr	Converted to gas	cumul	incr	Decom	cumul	incr	Decom	cumul	incr	Decom	cumul	incr	Abnd	cumul	
1	Nearshore (<10 m)																								
	Inner shelf (10 to <25 m)																								
	Middle shelf (25 to <60 m)																								
	Outer shelf (>=60m)			0																					
	Total			0																					
2	Nearshore (<10 m)																								
	Inner shelf (10 to <25 m)																								
	Middle shelf (25 to <60 m)																								
	Outer shelf (>=60m)			0																					
	Total			0																					
3	Nearshore (<10 m)																								
	Inner shelf (10 to <25 m)																								
	Middle shelf (25 to <60 m)					2																			
	Outer shelf (>=60m)			0																					
	Total		4	0		2																			
4	Nearshore (<10 m)																								
	Inner shelf (10 to <25 m)																								
	Middle shelf (25 to <60 m)					2																			
	Outer shelf (>=60m)			0																					
	Total		4	0		2																			
5	Nearshore (<10 m)																								
	Inner shelf (10 to <25 m)																								
	Middle shelf (25 to <60 m)					1																			
	Outer shelf (>=60m)			0		2																			
	Total		6	0		3																			
6	Nearshore (<10 m)																								
	Inner shelf (10 to <25 m)																								
	Middle shelf (25 to <60 m)					3																			
	Outer shelf (>=60m)			0																					
	Total		6	0		3																			
7	Nearshore (<10 m)																								
	Inner shelf (10 to <25 m)																								
	Middle shelf (25 to <60 m)																								
	Outer shelf (>=60m)			0																					
	Total			0		0																			
8	Nearshore (<10 m)																								
	Inner shelf (10 to <25 m)																								
	Middle shelf (25 to <60 m)																								
	Outer shelf (>=60m)			0																					
	Total			0		0																		0	
9	Nearshore (<10 m)											0			0									0	
	Inner shelf (10 to <25 m)											0			0									0	
	Middle shelf (25 to <60 m)					1						0	1		1									0	
	Outer shelf (>=60m)			3		1						0			0									0	
	Total		4	3	3	2	6		6	3		3	1		1				120		120	120		120	1.401
10	Nearshore (<10 m)					1			0			0			0						0			0	
	Inner shelf (10 to <25 m)					1			0			0			0						0			0	
	Middle shelf (25 to <60 m)					1			0			0			1						0			0	
	Outer shelf (>=60m)			9					0			0			0						0			0	
	Total		4	9	3	3	12		18	9		12	0		1						120	0		120	5.604
11	Nearshore (<10 m)								0			0			0						0			0	

Year	Water depth		Exploration well	Oil production wells	Service wells	Exploration Rig	Production platforms									In-use pipeline length (miles)									Oil Production MMbbl
							Wells			Oil Production Wells Only			Platform			Sum <= 10"			Sum >10"			Sum all			
							incr	Decom	cumul	incr	Converted to gas	cumul	incr	Decom	cumul	incr	Decom	cumul	incr	Decom	cumul	incr	Abnd	cumul	
	Inner shelf (10 to <25 m)								0			0			0						0			0	
	Middle shelf (25 to <60 m)					2			0			0			1						0			0	
	Outer shelf (>=60m)			9					0			0			0						0			0	
	Total		3	9	3	2	12		30	9		21	0		1	5		5			120	5		125	9.640
12	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)					1			0			0			0			0			0			0	
	Middle shelf (25 to <60 m)					1			0			0	1		2			0			0			0	
	Outer shelf (>=60m)			12					0			0			0			0			0			0	
	Total		3	12	6	2	18		48	12		33	1		2	0		5			120	0		125	14.473
13	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			2			0			0			0	
	Outer shelf (>=60m)			18					0			0			0			0			0			0	
	Total			18	6		24		72	18		51	0		2	0		5			120	0		125	21.349
14	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			2			0			0			0	
	Outer shelf (>=60m)			18					0			0			0			0			0			0	
	Total			18	6		24		96	18		69	0		2	5		10			120	5		130	27.467
15	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0	1		3			0			0			0	
	Outer shelf (>=60m)			21					0			0			0			0			0			0	
	Total			21	9		30		126	21		90	1		3	35		45			120	35		165	33.921
16	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0	1		4			0			0			0	
	Outer shelf (>=60m)			23					0			0			0			0			0			0	
	Total			23	9		32		158	23		113	1		4	0		45			120	0		165	40.199
17	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			4			0			0			0	
	Outer shelf (>=60m)			27					0			0			0			0			0			0	
	Total			27	9		36		194	27		140	0		4	5		50			120	5		170	47.060
18	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0	1		5			0			0			0	
	Outer shelf (>=60m)			30					0			0			0			0			0			0	
	Total			30	12		42		236	30		170	1		5	5		55			120	5		175	53.607
19	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0	1		6			0			0			0	
	Outer shelf (>=60m)			32					0			0			0			0			0			0	
	Total			32	12		44		280	32		202	1		6	0		55			120	0		175	59.753
20	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			6			0			0			0	
	Outer shelf (>=60m)			36					0			0			0			0			0			0	
	Total			36	12		48		328	36		238	0		6	20		75			120	20		195	66.422
21	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	

Year	Water depth		Exploration well	Oil production wells	Service wells	Exploration Rig	Production platforms									In-use pipeline length (miles)									Oil Production MMbbl
							Wells			Oil Production Wells Only			Platform			Sum <= 10"			Sum >10"			Sum all			
							incr	Decom	cumul	incr	Converted to gas	cumul	incr	Decom	cumul	incr	Decom	cumul	incr	Decom	cumul	incr	Abnd	cumul	
	Middle shelf (25 to <60 m)								0			0	1		7			0			0			0	
	Outer shelf (>=60m)			39					0			0			0			0			0			0	
	Total			39	15		54		382	39		277	1		7	5		80			120	5		200	72.754
22	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0	1		1			0			0			0	
	Middle shelf (25 to <60 m)								0			0			7			0			0			0	
	Outer shelf (>=60m)			41					0			0			0			0			0			0	
	Total			41	15		56		438	41	3	315	1		8	0		80			120	0		200	78.605
23	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			1			0			0			0	
	Middle shelf (25 to <60 m)								0			0			7			0			0			0	
	Outer shelf (>=60m)			38					0			0			0			0			0			0	
	Total			38	12		50		488	38	9	344	0		8	5		85			120	5		205	81.563
24	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			1			0			0			0	
	Middle shelf (25 to <60 m)								0			0	1		8			0			0			0	
	Outer shelf (>=60m)			39					0			0			0			0			0			0	
	Total			39	15		54		542	39	9	374	1		9	12		97			120	12		217	83.928
25	Nearshore (<10 m)								0			0	1		1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			1			0			0			0	
	Middle shelf (25 to <60 m)								0			0			8			0			0			0	
	Outer shelf (>=60m)			41					0			0			0			0			0			0	
	Total			41	15		56		598	41	12	403	1		10	0		97			120	0		217	86.725
26	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			1			0			0			0	
	Middle shelf (25 to <60 m)								0			0			8			0			0			0	
	Outer shelf (>=60m)			38					0			0			0			0			0			0	
	Total			38	12		50		648	38	18	423	0		10	5		102			120	5		222	87.316
27	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			1			0			0			0	
	Middle shelf (25 to <60 m)								0			0			8			0			0			0	
	Outer shelf (>=60m)			39					0			0	1		1			0			0			0	
	Total			39	15		54		702	39	18	444	1		11	5		107			120	5		227	87.751
28	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0	1		2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			8			0			0			0	
	Outer shelf (>=60m)			41					0			0			1			0			0			0	
	Total			41	15		56		758	41	21	464	1		12	0		107			120	0		227	89.103
29	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			8			0			0			0	
	Outer shelf (>=60m)			38					0			0			1			0			0			0	
	Total			38	12		50		808	38	23	479	0		12	5		112			120	5		232	88.795
30	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0	1		9			0			0			0	
	Outer shelf (>=60m)			39					0			0			1			0			0			0	
	Total			39	15		54		862	39	27	491	1		13	5		117			120	5		237	88.614
31	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0	1		10			0			0			0	

Year	Water depth		Exploration well	Oil production wells	Service wells	Exploration Rig	Production platforms									In-use pipeline length (miles)									Oil Production MMbbl
							Wells			Oil Production Wells Only			Platform			Sum <= 10"			Sum >10"			Sum all			
							incr	Decom	cumul	incr	Converted to gas	cumul	incr	Decom	cumul	incr	Decom	cumul	incr	Decom	cumul	incr	Abnd	cumul	
	Outer shelf (>=60m)			41					0			0			1			0			0			0	
	Total			41	15		56		918	41	30	502	1		14	0		117			120	0		237	89.511
32	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			10			0			0			0	
	Outer shelf (>=60m)			38					0			0			1			0			0			0	
	Total			38	12		50		968	38	32	508	0		14	20		137			120	20		257	88.865
33	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			10			0			0			0	
	Outer shelf (>=60m)			39					0			0	1		2			0			0			0	
	Total			39	15		54		1022	39	36	511	1		15	0		137			120	0		257	88.614
34	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			10			0			0			0	
	Outer shelf (>=60m)			33					0			0			2			0			0			0	
	Total			33	10		43		1065	33	39	505	0		15	0		137			120	0		257	85.755
35	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			10			0			0			0	
	Outer shelf (>=60m)			18					0			0			2			0			0			0	
	Total			18	6		24	6	1083	18	41	482	0		15	35		172			120	35		292	76.421
36	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0	1		11			0			0			0	
	Outer shelf (>=60m)			21					0			0			2			0			0			0	
	Total			21	9		30	12	1101	21	38	465	1		16	0		172			120	0		292	70.254
37	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			11			0			0			0	
	Outer shelf (>=60m)			20					0			0			2			0			0			0	
	Total			20	6		26	12	1115	20	39	446	0		16	0		172			120	0		292	65.405
38	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			11			0			0			0	
	Outer shelf (>=60m)			18					0			0			2			0			0			0	
	Total			18	6		24	18	1121	18	41	423	0		16	5		177			120	5		297	60.875
39	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0	1		12			0			0			0	
	Outer shelf (>=60m)			21					0			0			2			0			0			0	
	Total			21	9		30	24	1127	21	38	406	1		17	0		177			120	0		297	58.715
40	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			12			0			0			0	
	Outer shelf (>=60m)			20					0			0			2			0			0			0	
	Total			20	6		26	24	1129	20	39	387	0		17	0		177			120	0		297	56.857
41	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			12			0			0			0	
	Outer shelf (>=60m)			18					0			0			2			0			0			0	

Year	Water depth		Exploration well	Oil production wells	Service wells	Exploration Rig	Production platforms									In-use pipeline length (miles)									Oil Production MMbbl
							Wells			Oil Production Wells Only			Platform			Sum <= 10"			Sum >10"			Sum all			
							incr	Decom	cumul	incr	Converted to gas	cumul	incr	Decom	cumul	incr	Decom	cumul	incr	Decom	cumul	incr	Abnd	cumul	
	Total			18	6		24	30	1123	18	41	364	0		17	5		182			120	5		302	54.542
42	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			12			0			0			0	
	Outer shelf (>=60m)			21					0			0	1		3			0			0			0	
	Total			21	9		30	32	1121	21	38	347	1		18	5		187			120	5		307	54.023
43	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			12			0			0			0	
	Outer shelf (>=60m)			17					0			0			3			0			0			0	
	Total			17	5		22	36	1107	17	39	325			18			187			120	0		307	51.981
44	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			12			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				42	1065	0	41	284			18			187			120	0		307	41.427
45	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			12			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				44	1021	0	38	246			18		67	120			120	0	67	240	31.790
46	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			12			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				48	973	0	39	207			18			120			120	0		240	24.206
47	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			12			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				54	919	0	33	174			18			120			120	0		240	18.325
48	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			12			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				56	863	0	18	156			18			120			120	0		240	13.798
49	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			12			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				50	813	0	21	135			18			120			120	0		240	10.193
50	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			12			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				54	759	0	20	115			18			120			120	0		240	7.412
51	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			12			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				56	703	0	18	97			18			120			120	0		240	5.299

Year	Water depth		Exploration well	Oil production wells	Service wells	Exploration Rig	Production platforms									In-use pipeline length (miles)									Oil Production MMbbl
							Wells			Oil Production Wells Only			Platform			Sum <= 10"			Sum >10"			Sum all			
							incr	Decom	cumul	incr	Converted to gas	cumul	incr	Decom	cumul	incr	Decom	cumul	incr	Decom	cumul	incr	Abnd	cumul	
52	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			12			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				50	653	0	21	76			18			120			120	0		240	3.574
53	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			12			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				54	599	0	20	56			18			120			120	0		240	2.257
54	Nearshore (<10 m)								0			0			1			0			0			0	
	Inner shelf (10 to <25 m)								0			0			2			0			0			0	
	Middle shelf (25 to <60 m)								0			0			12			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				56	543	0	18	38			18			120			120	0		240	1.284
55	Nearshore (<10 m)								0			0		1	0			0			0			0	
	Inner shelf (10 to <25 m)								0			0		2	0			0			0			0	
	Middle shelf (25 to <60 m)								0			0		3	9			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				50	493	0	21	17		6	12			120			120	0		240	0.000
56	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			9			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				54	439	0	17	0			12			120			120	0		240	0.000
57	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			9			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				56	383	0		0			12			120			120	0		240	0.000
58	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			9			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				50	333	0		0			12			120			120	0		240	0.000
59	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			9			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				54	279	0		0			12			120			120	0		240	0.000
60	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			9			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				43	236	0		0			12			120			120	0		240	0.000
61	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			9			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				24	212	0		0			12			120			120	0		240	0.000
62	Nearshore (<10 m)								0			0			0			0			0			0	

Year	Water depth		Exploration well	Oil production wells	Service wells	Exploration Rig	Production platforms									In-use pipeline length (miles)									Oil Production MMbbl
							Wells			Oil Production Wells Only			Platform			Sum <= 10"			Sum >10"			Sum all			
							incr	Decom	cumul	incr	Converted to gas	cumul	incr	Decom	cumul	incr	Decom	cumul	incr	Decom	cumul	incr	Abnd	cumul	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			9			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				30	182	0		0			12			120			120	0		240	0.000
63	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			9			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				26	156	0		0			12			120			120	0		240	0.000
64	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			9			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				24	132	0		0			12			120			120	0		240	0.000
65	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			9			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				30	102	0		0			12			120			120	0		240	0.000
66	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			9			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				26	76	0		0			12			120			120	0		240	0.000
67	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			9			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				24	52	0		0			12			120			120	0		240	0.000
68	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			9			0			0			0	
	Outer shelf (>=60m)			0					0			0			3			0			0			0	
	Total			0				30	22	0		0			12			120			120	0		240	0.000
69	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0		9	0			0			0			0	
	Outer shelf (>=60m)			0					0			0		3	0			0			0			0	
	Total			0				22	0	0		0		12	0		120	0		120	0	0	240	0	0.000
70	Nearshore (<10 m)								0			0			0			0			0			0	
	Inner shelf (10 to <25 m)								0			0			0			0			0			0	
	Middle shelf (25 to <60 m)								0			0			0			0			0			0	
	Outer shelf (>=60m)			0					0			0			0			0			0			0	
	Total			0					0	0		0			0			0			0	0		0	0.000

APPENDIX C – OIL SPILL INDICATORS RESULTS

A breakdown of individual facilities project data and the results are presented in this appendix.

