Hebron

# HEBRON PROJECT

Comprehensive Study Report
Section 14.1 (revised, track changes)
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# 14 ACCIDENTAL HYDROCARBON SPILL EVENTS

A hydrocarbon spill or accidental release is the accidental event of greatest concern because it can result in higher magnitudes of environmental effects, compared to other Project-environment interactions. A hydrocarbon spill can affect marine mammals and birds, and the commercial fishery. For these reasons, it is important to understand the probability of its occurrence and fate, for planning and response purposes. To this end, the probability of varying sizes of hydrocarbon spills have been estimated using historical data from Newfoundland and other offshore oil and gas development regions, and the trajectories of credible spill scenarios have been modelled. The results are presented in this chapter.

For the purposes of the environmental assessment, two types of accidental events during drilling and production operations – blow-outs and "batch" spills – are assessed. Blow-outs are continuous spills lasting hours, days or weeks that could involve the discharge of large volumes of associated gas into the atmosphere, discharge of crude oil and certain amounts of gas condensate (a very low viscosity, highly volatile type of liquid petroleum oil) into surrounding waters. Blow-outs could occur from accidents during development drilling, well-completion activities, workovers and various production activities including wirelining, coiled tubing and snubbing operations. Batch spills are instantaneous or short-duration discharges of hydrocarbon that could occur from accidents on the drilling or production platforms where hydrocarbon is stored and handled. An oil spill could ~~also~~ potentially occur~~, although unlikely,~~ during offloading and/or transfer of crude oil at the offshore loading system (OLS).

Compared with other industries that have potential for discharging petroleum hydrocarbon into the marine environment, the industry of exploring, developing and producing offshore oil and gas (the offshore E&P industry) has a good record. A recent study on marine hydrocarbon pollution by the US National Research Council (NRC 2002) indicates that accidental petroleum discharges from platforms contribute only 0.07 percent of the total petroleum input to the world's oceans (0.86 thousand tonnes per year versus 1,300 thousand tonnes per year - see Table 14-1).

This section derives spill and blow-out statistics for the Hebron Project from world-wide statistics. The practices and technologies that will be used on the Project are world-class and will be in accordance with Canadian regulations and best practices.

**Table 14-1 Best Estimate of Annual Releases (1990 to 1999) of Petroleum by Source**

| Source | North America in thousands of tonnes | World-wide in thousands of tonnes |
|---|---|---|
| **Natural Seeps** | **160** | **600** |
| **Extraction of Petroleum** | **3.0** | **38** |
| • Platforms | 0.16 | 0.86 |
| • Atmospheric Deposition | 0.12 | 1.3 |
| • Produced waters | 2.7 | 36 |
| **Transportation of Petroleum** | **9.1** | **150** |
| • Pipeline Spills | 1.9 | 12 |
| • Tank Vessel Spills | 5.3 | 100 |
| • Operational Discharges (cargo washings) | na [A] | 36 |
| • Coastal Facility Spills | 1.9 | 4.9 |
| • Atmospheric Deposition | 0.01 | 0.4 |
| **Consumption of Petroleum** | **84** | **480** |
| • Land-Based (River and Runoff) | 54 | 140 |
| • Recreational Marine Vessel | 5.6 | nd [B] |
| • Spills (non-tank vessels) | 1.2 | 7.1 |
| • Operational Discharges (vessels 100 GT) | 0.10 | 270 |
| • Operational Discharges (vessels <100 GT) | 0.12 | nd [C] |
| • Atmospheric Deposition | 21 | 52 |
| • Jettisoned Aircraft Fuel | 1.5 | 7.5 |
| **TOTAL** | **260** | **1,300** |

Source: NRC 2002
Notes:
[A] Cargo washing is not allowed in US waters, but is not restricted in international waters. Thus, it was assumed that this practice does not occur frequently in US waters
[B] World-wide populations of recreational vessels were not available
[C] Insufficient data were available to develop estimates for this class of vessels

The petroleum industry usually uses the oil volume unit of petroleum barrel (bbl), which is different than a US barrel and a British barrel. There are 6.29 bbl in 1 cubic metre ($m^3$) and there are approximately 7.5 bbl per tonne. Most spill statistics used here are taken from publications that use the oil volume units of bbl, and bbl are used in the subsequent statistical analysis as a result.

Data sources used in this chapter have varying dates of publication. Sources such as the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE, until recently known as the U.S. Minerals Management Service, (MMS) are updated regularly, and the most recent data available are used in this report. Other sources used, notably Scandpower (2000), and NRC (2002) have not been updated.

## 14.1 Hydrocarbon Spill Probabilities

Spill probabilities are discussed separately for blow-outs and for other "batch" spills from drilling and production platforms, and for a range of spill sizes. The definition of oil spill sizes are provided in Table 14-2.

**Table 14-2 Definition of Hydrocarbon Spill Sizes**

| Hydrocarbon Spill Type | Spill Size | |
|---|---|---|
| | ~~Barrels~~bbl | m³ |
| Extremely Large | >150,000 | >23,850 |
| Very Large | >10,000 ~~to 150,000~~ | >1,590 ~~to 23,850~~ |
| Large | >1,000 ~~to 10,000~~ | >159 ~~to 1,590~~ |
| Small | <~~1 to~~ 1,000 | <0.159 ~~to 159~~ |
| Note: The top three categories are cumulative; for example, the large-spill category (>1,000 bbl) includes the very large and extremely large spills, and the very large category includes extremely large spills. This follows the approach used by BOEMRE statisticians upon which the "large" spill ferquencies are derived. For the small category, more detailed statistics are available and a further breakdown is made with discrete size ranges, specifically: 50 to 999 bbl, 1 to 49 bbl, 1 L to 1 bbl (159 L), and less than 1 L. | | |

## 14.1.1 Extremely Large and Very Large Oil Spills from Blow-outs

In the oil and gas industry, a distinction is made between two stages of petroleum field drilling: exploration drilling (including "delineation" drilling), where knowledge of the geological and depositional environment is speculative or limited; and development drilling, where the structure is better defined and drilling is under better control. Because exploration drilling at the Hebron site is now completed, the analysis concentrates on statistics related to development drilling, although reference is made to exploration-related statistics where appropriate. Blow-outs can also happen during production, workovers and well completion activities, and these are also addressed.

