RFF REPORT

The 2016 Arctic Offshore Drilling Safety Rule

Should It Stay or Should It Go?

Alan J. Krupnick and Isabel Echarte

RFF Report Series: *The Costs and Benefits of Eliminating or Modifying US Oil and Gas Regulations*

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The 2016 Arctic Offshore Drilling Safety Rule: Should It Stay or Should It Go?

Alan J. Krupnick and Isabel Echarte*

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* Krupnick: senior fellow, Resources for the Future (RFF); krupnick@rff.org. Echarte: research assistant, RFF; echarte@rff.org. We would like to thank RFF's Art Fraas, Jan Mares, and Justine Huetteman for their work on this project and BLM staff for help in understanding the methane RIAs.

This report is one in a series: The Costs and Benefits of Eliminating or Modifying US Oil and Gas Regulations.

Resources for the Future (RFF) is an independent, nonprofit research institution in Washington, DC. Its mission is to improve environmental, energy, and natural resource decisions through impartial economic research and policy engagement. RFF is committed to being the most widely trusted source of research insights and policy solutions leading to a healthy environment and a thriving economy.

Executive Summary

The Trump administration has prioritized increasing the production of US oil and natural gas, in part through reducing federal regulatory burdens that the administration says restrict development. President Trump signed Executive Order (EO) 13783 in March 2017, requiring agencies to review existing rules, guidance documents, and policies that potentially burden the development or use of domestically produced energy resources. This EO also specifically identified for review regulations applicable to the oil and gas sector. In response, the Department of the Interior (DOI) flagged its 2016 requirements for offshore exploratory drilling in the Arctic, herein referred to as the Arctic rule,[1] for review in a document outlining the agency's deregulatory efforts.[2] In that document, DOI stated it would consider "full rescission or revision" of the rule.

The Trump administration has also focused on reducing regulatory costs across the federal government more broadly with EO 13771, which ordered that two regulations be removed for every regulation implemented.[3] Subsequent guidance from the Office of Management and Budget (OMB 2017) for implementing EO 13771 emphasized that cost-benefit analysis is required for all major regulations being considered for elimination or modification (as has been the practice for new regulations since President Reagan's EO 12291).[4] But the OMB guidance and EO 13771 also laid out the controversial requirement that only the cost savings from repeal be considered in prioritizing rules for repeal; in other words, only cost savings (and not forgone benefits or net benefits) are to be counted when reviewing regulations under the two-for-one requirement. In a March letter to the Trump administration, 96 economists and other experts expressed concerns about this requirement (Linn and Krupnick 2017).

Following these actions, we sought to first catalog existing federal regulations promulgated after 2005 and nonregulatory federal activities of concern to the oil and gas industry.[5] We then turned toward assessing what the effects on industry and the public might be if some of these regulations were eliminated, modified, or delayed. To analyze these impacts, we updated the parameters used by each agency in its original regulatory impact analysis (RIA) and assessed the cost savings and forgone benefits associated with repealing and modifying the following rules:

- the Bureau of Land Management's (BLM's) Waste Prevention, Production Subject to Royalties, and Resource Conservation rule, hereafter referred to as the BLM methane rule
- the Environmental Protection Agency's (EPA's) Oil and Natural Gas Sector:

[1] 81 FR 46478, "Oil and Gas and Sulfur Operations in the Outer Continental Shelf—Requirements for Exploratory Drilling on the Arctic Outer Continental Shelf," July 15, 2016, https://www.gpo.gov/fdsys/pkg/FR-2016-07-15/pdf/2016-15699.pdf.

[2] 82 FR 50532, "Final Report: Review of the Department of the Interior Actions That Potentially Burden Domestic Energy," October 24, 2017, https://www.federalregister.gov/documents/2017/11/01/2017-23702/final-report-review-of-the-department-of-the-interior-actions-that-potentially-burden-domestic.

[3] 82 FR 9339, "Reducing Regulation and Controlling Regulatory Costs," February 3, 2017, https://www.federalregister.gov/documents/2017/02/03/2017-02451/reducing-regulation-and-controlling-regulatory-costs.

[4] 46 FR 13193, "Federal Regulation," February 17, 1981, https://www.archives.gov/federal-register/codification/executive-order/12291.html.

[5] Information about this catalog will be included in a forthcoming report summarizing the results of the project.