Summary of Platforms

PLATFORM	Total Oil Production, MMbbl	Small spills 50-99 bbl			Medium spills 100-999 bbl			Small and Medium spills 50-999 bbl			Large spills 1000-9999 bbl			Huge spills =>10000 bbl			Substantial spills =>1000 bbl			All spills		
Year		Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1.40	0.54	0.38	0.29	0.68	0.49	2.59	1.22	0.87	2.88	0.12	0.08	4.47	0.02	0.01	1.80	0.14	0.10	6.27	1.35	0.97	9.15
10	5.60	2.15	0.38	0.29	2.73	0.49	2.59	4.88	0.87	2.88	0.47	0.08	4.47	0.07	0.01	1.80	0.54	0.10	6.27	5.42	0.97	9.15
11	9.64	3.76	0.39	0.29	4.78	0.50	2.63	8.54	0.89	2.93	0.83	0.09	4.55	0.12	0.01	1.83	0.95	0.10	6.38	9.48	0.98	9.31
12	14.47	5.90	0.41	0.30	7.51	0.52	2.76	13.42	0.93	3.06	1.30	0.09	4.76	0.18	0.01	1.92	1.49	0.10	6.68	14.90	1.03	9.74
13	21.35	9.12	0.43	0.32	11.61	0.54	2.89	20.74	0.97	3.21	2.01	0.09	4.99	0.29	0.01	2.01	2.30	0.11	7.00	23.03	1.08	10.20
14	27.47	12.34	0.45	0.34	15.71	0.57	3.04	28.06	1.02	3.37	2.72	0.10	5.24	0.39	0.01	2.11	3.11	0.11	7.36	31.16	1.13	10.73
15	33.92	16.10	0.47	0.35	20.49	0.60	3.21	36.59	1.08	3.56	3.55	0.10	5.54	0.50	0.01	2.23	4.05	0.12	7.77	40.64	1.20	11.33
16	40.20	20.22	0.50	0.38	25.73	0.64	3.40	45.95	1.14	3.78	4.45	0.11	5.87	0.63	0.02	2.37	5.09	0.13	8.23	51.03	1.27	12.01
17	47.06	25.05	0.53	0.40	31.88	0.68	3.60	56.92	1.21	4.00	5.52	0.12	6.21	0.78	0.02	2.50	6.30	0.13	8.71	63.22	1.34	12.71
18	53.61	30.41	0.57	0.42	38.71	0.72	3.83	69.12	1.29	4.26	6.70	0.12	6.62	0.95	0.02	2.67	7.65	0.14	9.29	76.77	1.43	13.55
19	59.75	36.14	0.60	0.45	46.00	0.77	4.09	82.13	1.37	4.54	7.96	0.13	7.05	1.13	0.02	2.85	9.09	0.15	9.90	91.22	1.53	14.44
20	66.42	42.58	0.64	0.48	54.19	0.82	4.33	96.77	1.46	4.81	9.38	0.14	7.48	1.33	0.02	3.02	10.71	0.16	10.49	107.48	1.62	15.31
21	72.75	49.56	0.68	0.51	63.07	0.87	4.60	112.63	1.55	5.11	10.91	0.15	7.95	1.55	0.02	3.21	12.47	0.17	11.15	125.09	1.72	16.26
22	78.60	56.35	0.72	0.54	71.73	0.91	4.85	128.08	1.63	5.38	12.41	0.16	8.36	1.76	0.02	3.37	14.18	0.18	11.74	142.25	1.81	17.12
23	81.56	61.54	0.75	0.56	78.33	0.96	5.10	139.87	1.71	5.66	13.55	0.17	8.80	1.93	0.02	3.55	15.48	0.19	12.35	155.35	1.90	18.02
24	83.93	66.91	0.80	0.60	85.16	1.01	5.39	152.07	1.81	5.98	14.74	0.18	9.30	2.09	0.02	3.75	16.83	0.20	13.05	168.90	2.01	19.04
25	86.73	72.10	0.83	0.62	91.76	1.06	5.62	163.86	1.89	6.24	15.88	0.18	9.70	2.26	0.03	3.91	18.14	0.21	13.61	181.99	2.10	19.85
26	87.32	75.67	0.87	0.65	96.32	1.10	5.86	171.99	1.97	6.51	16.67	0.19	10.11	2.37	0.03	4.08	19.04	0.22	14.19	191.03	2.19	20.69
27	87.75	79.43	0.91	0.68	101.10	1.15	6.12	180.53	2.06	6.80	17.49	0.20	10.56	2.49	0.03	4.26	19.98	0.23	14.82	200.51	2.29	21.61
28	89.10	83.01	0.93	0.70	105.65	1.19	6.30	188.66	2.12	6.99	18.28	0.21	10.87	2.60	0.03	4.38	20.88	0.23	15.25	209.54	2.35	22.24

PLATFORM	Total Oil Production, MMbbl	Small spills 50-99 bbl			Medium spills 100-999 bbl			Small and Medium spills 50-999 bbl			Large spills 1000-9999 bbl			Huge spills =>10000 bbl			Substantial spills =>1000 bbl			All spills		
Year		Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}
29	88.80	85.69	0.97	0.72	109.07	1.23	6.52	194.76	2.19	7.24	18.87	0.21	11.26	2.68	0.03	4.54	21.56	0.24	15.80	216.32	2.44	23.04
30	88.61	87.84	0.99	0.74	111.80	1.26	6.70	199.64	2.25	7.44	19.35	0.22	11.56	2.75	0.03	4.66	22.10	0.25	16.23	221.74	2.50	23.67
31	89.51	89.81	1.00	0.75	114.31	1.28	6.78	204.11	2.28	7.53	19.78	0.22	11.70	2.81	0.03	4.72	22.59	0.25	16.42	226.70	2.53	23.96
32	88.86	90.88	1.02	0.76	115.67	1.30	6.91	206.55	2.32	7.68	20.02	0.23	11.93	2.84	0.03	4.81	22.86	0.26	16.74	229.41	2.58	24.42
33	88.61	91.42	1.03	0.77	116.35	1.31	6.97	207.77	2.34	7.74	20.13	0.23	12.03	2.86	0.03	4.85	23.00	0.26	16.89	230.77	2.60	24.63
34	85.75	90.34	1.05	0.79	114.99	1.34	7.12	205.33	2.39	7.91	19.90	0.23	12.29	2.83	0.03	4.96	22.73	0.27	17.25	228.06	2.66	25.16
35	76.42	86.23	1.13	0.84	109.75	1.44	7.63	195.98	2.56	8.47	18.99	0.25	13.16	2.70	0.04	5.31	21.69	0.28	18.47	217.67	2.85	26.94
36	70.25	83.19	1.18	0.88	105.88	1.51	8.00	189.07	2.69	8.89	18.32	0.26	13.81	2.60	0.04	5.57	20.93	0.30	19.38	209.99	2.99	28.27
37	65.41	79.79	1.22	0.91	101.55	1.55	8.25	181.34	2.77	9.16	17.57	0.27	14.23	2.50	0.04	5.74	20.07	0.31	19.97	201.41	3.08	29.13
38	60.87	75.67	1.24	0.93	96.32	1.58	8.40	171.99	2.83	9.33	16.67	0.27	14.50	2.37	0.04	5.85	19.04	0.31	20.35	191.03	3.14	29.68
39	58.71	72.63	1.24	0.92	92.45	1.57	8.36	165.08	2.81	9.29	16.00	0.27	14.43	2.27	0.04	5.82	18.27	0.31	20.25	183.35	3.12	29.54
40	56.86	69.23	1.22	0.91	88.12	1.55	8.23	157.35	2.77	9.14	15.25	0.27	14.20	2.17	0.04	5.73	17.42	0.31	19.93	174.77	3.07	29.08
41	54.54	65.12	1.19	0.89	82.88	1.52	8.07	148.00	2.71	8.96	14.34	0.26	13.93	2.04	0.04	5.62	16.38	0.30	19.55	164.38	3.01	28.51
42	54.02	62.08	1.15	0.86	79.01	1.46	7.77	141.09	2.61	8.63	13.67	0.25	13.40	1.94	0.04	5.41	15.62	0.29	18.81	156.71	2.90	27.44
43	51.98	58.14	1.12	0.84	74.00	1.42	7.56	132.15	2.54	8.40	12.81	0.25	13.05	1.82	0.04	5.26	14.63	0.28	18.31	146.77	2.82	26.71
44	41.43	50.81	1.23	0.92	64.67	1.56	8.29	115.47	2.79	9.21	11.19	0.27	14.31	1.59	0.04	5.77	12.78	0.31	20.08	128.25	3.10	29.28
45	31.79	44.01	1.38	1.03	56.01	1.76	9.36	100.02	3.15	10.39	9.69	0.30	16.15	1.38	0.04	6.51	11.07	0.35	22.66	111.09	3.49	33.05
46	24.21	37.03	1.53	1.14	47.13	1.95	10.34	84.17	3.48	11.48	8.16	0.34	17.85	1.16	0.05	7.20	9.32	0.38	25.05	93.48	3.86	36.53
47	18.32	31.13	1.70	1.27	39.62	2.16	11.48	70.75	3.86	12.75	6.86	0.37	19.81	0.97	0.05	7.99	7.83	0.43	27.81	78.58	4.29	40.56
48	13.80	27.91	2.02	1.51	35.52	2.57	13.67	63.43	4.60	15.18	6.15	0.45	23.59	0.87	0.06	9.52	7.02	0.51	33.11	70.45	5.11	48.30
49	10.19	24.15	2.37	1.77	30.74	3.02	16.02	54.89	5.39	17.79	5.32	0.52	27.64	0.76	0.07	11.15	6.08	0.60	38.79	60.97	5.98	56.57
50	7.41	20.57	2.78	2.07	26.19	3.53	18.76	46.76	6.31	20.84	4.53	0.61	32.38	0.64	0.09	13.06	5.18	0.70	45.44	51.93	7.01	66.28
51	5.30	17.35	3.27	2.45	22.09	4.17	22.14	39.44	7.44	24.58	3.82	0.72	38.20	0.54	0.10	15.41	4.37	0.82	53.61	43.81	8.27	78.20
52	3.57	13.60	3.80	2.84	17.31	4.84	25.72	30.90	8.65	28.56	2.99	0.84	44.38	0.43	0.12	17.90	3.42	0.96	62.28	34.32	9.60	90.83
53	2.26	10.02	4.44	3.32	12.75	5.65	30.00	22.77	10.09	33.32	2.21	0.98	51.78	0.31	0.14	20.89	2.52	1.12	72.66	25.29	11.20	105.98
54	1.28	6.80	5.29	3.95	8.65	6.74	35.79	15.45	12.03	39.74	1.50	1.17	61.75	0.21	0.17	24.91	1.71	1.33	86.67	17.16	13.36	126.41
Total LOF	**2,287.43**	**2,220.33**		**43.94**	**2,825.98**		**397.65**	**5,046.31**		**441.59**	**488.99**		**686.20**	**69.50**		**276.83**	**558.50**		**963.03**	**5,604.81**		**1,404.62**
Average LOF		**41.12**	**0.97**	**0.81**	**52.33**	**1.24**	**7.36**	**93.45**	**2.21**	**8.18**	**9.06**	**0.21**	**12.71**	**1.29**	**0.03**	**5.13**	**10.34**	**0.24**	**17.83**	**103.79**	**2.45**	**26.01**

Summary of Oil Production Wells in Operation

PRODUCTION OIL WELL		Small spills 50-99 bbl			Medium spills 100-999 bbl			Small and Medium spills 50-999 bbl			Large spills 1000-9999 bbl			Huge spills =>10,000 bbl			Enormous =>150,000 bbl			Substantial spills =>1000 bbl			All spills		
Year	Total Oil Production, MMbbl	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1.40	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.09	0.00	0.00	0.83	0.00	0.00	0.80	0.01	0.00	1.72	0.01	0.01	1.74
10	5.60	0.01	0.00	0.00	0.01	0.00	0.01	0.03	0.00	0.01	0.01	0.00	0.09	0.01	0.00	0.83	0.00	0.00	0.80	0.02	0.00	1.72	0.05	0.01	1.74
11	9.64	0.02	0.00	0.00	0.02	0.00	0.01	0.04	0.00	0.01	0.02	0.00	0.09	0.01	0.00	0.84	0.01	0.00	0.80	0.04	0.00	1.74	0.08	0.01	1.75
12	14.47	0.03	0.00	0.00	0.04	0.00	0.01	0.07	0.00	0.02	0.03	0.00	0.10	0.02	0.00	0.88	0.01	0.00	0.80	0.06	0.00	1.78	0.13	0.01	1.80
13	21.35	0.05	0.00	0.00	0.06	0.00	0.01	0.11	0.01	0.02	0.04	0.00	0.10	0.03	0.00	0.92	0.02	0.00	0.80	0.09	0.00	1.83	0.19	0.01	1.84
14	27.47	0.07	0.00	0.00	0.08	0.00	0.01	0.14	0.01	0.02	0.06	0.00	0.11	0.03	0.00	0.97	0.03	0.00	0.80	0.12	0.00	1.88	0.26	0.01	1.90
15	33.92	0.09	0.00	0.00	0.10	0.00	0.02	0.19	0.01	0.02	0.07	0.00	0.11	0.05	0.00	1.03	0.04	0.00	0.80	0.15	0.00	1.94	0.34	0.01	1.96
16	40.20	0.11	0.00	0.00	0.12	0.00	0.02	0.24	0.01	0.02	0.09	0.00	0.12	0.06	0.00	1.09	0.05	0.00	0.80	0.19	0.00	2.01	0.43	0.01	2.03
17	47.06	0.14	0.00	0.00	0.15	0.00	0.02	0.29	0.01	0.02	0.11	0.00	0.13	0.07	0.00	1.15	0.06	0.00	0.80	0.24	0.00	2.08	0.53	0.01	2.10
18	53.61	0.17	0.00	0.00	0.19	0.00	0.02	0.36	0.01	0.02	0.14	0.00	0.13	0.09	0.00	1.23	0.07	0.00	0.80	0.29	0.00	2.16	0.65	0.01	2.18
19	59.75	0.20	0.00	0.00	0.22	0.00	0.02	0.42	0.01	0.02	0.16	0.00	0.14	0.10	0.00	1.31	0.08	0.00	0.80	0.34	0.00	2.25	0.77	0.01	2.28
20	66.42	0.24	0.00	0.00	0.26	0.00	0.02	0.50	0.01	0.02	0.19	0.00	0.15	0.12	0.00	1.39	0.10	0.00	0.80	0.40	0.01	2.34	0.90	0.01	2.36
21	72.75	0.28	0.00	0.00	0.30	0.00	0.02	0.58	0.01	0.03	0.22	0.00	0.16	0.14	0.00	1.47	0.11	0.00	0.80	0.47	0.01	2.44	1.05	0.01	2.46
22	78.60	0.32	0.00	0.00	0.35	0.00	0.02	0.66	0.01	0.03	0.25	0.00	0.17	0.16	0.00	1.55	0.13	0.00	0.80	0.54	0.01	2.52	1.20	0.01	2.55
23	81.56	0.34	0.00	0.00	0.38	0.00	0.02	0.72	0.01	0.03	0.28	0.00	0.18	0.17	0.00	1.63	0.14	0.00	0.80	0.58	0.01	2.61	1.31	0.01	2.64
24	83.93	0.37	0.00	0.00	0.41	0.00	0.03	0.79	0.01	0.03	0.30	0.00	0.19	0.19	0.00	1.72	0.15	0.00	0.80	0.64	0.01	2.71	1.42	0.02	2.74
25	86.73	0.40	0.00	0.00	0.44	0.01	0.03	0.85	0.01	0.03	0.32	0.00	0.20	0.20	0.00	1.80	0.16	0.00	0.80	0.69	0.01	2.80	1.53	0.02	2.83
26	87.32	0.42	0.00	0.00	0.47	0.01	0.03	0.89	0.01	0.03	0.34	0.00	0.21	0.21	0.00	1.87	0.17	0.00	0.80	0.72	0.01	2.88	1.61	0.02	2.91
27	87.75	0.44	0.01	0.00	0.49	0.01	0.03	0.93	0.01	0.03	0.36	0.00	0.22	0.22	0.00	1.96	0.18	0.00	0.80	0.75	0.01	2.97	1.69	0.02	3.01