~~The definition of oil spill sizes are provided in Table 14-2.~~

~~**Table 14-2 Definition of Hydrocarbon Spill Sizes**~~

| ~~Hydrocarbon Spill Type~~ | ~~Spill Size~~ | |
|---|---|---|
| | ~~Barrels~~ | ~~m³~~ |
| ~~Extremely Large~~ | ~~>150,000~~ | ~~23,850~~ |
| ~~Very Large~~ | ~~10,000 to 150,000~~ | ~~1,590 to 23,850~~ |
| ~~Large~~ | ~~1,000 to 10,000~~ | ~~159 to 1,590~~ |
| ~~Small~~ | ~~1 to 1,000~~ | ~~0.159 to 159~~ |

In Canada, there have been no large petroleum spills from blow-outs. In the US, since offshore drilling began in the mid-1950s, there have been three oil-well blow-outs involving hydrocarbon spills greater than 50,000 bbl. Therefore, data from jurisdictions beyond North America must be used to develop a reasonable database on very large and extremely large oil-well blow-outs. All world-wide blow-outs involving the spillage of more than 10,000 bbls each are listed in Table 14-3.

**Table 14-3 Historical Extremely and~~&~~ Very Large Hydrocarbon Spills from Offshore Oil Well Blow-outs**

| Area | Reported Spill Size (bbl) | Date | Operation Underway | Duration (days) | Intervention Method |
|---|---|---|---|---|---|
| Extremely Large Spills (>150,000 bbl) | | | | | |

| Area | Reported Spill Size (bbl) | Date | Operation Underway | Duration (days) | Intervention Method |
|---|---|---|---|---|---|
| US, Gulf of Mexico (GOM)[A] | 4,000,000 | 2010 | Exploration drilling | 91 | Relief well |
| Mexico (*Ixtoc 1*)[B] | 3,000,000 | 1979 | Exploratory Drilling | 293 | Relief well |
| Iran[C] | see note | 1983 | Production | -- | |
| Mexico | 247,000 | 1986 | Workover | ?? | |
| Nigeria | 200,000 | 1980 | Development Drilling | 14 | Bridged |
| North Sea / Norway | 158,000 | 1977 | Workover | 7 | Capped |
| Very Large Spills (10,000) | | | | | |
| Iran | 100,000 | 1980 | Development Drilling | 8 | |
| US, Santa Barbara | 77,000 | 1969 | Production (platform) | 11 | Capped |
| Saudi Arabia | 60,000 | 1980 | Exploratory Drilling | 8 | Capped |
| Mexico | 56,000 | 1987 | Exploratory Drilling | 51 | |
| US, S. Timbalier 26 | 53,000 | 1970 | Wireline | 138 | Relief well & Capping |
| US, Main Pass 41 | 30,000 | 1970 | Production (Platform) | 49 | Capped (three relief wells also initiated) |
| Australia[D] | 30,000 | 2009 | Development drilling (primarily gas) | 74 | Relief well |
| US, Timbalier Bay / Greenhill | 11,500 | 1992 | Production | 11 | |
| Trinidad | 10,000 | 1973 | Development Drilling | 4 | |

Source: Gulf 1981, updated to 2010 by reference to the Oil Spill Intelligence Report and other sources

A Varying estimates of spill volume, most recent estimate reported

B Spill volume widely believed to be underestimated

C The Iranian Norwuz oil well blow-outs in the Gulf of Arabia, which started in February 1983, were not caused by exploration or drilling accidents, but were a result of military actions during the Iraq / Iran war

D Currently under investigation, spill volume is best estimate and may be subject to revision

Using the definition of "extremely large" spills (*i.e.*, hydrocarbon spills greater than 150,000 bbls), there have been six such spills in the history of offshore drilling, two of which occurred during development drilling, two of which occurred during production or workover activities and two occurred during exploration drilling.

#### 14.1.1.1 Blow-outs during Drilling

Spill frequencies are best expressed in terms of a risk exposure factor such as number of wells drilled. On a world-wide basis it has been estimated that 66,469 offshore development wells were drilled as of May 2010 (Deloitte 2010).

There have been two extremely large spills during offshore development drilling, so the frequency up to ~~the present~~ (2010) is (2/66,469) $3.0 \times 10^{-5}$ spills per well drilled, or one such spill for every 33,000 wells drilled. A similar analysis can be done for very large spills. Up to 2010~~the present~~, five development-drilling blow-outs have produced spills in the very large spill category (Table 14-3, including the recent incident in Australia). The spill frequency for these is (5/66,469) 7.5 x $10^{-5}$ spills per well drilled, or one such spill per every 13,000 wells drilled.

#### 14.1.1.2 Blow-outs during Production and Workovers

There have been two extremely large and five very large hydrocarbon spills from blow-outs during production and workovers (Table 14-3). Lack of production statistics makes it difficult to develop an exact risk exposure for these events. However, it is estimated that the total oil produced offshore on a world-wide basis up to 2002 has been approximately 125 billion bbl, and that the total producing oil well years has been 250,000 well-years (based on information in~~:~~ Gulf (1981),~~;~~ NAS (1985),~~;~~ E&P Forum (1992),~~;~~ MMS (1997)~~;~~ and current internet sources). Generally, in analyzing accidents in the oil and gas industry, the exposure variable of "well-years" is used to normalize data for the continuous operation of production. This exposure is also convenient to use for workovers inasmuch as these maintenance activities, although not continuous, usually occur with regularity, approximately every five to seven years during the lifetime of a well.

On this basis, the world-wide frequency of extremely large hydrocarbon spills from oil-well blow-outs that occurred during production or workovers is 8.0 x $10^{-6}$ blow-outs/well-year. For very large, the number is 2.0 x $10^{-5}$ blow-outs/well-year.

#### 14.1.1.3 Summary of Extremely Large and Very Large Oil Spills from Blow-outs

The above calculation of spill frequencies is based on an estimate of 250,000 oil-well years of world-wide experience and does not include gas-well experience, which, according to US OCS activity, could be 75 percent as much as oil-well experience. In other words, the frequencies calculated above, however low, are actually substantially lower when considering gas-well experience as well as oil-well experience. Because world-wide gas-well experience is not easy to estimate, the above spill frequencies will be used as a conservative~~worst~~ case.