Emission Standards for New, Reconstructed, and Modified Sources rule amending the New Source Performance Standards, hereafter referred to as the EPA methane rule

- the Bureau of Safety and Environmental Enforcement's (BSEE's) Oil and Gas and Sulfur Operations in the Outer Continental Shelf—Blowout Preventer Systems and Well Control rule, hereafter referred to as the well control rule
- the Pipeline and Hazardous Materials Safety Administration's (PHMSA's) Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains rule, hereafter referred to as the tank car rule
- BSEE's and the Bureau of Ocean Energy Management's (BOEM's) "Oil and Gas and Sulphur Operations on the Outer Continental Shelf—Requirements for Exploratory Drilling on the Arctic Outer Continental Shelf rule, hereafter referred to as the Arctic rule
- PHMSA's Pipeline Safety: Integrity Management Program for Gas Distribution Pipelines rule

This report analyzes the Obama administration's 2016 Arctic rule. With the rule, BSEE and BOEM sought to increase environmental safeguards for Arctic drilling from mobile offshore development units (MODUs), or drill ships. (The rule does not cover drilling from other methods, such as man-made islands.) The Arctic rule was implemented in response to a number of offshore drilling accidents, including the 2010 Deepwater Horizon oil spill and several incidents and close calls during Shell's initial Arctic exploration attempts.

BSEE and BOEM estimated that the rule would result in $1.7 billion to $2 billion in costs (in 2014$), though the offices were unable to estimate the benefits of the rule. We explore various cost scenarios as a sensitivity analysis, and for the benefits, we conduct a break-even analysis and construct a range of potential benefits to better inform the reader of the rule's cost effectiveness.

We replicated BSEE and BOEM's cost estimate and then conducted several sensitivity analyses on that estimate. We found that a warmer Arctic in the future, with a longer potential drilling season, would reduce the costs (and cost savings of repeal) of the rule by 17 percent. Higher cost estimates (as suggested in Shell's [2015] comments to DOI) increase the costs of the rule 20 to 40 percent. All of these cost estimates, however, assume that Arctic offshore drilling from MODUs begins this year. We also looked at how implementing the rule in later years would affect costs. If drilling begins (and the rule is implemented) in 2023, the costs decrease 14 to 30 percent. If drilling begins in 20 years, the costs decrease by almost half to three-quarters. The potential costs of the rule depend largely on uncertain assumptions, including future climate and when drilling in the Arctic would begin.

Though BSEE and BOEM were unable to calculate the benefits of the rule, we did some illustrative calculations. We first conducted a break-even analysis looking at the barrels (bbl) of spilled oil that would have to be avoided for the benefits of the rule to match the costs. We find that the avoided amount of oil spilled would range between 75,000 and 757,000 barrels of oil, or 4 and 37 days of uncontrolled flow of oil. We note that while such a spill is possible, it is actually very unlikely according to BOEM's (2016a) oil spills frequency estimates. The break-even analysis likewise does not take into account the effectiveness of the rule, in terms of how much oil spill risk is reduced—a figure that is unknown. So we calculate a benefits estimate using the social cost of a spilled barrel of oil and the frequency of oil spills for risk

reduction levels between 1 percent and 100 percent. We find that even at 100 percent (i.e., assuming that the rule will fully prevent any catastrophic oil spills), the benefits are orders of magnitude smaller than the costs of rule. The costs outweigh the benefits by at least $900 million—even at 100 percent risk reduction. But there are two main caveats to that benefits estimate. First, every input to that estimate is highly uncertain, as Arctic drilling has not occurred to any great extent and an oil spill has never occurred there. Both the likelihood and consequences of an oil spill are essentially unknown in that region. And second, the benefits estimate we calculated may omit what could be a large risk premium, meaning that the public's willingness to pay to prevent a catastrophic Arctic oil spill is potentially large enough to match or exceed the costs of the rule. Our results support the need for further study given the extremely large uncertainty in estimating the benefits of the rule. Any changes to the rule that could potentially increase the risk of a spill should be avoided without better information.

We also explore two modifications to the rule, one suggested by Harvard Law School's Emmett Environmental Law and Policy Clinic and another suggested by Shell, finding that the former significantly increases the costs of the rule and the latter may significantly decrease the costs of the rule.

1. Introduction

The Trump administration has identified increasing oil and natural gas production as a priority for the United States, in part through reducing federal regulatory burdens that the administration says restrict development. President Trump signed Executive Order (EO) 13783 in March 2017, requiring agencies to review existing rules, policies, guidance documents, and related materials that potentially burden the development or use of domestically produced energy resources.[6] This EO also specifically identifies for review regulations applicable to the oil and gas sector.

The Trump administration has also focused on reducing regulatory costs across the federal government more broadly under EO 13771, which orders that two regulations be removed for every regulation implemented.[7] Subsequent guidance from the Office of Management and Budget (OMB) for implementing EO 13771 emphasizes that cost-benefit analysis is required for all major regulations being considered for elimination or modification, as well as for new regulations (OMB 2017). But it also lays out the controversial requirement that only the cost savings from repeal be considered in prioritizing rules for repeal as well as in scoring against the costs imposed by new regulations.