PRODUCTION OIL WELL	Total Oil Production, MMbbl	Small spills 50-99 bbl			Medium spills 100-999 bbl			Small and Medium spills 50-999 bbl			Large spills 1000-9999 bbl			Huge spills =>10,000 bbl			Enormous =>150,000 bbl			Substantial spills =>1000 bbl			All spills		
Year		Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}
28	89.10	0.46	0.01	0.00	0.51	0.01	0.03	0.97	0.01	0.03	0.37	0.00	0.22	0.23	0.00	2.01	0.19	0.00	0.80	0.79	0.01	3.04	1.76	0.02	3.07
29	88.80	0.48	0.01	0.00	0.53	0.01	0.03	1.01	0.01	0.04	0.38	0.00	0.23	0.24	0.00	2.09	0.19	0.00	0.80	0.81	0.01	3.12	1.82	0.02	3.15
30	88.61	0.49	0.01	0.00	0.54	0.01	0.03	1.03	0.01	0.04	0.39	0.00	0.24	0.25	0.00	2.14	0.20	0.00	0.80	0.83	0.01	3.18	1.87	0.02	3.22
31	89.51	0.50	0.01	0.00	0.55	0.01	0.03	1.05	0.01	0.04	0.40	0.00	0.24	0.25	0.00	2.17	0.20	0.00	0.80	0.85	0.01	3.21	1.91	0.02	3.25
32	88.86	0.51	0.01	0.00	0.56	0.01	0.03	1.07	0.01	0.04	0.41	0.00	0.24	0.25	0.00	2.21	0.20	0.00	0.80	0.86	0.01	3.26	1.93	0.02	3.29
33	88.61	0.51	0.01	0.00	0.56	0.01	0.03	1.07	0.01	0.04	0.41	0.00	0.25	0.26	0.00	2.23	0.20	0.00	0.80	0.87	0.01	3.28	1.94	0.02	3.32
34	85.75	0.51	0.01	0.00	0.56	0.01	0.03	1.06	0.01	0.04	0.40	0.00	0.25	0.25	0.00	2.28	0.20	0.00	0.80	0.86	0.01	3.33	1.92	0.02	3.37
35	76.42	0.48	0.01	0.00	0.53	0.01	0.04	1.01	0.01	0.04	0.39	0.01	0.27	0.24	0.00	2.44	0.19	0.00	0.80	0.82	0.01	3.51	1.83	0.02	3.55
36	70.25	0.47	0.01	0.00	0.51	0.01	0.04	0.98	0.01	0.04	0.37	0.01	0.28	0.23	0.00	2.56	0.19	0.00	0.80	0.79	0.01	3.64	1.77	0.02	3.69
37	65.41	0.45	0.01	0.01	0.49	0.01	0.04	0.94	0.01	0.05	0.36	0.01	0.29	0.22	0.00	2.64	0.18	0.00	0.80	0.76	0.01	3.73	1.69	0.02	3.77
38	60.87	0.42	0.01	0.01	0.47	0.01	0.04	0.89	0.01	0.05	0.34	0.01	0.30	0.21	0.00	2.69	0.17	0.00	0.80	0.72	0.01	3.79	1.61	0.02	3.83
39	58.71	0.41	0.01	0.01	0.45	0.01	0.04	0.85	0.01	0.05	0.32	0.01	0.29	0.20	0.00	2.67	0.16	0.00	0.80	0.69	0.01	3.77	1.54	0.02	3.82
40	56.86	0.39	0.01	0.01	0.43	0.01	0.04	0.81	0.01	0.05	0.31	0.01	0.29	0.19	0.00	2.63	0.15	0.00	0.80	0.66	0.01	3.72	1.47	0.02	3.77
41	54.54	0.36	0.01	0.01	0.40	0.01	0.04	0.76	0.01	0.04	0.29	0.01	0.28	0.18	0.00	2.58	0.15	0.00	0.80	0.62	0.01	3.67	1.38	0.02	3.71
42	54.02	0.35	0.01	0.00	0.38	0.01	0.04	0.73	0.01	0.04	0.28	0.01	0.27	0.17	0.00	2.48	0.14	0.00	0.80	0.59	0.01	3.56	1.32	0.02	3.60
43	51.98	0.33	0.01	0.00	0.36	0.01	0.04	0.68	0.01	0.04	0.26	0.01	0.27	0.16	0.00	2.42	0.13	0.00	0.80	0.55	0.01	3.49	1.24	0.02	3.53
44	41.43	0.28	0.01	0.01	0.31	0.01	0.04	0.60	0.01	0.05	0.23	0.01	0.29	0.14	0.00	2.65	0.11	0.00	0.80	0.48	0.01	3.75	1.08	0.02	3.79
45	31.79	0.25	0.01	0.01	0.27	0.01	0.05	0.52	0.02	0.05	0.20	0.01	0.33	0.12	0.00	2.99	0.10	0.00	0.80	0.42	0.01	4.12	0.93	0.03	4.18
46	24.21	0.21	0.01	0.01	0.23	0.01	0.05	0.43	0.02	0.06	0.17	0.01	0.36	0.10	0.00	3.31	0.08	0.00	0.80	0.35	0.01	4.47	0.79	0.03	4.53
47	18.32	0.17	0.01	0.01	0.19	0.01	0.06	0.37	0.02	0.06	0.14	0.01	0.40	0.09	0.00	3.67	0.07	0.00	0.80	0.30	0.01	4.88	0.66	0.03	4.94
48	13.80	0.16	0.01	0.01	0.17	0.01	0.07	0.33	0.02	0.08	0.12	0.01	0.48	0.08	0.01	4.37	0.06	0.00	0.80	0.27	0.02	5.66	0.59	0.04	5.73
49	10.19	0.14	0.01	0.01	0.15	0.01	0.08	0.28	0.03	0.09	0.11	0.01	0.56	0.07	0.01	5.12	0.05	0.00	0.80	0.23	0.02	6.49	0.51	0.05	6.58
50	7.41	0.12	0.02	0.01	0.13	0.02	0.09	0.24	0.03	0.10	0.09	0.01	0.66	0.06	0.01	6.00	0.05	0.00	0.80	0.20	0.02	7.46	0.44	0.05	7.57
51	5.30	0.10	0.02	0.01	0.11	0.02	0.11	0.20	0.04	0.12	0.08	0.01	0.78	0.05	0.01	7.08	0.04	0.00	0.80	0.16	0.02	8.66	0.37	0.06	8.78
52	3.57	0.08	0.02	0.02	0.08	0.02	0.13	0.16	0.04	0.14	0.06	0.02	0.90	0.04	0.01	8.23	0.03	0.00	0.80	0.13	0.03	9.93	0.29	0.07	10.07
53	2.26	0.06	0.02	0.02	0.06	0.03	0.15	0.12	0.05	0.17	0.04	0.02	1.06	0.03	0.01	9.60	0.02	0.00	0.80	0.10	0.03	11.45	0.21	0.08	11.62
54	1.28	0.04	0.03	0.02	0.04	0.03	0.18	0.08	0.06	0.20	0.03	0.02	1.26	0.02	0.01	11.45	0.02	0.00	0.80	0.06	0.04	13.51	0.14	0.10	13.71
Total LOF	**2,287.43**	**12.41**		**0.25**	**13.65**		**1.95**	**26.06**		**2.19**	**9.93**		**13.99**	**6.21**		**127.20**	**4.96**		**36.87**	**21.10**		**178.06**	**47.16**		**180.25**
Average LOF		**0.23**	**0.01**	**0.00**	**0.25**	**0.01**	**0.04**	**0.48**	**0.01**	**0.04**	**0.18**	**0.00**	**0.26**	**0.11**	**0.00**	**2.36**	**0.09**	**0.00**	**0.68**	**0.39**	**0.01**	**3.30**	**0.87**	**0.02**	**3.34**

Summary of Oil Production Wells Drilled

DRILLING	Total Oil Production, MMbbl	Small spills 50-99 bbl			Medium spills 100-999 bbl			Small and Medium spills 50-999 bbl			Large spills 1000-9999 bbl			Huge spills =>10,000 bbl			Enormous =>150,000 bbl			Substantial spills =>1000 bbl			All spills		
Year		Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1.40	0.04	0.03	0.02	0.04	0.03	0.17	0.08	0.06	0.19	0.03	0.02	1.28	0.02	0.02	11.93	0.01	0.00	9.02	0.07	0.04	22.22	0.15	0.10	22.41
10	5.60	0.11	0.02	0.02	0.13	0.02	0.13	0.25	0.04	0.14	0.10	0.02	0.96	0.06	0.01	8.95	0.04	0.00	9.02	0.21	0.03	18.92	0.45	0.08	19.06
11	9.64	0.11	0.01	0.01	0.13	0.01	0.07	0.25	0.03	0.08	0.10	0.01	0.56	0.06	0.01	5.20	0.04	0.00	9.02	0.21	0.02	14.77	0.45	0.05	14.86
12	14.47	0.15	0.01	0.01	0.18	0.01	0.07	0.33	0.02	0.07	0.13	0.01	0.49	0.09	0.01	4.62	0.05	0.00	9.02	0.27	0.02	14.13	0.60	0.04	14.20
13	21.35	0.23	0.01	0.01	0.27	0.01	0.07	0.50	0.02	0.08	0.20	0.01	0.50	0.13	0.01	4.70	0.08	0.00	9.02	0.41	0.02	14.22	0.91	0.04	14.29
14	27.47	0.23	0.01	0.01	0.27	0.01	0.05	0.50	0.02	0.06	0.20	0.01	0.39	0.13	0.00	3.65	0.08	0.00	9.02	0.41	0.02	13.06	0.91	0.03	13.12
15	33.92	0.27	0.01	0.01	0.31	0.01	0.05	0.58	0.02	0.06	0.24	0.01	0.37	0.15	0.00	3.45	0.09	0.00	9.02	0.48	0.02	12.83	1.06	0.03	12.89
16	40.20	0.29	0.01	0.01	0.34	0.01	0.05	0.63	0.02	0.05	0.26	0.01	0.34	0.17	0.00	3.19	0.10	0.00	9.02	0.53	0.02	12.54	1.16	0.03	12.60
17	47.06	0.34	0.01	0.01	0.40	0.01	0.05	0.74	0.02	0.05	0.30	0.01	0.34	0.19	0.00	3.20	0.12	0.00	9.02	0.62	0.02	12.55	1.36	0.03	12.61
18	53.61	0.38	0.01	0.01	0.44	0.01	0.04	0.83	0.02	0.05	0.34	0.01	0.33	0.22	0.00	3.12	0.14	0.00	9.02	0.69	0.01	12.47	1.51	0.03	12.52
19	59.75	0.41	0.01	0.01	0.47	0.01	0.04	0.88	0.01	0.05	0.36	0.01	0.32	0.23	0.00	2.98	0.14	0.00	9.02	0.73	0.01	12.32	1.61	0.03	12.37
20	66.42	0.46	0.01	0.01	0.53	0.01	0.04	0.99	0.01	0.05	0.40	0.01	0.32	0.26	0.00	3.02	0.16	0.00	9.02	0.82	0.01	12.36	1.81	0.03	12.41
21	72.75	0.50	0.01	0.01	0.58	0.01	0.04	1.07	0.01	0.05	0.44	0.01	0.32	0.28	0.00	2.99	0.18	0.00	9.02	0.89	0.01	12.32	1.97	0.03	12.37
22	78.60	0.52	0.01	0.00	0.61	0.01	0.04	1.13	0.01	0.05	0.46	0.01	0.31	0.30	0.00	2.91	0.18	0.00	9.02	0.94	0.01	12.23	2.07	0.03	12.28
23	81.56	0.48	0.01	0.00	0.56	0.01	0.04	1.05	0.01	0.04	0.43	0.01	0.28	0.27	0.00	2.60	0.17	0.00	9.02	0.87	0.01	11.89	1.92	0.03	11.93
24	83.93	0.50	0.01	0.00	0.58	0.01	0.04	1.07	0.01	0.04	0.44	0.01	0.28	0.28	0.00	2.59	0.18	0.00	9.02	0.89	0.01	11.88	1.97	0.03	11.92
25	86.73	0.52	0.01	0.00	0.61	0.01	0.04	1.13	0.01	0.04	0.46	0.01	0.28	0.30	0.00	2.63	0.18	0.00	9.02	0.94	0.01	11.93	2.07	0.03	11.97
26	87.32	0.48	0.01	0.00	0.56	0.01	0.03	1.05	0.01	0.04	0.43	0.00	0.26	0.27	0.00	2.42	0.17	0.00	9.02	0.87	0.01	11.70	1.92	0.02	11.74
27	87.75	0.50	0.01	0.00	0.58	0.01	0.04	1.07	0.01	0.04	0.44	0.00	0.26	0.28	0.00	2.48	0.18	0.00	9.02	0.89	0.01	11.76	1.97	0.02	11.80

DRILLING	Total Oil Production, MMbbl	Small spills 50-99 bbl			Medium spills 100-999 bbl			Small and Medium spills 50-999 bbl			Large spills 1000-9999 bbl			Huge spills =>10,000 bbl			Enormous =>150,000 bbl			Substantial spills =>1000 bbl			All spills		
Year		Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}
28	89.10	0.52	0.01	0.00	0.61	0.01	0.04	1.13	0.01	0.04	0.46	0.01	0.27	0.30	0.00	2.56	0.18	0.00	9.02	0.94	0.01	11.85	2.07	0.03	11.89
29	88.80	0.48	0.01	0.00	0.56	0.01	0.03	1.05	0.01	0.04	0.43	0.00	0.25	0.27	0.00	2.38	0.17	0.00	9.02	0.87	0.01	11.65	1.92	0.02	11.69
30	88.61	0.50	0.01	0.00	0.58	0.01	0.04	1.07	0.01	0.04	0.44	0.00	0.26	0.28	0.00	2.45	0.18	0.00	9.02	0.89	0.01	11.73	1.97	0.02	11.77
31	89.51	0.52	0.01	0.00	0.61	0.01	0.04	1.13	0.01	0.04	0.46	0.01	0.27	0.30	0.00	2.55	0.18	0.00	9.02	0.94	0.01	11.84	2.07	0.03	11.88
32	88.86	0.48	0.01	0.00	0.56	0.01	0.03	1.05	0.01	0.04	0.43	0.00	0.25	0.27	0.00	2.38	0.17	0.00	9.02	0.87	0.01	11.65	1.92	0.02	11.69
33	88.61	0.50	0.01	0.00	0.58	0.01	0.04	1.07	0.01	0.04	0.44	0.00	0.26	0.28	0.00	2.45	0.18	0.00	9.02	0.89	0.01	11.73	1.97	0.02	11.77
34	85.75	0.42	0.00	0.00	0.49	0.01	0.03	0.91	0.01	0.03	0.37	0.00	0.23	0.24	0.00	2.14	0.15	0.00	9.02	0.76	0.01	11.39	1.66	0.02	11.42
35	76.42	0.23	0.00	0.00	0.27	0.00	0.02	0.50	0.01	0.02	0.20	0.00	0.14	0.13	0.00	1.31	0.08	0.00	9.02	0.41	0.01	10.47	0.91	0.02	10.49
36	70.25	0.27	0.00	0.00	0.31	0.00	0.02	0.58	0.01	0.03	0.24	0.00	0.18	0.15	0.00	1.67	0.09	0.00	9.02	0.48	0.01	10.86	1.06	0.02	10.89
37	65.41	0.25	0.00	0.00	0.30	0.00	0.02	0.55	0.01	0.03	0.22	0.00	0.18	0.14	0.00	1.70	0.09	0.00	9.02	0.46	0.01	10.90	1.01	0.02	10.93
38	60.87	0.23	0.00	0.00	0.27	0.00	0.02	0.50	0.01	0.03	0.20	0.00	0.18	0.13	0.00	1.65	0.08	0.00	9.02	0.41	0.01	10.84	0.91	0.02	10.87
39	58.71	0.27	0.00	0.00	0.31	0.01	0.03	0.58	0.01	0.03	0.24	0.00	0.21	0.15	0.00	1.99	0.09	0.00	9.02	0.48	0.01	11.22	1.06	0.02	11.25
40	56.86	0.25	0.00	0.00	0.30	0.01	0.03	0.55	0.01	0.03	0.22	0.00	0.21	0.14	0.00	1.96	0.09	0.00	9.02	0.46	0.01	11.19	1.01	0.02	11.22
41	54.54	0.23	0.00	0.00	0.27	0.00	0.03	0.50	0.01	0.03	0.20	0.00	0.20	0.13	0.00	1.84	0.08	0.00	9.02	0.41	0.01	11.05	0.91	0.02	11.08
42	54.02	0.27	0.00	0.00	0.31	0.01	0.03	0.58	0.01	0.03	0.24	0.00	0.23	0.15	0.00	2.17	0.09	0.00	9.02	0.48	0.01	11.41	1.06	0.02	11.45
43	51.98	0.22	0.00	0.00	0.25	0.00	0.03	0.47	0.01	0.03	0.19	0.00	0.19	0.12	0.00	1.82	0.08	0.00	9.02	0.39	0.01	11.03	0.86	0.02	11.06
44	41.43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	31.79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	24.21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	18.32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	13.80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	10.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	7.41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	5.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	3.57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	2.26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	1.284	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total LOF	2,287.43	12.14		0.19	14.15		1.57	26.29		1.75	10.71		11.72	6.88		109.64	4.30		315.57	21.89		436.92	48.18		438.68
Average LOF		0.22	0.01	0.00	0.26	0.01	0.03	0.49	0.01	0.03	0.20	0.00	0.22	0.13	0.00	2.03	0.08	0.00	5.84	0.41	0.01	8.09	0.89	0.02	8.12