Finally, it is emphasized that the very low spill frequencies derived above for extremely large spills are based on spills in countries (except Norway) that do not generally have regulatory standards as stringent as those existing in North America. For example, the largest hydrocarbon spill in history, the *Ixtoc I* oil-well blow-out in the Bay of Campeche, Mexico, that occurred in 1979, was caused by drilling procedures (used by PEMEX, Mexico's national oil company) that are not practised in US or Canadian waters and that are contrary to US and Canadian regulations and to the accepted practices within the international oil and gas industry. Therefore, extremely large spill frequencies in North America are expected to be even lower.

In spite of this declining trend, large blow-out events can still occur. On April 20, 2010, a fire and explosion occurred on Transocean's Deepwater Horizon drilling facility while drilling an exploration well on British Petroleum's Mississippi Canyon Block 252, approximately 66 km offshore Louisiana in the US GOM. At the time of writing this report, the cause of this incident is still under investigation. The well was initially reported to be discharging approximately 5,000 bbls per day; more recent estimates place the rate at 12,000 to 19,000 bbl/day.

Despite this recent event, the overall trend of spills and blow-outs is decreasing world-wide. A spill of the magnitude of the Deepwater Horizon blow-out is unprecedented. An investigation will likely result in lessons learned in terms of improved technology, and operational, safety and environmental procedures. However, in spite of potential improvements and advancements in spill prevention technology and practices, there still remains an element of safety and environmental risk in any drilling operation.

With respect to the Hebron Project, there will be an estimated 40 development wells drilled, and an estimated 200 well-years of production[1]. Using the above world-wide spill frequency statistics as a basis for prediction, the spill frequencies estimated for the Project would be as follows:

- Predicted frequency of extremely large hydrocarbon spills from blow-outs during a drilling operation, based on an exposure of wells drilled: 40 x 3.0 x $10^{-5}$ = 1.2 x $10^{-3}$, or a 0.12 percent chance over the drilling period
- Predicted frequency of very large hydrocarbon spills from drilling blow-outs based on an exposure of wells drilled: 40 x 7.5 x $10^{-5}$ = 3.0 x $10^{-3}$ or a 0.3 percent chance over the drilling period
- Predicted frequency of extremely large hydrocarbon spills from production/workover blow-outs, based on an exposure of well-years = 200 x 8.0 x $10^{-6}$ = 1.6 x $10^{-3}$ or a 0.16 percent chance over the Project's lifetime (30 years) or a one-in-19,000 chance per year
- Predicted frequency of very large hydrocarbon spills from production/workover blow-outs, based on an exposure of well-years = 200 x 2.0 x $10^{-5}$ = 4.0 x $10^{-3}$ or a one-in-7,500 chance per year

### 14.1.2 Blow-outs Involving Smaller Discharges of Oil or Only Gas

Gas blow-outs from offshore wells that do not involve a discharge of liquid petroleum are generally believed to be relatively innocuous to the marine environment. However, such blow-outs may represent a threat to human life and property because of the possibility of explosion and fire.

Two sources are used for historical statistics on blow-outs involving only gas or small hydrocarbon discharges. A particularly good source for US blow-outs is the BOEMRE web page (www.boemre.gov), because BOEMRE keeps track of spills down to 1 bbl in size. This is not the case in other parts of the

[1] Assumes half of all development wells are "oil producers" and that production wells have an average well-life of 10 years.

world. Scandpower (2000) provides a report on blow-outs in the North Sea and in the US GOM, although the report provides no information as to whether or not hydrocarbon spills were involved in the reported blow-outs.

The ~~-~~US ~~OCS~~ Outer Continental Shelf (OCS) data, representing the 34-year period from 1972 to 2006, are provided in Table 14-4 (Note that ~~MMS~~BOEMRE updates their data on a regular basis, but the most recent data they have published is for 2006). There are no large spills in the entire database. The ~~ongoing~~ 2010 blow-out in the US Gulf of Mexico (US GOM) would fit into the extremely large category, but is classified as an exploratory well.

The total number of development wells drilled in the US OCS from 1972 to 2006 is not shown in Table 14-4, but an estimate of 21,000 can be inferred from other sections of MMS (1997), E&P Forum (1996) and from current internet sources. The number of blow-outs from development drilling is 63 (with the four blow-outs from sulphur drilling removed); therefore, the blow-out frequency is 3.0 x $10^{-3}$ blow-outs per well drilled.

**Table 14-4 Blow-outs and Spillage from US Federal Offshore Wells, 1972 to 2006**

| Year | Well Starts | Drilling Blow-outs | | | | Non-drilling Blow-outs | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Exploration | | Development | | Production | | Workover | | Completion | | Total Blow-outs | | OCS Production |
| | | No. | bbl | No. | bbl | No. | bbl | No. | bbl | No. | bbl | No. | bbl | MMbbl |
| 1972 | 845 | 2 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 396.0 |
| 1973 | 820 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 384.8 |
| 1974 | 816 | 1 | 0 | 1 | 0 | 4 | 275 | 0 | 0 | 0 | 0 | 6 | 275 | 354.9 |
| 1975 | 372 | 4 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 7 | 0 | 325.3 |
| 1976 | 1,038 | 1 | 0 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 314.5 |
| 1977 | 1,064 | 3 | 0 | 1 | 0 | 1 | 0 | 3 | 0 | 1 | 0 | 9 | 0 | 296.0 |
| 1978 | 980 | 3 | 0 | 4 | 0 | 0 | 0 | 3 | 0 | 1 | 0 | 11 | 0 | 288.0 |
| 1979 | 1,149 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 274.2 |
| 1980 | 1,307 | 3 | 0 | 1 | 0 | 2 | 1 | 1 | 0 | 1 | 0 | 8 | 1 | 274.7 |
| 1981 | 1,284 | 1 | 0 | 2 | 0 | 1 | 0 | 3 | 64 | 3 | 0 | 10 | 64 | 282.9 |
| 1982 | 1,035 | 1 | 0 | 4 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 9 | 0 | 314.5 |
| 1983 | 1,151 | 5 | 0 | 5 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 12 | 0 | 350.8 |
| 1984 | 1,386 | 3 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 5 | 0 | 385.1 |
| 1985 | 1,000 | 3 | 0 | 1 | 0 | 0 | 0 | 2 | 40 | 0 | 0 | 6 | 40 | 380.0 |
| 1986 | 1,538 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 384.3 |
| 1987 | 772 | 2 | 0 | 0 | 0 | 3 | 0 | 1 | 0 | 2 | 60 | 8 | 60 | 358.8 |
| 1988 | 1,007 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 332.7 |
| 1989 | 911 | 2 | 0 | [1]5 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 11 | 0 | 313.7 |
| 1990 | 987 | 1 | 0 | 1 | 0 | 0 | 0 | 3 | 9 | 1 | 0 | 6 | 9 | 304.5 |
| 1991 | 667 | 3 | 0 | [2]3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 326.4 |
| 1992 | 943 | 3 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 100 | 337.9 |
| 1993 | 717[3] | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 352.7 |
| 1994 | 717[3] | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 370.4 |
| 1995 | 717[3] | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 429.2 |
| 1996 | 921 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 4 | 0 | 433.1 |