2. Objectives

The goals of our project were to catalog the regulations that may be reviewed by the Trump administration and select several for in-depth assessments, including cost-benefit analyses to estimate the potential impacts on industry and the public if the regulations are eliminated, modified, or delayed.[8] These impacts include cost savings and forgone benefits from changes to regulations (as costs and benefits are defined in Circular A-4 [OMB 2003]), the effects on industry costs, and any changes to environmental and health outcomes.

This project includes two main products. The first is the forthcoming catalog, which inventories existing federal regulations promulgated after 2005 and other federal activities of concern to industry (e.g., permitting) relevant to the development and transportation of oil and gas resources. The second product is a series of reports that present our analyses of the cost savings and forgone benefits associated with the repeal or modification of six major regulations affecting the oil and gas sector (outlined in the executive summary).[9] The six rules were chosen to cover a wide range of types of rules and are not meant to suggest relative importance or that any are most targeted by the Trump administration. They illustrate the technical challenges and opportunities presented in performing cost-benefit analyses to support the repeal or modification of the rules.

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[6] "Presidential Executive Order on Promoting Energy Independence and Economic Growth," https://www.whitehouse.gov/the-press-office/2017/03/28/presidential-executive-order-promoting-energy-independence-and-economi-1.

[7] 82 FR 9339.

[8] We will discuss this catalog in a forthcoming summary report.

[9] This report is the first in the series. As defined by EO 12866, a "'significant regulatory action' means any regulatory action that is likely to result in a rule that may: (1) Have an annual effect on the economy of $100 million or more," among other criteria. https://www.archives.gov/federal-register/executive-orders/1993-clinton.html#12866.

This report covers the BSEE and BOEM Arctic rule.[10] A forthcoming summary report will include cross-cutting analyses to compare the results of these six analyses—in particular, ranking the results by net benefits (preferred by economists) and also cost savings, the metric emphasized by OMB's guidance related to EO 13771.

3. Methods

The objective of each cost-benefit analysis was to calculate the cost savings and forgone benefits associated with repeal (also referred to as elimination) and modification of the rule or, in certain cases, delay of the rule. To meet this objective, we carefully read each proposed and final rule and its associated RIA, as well as any technical support documentation available for the rule. We also noted stakeholder comments and concerns as addressed in the *Federal Register* notice for the final rule (the agency's formal response to commenters), as well as any text in the final rule addressing comments. In addition, we searched for any parallel industry analyses and subsequent industry comments gathered as part of the Trump administration's regulatory reform initiative. Table 1 defines key terminology used in this report and across the series.

TABLE 1. DEFINITIONS OF KEY TERMINOLOGY

Term	Definition
Cost savings or avoided costs	The amount saved by eliminating or modifying the rule (i.e., the opposite of the costs of implementing a rule)
Benefits forgone	Benefits that would not be realized by eliminating or modifying the rule (i.e., the opposite of the benefits of implementing a rule)
Net benefits of repeal or elimination	The cost savings of a rule minus the benefits forgone with a positive result, meaning eliminating the rule has a positive net welfare effect on society. Net benefits can be negative, in which case they could be termed net costs to society.
Replication	Re-created original RIA and changed nomenclature to put into rule elimination terms, defining costs as cost savings, benefits as benefits forgone, and net benefits (costs) as net benefits (costs) of repeal or elimination
Corrections	Changes to underlying assumptions to bring the replication up to date and make it comparable across different rules
Baseline	The result of corrections to the replication. All subsequent scenarios are compared with the baseline.
Repeal baseline	The result of subtracting forgone benefits from costs saved (the inverse of the baseline)
Costs adjustment scenarios	Sensitivity analyses using changes to underlying cost parameters/assumptions in the original RIA
Benefits adjustment scenarios	Sensitivity analyses using changes to underlying benefit parameters/assumptions in the original RIA
Rule modification	Changes to the requirements of the rule itself (i.e., sources covered, frequency of surveying), as opposed to changes in parameters/assumptions used in the RIA

[10] 81 FR 46478.

We took the following steps to conduct our analyses, for this report on the Arctic rule and across the report series: Each discussion of a rule begins with background on the purpose of the rule, its history, and its current status (e.g., whether it has been repealed or is slated for repeal or modification). Next, we summarize the rule with details to provide context about the consequences of repeal or modification of all or some of its parts. We then replicated the cost-benefit analysis presented in the final RIA by creating a series of spreadsheets of extracted data and other information. We were able to replicate the analyses with only very minor differences.

3.1. Corrections to Generate a Baseline

To ensure that the cost savings, forgone benefits, and net benefits of repeal reflect the most accurate, currently available information, we changed some of the underlying assumptions of the RIA (and refer to these changes as corrections). We also made corrections where we could to address compliance issues for calculating the costs and benefits of repealing a regulation. These issues are explained below and generally apply to the set of regulations we analyzed.