Summary of Exploration Wells

EXPLORATION WELL	Total Oil Production, MMbbl	Small spills 50-99 bbl			Medium spills 100-999 bbl			Small and Medium spills 50-999 bbl			Large spills 1000-9999 bbl			Huge spills =>10,000 bbl			Enormous =>150,000 bbl			Substantial spills =>1000 bbl			All spills		
Year		Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0.26	0	0	0.30	0	0	0.57	0	0	0.23	0	0	0.15	0	0	0.09	0	0	0.47	0	0	1.03	0	0
4	0	0.26	0	0	0.30	0	0	0.57	0	0	0.23	0	0	0.15	0	0	0.09	0	0	0.47	0	0	1.03	0	0
5	0	0.39	0	0	0.46	0	0	0.85	0	0	0.34	0	0	0.22	0	0	0.14	0	0	0.70	0	0	1.55	0	0
6	0	0.39	0	0	0.46	0	0	0.85	0	0	0.34	0	0	0.22	0	0	0.14	0	0	0.70	0	0	1.55	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1.40	0.26	0.19	0.14	0.30	0.22	1.17	0.57	0.40	1.31	0.23	0.16	8.64	0.15	0.11	81.96	0.09	0.02	46.08	0.47	0.29	136.68	1.03	0.70	137.99
10	5.60	0.26	0.05	0.04	0.30	0.05	0.29	0.57	0.10	0.33	0.23	0.04	2.16	0.15	0.03	20.49	0.09	0.02	46.08	0.47	0.09	68.73	1.03	0.19	69.06
11	9.64	0.20	0.02	0.02	0.23	0.02	0.13	0.42	0.04	0.14	0.17	0.02	0.94	0.11	0.01	8.93	0.07	0.02	46.08	0.35	0.05	55.96	0.78	0.10	56.10
12	14.47	0.20	0.01	0.01	0.23	0.02	0.08	0.42	0.03	0.10	0.17	0.01	0.63	0.11	0.01	5.95	0.07	0.02	46.08	0.35	0.04	52.66	0.78	0.07	52.75
13	21.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total LOF	**2,287.43**	**2.22**		**0.20**	**2.59**		**1.68**	**4.81**		**1.88**	**1.93**		**12.37**	**1.26**		**117.33**	**0.78**		**184.33**	**3.98**		**314.03**	**8.79**		**315.91**
Average LOF		**0.04**	**0.00**	**0.00**	**0.05**	**0.00**	**0.03**	**0.09**	**0.00**	**0.03**	**0.04**	**0.00**	**0.23**	**0.02**	**0.00**	**2.17**	**0.01**	**0.00**	**3.41**	**0.07**	**0.00**	**5.82**	**0.16**	**0.00**	**5.85**

Summary of Pipelines Diameter > 10"

PIPELINE > 10"		Small spills 50-99 bbl			Medium spills 100-999 bbl			Small and Medium spills 50-999 bbl			Large spills 1000-9999 bbl			Huge spills =>10000 bbl			Substantial spills =>1000 bbl			All spills		
Year	Total Oil Production, MMbbl	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1.40	3.54	4.83	1.80	6.76	4.83	22.40	10.31	9.66	24.20	4.78	3.41	161.66	1.30	0.93	143.70	6.08	4.34	305.36	16.39	14.00	329.56
10	5.60	3.54	1.21	0.45	6.76	1.21	5.60	10.31	2.41	6.05	4.78	0.85	40.41	1.30	0.23	35.93	6.08	1.09	76.34	16.39	3.50	82.39
11	9.64	3.54	0.70	0.26	6.76	0.70	3.26	10.31	1.40	3.52	4.78	0.50	23.49	1.30	0.14	20.88	6.08	0.63	44.37	16.39	2.03	47.89
12	14.47	3.54	0.47	0.17	6.76	0.47	2.17	10.31	0.93	2.34	4.78	0.33	15.65	1.30	0.09	13.91	6.08	0.42	29.56	16.39	1.35	31.90
13	21.35	3.54	0.32	0.12	6.76	0.32	1.47	10.31	0.63	1.59	4.78	0.22	10.61	1.30	0.06	9.43	6.08	0.28	20.04	16.39	0.92	21.63
14	27.47	3.54	0.25	0.09	6.76	0.25	1.14	10.31	0.49	1.23	4.78	0.17	8.25	1.30	0.05	7.33	6.08	0.22	15.57	16.39	0.71	16.81
15	33.92	3.54	0.20	0.07	6.76	0.20	0.93	10.31	0.40	1.00	4.78	0.14	6.68	1.30	0.04	5.93	6.08	0.18	12.61	16.39	0.58	13.61
16	40.20	3.54	0.17	0.06	6.76	0.17	0.78	10.31	0.34	0.84	4.78	0.12	5.63	1.30	0.03	5.01	6.08	0.15	10.64	16.39	0.49	11.49
17	47.06	3.54	0.14	0.05	6.76	0.14	0.67	10.31	0.29	0.72	4.78	0.10	4.81	1.30	0.03	4.28	6.08	0.13	9.09	16.39	0.42	9.81
18	53.61	3.54	0.13	0.05	6.76	0.13	0.59	10.31	0.25	0.63	4.78	0.09	4.22	1.30	0.02	3.76	6.08	0.11	7.98	16.39	0.37	8.61
19	59.75	3.54	0.11	0.04	6.76	0.11	0.53	10.31	0.23	0.57	4.78	0.08	3.79	1.30	0.02	3.37	6.08	0.10	7.16	16.39	0.33	7.73
20	66.42	3.54	0.10	0.04	6.76	0.10	0.47	10.31	0.20	0.51	4.78	0.07	3.41	1.30	0.02	3.03	6.08	0.09	6.44	16.39	0.30	6.95
21	72.75	3.54	0.09	0.03	6.76	0.09	0.43	10.31	0.19	0.47	4.78	0.07	3.11	1.30	0.02	2.77	6.08	0.08	5.88	16.39	0.27	6.35
22	78.60	3.54	0.09	0.03	6.76	0.09	0.40	10.31	0.17	0.43	4.78	0.06	2.88	1.30	0.02	2.56	6.08	0.08	5.44	16.39	0.25	5.87
23	81.56	3.54	0.08	0.03	6.76	0.08	0.38	10.31	0.17	0.42	4.78	0.06	2.78	1.30	0.02	2.47	6.08	0.07	5.24	16.39	0.24	5.66
24	83.93	3.54	0.08	0.03	6.76	0.08	0.37	10.31	0.16	0.40	4.78	0.06	2.70	1.30	0.02	2.40	6.08	0.07	5.10	16.39	0.23	5.50
25	86.73	3.54	0.08	0.03	6.76	0.08	0.36	10.31	0.16	0.39	4.78	0.06	2.61	1.30	0.02	2.32	6.08	0.07	4.93	16.39	0.23	5.32
26	87.32	3.54	0.08	0.03	6.76	0.08	0.36	10.31	0.15	0.39	4.78	0.05	2.59	1.30	0.01	2.31	6.08	0.07	4.90	16.39	0.22	5.29
27	87.75	3.54	0.08	0.03	6.76	0.08	0.36	10.31	0.15	0.39	4.78	0.05	2.58	1.30	0.01	2.29	6.08	0.07	4.87	16.39	0.22	5.26
28	89.10	3.54	0.08	0.03	6.76	0.08	0.35	10.31	0.15	0.38	4.78	0.05	2.54	1.30	0.01	2.26	6.08	0.07	4.80	16.39	0.22	5.18

PIPELINE > 10"		Small spills 50-99 bbl			Medium spills 100-999 bbl			Small and Medium spills 50-999 bbl			Large spills 1000-9999 bbl			Huge spills =>10000 bbl			Substantial spills =>1000 bbl			All spills		
Year	Total Oil Production, MMbbl	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}
29	88.80	3.54	0.08	0.03	6.76	0.08	0.35	10.31	0.15	0.38	4.78	0.05	2.55	1.30	0.01	2.27	6.08	0.07	4.82	16.39	0.22	5.20
30	88.61	3.54	0.08	0.03	6.76	0.08	0.35	10.31	0.15	0.38	4.78	0.05	2.56	1.30	0.01	2.27	6.08	0.07	4.83	16.39	0.22	5.21
31	89.51	3.54	0.08	0.03	6.76	0.08	0.35	10.31	0.15	0.38	4.78	0.05	2.53	1.30	0.01	2.25	6.08	0.07	4.78	16.39	0.22	5.16
32	88.86	3.54	0.08	0.03	6.76	0.08	0.35	10.31	0.15	0.38	4.78	0.05	2.55	1.30	0.01	2.27	6.08	0.07	4.81	16.39	0.22	5.20
33	88.61	3.54	0.08	0.03	6.76	0.08	0.35	10.31	0.15	0.38	4.78	0.05	2.56	1.30	0.01	2.27	6.08	0.07	4.83	16.39	0.22	5.21
34	85.75	3.54	0.08	0.03	6.76	0.08	0.37	10.31	0.16	0.40	4.78	0.06	2.64	1.30	0.02	2.35	6.08	0.07	4.99	16.39	0.23	5.38
35	76.42	3.54	0.09	0.03	6.76	0.09	0.41	10.31	0.18	0.44	4.78	0.06	2.96	1.30	0.02	2.63	6.08	0.08	5.60	16.39	0.26	6.04
36	70.25	3.54	0.10	0.04	6.76	0.10	0.45	10.31	0.19	0.48	4.78	0.07	3.22	1.30	0.02	2.87	6.08	0.09	6.09	16.39	0.28	6.57
37	65.41	3.54	0.10	0.04	6.76	0.10	0.48	10.31	0.21	0.52	4.78	0.07	3.46	1.30	0.02	3.08	6.08	0.09	6.54	16.39	0.30	7.06
38	60.87	3.54	0.11	0.04	6.76	0.11	0.52	10.31	0.22	0.56	4.78	0.08	3.72	1.30	0.02	3.31	6.08	0.10	7.03	16.39	0.32	7.58
39	58.71	3.54	0.12	0.04	6.76	0.12	0.53	10.31	0.23	0.58	4.78	0.08	3.86	1.30	0.02	3.43	6.08	0.10	7.29	16.39	0.33	7.86
40	56.86	3.54	0.12	0.04	6.76	0.12	0.55	10.31	0.24	0.60	4.78	0.08	3.98	1.30	0.02	3.54	6.08	0.11	7.52	16.39	0.34	8.12
41	54.54	3.54	0.12	0.05	6.76	0.12	0.58	10.31	0.25	0.62	4.78	0.09	4.15	1.30	0.02	3.69	6.08	0.11	7.84	16.39	0.36	8.46
42	54.02	3.54	0.13	0.05	6.76	0.13	0.58	10.31	0.25	0.63	4.78	0.09	4.19	1.30	0.02	3.73	6.08	0.11	7.92	16.39	0.36	8.55
43	51.98	3.54	0.13	0.05	6.76	0.13	0.60	10.31	0.26	0.65	4.78	0.09	4.36	1.30	0.03	3.87	6.08	0.12	8.23	16.39	0.38	8.88
44	41.43	3.54	0.16	0.06	6.76	0.16	0.76	10.31	0.33	0.82	4.78	0.12	5.47	1.30	0.03	4.86	6.08	0.15	10.33	16.39	0.47	11.14
45	31.79	3.54	0.21	0.08	6.76	0.21	0.99	10.31	0.43	1.07	4.78	0.15	7.12	1.30	0.04	6.33	6.08	0.19	13.46	16.39	0.62	14.52
46	24.21	3.54	0.28	0.10	6.76	0.28	1.30	10.31	0.56	1.40	4.78	0.20	9.36	1.30	0.05	8.32	6.08	0.25	17.67	16.39	0.81	19.07
47	18.32	3.54	0.37	0.14	6.76	0.37	1.71	10.31	0.74	1.85	4.78	0.26	12.36	1.30	0.07	10.99	6.08	0.33	23.34	16.39	1.07	25.19
48	13.80	3.54	0.49	0.18	6.76	0.49	2.27	10.31	0.98	2.46	4.78	0.35	16.41	1.30	0.09	14.59	6.08	0.44	31.00	16.39	1.42	33.46
49	10.19	3.54	0.66	0.25	6.76	0.66	3.08	10.31	1.33	3.33	4.78	0.47	22.22	1.30	0.13	19.75	6.08	0.60	41.97	16.39	1.92	45.29
50	7.41	3.54	0.91	0.34	6.76	0.91	4.23	10.31	1.83	4.57	4.78	0.64	30.55	1.30	0.18	27.16	6.08	0.82	57.71	16.39	2.65	62.29
51	5.30	3.54	1.28	0.47	6.76	1.28	5.92	10.31	2.55	6.40	4.78	0.90	42.74	1.30	0.25	37.99	6.08	1.15	80.73	16.39	3.70	87.13
52	3.57	3.54	1.89	0.70	6.76	1.89	8.78	10.31	3.79	9.49	4.78	1.34	63.37	1.30	0.36	56.33	6.08	1.70	119.69	16.39	5.49	129.18
53	2.26	3.54	3.00	1.11	6.76	3.00	13.90	10.31	5.99	15.02	4.78	2.12	100.34	1.30	0.58	89.19	6.08	2.69	189.53	16.39	8.69	204.55
54	1.28	3.54	5.27	1.96	6.76	5.27	24.44	10.31	10.53	26.40	4.78	3.72	176.36	1.30	1.01	156.77	6.08	4.73	333.14	16.39	15.27	359.54
Total LOF	**2,287.43**	**162.99**		**9.40**	**311.14**		**117.24**	**474.13**		**126.64**	**219.78**		**846.00**	**59.90**		**752.03**	**279.68**		**1,598.03**	**753.81**		**1,724.67**
Average LOF		**3.02**	**0.07**	**0.17**	**5.76**	**0.14**	**2.17**	**8.78**	**0.21**	**2.35**	**4.07**	**0.10**	**15.67**	**1.11**	**0.03**	**13.93**	**5.18**	**0.12**	**29.59**	**13.96**	**0.33**	**31.94**

Summary of Pipelines Diameter ≤ 10”