| Year | Well Starts | Drilling Blow-outs | | | | Non-drilling Blow-outs | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Exploration | | Development | | Production | | Workover | | Completion | | Total Blow-outs | | OCS Production |
| | | No. | bbl | No. | bbl | No. | bbl | No. | bbl | No. | bbl | No. | bbl | MMbbl |
| 1997 | 1,333 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 5 | 0 | 466.0 |
| 1998 | 1,325 | 1 | 0 | 1 | 0 | 2 | 0 | 3 | 0 | 0 | 0 | 7 | 2 | 490.5 |
| 1999 | 364 | 1 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 5 | 0 | 534.6 |
| 2000 | 1,061 | 5 | 200 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 200 | 551.6 |
| 2001 | 1,007 | 1 | 0 | 4 | 1 | 2 | 0 | 2 | 0 | 1 | 0 | 10 | 1 | 591.5 |
| 2002 | 828 | 1 | 0 | 2 | 0 | 2 | 350 | 1 | 1 | 0 | 0 | 6 | 351 | 602.1 |
| 2003 | 835 | 1 | 0 | 1 | 0 | 2 | 1 | 1 | 10 | 0 | 0 | 5 | 11 | 594.7 |
| 2004 | 861 | 2 | 16 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 4 | 17 | 567.0 |
| 2005 | 1,232 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 497.4 |
| 2006 | 1,586 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 50 | 2 | 50 | 503.1 |
| **Total** | **34,576** | **67** | **316** | **91** | **1** | **24** | **627** | **39** | **125** | **15** | **110** | **207** | **1181** | **13963.9** |

1 Two of the drilling blow-outs occurred during drilling for sulphur
2. Two of the drilling blow-outs occurred during drilling for sulphur
3 Estimated: cumulative total correct

The statistic, based mostly on US OCS drilling and blow-out records over the past 30 years, is derived on a conservative basis and does not take into account recent improvements in safety and blow-out prevention that have tended to reduce blow-out frequencies. There is also concern over gas releases and their effect on workers. For this reason, a more realistic assessment of the probability of a gas blow-out is required. The main factors that need to be re-considered are: (1) the differences between "shallow gas" blow-outs and deep-well blow-outs; (2) special blow-out prevention activities that exist for deep well drilling in Canada; and (3) decreases in blow-out frequency in recent years due to improvements in blow-out prevention. All three issues are covered thoroughly in Scandpower (2000), and this source is used heavily in the following analysis.

### ~~14.1.1.2~~14.1.2.1 Shallow Gas v~~V~~ersus Deep Blow-out

A blow-out might occur if shallow gas is encountered unexpectedly during drilling operations. The driller has interest in shallow gas from the mudline to approximately 914 m (3,000 feet) and below. Gas that is trapped in the shallow sediments can originate from deeper gas reservoirs, but can also come from biogenic activity in the shallow sediments. The probabilities of the various blow-out categories are shown in Table 14-5, abstracted from Scandpower (2000).

**Table 14-5 Development Drilling and Blow-outs in the US Gulf of Mexico Outer Continental Shelf and North Sea, 1987 to 1997**

| Area | Number of Development Wells | Shallow Gas Blow-outs | Shallow Gas Release during Drilling | Deep Blow-outs | Deep Well Releases during Drilling | Total Blow-outs and Releases |
|---|---|---|---|---|---|---|
| US GOM | 8,466 | 13 | 10 | 4 | 1 | 28 |
| UK | 3,086 | 1 | 0 | 0 | 2 | 3 |
| Norway | 1,202 | 1 | 1 | 0 | 0 | 2 |
| Totals | 12,754 | 15 | 11 | 4 | 3 | 33 |

Source: after Scandpower (2000)
Notes:
A blow-out is an incident where hydrocarbons flow from the well to the surface, all barriers are non-functional and well control can only be regained by means that were not available when the incident started
A deep blow-out is defined as one that occurs after the Blow-out Preventor (BOP) is set
A shallow gas blow-out is a release of gas prior to the BOP being set
A well release is an incident where hydrocarbons flow from the well to the surface and is stopped by one or several barriers that were available when the incident started. In this case, hydrocarbons do not enter the environment

The values in Table 14-5 (for the US GOM) are reasonably consistent with the values in Table 14-4, which show 29 blow-outs for the period 1980 to 1997. This means that the ~~MMS~~BOEMRE (the US regulator) classifies "blow-outs" in Table 14-5 as *all* categories in Table 14-5 (*i.e.*, well releases as well as blow-outs). The blow-out frequency from Table 14-5 for the US GOM is 28/8,466 = 3.3 x $10^{-3}$, which is close to the value derived earlier (3.0 x $10^{-3}$).

The important statistic to note in Table 14-5 is that the vast majority of blow-outs and well releases are of the shallow gas variety. Specifically, the breakdown for shallow gas blow-out frequency versus deep blow-out frequency is shown in Table 14-6. It is clearly seen that: (1) shallow gas blow-out frequencies are approximately four times lower in the North Sea compared to the US GOM OCS; and (2) deep blow-out/release frequencies can be (*e.g.*, for the US GOM) as much as six times lower than shallow gas blow-out / ~~-~~ releases.