First, where possible, we updated data, mainly based on the US Energy Information Administration's (EIA's) oil and gas price estimates released in the *Annual Energy Outlook* each year. Second, if an RIA originally subtracted cost savings from costs, we added cost savings to the benefits side of the equation (and made corresponding adjustments to the RIA cost estimates) so that our analyses remain consistent with recent OMB guidance for EO 13771. Third, we also made some further accounting corrections for comparability across rules, including the start and end year analyzed (and implicitly, the period analyzed). As regulations often have an indefinite lifetime, the endpoint for an analysis can be arbitrary. In comparing rules, those with longer periods analyzed will have greater net present values of both benefits and costs, other things equal. The Arctic rule, for example, uses a 10-year period of analysis, whereas PHMSA's tank car rule for hazardous materials uses a 20-year period of analysis and EPA's methane rule uses the years 2020 and 2025 alone. To address this issue, in our forthcoming summary report, we will compare the net present values of costs, benefits, and net benefits over 10 years.

Once we updated and corrected the baseline, we created our repeal baseline, which we use to assess the cost savings and benefits forgone associated with repealing a regulation. We subtract the benefits forgone (a cost of repealing a rule) from the costs avoided (the benefit of repealing a rule) to calculate the net benefits of repeal. As discussed above, the Arctic rule's RIA did not calculate the benefits or net benefits of the rule, so our repeal baseline estimates the costs only. The first equation below illustrates the benefits of keeping the rule (termed baseline). Scenarios that modify the rule are compared against the baseline for keeping the rule rather than against the repeal baseline, as we do not believe the administration would modify the rule only to later repeal it. The second equation below describes the calculation of the net benefits of repeal, which we use to calculate the repeal baseline. Both baselines include the corrections outlined above.

BASELINE

Net benefits (of keeping or modifying the rule) = Benefits – Costs

REPEAL BASELINE

Net benefits (of repeal) = Costs avoided – Benefits forgone

The regulated entities may have already begun to comply with the regulation after its passage, until its repeal or until a plan to repeal or modify the rule is publicized. Capital expenditures spent to comply with a

regulation are sunk costs, so they should not be counted as cost savings if a regulation is eliminated. Future operating costs, however, would count as costs saved if a regulation is eliminated. To the extent that compliance has already occurred, cost savings and forgone benefits would be lower. Where the RIA provided a clear schedule for compliance and to the extent that compliance has already occurred, an adjustment was made, though that is not always the case. These issues do not apply to the Arctic rule, where compliance has not yet begun.

RIAs often account for overlapping or duplicative state regulations, for instance, by not counting costs and benefits from compliance in states with existing regulations. In between the time a regulation is finalized and eliminated, however, additional states may pass overlapping or duplicative regulations. Thus, if a federal regulation is eliminated, state regulations (where applicable) will still be in force, and there will be less or no associated cost savings from repeal in those states, depending on the stringency of their regulations. One could also argue that states' proposed regulations should also be taken into account.[11] We note here that state regulations would not address what is covered by the Arctic rule, as the rule applies only to federal waters.

3.2. Cost Adjustment Scenarios

Working from the repeal baseline, we built scenarios that change the underlying assumptions of the RIA to assess any changes to the costs of the rule if the compliance costs of certain provisions were more or less expensive.

First, we searched the RIA for alternative cost assumptions. Second, we searched the rule's docket for comments that provided enough information for us to use an alternative cost assumption. If we found compelling evidence in either source, we recalculated the cost savings, benefits forgone, and net benefits of repeal to account for this input. The comments we used were submitted by stakeholders, including the American Petroleum Institute (API), Independent Petroleum Association of America (IPAA), Western Energy Alliance, Sierra Club, Environmental Defense Fund, and Pew Charitable Trusts. We also searched for comments submitted to the agencies in the spring of 2017, when they requested public input on the Trump administration's regulatory reform efforts.

3.3. Benefits Adjustment Scenarios

In addition to cost adjustments, we made adjustments to the benefits for rules that measured them, using the same process described above and also making what we considered reasonable changes to various assumptions, such as using alternative estimates for the social cost of carbon (SCC) or a range of potential risk reduction levels.

Benefits measurements were often subject to large uncertainties, so for several rules we conducted break-even analyses, a method often employed in RIAs. Break-even analysis in the context of repealing a rule calculates what the uncertain parameter would have to be to equate forgone benefits to cost savings. If decisionmakers think the real value of this parameter is likely to be larger than the break-even parameter estimate, then repeal would not be warranted (in terms of economic efficiency). Symmetrically, if they think the parameter is lower, it may be economically efficient to repeal the rule. In the face of large uncertainty, a risk-averse regulator may choose not to repeal a regulation when it is unclear whether the parameter is lower or higher than the break-even estimate.