PIPELINE <= 10"		Small spills 50-99 bbl			Medium spills 100-999 bbl			Small and Medium spills 50-999 bbl			Large spills 1000-9999 bbl			Huge spills =>10000 bbl			Substantial spills =>1000 bbl			All spills		
Year	Total Oil Production, MMbbl	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	5.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	9.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	14.47	0.13	0.01	0.01	0.25	0.02	0.08	0.38	0.03	0.09	0.18	0.01	0.58	0.05	0.00	0.52	0.23	0.02	1.10	0.61	0.04	1.18
13	21.35	0.13	0.01	0.00	0.25	0.01	0.05	0.38	0.02	0.06	0.18	0.01	0.39	0.05	0.00	0.35	0.23	0.01	0.74	0.61	0.03	0.80
14	27.47	0.13	0.00	0.00	0.25	0.01	0.04	0.38	0.01	0.05	0.18	0.01	0.31	0.05	0.00	0.27	0.23	0.01	0.58	0.61	0.02	0.62
15	33.92	0.26	0.01	0.01	0.50	0.01	0.07	0.76	0.02	0.07	0.35	0.01	0.50	0.10	0.00	0.44	0.45	0.01	0.94	1.22	0.04	1.01
16	40.20	1.18	0.03	0.02	2.26	0.06	0.26	3.44	0.09	0.28	1.59	0.04	1.88	0.43	0.01	1.67	2.03	0.05	3.55	5.47	0.14	3.83
17	47.06	1.18	0.03	0.02	2.26	0.05	0.22	3.44	0.07	0.24	1.59	0.03	1.61	0.43	0.01	1.43	2.03	0.04	3.03	5.47	0.12	3.27
18	53.61	1.31	0.02	0.02	2.51	0.05	0.22	3.82	0.07	0.23	1.77	0.03	1.57	0.48	0.01	1.39	2.25	0.04	2.96	6.08	0.11	3.19
19	59.75	1.45	0.02	0.02	2.76	0.05	0.21	4.20	0.07	0.23	1.95	0.03	1.55	0.53	0.01	1.37	2.48	0.04	2.92	6.68	0.11	3.15
20	66.42	1.45	0.02	0.02	2.76	0.04	0.19	4.20	0.06	0.21	1.95	0.03	1.39	0.53	0.01	1.24	2.48	0.04	2.63	6.68	0.10	2.84
21	72.75	1.97	0.03	0.02	3.76	0.05	0.24	5.73	0.08	0.26	2.66	0.04	1.73	0.72	0.01	1.54	3.38	0.05	3.27	9.11	0.13	3.53
22	78.60	2.10	0.03	0.02	4.01	0.05	0.24	6.11	0.08	0.26	2.83	0.04	1.71	0.77	0.01	1.52	3.61	0.05	3.23	9.72	0.12	3.49
23	81.56	2.10	0.03	0.02	4.01	0.05	0.23	6.11	0.07	0.25	2.83	0.03	1.65	0.77	0.01	1.46	3.61	0.04	3.11	9.72	0.12	3.36
24	83.93	2.23	0.03	0.02	4.26	0.05	0.24	6.50	0.08	0.25	3.01	0.04	1.70	0.82	0.01	1.51	3.83	0.05	3.21	10.33	0.12	3.47
25	86.73	2.55	0.03	0.02	4.86	0.06	0.26	7.41	0.09	0.28	3.44	0.04	1.88	0.94	0.01	1.67	4.37	0.05	3.55	11.79	0.14	3.83
26	87.32	2.55	0.03	0.02	4.86	0.06	0.26	7.41	0.08	0.28	3.44	0.04	1.87	0.94	0.01	1.66	4.37	0.05	3.53	11.79	0.14	3.80
27	87.75	2.68	0.03	0.02	5.12	0.06	0.27	7.80	0.09	0.29	3.61	0.04	1.95	0.99	0.01	1.74	4.60	0.05	3.69	12.40	0.14	3.98
28	89.10	2.81	0.03	0.02	5.37	0.06	0.28	8.18	0.09	0.30	3.79	0.04	2.02	1.03	0.01	1.79	4.83	0.05	3.81	13.00	0.15	4.11

PIPELINE <= 10"		Small spills 50-99 bbl			Medium spills 100-999 bbl			Small and Medium spills 50-999 bbl			Large spills 1000-9999 bbl			Huge spills =>10000 bbl			Substantial spills =>1000 bbl			All spills		
Year	Total Oil Production, MMbbl	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}
29	88.80	2.81	0.03	0.02	5.37	0.06	0.28	8.18	0.09	0.30	3.79	0.04	2.02	1.03	0.01	1.80	4.83	0.05	3.82	13.00	0.15	4.13
30	88.61	2.94	0.03	0.02	5.62	0.06	0.29	8.56	0.10	0.32	3.97	0.04	2.12	1.08	0.01	1.89	5.05	0.06	4.01	13.61	0.15	4.33
31	89.51	3.07	0.03	0.02	5.87	0.07	0.30	8.94	0.10	0.33	4.15	0.05	2.20	1.13	0.01	1.95	5.28	0.06	4.15	14.22	0.16	4.48
32	88.86	3.07	0.03	0.02	5.87	0.07	0.31	8.94	0.10	0.33	4.15	0.05	2.21	1.13	0.01	1.97	5.28	0.06	4.18	14.22	0.16	4.51
33	88.61	3.60	0.04	0.03	6.87	0.08	0.36	10.47	0.12	0.39	4.85	0.05	2.60	1.32	0.01	2.31	6.18	0.07	4.91	16.65	0.19	5.29
34	85.75	3.60	0.04	0.03	6.87	0.08	0.37	10.47	0.12	0.40	4.85	0.06	2.68	1.32	0.02	2.39	6.18	0.07	5.07	16.65	0.19	5.47
35	76.42	3.60	0.05	0.03	6.87	0.09	0.42	10.47	0.14	0.45	4.85	0.06	3.01	1.32	0.02	2.68	6.18	0.08	5.69	16.65	0.22	6.14
36	70.25	4.52	0.06	0.05	8.63	0.12	0.57	13.15	0.19	0.62	6.10	0.09	4.11	1.66	0.02	3.66	7.76	0.11	7.77	20.90	0.30	8.38
37	65.41	4.52	0.07	0.05	8.63	0.13	0.61	13.15	0.20	0.66	6.10	0.09	4.42	1.66	0.03	3.93	7.76	0.12	8.34	20.90	0.32	9.01
38	60.87	4.52	0.07	0.05	8.63	0.14	0.66	13.15	0.22	0.71	6.10	0.10	4.75	1.66	0.03	4.22	7.76	0.13	8.97	20.90	0.34	9.68
39	58.71	4.65	0.08	0.06	8.88	0.15	0.70	13.53	0.23	0.76	6.27	0.11	5.06	1.71	0.03	4.50	7.98	0.14	9.57	21.51	0.37	10.32
40	56.86	4.65	0.08	0.06	8.88	0.16	0.72	13.53	0.24	0.78	6.27	0.11	5.23	1.71	0.03	4.65	7.98	0.14	9.88	21.51	0.38	10.66
41	54.54	4.65	0.09	0.06	8.88	0.16	0.76	13.53	0.25	0.82	6.27	0.11	5.45	1.71	0.03	4.85	7.98	0.15	10.30	21.51	0.39	11.11
42	54.02	4.78	0.09	0.06	9.13	0.17	0.78	13.91	0.26	0.85	6.45	0.12	5.66	1.76	0.03	5.03	8.21	0.15	10.69	22.12	0.41	11.54
43	51.98	4.78	0.09	0.07	9.13	0.18	0.81	13.91	0.27	0.88	6.45	0.12	5.88	1.76	0.03	5.23	8.21	0.16	11.11	22.12	0.43	11.99
44	41.43	4.78	0.12	0.08	9.13	0.22	1.02	13.91	0.34	1.10	6.45	0.16	7.38	1.76	0.04	6.56	8.21	0.20	13.94	22.12	0.53	15.04
45	31.79	4.78	0.15	0.11	9.13	0.29	1.33	13.91	0.44	1.44	6.45	0.20	9.62	1.76	0.06	8.55	8.21	0.26	18.17	22.12	0.70	19.61
46	24.21	3.02	0.12	0.09	5.77	0.24	1.11	8.79	0.36	1.19	4.08	0.17	7.98	1.11	0.05	7.10	5.19	0.21	15.08	13.98	0.58	16.27
47	18.32	3.02	0.16	0.12	5.77	0.31	1.46	8.79	0.48	1.58	4.08	0.22	10.54	1.11	0.06	9.37	5.19	0.28	19.91	13.98	0.76	21.49
48	13.80	3.02	0.22	0.16	5.77	0.42	1.94	8.79	0.64	2.09	4.08	0.30	14.00	1.11	0.08	12.45	5.19	0.38	26.45	13.98	1.01	28.54
49	10.19	3.02	0.30	0.21	5.77	0.57	2.63	8.79	0.86	2.84	4.08	0.40	18.95	1.11	0.11	16.85	5.19	0.51	35.80	13.98	1.37	38.64
50	7.41	3.02	0.41	0.29	5.77	0.78	3.61	8.79	1.19	3.90	4.08	0.55	26.06	1.11	0.15	23.17	5.19	0.70	49.23	13.98	1.89	53.13
51	5.30	3.02	0.57	0.40	5.77	1.09	5.05	8.79	1.66	5.46	4.08	0.77	36.45	1.11	0.21	32.41	5.19	0.98	68.87	13.98	2.64	74.32
52	3.57	3.02	0.85	0.60	5.77	1.61	7.49	8.79	2.46	8.09	4.08	1.14	54.05	1.11	0.31	48.05	5.19	1.45	102.10	13.98	3.91	110.19
53	2.26	3.02	1.34	0.95	5.77	2.56	11.86	8.79	3.89	12.81	4.08	1.81	85.58	1.11	0.49	76.09	5.19	2.30	161.67	13.98	6.19	174.48
54	1.28	3.02	2.35	1.67	5.77	4.49	20.84	8.79	6.84	22.51	4.08	3.17	150.42	1.11	0.87	133.75	5.19	4.04	284.17	13.98	10.88	306.68
Total LOF	**2,287.43**	**122.76**		**5.58**	**234.31**		**69.64**	**357.07**		**75.23**	**165.56**		**502.70**	**45.13**		**446.97**	**210.69**		**949.67**	**567.75**		**1,024.90**
Average LOF		**2.27**	**0.05**	**0.10**	**4.34**	**0.10**	**1.29**	**6.61**	**0.16**	**1.39**	**3.07**	**0.07**	**9.31**	**0.84**	**0.02**	**8.28**	**3.90**	**0.09**	**17.59**	**10.51**	**0.25**	**18.98**

Summary of Pipelines (All diameters)

PIPELINE		Small spills 50-99 bbl			Medium spills 100-999 bbl			Small and Medium spills 50-999 bbl			Large spills 1000-9999 bbl			Huge spills =>10000 bbl			Substantial spills =>1000 bbl			All spills		
Year	Total Oil Production, MMbbl	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1.40	3.54	2.53	1.80	6.76	4.83	22.40	10.31	7.36	24.20	4.78	3.41	161.66	1.30	0.93	143.70	6.08	4.34	305.36	16.39	11.70	329.56
10	5.60	3.54	0.63	0.45	6.76	1.21	5.60	10.31	1.84	6.05	4.78	0.85	40.41	1.30	0.23	35.93	6.08	1.09	76.34	16.39	2.92	82.39
11	9.64	3.54	0.37	0.26	6.76	0.70	3.26	10.31	1.07	3.52	4.78	0.50	23.49	1.30	0.14	20.88	6.08	0.63	44.37	16.39	1.70	47.89
12	14.47	3.67	0.25	0.18	7.01	0.48	2.25	10.69	0.74	2.43	4.96	0.34	16.23	1.35	0.09	14.43	6.31	0.44	30.65	16.99	1.17	33.08
13	21.35	3.67	0.17	0.12	7.01	0.33	1.52	10.69	0.50	1.65	4.96	0.23	11.00	1.35	0.06	9.78	6.31	0.30	20.78	16.99	0.80	22.43
14	27.47	3.67	0.13	0.09	7.01	0.26	1.18	10.69	0.39	1.28	4.96	0.18	8.55	1.35	0.05	7.60	6.31	0.23	16.15	16.99	0.62	17.43
15	33.92	3.81	0.11	0.08	7.27	0.21	0.99	11.07	0.33	1.07	5.13	0.15	7.17	1.40	0.04	6.38	6.53	0.19	13.55	17.60	0.52	14.62
16	40.20	4.73	0.12	0.08	9.02	0.22	1.04	13.75	0.34	1.12	6.37	0.16	7.51	1.74	0.04	6.68	8.11	0.20	14.19	21.86	0.54	15.32
17	47.06	4.73	0.10	0.07	9.02	0.19	0.89	13.75	0.29	0.96	6.37	0.14	6.42	1.74	0.04	5.71	8.11	0.17	12.12	21.86	0.46	13.09
18	53.61	4.86	0.09	0.06	9.27	0.17	0.80	14.13	0.26	0.87	6.55	0.12	5.79	1.79	0.03	5.15	8.33	0.16	10.94	22.46	0.42	11.81
19	59.75	4.99	0.08	0.06	9.52	0.16	0.74	14.51	0.24	0.80	6.73	0.11	5.34	1.83	0.03	4.74	8.56	0.14	10.08	23.07	0.39	10.88
20	66.42	4.99	0.08	0.05	9.52	0.14	0.67	14.51	0.22	0.72	6.73	0.10	4.80	1.83	0.03	4.27	8.56	0.13	9.07	23.07	0.35	9.79
21	72.75	5.51	0.08	0.05	10.53	0.14	0.67	16.04	0.22	0.73	7.44	0.10	4.84	2.03	0.03	4.31	9.46	0.13	9.15	25.50	0.35	9.88
22	78.60	5.65	0.07	0.05	10.78	0.14	0.64	16.42	0.21	0.69	7.61	0.10	4.59	2.07	0.03	4.08	9.69	0.12	8.67	26.11	0.33	9.36
23	81.56	5.65	0.07	0.05	10.78	0.13	0.61	16.42	0.20	0.66	7.61	0.09	4.42	2.07	0.03	3.93	9.69	0.12	8.36	26.11	0.32	9.02
24	83.93	5.78	0.07	0.05	11.03	0.13	0.61	16.80	0.20	0.66	7.79	0.09	4.40	2.12	0.03	3.91	9.91	0.12	8.31	26.72	0.32	8.97
25	86.73	6.09	0.07	0.05	11.63	0.13	0.62	17.72	0.20	0.67	8.22	0.09	4.49	2.24	0.03	3.99	10.45	0.12	8.48	28.17	0.32	9.15
26	87.32	6.09	0.07	0.05	11.63	0.13	0.62	17.72	0.20	0.67	8.22	0.09	4.46	2.24	0.03	3.96	10.45	0.12	8.42	28.17	0.32	9.09
27	87.75	6.22	0.07	0.05	11.88	0.14	0.63	18.10	0.21	0.68	8.39	0.10	4.53	2.29	0.03	4.03	10.68	0.12	8.56	28.78	0.33	9.24
28	89.10	6.35	0.07	0.05	12.13	0.14	0.63	18.48	0.21	0.68	8.57	0.10	4.56	2.34	0.03	4.05	10.91	0.12	8.61	29.39	0.33	9.29
29	88.80	6.35	0.07	0.05	12.13	0.14	0.63	18.48	0.21	0.68	8.57	0.10	4.57	2.34	0.03	4.07	10.91	0.12	8.64	29.39	0.33	9.33