**Table 14-6 Blow-out Frequencies for the US Gulf of Mexico and North Sea, 1980 to 1997**

| | Shallow Gas Blow-out/Release | | Deep Blow-out/Release | |
|---|---|---|---|---|
| | **US GOM** | **North Sea** | **US GOM** | **North Sea** |
| Blow-outs/Releases per Wells Drilled | 27 x $10^{-4}$ | 7.0 x $10^{-4}$ | 5.9 x $10^{-4}$ | 4.7 x $10^{-4}$ |
| Wells Drilled per Blow-out/Release | 370 | 1400 | 1700 | 2100 |

Deep blow-outs (and not well releases) are the primary concern because releases by definition do not involve a discharge of hydrocarbons into the environment. There have been four deep blow-outs from development drilling in the US GOM and none in the North Sea from 1987 to 1997 (Table 14-5). The reason for this, according to Scandpower (2000), is that North Sea operators are required by law to always have two barriers during exploration and development drilling, and this is not the case in the US. Regulations in Canada (*i.e.*, two barriers[2]) are similar to ~~the~~ those in the North Sea~~'s apply in Canada (*i.e.*, two barriers)~~, so it is fair to derive blow-out frequencies for Canada on the basis of North Sea statistics. ~~This would suggest that there will~~

[2] Section 36 paragraph (2) of the *Newfoundland Offshore Petroleum Drilling and Production Regulations* states that "After setting the surface casing, the operator shall ensure that at least two independent and tested well barriers are in place during all well operations." It is the Operator's intention to adhere to all requirements for well control and regulatory requirements.

be an extremely low risk of a deep blow-out during drilling at Hebron, and thus virtually no chance of a large flow of $H_2S$ into the environment.

Finally, it is worth noting (Table 14-7) that shallow gas blow-out frequencies in the North Sea and in the US GOM have been on the decline in the most recent years of the record.

**Table 14-7 Shallow Gas Exploration and Development Drilling Blow-out Frequencies over Time, 1980 to 1997**

| Time Period | No. of Blow-outs | Number of Exploration and Development Wells Drilled | Blow-out Frequency |
|---|---|---|---|
| 18 years (1980 to 1997) | 53 | 22,084 | $24.0 \times 10^{-4}$ |
| 10 years (1988 to 1997) | 23 | 13,870 | $16.6 \times 10^{-4}$ |
| 5 years (1993 to 1997) | 5 | 7,581 | $6.6 \times 10^{-4}$ |
| 3 years (1995 to 1997) | 1 | 4,924 | $2.0 \times 10^{-4}$ |
| Source: Scandpower (2000) | | | |

A more recent analysis by Scandpower (2006), summarized in IAOGP (2010), confirms the reduced frequencies in recent years. The data, is based on the 20-year record to 2005, and indicates a deep blow-out frequency of $4.8 \times 10^{-5}$. Using this figure results in a probability of one blow-out for every 21,000 wells drilled. For a drilling program involving 40 wells, this statistic yields a deep well blow-out probability of 1-in-520.

#### 14.1.1.3 14.1.2.2 Blow-outs During Production Operations

The best accident exposure variable to use for production and wireline operations is well-years. It is also convenient to link completions and workovers to well-years of operation. The number of oil and gas well-years for the population in Table 14-4 from 1972 through 2005 can be estimated from other tables in MMS references; the number is approximately 235,000 producing well-years.

For all the gas-producing areas and oil-producing areas of the US OCS, 55 blow-outs occurred during production, workovers and completions (Table 14-4). This yields a blow-out frequency of $76/235{,}000 = 3.23 \times 10^{-4}$ blow-outs per well-year. The equivalent number for the US OCS and North Sea areas for the period 1980 to 1997 is $1.83 \times 10^{-4}$ blow-outs per well-year (Table 14-8).

**Table 14-8 Frequency over Time of Blow-outs during Production, Wireline Operations, Workovers and Completions, US Gulf of Mexico and North Sea, 1980 to 1997**

| Period | Blow-outs: Production and Wireline | Blow-outs: Completions and Workovers | Total Blow-outs | Well-years | Blow-out Frequency |
|---|---|---|---|---|---|
| 18 years (1980 to 1997) | 10 | 21 | 31 | 168,583 | $1.83 \times 10^{-4}$ |
| 10 years (1988 to 1997) | 3 | 7 | 10 | 108,357 | $9.92 \times 10^{-5}$ |
| 5 years (1993 to 1997) | 1 | 3 | 4 | 55,188 | $7.25 \times 10^{-5}$ |
| 3 years (1995 to 1997) | 1 [a] | 3 | 4 | 34,895 | $1.15 \times 10^{-4}$ |
| Source: Scandpower (2000) | | | | | |

As was done for the case of blow-outs during development drilling, it is important to note that blow-out frequencies during production operations in the North Sea and in the US GOM have been on the decline over recent years (Table 14-8).

~~A more recent analysis by~~ Scandpower (2006), ~~summarized in IAOGP (2010)~~, does not allow a comparison for each of the operations listed in Table 14-8, but confirms the overall blow-out frequency for production, wireline operations, completions and workovers in recent years. The data, based on the 20-year record to 2005, indicate an overall blow-out frequency for these operations of $1.85 \times 10^{-4}$, based on 33 incidents over 177,474 well-years.

A certain percentage of the blow-outs involved some discharge of hydrocarbon. Of the 78 blow-outs that occurred during the four operations of production, wirelining, workovers and completions, only 12, or 15.4 percent, involved hydrocarbon (note that the average size of the 12 spills was only 72 bbl). Therefore, the frequency of blow-outs that produced a hydrocarbon spill from well blow-outs during the four above-noted operations is calculated to be $0.154 \times 1.85 \times 10^{-4} = 2.8 \times 10^{-5}$ blow-outs/well-year.

#### 14.1.2.3 Summary of Blow-out Frequencies Involving Smaller Discharges of Oil or Only Gas

There are an estimated 40 wells to be drilled for the Project, so the calculated number of deep blow-outs during development drilling becomes $40 \times 4.8 \times 10^{-5} = 1.92 \times 10^{-3}$, or a probability of approximately 1-in-520. ~~However, according to the statistics in Table 14-4, the chances of having an hydrocarbon discharge associated with the blow-out are extremely low.~~

~~With respect to the Hebron Project, there will be an estimated 40 development wells drilled, and an estimated 200 well-years of production[3]. Using the above world-wide spill frequency statistics as a basis for prediction, the spill frequencies estimated for the Project would be as follows:~~

- ~~Predicted frequency of extremely large hydrocarbon spills from blow-outs during a drilling operation, based on an exposure of wells drilled: $40 \times 3.0 \times 10^{-5} = 1.2 \times 10^{-3}$, or a 0.12 percent chance over the drilling period~~
- ~~Predicted frequency of very large hydrocarbon spills from drilling blow-outs based on an exposure of wells drilled: $40 \times 7.5 \times 10^{-5} = 3.0 \times 10^{-3}$ or a 0.3 percent chance over the drilling period~~

For gas blow-outs occurring during production and workovers, the statistic for Hebron becomes 200 well-years x $1.17 \times 10^{-4}$ blow-outs/well-year, approximately a 1-in-1,300 chance per year, or approximately 2.3 percent probability over the 30-year life of the Project.