[11] It may be a step too far to assume that some states will be incentivized to pass legislation offsetting the effect of eliminating a federal regulation.

Under guidance from the Trump administration, agencies are increasingly questioning the valuation of ancillary benefits (cobenefits) of various rules. These refer to benefits that come along with efforts aimed at addressing another pollutant or activity, such as the climate benefits of reducing mercury pollution. Agencies sometimes forgo the valuation of ancillary benefits, particularly when benefits exceed costs by a wide margin. Agencies may choose to do so because they find it difficult or impossible to quantify, and doing so in cases of large uncertainty may complicate interpretation of the results.

The Trump administration critiqued the inclusion of ancillary benefits in RIAs, arguing that they mask the "true net costs" of rulemakings (EPA 2017). When looking at the forgone benefits of repeal, however, ignoring forgone ancillary benefits is not justifiable because they still would have accrued to society regardless of whether these benefits were the target of a regulation. Counting these ancillary benefits ensures that an analysis accurately describes the true net costs of a rulemaking (Krupnick and Keyes 2017). Nevertheless, in this project we were not able to account for ancillary benefits if they were missing from the original RIA.

3.4. Rule Modification Scenarios

There are innumerable ways any given rule can be modified, including changes to the sources covered or the frequency of monitoring and reporting. We limited the possibilities for modification to what was quantifiable based on agency estimates for alternative requirements, quantitative estimates provided by industry or other stakeholder comments, and our judgment about what would make for an enlightening modification. Coming from industry, the requested modifications would generally lower the costs of a rule but may also lower the benefits. Symmetrically, the requested modifications coming from environmental groups would generally increase the benefits of a rule but may also increase the costs. Because the modifications are highly specific to individual rules, we address them in detail in our analysis of each rule's RIA.

3.5. Discussion and Conclusions

After presenting the multiple cost-benefit analyses for repeal and modification of each rule, we provide a qualitative discussion of aspects of repealing or modifying a rule that we could not quantify. These were often driven by comments that criticize some aspect of a rule but provide no basis for empirical analysis of how the costs and benefits would change if the rule were altered to address the comment. We also tracked the agency's response to comments as well as the nonmonetized effects of the rules (often indirect or distributional), such as impacts on jobs or commodity prices.

We conclude each report by summarizing the rule-specific analyses and generalizing about whether certain types of modifications or repeal make sense from an economic efficiency (net benefit) perspective. We do not compare our results across rules in each individual report. A forthcoming summary report will include cross-cutting analyses and comparisons.

4. Background

4.1. Purpose

BSEE and BOEM's motivation in promulgating this regulation under the Obama administration was to "ensure the safe, effective, and responsible exploration of the Arctic OCS [Outer Continental Shelf] oil and gas resources, while protecting the marine, coastal, and human environments, and Alaska Natives' cultural traditions and access to

subsistence resources."[12] The rule created additional requirements for operators seeking to conduct exploratory drilling in the Beaufort and Chukchi Seas (in addition to and beyond those already in place for all US offshore drilling). The requirements aim to prevent pollution from drilling waste, further reduce the potential for oil spills, and minimize the size of a spill should one occur.

The Obama administration sought to impose these additional requirements because of the unique challenges facing operators in the Arctic, including extreme weather conditions, sea ice, and geographic remoteness. These conditions translate into increased risks—BOEM's modeling suggests that a hypothetical, long-term exploration and production program in the Chukchi Sea (including 500 producing wells with eight production platforms over 77 years) leads to a 75 percent chance of an oil spill of more than 1,000 barrels of oil (BOEM 2015b).

Drilling in the Arctic OCS has occurred sporadically, beginning in the late 1970s and early 1980s, with almost all the wells now plugged and abandoned (BOEM 2018). Drilling most recently occurred in 2015, when Shell experienced a series of safety issues and setbacks and later decided to indefinitely suspend its Arctic OCS operations and let its leases expire (Eilperin and Mufson 2015). These safety issues included one drill ship nearly running aground because of high winds and later giving up drilling because of sea ice. That drill ship later caught fire, while another rig was set adrift by high winds and waves, eventually running aground (Plumer 2015).

The Obama administration then closed lease sales for Arctic offshore drilling beginning in 2017 (BOEM 2016b). The Trump administration, however, has taken actions to reverse that decision (BOEM 2018), and one company has received permits to drill exploration wells in the Beaufort Sea (BSEE 2017a). In December 2017, that company was able to spud a well in that area by drilling horizontally 6.5 miles from an existing man-made island where drilling is already occurring in state waters (Williams 2017).