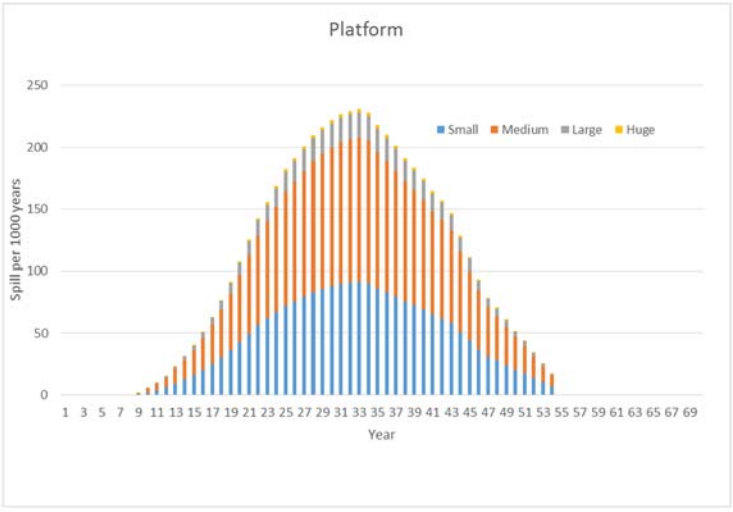
PIPELINE		Small spills 50-99 bbl			Medium spills 100-999 bbl			Small and Medium spills 50-999 bbl			Large spills 1000-9999 bbl			Huge spills =>10000 bbl			Substantial spills =>1000 bbl			All spills		
Year	**Total Oil Production, MMbbl**	**Freq., Spills per 10^3 years**	**Freq., spills per 10^9 bbl produced**	**Spill index, 10^{-7}**	**Freq., Spills per 10^3 years**	**Freq., spills per 10^9 bbl produced**	**Spill index, 10^{-7}**	**Freq., Spills per 10^3 years**	**Freq., spills per 10^9 bbl produced**	**Spill index, 10^{-7}**	**Freq., Spills per 10^3 years**	**Freq., spills per 10^9 bbl produced**	**Spill index, 10^{-7}**	**Freq., Spills per 10^3 years**	**Freq., spills per 10^9 bbl produced**	**Spill index, 10^{-7}**	**Freq., Spills per 10^3 years**	**Freq., spills per 10^9 bbl produced**	**Spill index, 10^{-7}**	**Freq., Spills per 10^3 years**	**Freq., spills per 10^9 bbl produced**	**Spill index, 10^{-7}**
30	88.61	6.49	0.07	0.05	12.38	0.14	0.65	18.87	0.21	0.70	8.75	0.10	4.68	2.38	0.03	4.16	11.13	0.13	8.84	30.00	0.34	9.54
31	89.51	6.62	0.07	0.05	12.63	0.14	0.65	19.25	0.22	0.71	8.92	0.10	4.73	2.43	0.03	4.20	11.36	0.13	8.93	30.61	0.34	9.63
32	88.86	6.62	0.07	0.05	12.63	0.14	0.66	19.25	0.22	0.71	8.92	0.10	4.76	2.43	0.03	4.23	11.36	0.13	8.99	30.61	0.34	9.70
33	88.61	7.14	0.08	0.06	13.63	0.15	0.71	20.78	0.23	0.77	9.63	0.11	5.15	2.63	0.03	4.58	12.26	0.14	9.73	33.04	0.37	10.50
34	85.75	7.14	0.08	0.06	13.63	0.16	0.74	20.78	0.24	0.80	9.63	0.11	5.32	2.63	0.03	4.73	12.26	0.14	10.06	33.04	0.39	10.85
35	76.42	7.14	0.09	0.07	13.63	0.18	0.83	20.78	0.27	0.89	9.63	0.13	5.97	2.63	0.03	5.31	12.26	0.16	11.29	33.04	0.43	12.18
36	70.25	8.06	0.11	0.08	15.39	0.22	1.02	23.45	0.33	1.10	10.87	0.15	7.34	2.96	0.04	6.52	13.84	0.20	13.86	37.29	0.53	14.96
37	65.41	8.06	0.12	0.09	15.39	0.24	1.09	23.45	0.36	1.18	10.87	0.17	7.88	2.96	0.05	7.01	13.84	0.21	14.89	37.29	0.57	16.06
38	60.87	8.06	0.13	0.09	15.39	0.25	1.17	23.45	0.39	1.27	10.87	0.18	8.47	2.96	0.05	7.53	13.84	0.23	15.99	37.29	0.61	17.26
39	58.71	8.19	0.14	0.10	15.64	0.27	1.24	23.83	0.41	1.34	11.05	0.19	8.92	3.01	0.05	7.93	14.06	0.24	16.85	37.90	0.65	18.19
40	56.86	8.19	0.14	0.10	15.64	0.28	1.28	23.83	0.42	1.38	11.05	0.19	9.21	3.01	0.05	8.19	14.06	0.25	17.40	37.90	0.67	18.78
41	54.54	8.19	0.15	0.11	15.64	0.29	1.33	23.83	0.44	1.44	11.05	0.20	9.60	3.01	0.06	8.54	14.06	0.26	18.14	37.90	0.69	19.58
42	54.02	8.33	0.15	0.11	15.89	0.29	1.36	24.22	0.45	1.47	11.23	0.21	9.85	3.06	0.06	8.76	14.29	0.26	18.61	38.50	0.71	20.08
43	51.98	8.33	0.16	0.11	15.89	0.31	1.42	24.22	0.47	1.53	11.23	0.22	10.24	3.06	0.06	9.10	14.29	0.27	19.34	38.50	0.74	20.87
44	41.43	8.33	0.20	0.14	15.89	0.38	1.78	24.22	0.58	1.92	11.23	0.27	12.85	3.06	0.07	11.42	14.29	0.34	24.27	38.50	0.93	26.19
45	31.79	8.33	0.26	0.19	15.89	0.50	2.32	24.22	0.76	2.51	11.23	0.35	16.74	3.06	0.10	14.88	14.29	0.45	31.62	38.50	1.21	34.13
46	24.21	6.56	0.27	0.19	12.53	0.52	2.40	19.10	0.79	2.59	8.85	0.37	17.34	2.41	0.10	15.41	11.27	0.47	32.75	30.36	1.25	35.34
47	18.32	6.56	0.36	0.25	12.53	0.68	3.17	19.10	1.04	3.43	8.85	0.48	22.90	2.41	0.13	20.36	11.27	0.61	43.26	30.36	1.66	46.68
48	13.80	6.56	0.48	0.34	12.53	0.91	4.21	19.10	1.38	4.55	8.85	0.64	30.41	2.41	0.17	27.04	11.27	0.82	57.45	30.36	2.20	62.00
49	10.19	6.56	0.64	0.46	12.53	1.23	5.70	19.10	1.87	6.16	8.85	0.87	41.17	2.41	0.24	36.60	11.27	1.11	77.77	30.36	2.98	83.93
50	7.41	6.56	0.89	0.63	12.53	1.69	7.84	19.10	2.58	8.47	8.85	1.19	56.62	2.41	0.33	50.33	11.27	1.52	106.95	30.36	4.10	115.42
51	5.30	6.56	1.24	0.88	12.53	2.36	10.97	19.10	3.60	11.85	8.85	1.67	79.19	2.41	0.46	70.41	11.27	2.13	149.60	30.36	5.73	161.45
52	3.57	6.56	1.84	1.30	12.53	3.51	16.27	19.10	5.34	17.57	8.85	2.48	117.41	2.41	0.68	104.38	11.27	3.15	221.79	30.36	8.50	239.37
53	2.26	6.56	2.91	2.07	12.53	5.55	25.76	19.10	8.46	27.83	8.85	3.92	185.92	2.41	1.07	165.28	11.27	4.99	351.20	30.36	13.45	379.03
54	1.28	6.56	5.11	3.63	12.53	9.76	45.28	19.10	14.87	48.91	8.85	6.89	326.79	2.41	1.88	290.52	11.27	8.77	617.31	30.36	23.64	666.22
Total LOF	**2,287.43**	**285.75**		**14.98**	**545.45**		**186.89**	**831.20**		**201.87**	**385.34**		**1,348.70**	**105.03**		**1,199.00**	**490.37**		**2,547.70**	**1,321.57**		**2,749.57**
Average LOF		**5.29**	**0.12**	**0.28**	**10.10**	**0.24**	**3.46**	**15.39**	**0.36**	**3.74**	**7.14**	**0.17**	**24.98**	**1.95**	**0.05**	**22.20**	**9.08**	**0.21**	**47.18**	**24.47**	**0.58**	**50.92**

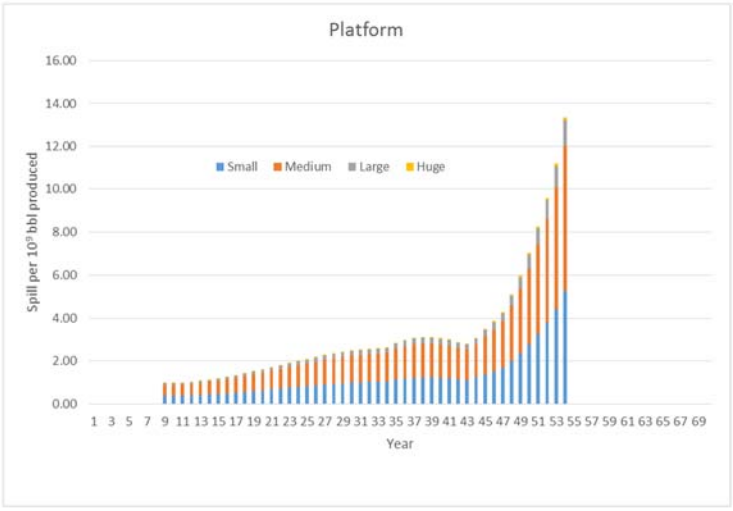
Total Oil Spill Summary

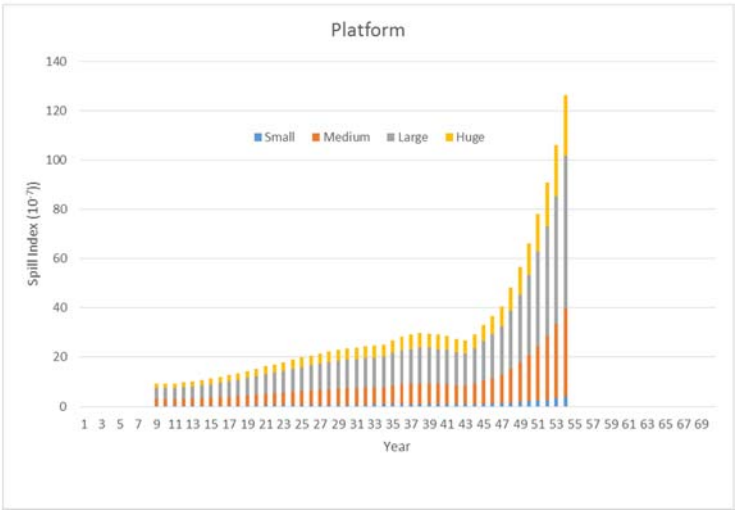
Total		Small spills 50-99 bbl			Medium spills 100-999 bbl			Small and Medium spills 50-999 bbl			Large spills 1000-9999 bbl			Huge spills =>10,000 bbl			Enormous =>150,000 bbl			Substantial spills =>1000 bbl			All spills		
Year	Total Oil Production, MMbbl	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0.57	0	0	0	0	0	0	0	0	0.09	0	0	0.47	0	0	1.03	0	0
4	0	0	0	0	0	0	0	0.57	0	0	0	0	0	0	0	0	0.09	0	0	0.47	0	0	1.03	0	0
5	0	0	0	0	0	0	0	0.85	0	0	0	0	0	0	0	0	0.14	0	0	0.70	0	0	1.55	0	0
6	0	0	0	0	0	0	0	0.85	0	0	0	0	0	0	0	0	0.14	0	0	0.70	0	0	1.55	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1.40	4.38	3.13	2.24	7.80	5.57	26.35	12.18	8.70	28.59	5.16	3.68	176.13	1.49	1.06	240.22	0.11	0.03	55.90	6.76	4.77	472.26	18.94	13.47	500.85
10	5.60	6.08	1.08	0.79	9.95	1.78	8.62	16.03	2.86	9.41	5.59	1.00	48.09	1.59	0.28	67.99	0.14	0.03	55.90	7.31	1.31	171.99	23.34	4.17	181.40
11	9.64	7.63	0.79	0.58	11.93	1.24	6.10	19.56	2.03	6.68	5.89	0.61	29.63	1.61	0.17	37.69	0.12	0.03	55.90	7.62	0.81	123.22	27.18	2.84	129.90
12	14.47	9.96	0.69	0.50	14.97	1.03	5.17	24.93	1.72	5.68	6.59	0.46	22.20	1.75	0.12	27.80	0.14	0.03	55.90	8.47	0.60	105.90	33.40	2.33	111.58
13	21.35	13.08	0.61	0.45	18.95	0.89	4.49	32.03	1.50	4.95	7.21	0.34	16.59	1.79	0.08	17.41	0.10	0.00	9.82	9.10	0.43	43.82	41.13	1.93	48.77
14	27.47	16.32	0.59	0.44	23.07	0.84	4.29	39.38	1.43	4.73	7.93	0.29	14.29	1.90	0.07	14.34	0.11	0.00	9.82	9.94	0.36	38.45	49.32	1.80	43.18
15	33.92	20.26	0.60	0.44	28.17	0.83	4.27	48.43	1.43	4.71	8.99	0.26	13.19	2.10	0.06	13.08	0.13	0.00	9.82	11.21	0.33	36.09	59.65	1.76	40.80
16	40.20	25.35	0.63	0.47	35.22	0.88	4.50	60.56	1.51	4.97	11.17	0.28	13.84	2.59	0.06	13.32	0.15	0.00	9.82	13.91	0.35	36.98	74.48	1.85	41.95
17	47.06	30.25	0.64	0.48	41.45	0.88	4.55	71.71	1.52	5.03	12.30	0.26	13.10	2.79	0.06	12.56	0.18	0.00	9.82	15.27	0.33	35.47	86.97	1.85	40.50
18	53.61	35.82	0.67	0.50	48.61	0.91	4.70	84.43	1.58	5.20	13.72	0.26	12.88	3.04	0.06	12.16	0.20	0.00	9.82	16.96	0.32	34.86	101.39	1.89	40.05
19	59.75	41.73	0.70	0.52	56.21	0.94	4.89	97.95	1.64	5.41	15.21	0.25	12.85	3.30	0.06	11.88	0.22	0.00	9.82	18.73	0.31	34.55	116.67	1.95	39.96
20	66.42	48.26	0.73	0.54	64.51	0.97	5.06	112.77	1.70	5.60	16.70	0.25	12.75	3.54	0.05	11.69	0.26	0.00	9.82	20.50	0.31	34.26	133.27	2.01	39.86
21	72.75	55.84	0.77	0.57	74.48	1.02	5.34	130.32	1.79	5.91	19.01	0.26	13.27	4.00	0.05	11.97	0.29	0.00	9.82	23.29	0.32	35.06	153.61	2.11	40.97
22	78.60	62.83	0.80	0.59	83.45	1.06	5.55	146.29	1.86	6.14	20.73	0.26	13.43	4.29	0.05	11.91	0.31	0.00	9.82	25.34	0.32	35.16	171.63	2.18	41.30
23	81.56	68.01	0.83	0.62	90.05	1.10	5.78	158.06	1.94	6.40	21.87	0.27	13.68	4.45	0.05	11.71	0.31	0.00	9.82	26.62	0.33	35.21	184.68	2.27	41.61
24	83.93	73.55	0.88	0.65	97.18	1.16	6.06	170.73	2.03	6.71	23.26	0.28	14.17	4.69	0.06	11.98	0.33	0.00	9.82	28.27	0.34	35.96	199.00	2.37	42.67
25	86.73	79.11	0.91	0.68	104.44	1.20	6.31	183.55	2.12	6.99	24.87	0.29	14.67	4.99	0.06	12.33	0.35	0.00	9.82	30.21	0.35	36.82	213.77	2.47	43.80
26	87.32	82.67	0.95	0.70	108.97	1.25	6.54	191.65	2.19	7.24	25.65	0.29	15.03	5.09	0.06	12.34	0.34	0.00	9.82	31.08	0.36	37.19	222.72	2.55	44.44
27	87.75	86.59	0.99	0.73	114.04	1.30	6.81	200.64	2.29	7.55	26.68	0.30	15.57	5.28	0.06	12.72	0.35	0.00	9.82	32.31	0.37	38.11	232.95	2.66	45.66
28	89.10	90.35	1.01	0.75	118.90	1.33	7.00	209.25	2.35	7.75	27.68	0.31	15.92	5.46	0.06	13.01	0.37	0.00	9.82	33.51	0.38	38.75	242.76	2.73	46.50
29	88.80	93.01	1.05	0.78	122.29	1.38	7.22	215.30	2.42	8.00	28.25	0.32	16.32	5.53	0.06	13.08	0.36	0.00	9.82	34.14	0.39	39.21	249.44	2.81	47.22