For gas blow-outs that occur during production and workovers that involve some hydrocarbon discharge (>1 bbl), the statistic for Hebron becomes

~~[3] Assumes half of all development wells are "oil producers" and that production wells have an average well-life of 10 years.~~

200 well-years x 1.04 x $10^{-5}$ blow-outs/well-year, or approximately a 1-in-14,000 chance per year.

In summary, the probability of having a deep blow-out is a 0.02 percent chance (1-in-520)~~, with virtually no chance of hydrocarbon release~~. During production, the risk of having a gas blow-out will decrease to a 1-in-1,300 chance per year; and gas blow-outs with the possibility ~~involving small amounts~~ of discharged hydrocarbon (>1 bbl) would be expected once every 14,000 years.

### ~~14.1.2~~14.1.3 Large Platform Spills

There have been very few large spills from platforms operating in US OCS waters. In addition to the five from ~~blowout~~blow-outs noted in Table 14-3 there have been seven others, which includes all US platform spills up to the present (Table 14-9). Note, that this does not include the 2010 Macondo blow-out, which occurred during exploration drilling.

**Table 14-9 Hydrocarbon Spills of Greater than or Equal to 1,000 bbl from Platforms on the US Outer Continental Shelf, 1964 ~~to present~~ to 2010**

| Date | Location | Size (bbl) | Cause |
|---|---|---|---|
| 04/08/64 | Eugene Island Block 208 | 2,559 | Collision |
| 10/03/64 | Eugene Island Ship Shoal | 11,869 | Hurricane (7 platforms) |
| 07/19/65 | Ship Shoal Block 29 | 1,688 | Blow-out (condensate) |
| 01/28/69 | Santa Barbara Channel | 77,000[A] | Blow-out |
| 03/16/69 | Ship Shoal Block 72 | 2,500 | Collision, weather |
| 02/10/70 | Main Pass Block 41 | 30,000 | Blow-out |
| 12/01/70 | South Timbalier Block 26 | 53,000 | Blow-out |
| 01/09/73 | West Delta Block 79 | 9,935 | Storage tank rupture |
| 11/23/79 | Main Pass Block 151 | 1,500[B] | Collision, weather, tank spill |
| 11/13/80 | High Island Block 206 | 1,456 | Pump failure, hurricane, tank spill |
| 09/29/92 | Timbalier Bay/Greenhill | 11,500[C] | Production well blow-out |
| 09/24/05 | Cameron/Eugene Is./Green Canyon | 3,915 | Hurricane (9 platforms) |

Source: ~~MMS~~BOEMRE OCS Spill Database, April 2010, www.~~mms~~boemre.gov/stats/index.htm
A Estimates vary between 10,000 to 77,000 bbl
B Refined product
C This spill was in Louisiana State waters and not OCS waters, but is included for interest

All but two of the OCS spills in Table 14-9 occurred prior to 1980. ~~MMS~~BOEMRE statisticians responsible for analyzing and predicting hydrocarbon spill frequencies associated with offshore oil and gas activities in the OCS have decreased the estimate gradually over the past 15 years, mostly in recognition of a statistical trend towards lower spill frequency. The estimate derived from statistics in Anderson and LaBelle (2001) is 1.5 x $10^{-5}$ spills/well-year for spills equal or greater than 1,000 bbl and 5.5 x $10^{-6}$ spills/well-year for spills equal or greater than 10,000 bbl[4].

[4] These numbers are derived from statistics developed by Anderson and LaBelle (2001), who use an exposure of

The production well-years for Hebron is 200; therefore, the equivalent annual probabilities are one in 10,000 and one in 27,000.

Note that the above statistic for spills >10,000 bbl (*i.e.*, 5.5 x $10^{-6}$ spills/well-year) is almost four times smaller than the statistic derived earlier for production blow-out spills >10,000 bbl (*i.e.*, 2.0 x $10^{-5}$). This is impossible because the first category includes blow-out spills. The reason for the anomaly is that the US record was used for the former and the world-wide record was used for the latter. The world-wide statistic is higher than the US-derived one because the former was developed on a very conservative basis, which considered an exposure of only oil wells and not gas wells. Another reason is that spills occur less frequently in US waters compared with the rest of the world.

It is noted that there has been one production-related spill in Newfoundland and Labrador waters greater than 1,000 bbl, in 2004. There have been no spills greater than 10,000 bbl. Given the limited statistical database of Newfoundland and Labrador production operations, the US statistics are used in the frequency calculation.

~~The production well-years for Hebron is 200; therefore, the equivalent annual probabilities are one in 10,000 and one in 27,000.~~

### ~~14.1.3~~14.1.4 Platform Spills Involving Small Discharges

Small spills occur with some regularity at offshore platforms. The data in Table 14-10 are derived from a more detailed table in MMS (1997) and covers small spills of all pollutants from facilities and operations on Federal OCS leases from the period 1971 to 1995. The spills involved various pollutants including crude oil, condensate, refined product, mineral oil and diesel. The period between 1971 and 1995 involved the production of 8.5 billion bbl of oil and condensate and 186,058 well-years of oil and gas production activity (MMS 1997). See Table 14-10 for the spill frequency.

**Table 14-10 Frequency of Platform Spills in the Ranges of 1 to 49.9 bbl and 50 to 999 bbl (US OCS 1971 to 1995)**

| Spill Size Range | Number of Spills |
|---|---|
| 1 to 49.9 bbl | 1,898 |
| 50 to 999 bbl | 90 |
| Total volume of 1,898 + 90 spills = 123,023 bbl | |

There have been very few large spills related to development or production in Canadian waters, which has necessitated the use of US and world-wide statistics. However, there is a reasonably-sized database on small spill incidents in Newfoundland and Labrador waters. Spill statistics are

"billions of barrels of oil produced" and consider the period 1964 to 1999. During this period, 46,000 bbl of oil were produced per well-year, considering both oil and gas wells. The frequencies derived by the authors for spills greater than 1,000 bbl and 10,000 bbl are 0.32 and 0.12 spills per billion bbl produced, respectively. The equivalent numbers for the last 15 years are considerably less.

maintained and reported by the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) (C-NLOPB 2010d~~9~~).