4.2. Regulatory History and Current Status

Though the rule was finalized in July 2016, compliance has not yet begun. Even though an operator was able to drill a well into federal waters, the Arctic rule did not apply because the drilling occurred on land, whereas the rule applies to mobile offshore drilling units (MODUs), such as the drill ships used by Shell in 2012 and 2015. Other federal OCS rules do apply (BSEE 2017b).

In October 2017, however, DOI stated that it is considering full rescission or revision of the Arctic rule in its document listing potential actions to reduce "burdens" on domestic energy and to comply with President Trump's EO 13771 (DOI 2017). The document states specifically that DOI is considering making modifications to certain pollution capture requirements, eliminating requirements for technologies that can contain spills within seven days of a loss of well control, expanding the potential drilling season (by removing language regarding the ability to drill a relief well before expected sea ice encroachment), and other potential changes. The document states that the benefits of such changes include "allowing greater flexibility for operators to continue drilling into hydrocarbon zones later in the Arctic drilling season" (DOI 2017, 22–23).

4.3. Rule Summary

The rule, as finalized in July 2016, sought to reduce the potential for and size of oil spills and to mitigate other environmental impacts

[12] 81 FR 46478.

from drilling. Requirements for the rule include ensuring that an operator does the following:

1. Designs and conducts exploration programs in a manner that accounts for Arctic OCS conditions;
2. Develops an integrated operations plan (IOP) that addresses all phases of its proposed Arctic OCS exploration program, and submits the IOP to BOEM at least 90 days in advance of filing its Exploration Plan (EP);
3. Has access to, and the ability to promptly deploy, Source Control and Containment Equipment (SCCE) while drilling below, or working below, the surface casing;
4. Has access to a separate relief rig located in a geographic position to be able to timely drill a relief well under the conditions expected at the site in the event of a loss of well control;
5. Has the capability to predict, track, report, and respond to ice conditions and adverse weather events;
6. Effectively manages and oversees contractors; and,
7. Develops and implements an Oil Spill Response Plan (OSRP) that is designed and executed in a manner that accounts for the unique Arctic OCS operating environment, and has the necessary equipment, training, and personnel for oil spill response on the Arctic OCS.[13]

The Trump administration's potential modifications would keep most of these requirements in place, though a repeal of the rule is likewise being considered (DOI 2017). The changes being contemplated include the following:

- modifying requirement to capture water-based muds and cuttings;
- eliminating the requirement for a cap and flow system and containment dome that are capable of being located at the well site within 7 days of loss of well control;
- eliminating the reference to the expected return of sea ice from the requirement to be able to drill a relief well within 45 days of loss of well control; and
- eliminating the reference to equivalent technology from the mudline cellar requirement.[14]

5. Analysis

Below, we describe our adjustments to the original RIA to generate a baseline and a number of scenarios and sensitivity analyses. All these results are provided as total costs, total benefits, and total net benefits over a 10-year period, in net present value at 3 percent and 7 percent discount rates in 2012$. Unlike most other RIAs, the original analysis did not have a specific start date, as it could not predict when drilling might begin in the Arctic, given the economic conditions and oil prices at the time. Though drilling has begun, we maintain BSEE's original 10-year period of analysis and assumptions regarding the number of operators over that time. Changing those assumptions would be complicated and would require assumptions about a large number of unknowns regarding potential future development.

[13] 81 FR 46478–79.

[14] DOI (2017)

Although BSEE and BOEM's RIA did not calculate the benefits of the rule, using the information provided in the RIA, we were able to construct a measure for the potential benefits similar to the approach taken by BSEE in its 2016 well control rule.[15] This benefits estimate allowed us to conduct a break-even analysis for two unknowns: the frequency of oil spills in the Arctic (without the rule) and the risk reduction from implementing the rule.

5.1. Replication

In all, we were able to replicate BSEE and BOEM's results for the cost estimates as produced in their 2016 final RIA, off by only 1 percent as shown in Table 2. As stated above, BSEE and BOEM did not calculate benefits, so we did not include benefits or net benefits estimates here.

5.2. Corrections to Generate a Baseline

Arctic drilling using MODUs (i.e., not from land) has not yet occurred following publication of this rule, and the final rule's RIA did not choose a specific start date for the purposes of its analysis (i.e., it assumed operations will begin in year 1 and its analysis goes through year 10, as opposed to choosing a calendar year such as 2019). We therefore do not need to update the baseline and do not make any changes in this regard. We did find a small number of minor multiplication errors that we adjusted, as seen in Table 2 below. This adjustment, in addition to rounding differences, changed the 10-year costs of the rule by only 1 percent.