Total Year	Total Oil Production, MMbbl	Small spills 50-99 bbl			Medium spills 100-999 bbl			Small and Medium spills 50-999 bbl			Large spills 1000-9999 bbl			Huge spills =>10,000 bbl			Enormous =>150,000 bbl			Substantial spills =>1000 bbl			All spills		
		Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}	Freq., Spills per 10^3 years	Freq., spills per 10^9 bbl produced	Spill index, 10^{-7}
30	88.61	95.31	1.08	0.80	125.30	1.41	7.42	220.61	2.49	8.22	28.92	0.33	16.74	5.66	0.06	13.42	0.37	0.00	9.82	34.95	0.40	39.98	255.56	2.88	48.19
31	89.51	97.45	1.09	0.81	128.10	1.43	7.51	225.54	2.52	8.32	29.56	0.33	16.94	5.79	0.06	13.64	0.39	0.00	9.82	35.74	0.40	40.40	261.28	2.92	48.72
32	88.86	98.49	1.11	0.83	129.42	1.46	7.64	227.91	2.56	8.47	29.77	0.34	17.19	5.80	0.07	13.64	0.37	0.00	9.82	35.95	0.41	40.64	263.86	2.97	49.11
33	88.61	99.57	1.12	0.84	131.13	1.48	7.76	230.70	2.60	8.59	30.61	0.35	17.69	6.02	0.07	14.12	0.38	0.00	9.82	37.01	0.42	41.63	267.71	3.02	50.22
34	85.75	98.41	1.15	0.85	129.67	1.51	7.92	228.08	2.66	8.78	30.30	0.35	18.09	5.94	0.07	14.11	0.35	0.00	9.82	36.60	0.43	42.02	264.68	3.09	50.80
35	76.42	94.08	1.23	0.92	124.18	1.62	8.51	218.27	2.86	9.43	29.21	0.38	19.55	5.70	0.07	14.37	0.27	0.00	9.82	35.18	0.46	43.74	253.45	3.32	53.16
36	70.25	91.98	1.31	0.97	122.09	1.74	9.08	214.08	3.05	10.06	29.80	0.42	21.61	5.95	0.08	16.32	0.28	0.00	9.82	36.03	0.51	47.75	250.11	3.56	57.80
37	65.41	88.55	1.35	1.01	117.73	1.80	9.40	206.28	3.15	10.41	29.03	0.44	22.58	5.83	0.09	17.09	0.27	0.00	9.82	35.12	0.54	49.49	241.41	3.69	59.90
38	60.87	84.39	1.39	1.03	112.44	1.85	9.64	196.83	3.23	10.67	28.08	0.46	23.44	5.67	0.09	17.71	0.25	0.00	9.82	34.00	0.56	50.97	230.83	3.79	61.64
39	58.71	81.50	1.39	1.03	108.84	1.85	9.67	190.34	3.24	10.70	27.61	0.47	23.86	5.64	0.10	18.42	0.26	0.00	9.82	33.50	0.57	52.09	223.85	3.81	62.79
40	56.86	78.07	1.37	1.02	104.48	1.84	9.58	182.55	3.21	10.60	26.83	0.47	23.92	5.52	0.10	18.51	0.24	0.00	9.82	32.59	0.57	52.25	215.14	3.78	62.84
41	54.54	73.91	1.36	1.01	99.19	1.82	9.47	173.10	3.17	10.47	25.88	0.47	24.01	5.36	0.10	18.58	0.23	0.00	9.82	31.47	0.58	52.40	204.57	3.75	62.88
42	54.02	71.02	1.31	0.98	95.60	1.77	9.20	166.61	3.08	10.18	25.41	0.47	23.76	5.33	0.10	18.82	0.23	0.00	9.82	30.97	0.57	52.39	197.59	3.66	62.57
43	51.98	67.01	1.29	0.96	90.50	1.74	9.04	157.51	3.03	10.00	24.48	0.47	23.75	5.17	0.10	18.61	0.21	0.00	9.82	29.85	0.58	52.17	187.37	3.61	62.17
44	41.43	59.42	1.43	1.06	80.87	1.95	10.11	140.29	3.39	11.17	22.64	0.55	27.44	4.79	0.12	19.84	0.11	0.00	0.80	27.55	0.66	48.09	167.84	4.05	59.26
45	31.79	52.58	1.65	1.23	72.18	2.27	11.72	124.76	3.92	12.95	21.12	0.66	33.22	4.56	0.14	24.39	0.10	0.00	0.80	25.78	0.81	58.41	150.53	4.73	71.36
46	24.21	43.80	1.81	1.34	59.89	2.47	12.79	103.70	4.28	14.14	17.17	0.71	35.55	3.68	0.15	25.92	0.08	0.00	0.80	20.93	0.86	62.27	124.63	5.15	76.40
47	18.32	37.87	2.07	1.53	52.34	2.86	14.71	90.21	4.92	16.24	15.85	0.86	43.12	3.47	0.19	32.02	0.07	0.00	0.80	19.39	1.05	75.94	109.60	5.98	92.19
48	13.80	34.63	2.51	1.86	48.22	3.50	17.95	82.85	6.00	19.81	15.12	1.10	54.49	3.36	0.24	40.93	0.06	0.00	0.80	18.55	1.34	96.22	101.40	7.35	116.03
49	10.19	30.85	3.03	2.24	43.42	4.26	21.80	74.27	7.29	24.04	14.28	1.40	69.37	3.24	0.32	52.87	0.05	0.00	0.80	17.57	1.72	123.04	91.84	9.01	147.08
50	7.41	27.25	3.68	2.71	38.84	5.24	26.70	66.10	8.92	29.41	13.48	1.82	89.65	3.11	0.42	69.40	0.05	0.00	0.80	16.64	2.24	159.85	82.73	11.16	189.26
51	5.30	24.02	4.53	3.34	34.72	6.55	33.22	58.74	11.09	36.56	12.75	2.41	118.17	3.00	0.57	92.90	0.04	0.00	0.80	15.80	2.97	211.87	74.54	14.06	248.43
52	3.57	20.24	5.66	4.16	29.92	8.37	42.11	50.16	14.03	46.27	11.91	3.33	162.69	2.88	0.80	130.51	0.03	0.00	0.80	14.82	4.14	294.00	64.97	18.17	340.27
53	2.26	16.64	7.37	5.40	25.34	11.23	55.91	41.98	18.60	61.31	11.10	4.92	238.75	2.75	1.22	195.77	0.02	0.00	0.80	13.88	6.14	435.32	55.86	24.74	496.63
54	1.28	13.40	10.44	7.61	21.23	16.53	81.24	34.63	26.97	88.85	10.38	8.08	389.80	2.64	2.06	326.88	0.02	0.00	0.80	13.04	10.14	717.48	47.67	37.11	806.33
Total LOF	**2,287.43**	**2,532.85**		**59.56**	**3,401.83**		**589.73**	**5,934.68**		**649.28**	**896.90**		**2,072.98**	**188.88**		**1,830.00**	**10.05**		**536.76**	**1,095.83**		**4,439.74**	**7,030.51**		**5,089.02**
Average LOF		**46.90**	**1.11**	**1.10**	**63.00**	**1.49**	**10.92**	**109.90**	**2.59**	**12.02**	**16.61**	**0.39**	**38.39**	**3.50**	**0.08**	**33.89**	**0.19**	**0.00**	**9.94**	**20.29**	**0.48**	**82.22**	**130.19**	**3.07**	**94.24**

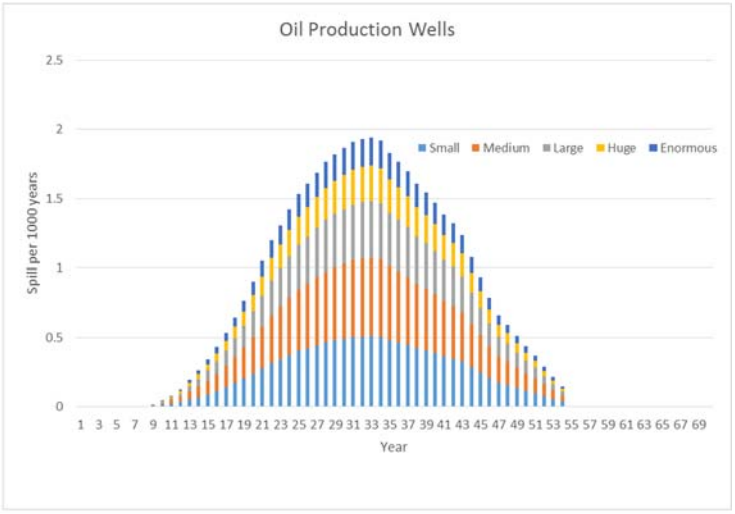
Spill Indicators - Platform

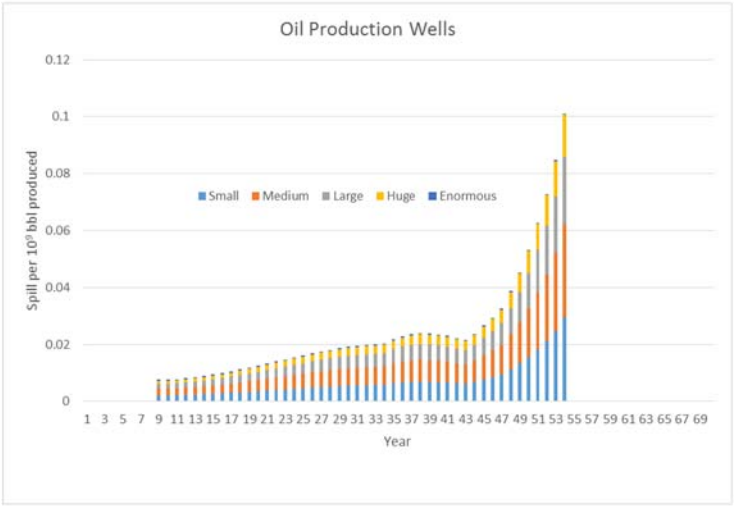


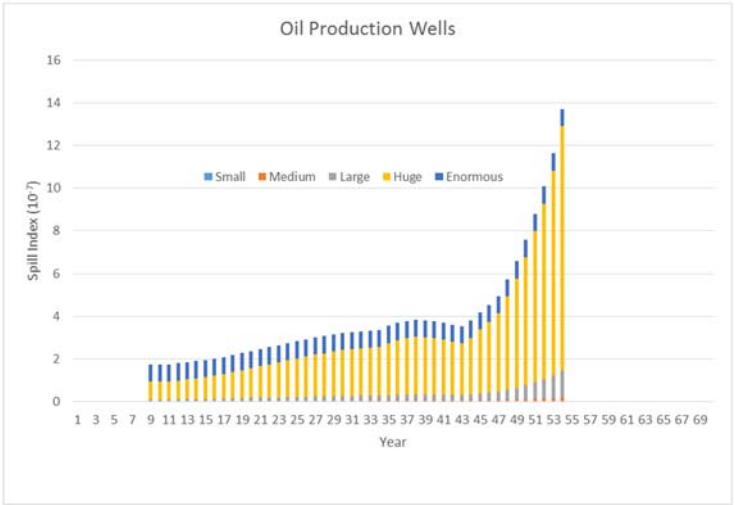




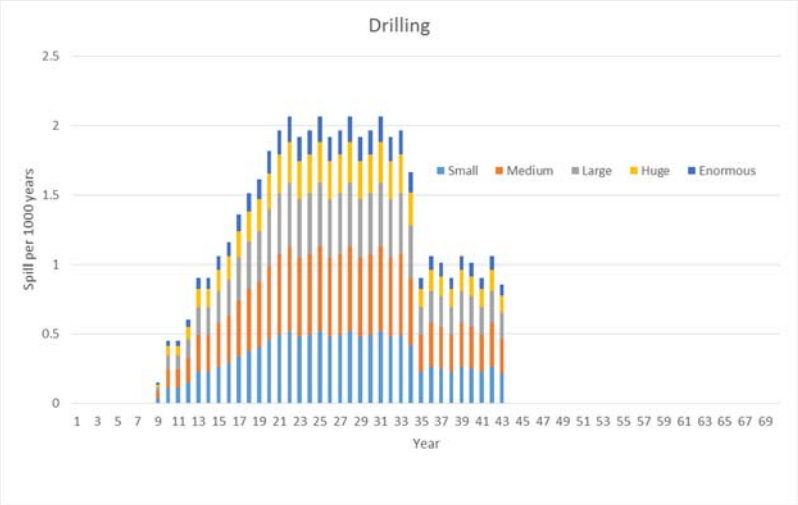
Spill Indicators – Oil Production Wells in Operation

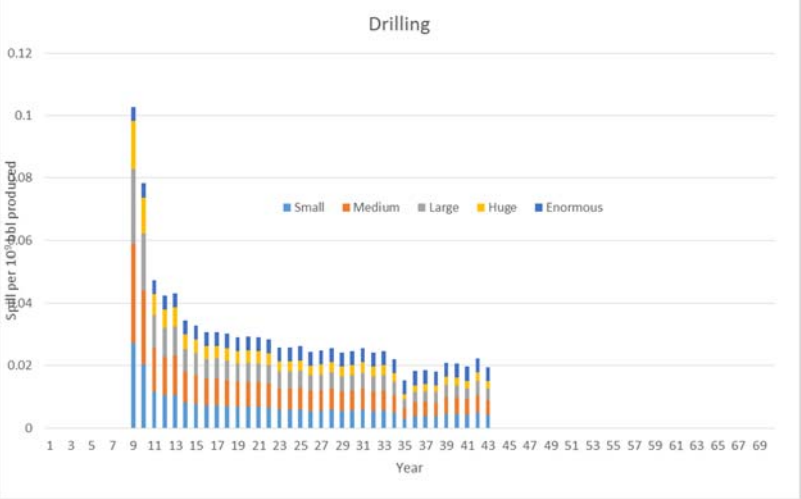


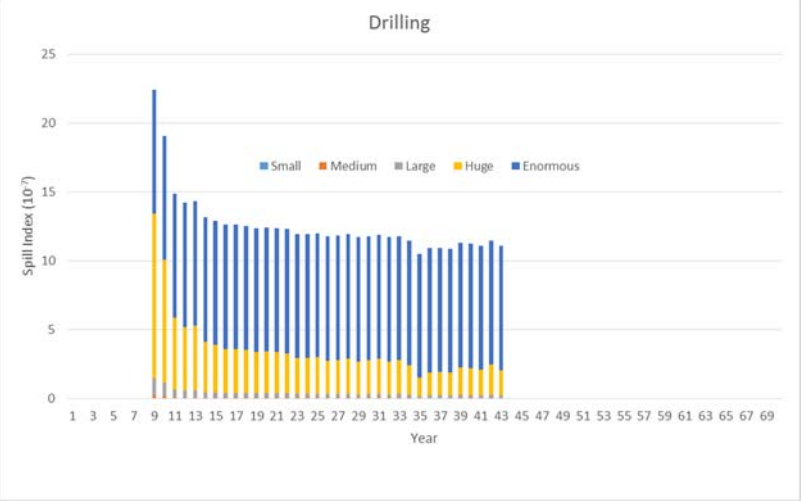




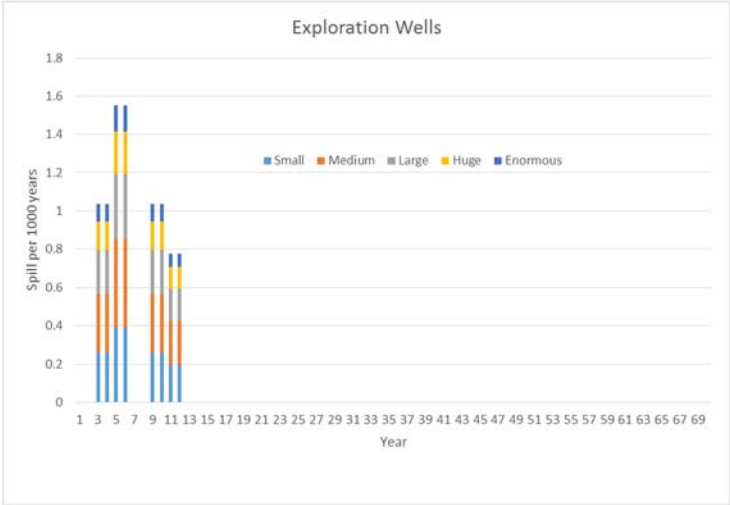
Spill Indicators –Production Wells while Drilling