Production in Newfoundland and Labrador waters commenced in 1997 at the Hibernia location, with Terra Nova coming on stream in 2001 and White Rose in 2004. Using the well statistics ~~i~~on the C-NLOPB website, these three fields have a total of ~~325~~472 producing well-years to ~~date~~the end of 2010. Tables 14-11 through 14-14 provide an overview of spill statistics for the Newfoundland and Labrador Offshore area. The spill incidents involving 1 bbl or more of hydrocarbon during that period are listed in Table 14-11. These spills include spills of crude, diesel –and other hydrocarbons resulting from production and loading operations. Spills of synthetic-based muds are provided in Table 14.14. As noted in Section 4.1.2, there was one crude spill ~~of~~ greater than 1,000 bbl, in 2004.

**Table 14-11 Frequency of Platform Spills in the Ranges of 1 to 49.9 bbl and 50 to 999 bbl (Newfoundland and Labrador Waters, 1997 to ~~present2009)~~2010)**

| Spill Size Range | Number of Spills |
|---|---|
| 1 to 49.9 bbl | ~~191121~~12 |
| 50 to 999 bbl | 0 |

A disproportionate number (~~13 712~~7 of ~~191121~~12) of these spills occurred in the first three years of operations, so it is reasonable to focus on the more recent years of production experience (Table 14-12). For the years 2000 to ~~2009~~2010, there were a total of ~~312~~452 producing well-years.

**Table 14-12 Frequency of Platform Spills in the Ranges of 1 to 49.9 bbl and 50 to 999 bbl (Newfoundland and Labrador Waters, 2000 to ~~present2009~~2010)**

| Spill Size Range | Number of Spills |
|---|---|
| 1 to 49.9 bbl | ~~64~~95 |
| 50 to 999 bbl | 0 |

For the smallest size range, statistics from Newfoundland and Labrador operations can be used, but as there have been zero spills in the second category, US GOM statistics will be used. Based on this, the frequency of spills in the range of 1 to 49.9 bbl is ~~1.3~~1.1 x $10^{-2}$ (~~4/312~~5/452) and for the range 50 to 99 bbl is 4.8 x $10^{-4}$ (90/186,058).

The C-NLOPB also provides a statistical record of spills of greater than 1 L but less than 1 bbl (159 L), and of spills of 1 L and less~~;.~~ ~~T~~these are presented in Table 14-13.~~, but are not used for any predictive purpose.~~ As in the previous category of spill size, a disproportionate number of these spills occurred in the first three years of operations, so it is reasonable to focus on the more recent years of production experience – 2000 to ~~2009.~~2010 For these years (2000 to ~~2009~~2010), there were a total of ~~312~~ 452producing well-years, with ~~87~~86 spills in the 1 to 159 L category, and ~~201~~218 spills less than 1 L. Note that the totals in Table 14-13 indicate all spills from 1997 to 2010~~09~~.

Based on this, the average spill frequency is 0.190 spills per well-year in the 1 to 159 L category, and 0.482 spills per well-year less than 1 L.

**Table 14-13 Record of Very Small Spills in Newfoundland and Labrador Waters, 1997 to 2009p2010resent**

| Year | Spills Greater Than 1 L and Less Than 159 L (1 bbarrel) | | Spills of 1 L and Less | |
|---|---|---|---|---|
| | Number | Total volume (L) | Number | Total volume (L) |
| 1997 | 7 | 123 | 0 | 0 |
| 1998 | 20 | 640638 | 3 | 1.6 |
| 1999 | 2423 | 1,193636.4 | 9 | 4.72 |
| 2000 | 2 | 62 | 2 | 1.1 |
| 2001 | 7 | 26126 | 8 | 4.21 |
| 2002 | 5 | 1625.6 | 19 | 5.2 |
| 2003 | 10 | 186185.8 | 9 | 2.48 |
| 2004 | 2118 | 193188.9 | 30 | 8.97 |
| 2005 | 11 | 181180.7 | 28 | 8.96 |
| 2006 | 5 | 20 | 27 | 9.24 |
| 2007 | 3 | 93 | 34 | 4.28 |
| 2008 | 1211 | 337335.5 | 22 | 2.89 |
| 2009 | 11 | 215288.3.8 | 22 | 4.97 |
| 2010 | 3 | 20.3 | 17 | 4.21 |
| Total | 138149136 | 2923.53,284.9 | 213230 | 58.6262.83 |

Regarding spills from the offshore loading systemsOLSs for all production facilities from 1997 to 2010, there were 10 spills greater than 1 L. Of these, one was in the range of 1 to 49.9 bbl, none in the 50 to 999 bbl range, and none greater than 1,000 bbl.

Just considering the spills from the offshore loading systems for all production platforms, OLS, from 1997 to July 2010, there were 151114 spills greater than 1 L. Of these, twoone werewas in the range of 1 to 49.9 bbl, none in the 50 to 999 bbl range and onenone greater than 1,000 bbl.

### 14.1.5 Spills of Synthetic-based Muds

The C-NLOPB records spills of synthetic-based mud (SBM) and fluids, and these are summarized in Table 14-14 for the years 1997 through 20092010. In the largest such spill to date, in 2004, approximately 96,600 L (608 bbl) of SBM were spilled from the diverter line of the GSF Grand Banks at the White Rose location. The spill frequency is calculated based on the 200219 wells spudded during this period.

Table 14-14 Spills of Synthetic-based Muds, 1997 to 20092010.

| Spill Size Range | Number of Spills | Frequency, per well |
|---|---|---|
| >1 L | 361336 | 0.180.16 |
| 159 to 7,934 L (1 to 49.9 bbl) | 18 | 0.090.082 |
| 7,935 to 159,000 L (0550 to 999 bbl) | 5 | 0.0250.023 |
| >159,000 L (1,000 bbl) | 0 | 0 |

## ~~14.1.4~~14.1.6 Summary of Blow-out and Spill Frequencies

The calculated hydrocarbon spill probabilities for the Project are summarized in Table 14-15.