TABLE 2. GENERATING A BASELINE, NET PRESENT VALUE (MILLION 2014$)

	3%			7%		
KEEPING RULE						
	Costs	**Benefits**	**Net Benefits**	**Costs**	**Benefits**	**Net Benefits**
Original	2,048	—	—	1,739	—	—
Replication	2,064	—	—	1,753	—	—
% Difference	*1%*	—	—	*1%*	—	—
Baseline	**2,064**	—	—	**1,752**	—	—
% Difference	*1%*	—	—	*1%*	—	—
REPEALING RULE						
	Costs Avoided	**Benefits Forgone**	**Net Benefits of Repeal**	**Costs Avoided**	**Benefits Forgone**	**Net Benefits of Repeal**
Repeal Baseline	**2,064**	—	—	**1,752**	—	—
% Difference	*0%*	—	—	*0%*	—	—

[15] 81 FR 25888, "Oil and Gas and Sulfur Operations in the Outer Continental Shelf—Blowout Preventer Systems and Well Control," April 29, 2016, https://www.gpo.gov/fdsys/pkg/FR-2016-04-29/pdf/2016-08921.pdf.

5.3. Cost Adjustment Scenarios

Environmental and industry comments provided a number of recommendations for improving the proposed RIA. BSEE accepted the majority of these recommendations, such as Shell's (2015) costlier estimate of pollution prevention requirements and a rig cost assumption from Pew Charitable Trusts (2015). Comments submitted following the publication of the final rule and final RIA did not specifically address cost or benefits measurements. Therefore, only a few possible cost adjustments remained from the proposed RIA comments for use in our analysis.

We chose to focus our analysis on a more uncertain measure, the share of the drilling season when operators would be prohibited from continuing their activities (termed the shoulder season), and one cost estimate that we were able to adjust, the daily rig operating costs.

The first two scenarios in Table 3 adjust the length of the drilling season. This figure is used to estimate the cost of limiting the time when companies are able to operate during the drilling season (or prior to sea ice encroachment). The rule specifies that operators must be able to access a second relief rig that can complete and abandon a well prior to sea ice encroachment in the fall but no later than 45 days after the loss of well control.[16] The shoulder season is the amount of time at the end of the drilling season needed to complete and abandon a relief well prior to sea ice encroachment. Though the requirement states that a relief well must be drilled and abandoned within 45 days, BSEE states that cutting the drilling season shorter by more than 34 days (the time needed to drill and abandon a relief well) would be a result of "operator choice and decisions regarding staging and capabilities, not the rule (i.e., BOEM and BSEE certainly are not requiring operators to take longer than necessary to perform relief well operations)" (BSEE and BOEM 2016, 50). The cost of limiting the shoulder season is the share of the drilling season when companies cannot operate multiplied by the annual cost of the drilling rig.[17]

TABLE 3. COST ADJUSTMENTS, NET PRESENT VALUE (MILLION 2014$)

	3%			7%		
	REPEALING RULE					
	Costs Avoided	Benefits Forgone	Net Benefits of Repeal	Costs Avoided	Benefits Forgone	Net Benefits of Repeal
Repeal Baseline	**2,064**	—	—	**1,752**	—	—
% Difference	*1%*	—	—	*1%*	—	—
Longer Drilling Season	1,711	—	—	1,462	—	—
% Difference	*-17%*	—	—	*-17%*	—	—
Longer Shoulder Season	2,502	—	—	2,112	—	—
% Difference	*21%*	—	—	*21%*	—	—
Shorter Drilling Season	2,302	—	—	1,948	—	—
% Difference	*12%*	—	—	*11%*	—	—
Higher Rig Operating Costs	2,857	—	—	2,404	—	—
% Difference	*38%*	—	—	*37%*	—	—

[16] *Abandon* is a technical term, meaning to shut the well down indefinitely so it is not in any danger of leaking.

[17] The share of the drilling season is 34 days divided by 116 days (the RIA's assumed drilling season length), or 29 percent. The annual cost of a leased drilling rig is $186 million, so the cost of idle drilling time per rig per season is $54 million.

In the first scenario in Table 3, we assume the drilling season will be 36 days longer.[18] The RIA assumed the drilling season would be 116 days (from July 7 to October 31), but in 2017, sea ice encroachment was projected to occur about 36 days later than the historic mean (NOAA 2017). This scenario is included to illustrate what the costs of this rule might look like in a warmer future—as it is unclear when drilling on the Arctic OCS using drill ships might occur, using historical ice encroachment data may not reflect the true cost of keeping the rule or the cost savings of repealing the rule. Because of climate change and a warming Arctic, it is likely the drilling season will continue to be longer than historic means would suggest. The extended drilling season reduces the total costs of the rule by $290 million to over $350 million.