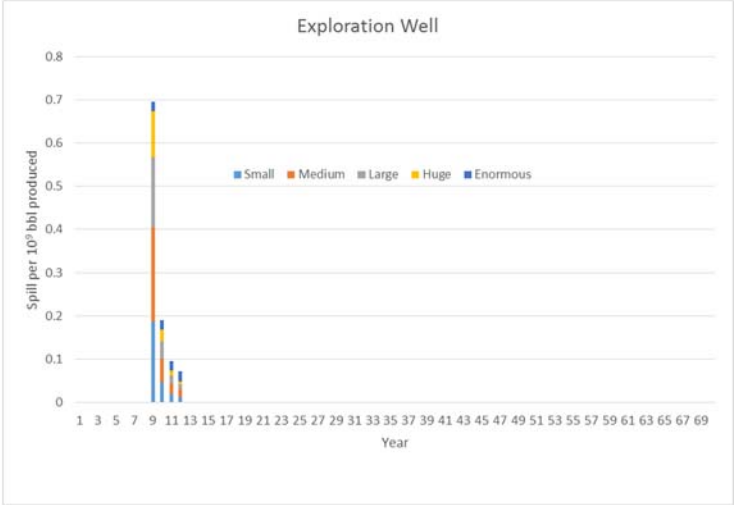


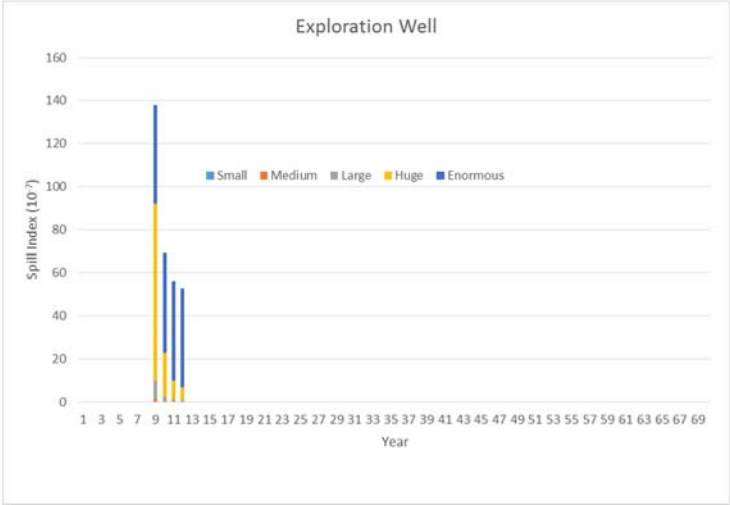




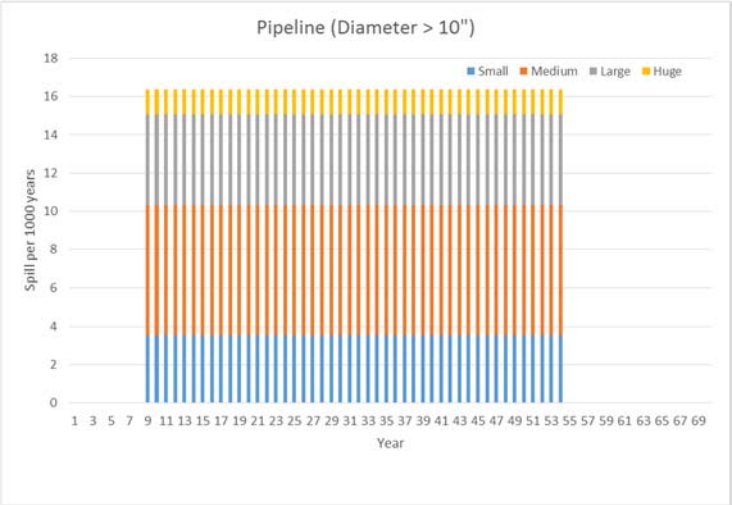
Spill Indicators –Exploration Wells

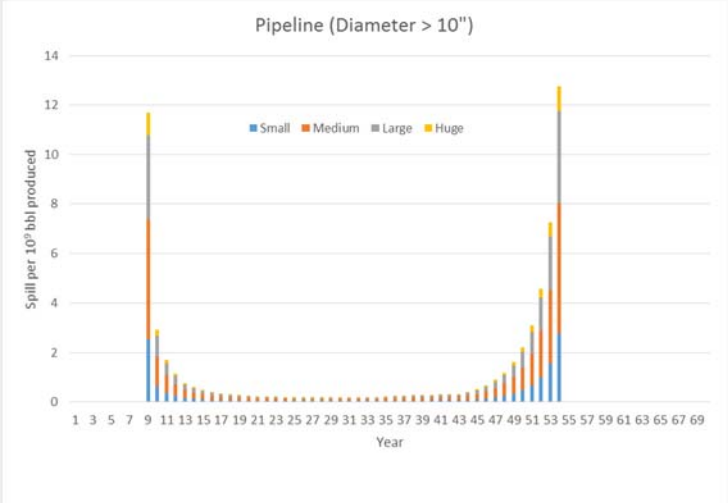


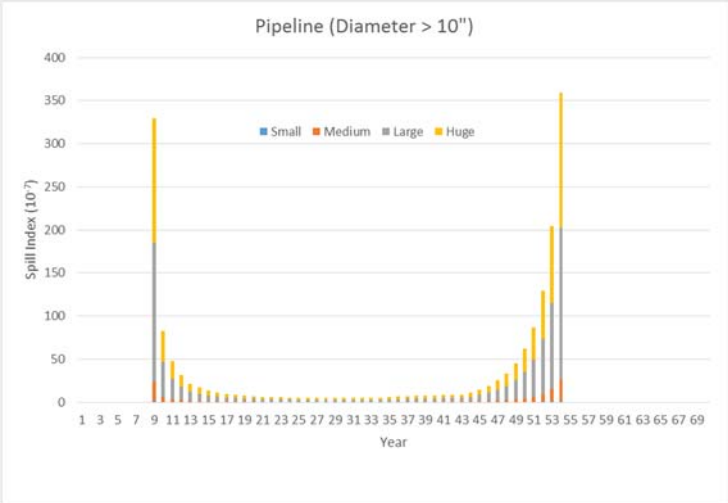




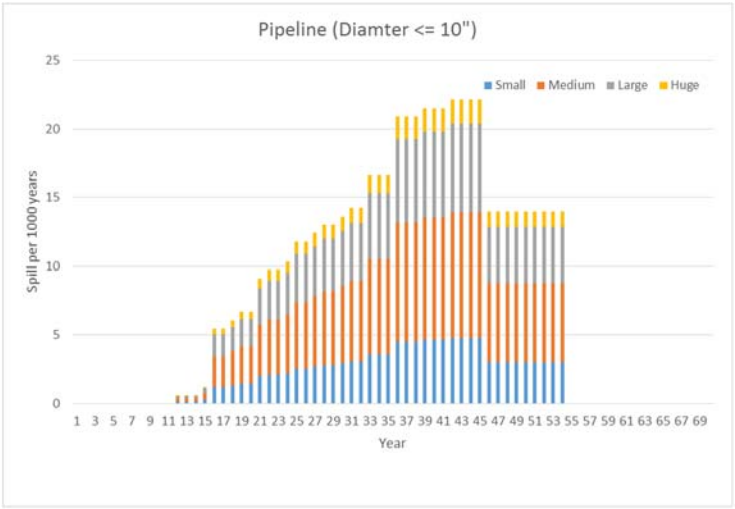
Spill Indicators –Pipeline (diameter > 10”)

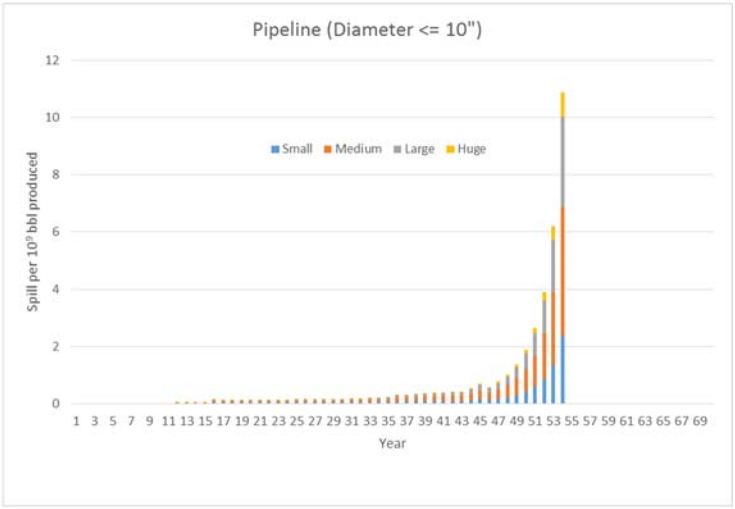


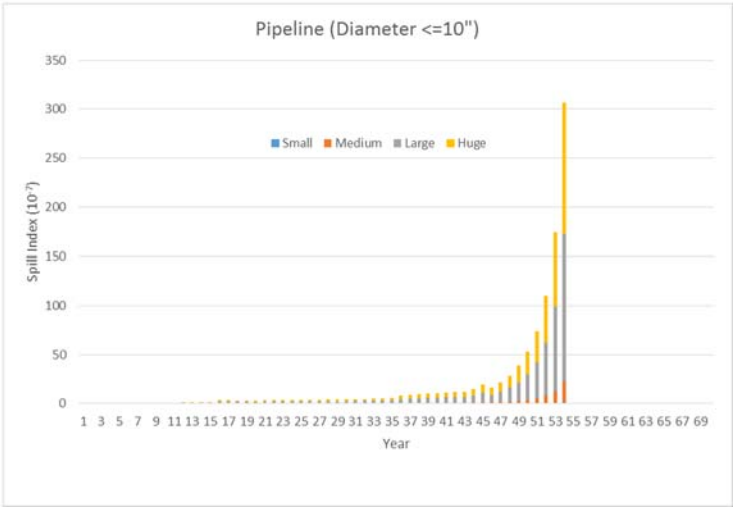




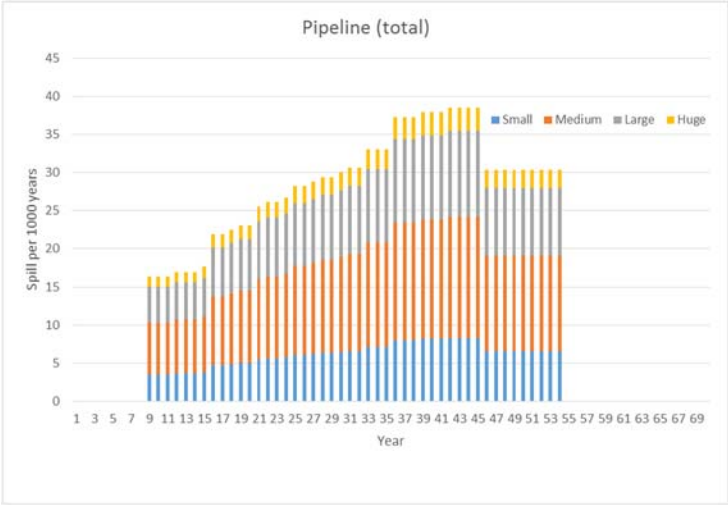
Spill Indicators –Pipeline (diameter ≤ 10”)

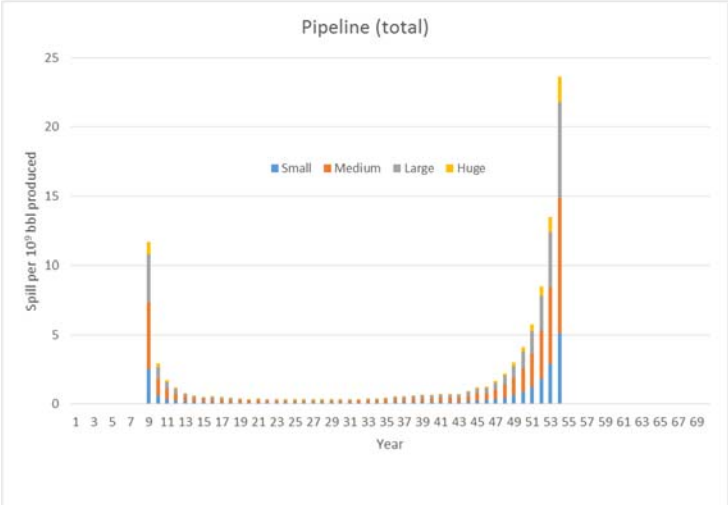


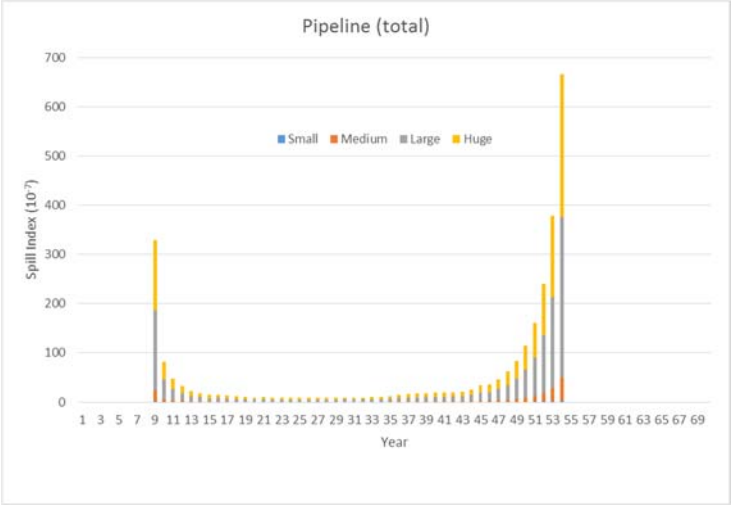




Spill Indicators –Pipeline (Total- all sizes)







Department of the Interior (DOI)

The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors the Nation’s trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

BOEM
Bureau of Ocean Energy Management

Bureau of Ocean Energy Management (BOEM)

The mission of the Bureau of Ocean Energy Management is to manage development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way.

BOEM Environmental Studies Program

The mission of the Environmental Studies Program is to provide the information needed to predict, assess, and manage impacts from offshore energy and marine mineral exploration, development, and production activities on human, marine, and coastal environments. The proposal, selection, research, review, collaboration, production, and dissemination of each of BOEM’s Environmental Studies follows the DOI Code of Scientific and Scholarly Conduct, in support of a culture of scientific and professional integrity, as set out in the DOI Departmental Manual (305 DM 3).