**Table 14-15 Predicted Probability of Blow-outs and Spills for the Hebron Project~~,~~**

| Event | Historical Frequency | Hebron Exposure[B] | Life of Project Probabiltiy[C] ~~Annual Probability~~ |
|---|---|---|---|
| **Blow-outs** | | | |
| 1. Deep blow-out during development drilling | 4.8 x $10^{-5}$/wells drilled | 40 wells drilled | ~~one in 16,000~~1.92 x 10-3 |
| ~~2. Gas blow-out during production~~ | ~~1.85 x $10^{-4}$/well-years~~ | ~~200 well-years~~ | ~~one in 810~~ |
| 3. Blowout during production involving some hydrocarbon discharge >1 bbl | 2.8 x $10^{-5}$/well-years | 200 well-years | ~~one in 5,300~~5.6 x 10-3 |
| 4. Development drilling blow-out with hydrocarbon spill >10,000 bbl | 7.5 x $10^{-5}$/wells drilled | 40 wells drilled | ~~one in 10,000~~3 x 10-3 |
| 5. Development drilling blow-out with hydrocarbon spill >150,000 bbl | 3.0 x $10^{-5}$/wells drilled | 40 wells drilled | ~~one in 25,000~~1.2 x 10-3 |
| 6. Production/workover blow-out with hydrocarbon spill >10,000 bbl | 2.0 x $10^{-5}$/well-year | 200 well-years | ~~one in 7,500~~4 x 10-3 |
| 7. Production/workover blow-out with hydrocarbon spill >150,000 bbl | 8.0 x $10^{-6}$/well-year | 200 well-years | ~~one in 19,000~~1.6 x 10-3 |
| **Platform Spills[A~~1~~] (including blow-outs)** | | | |
| 8. Hydrocarbon spill >10,000 bbl | 5.5 x $10^{-6}$/well-year | 200 well-years | ~~one in 27,000~~1.1 x 10-3 |
| 9. Hydrocarbon spill >1000 bbl | 1.5 x $10^{-5}$/well-year | 200 well-years | ~~one in 10,000~~3 x 10-3 |
| 10. Hydrocarbon spill 50 to 999 bbl | 4.8 x $10^{-4}$/well-year | 200 well-years | ~~one in 310~~9.6 x 10-2 |
| 11. Hydrocarbon spill 1 to 49 bbl | ~~1.3~~1.1 x $10^{-2}$/well-year | 200 well-years | ~~one in 12~~14 2.2 |
| 12. Hydrocarbon spill 1 L to 1 bbl (159 L) | 0.190/well-year | 200 well-years | ~~1.3 per year~~38 |
| 13. Hydrocarbon spill less than 1 L | 0.482/well-year | 200 well-years | ~~3.2 per year~~96.4 |

[A]~~1.~~ Platform spills greater than 150,000 b~~blarrels~~ are not included in the table as it would simply duplicate the statistic for blow-outs greater than 150,000 bbls: it would be virtually impossible to have a spill of this size from anything other than a blow-out.

[B]~~3.~~ Hebron Exposure is the number of events ove the life of the ~~p~~Project. This is either defined as number of well-years for production related activities, or number of wells drilled for drilling related activities.

[C]~~2.~~ Life of project probability is calculated by mulitpling the Historical Frequency by Hebron Exposure.

The annual probability of having a large or very large spill as a result of an accident on a platform is 1-in-10,000 and 1-in-27,000, respectively. This is calculated on the basis of US OCS experience.

During the drilling of up to 40 development wells, the chances of an extremely large and very large oil well blow-out from development drilling are very small. Over the 30-year life of the Project, the annual probability of this happening is 1-in-25,000 for the extremely large spill; and 1-in-10,000 for a very large spill. For similar sized blow-outs from production activities and workovers that might occur over the 30-year production period, one extremely large oil well blow-out would be expected every 19,000 years and one very large oil well blow-out expected every 7,500 years of production. These predictions are based on world-wide blow-out data and are strongly influenced by blow-outs that have occurred in Mexico, Africa and the Middle East, where drilling and production regulations may be less rigorous; hence, probability for the Project would be expected to be even smaller.

Considering experience in the North Sea and the US GOM, and taking into account the trend toward fewer blow-outs, the prediction for Hebron is that the probability of having a deep blow-out is a 0.2 percent chance for the Project, or 0.0064 percent per year (1-in-16,000). During production at Hebron, ~~gas blow-outs might be expected to occur every 800 years and~~ blow-outs ~~involving~~ with the possibility~~small amounts~~ of discharged hydrocarbon (>1 bbl) might be expected to occur once every 5,000 years.

### 14.1.7 ExxonMobil Experience

As reported by the C-NLOPB and CNSOPB, since 2001, ExxonMobil drilling operations in eastern Canada have not had a reportable spill greater than 1 bbl for the 63 wells drilled in the region. There were 14 wells drilled with a jack-up drilling unit in Nova Scotia, 46 wells were drilled from the Hibernia Platform, and three wells were drilled from floating mobile offshore drilling units in Nova Scotia and on the Grand Banks. In the Newfoundland and Labrador offshore area, ExxonMobil has not had a crude spill greater than 1 L associated with its drilling operations.

ExxonMobil's well control philosophy is focused on prevention using safety / risk management systems, management of change procedures and global standards. ExxonMobil has a mature Operations Integrity Management System (OIMS) that emphasizes relentless attention to Safety, Well Control and Environmental Protection. This includes proper preparation for wells (well control equipment inspections / tests), detecting the influx early, closing-in the well efficiently (personnel training / drills) and circulating out the kick with kill-weight mud in a controlled manner.

Defining "blow-out" as an uncontrolled flow that was not brought under control using the rig's well control system, the last offshore drilling "blow-out" experienced by Exxon was in the GOM in 1983 (Penrod 52 jackup rig). The last offshore "blow-out" was experienced by Mobil in the North Sea in 1990 (Maersk Vinlander semisubmersible rig). Both were shallow gas "blow-outs" with no personnel injuries or release of liquid hydrocarbons to the sea. ExxonMobil has had other well control incidents, but were safely brought under control using well control equipment and procedures. None escalated into "blow-outs".

Since the implementation of OIMS (circa 1992), neither Exxon nor ExxonMobil have experienced a "blow-out" during offshore drilling operations.