Though the authors of the RIA stated that they consistently made decisions to estimate costs conservatively (i.e., to avoid underestimating costs), we include two scenarios based on industry comments to illustrate what the costs of the rule might look like if BSEE and BOEM did underestimate these costs, as industry claims. First, Shell (2015) argued in its comments that the drilling season will actually be closer to 100 days. Though Shell did not cite a source for that statement, we chose to assess the Arctic rule's costs under a 100-day drilling season to illustrate the impact on costs, even though such a scenario is unlikely.[19] The costs of the rule are greater by about $200 million to $240 million.

And second, Shell (2015) suggested that the daily rig operating costs are 1.5 times greater than what BSEE used in the final RIA. In its initial RIA (for the proposed rule), BSEE and BOEM assumed the daily per rig operating cost was closer to $2 million, but in the final RIA, the agencies amended this figure to almost $4 million, based on the costs of two rigs contracted in 2015 to drill in the Arctic. BSEE and BOEM stated that the $4 million figure may overestimate costs because less costly drill ships can be used (compared with the ones used in 2015) but chose to take a "conservative" approach in estimating costs. Shell, however, argued that the daily per rig operating cost should be $6 million in its comments to BOEM and BSEE. Using that higher figure increases the costs of the rule by $650 million to $800 million, to between $2.4 billion and $2.8 billion in total.[20]

What has the greatest impact on the cost estimate, however, is not differing assumptions for operating costs. Rather, it is the year that drilling would begin in the Arctic. The RIA does not assume which year drilling (and implementation) would begin, so we consider the four situations presented in Table 4: if drilling starts in 2018, as is assumed in the above cost scenarios, and if drilling begins in 5, 10, or 20 years. With a 3 percent discount rate, if drilling begins in 20 years, the costs of the rule are almost half what they would be if drilling begins now. With a 7 percent discount rate, if drilling begins in 20 years, the costs of the rule are almost one-quarter of what they would be if drilling begins now. It is likely that offshore drilling from a MODU will not begin in the Arctic in the current year (given lease purchases), so the costs will probably be at least somewhat lower that they are assumed to be in the above cost scenarios.

[18] The share of the drilling season lost in this scenario is 22 percent.

[19] The share of the drilling season lost in this scenario is 34 percent.

[20] Translating the daily rig operating costs reported at the beginning of the RIA ($4 million) to the daily rig operating cost used for the shoulder season estimate ($510,000) is unclear. The difference seems to stem from differing needs for support vessels, but we are unable to easily translate the $4 million cost into the $510,000 cost. So to use Shell's cost estimates, we simply multiply all daily rig operating costs by 1.5. There is room for error in that calculation, but we believe this method is sufficient for a sensitivity analysis.

TABLE 4. COST ESTIMATES ADJUSTED BY INITIAL DRILLING YEAR (2014$)

3%				
Year Drilling Begins	Repeal Baseline	Longer Drilling Season	Shorter Drilling Season (Shell)	Higher Daily Rig Operating Costs (Shell)
2018	2,064	1,711	2,302	2,857
2023	1,780	1,476	1,986	2,464
2028	1,536	1,273	1,713	2,126
2038	1,143	947	1,275	1,582
7%				
	Repeal Baseline	Longer Drilling Season	Shorter Drilling Season (Shell)	Higher Daily Rig Operating Costs (Shell)
2018	1,752	1,462	1,948	2,404
2023	1,249	1,043	1,389	1,714
2028	891	743	990	1,222
2038	453	378	503	621

Across scenarios, the potential cost savings from repealing the Arctic rule could be quite large, between $1.5 billion and $2.8 billion depending on the discount rate and scenario. However, the costs of the rule could be as low as about $378 million (under a 7 percent discount rate assuming a longer drilling season) if implementation of the rule does not begin for 20 years.

5.4. Benefits Estimation Scenarios

The Arctic rule aims to reduce the risk of a spill as well as the severity of a spill if one were to occur. The rule also aims to minimize pollution by preventing the discharge of certain wastes and to provide information to federal agencies. Oil spills and pollution result in ecological damages, cleanup costs, injuries and deaths, and, in the Arctic, subsistence impacts for native communities. The rule's benefits are from reducing the risks of those impacts.

The final RIA, however, did not calculate the physical or monetized benefits from the rule; rather, it focused largely on a qualitative discussion of the aforementioned benefits. The stated reasoning behind this decision was the large uncertainty regarding the rule's oil spill risk reduction, or how successful the rule would be at reducing the frequency and severity of oil spills.

The initial RIA that accompanied the proposed rule included a break-even analysis to assess the size of the oil spill prevented if a spill were to occur (BSEE and BOEM 2015). Shell's (2015) comments argued that the analysis was flawed because it did not account for the frequency of a spill. We disagree and therefore chose to include a similar analysis, but we also accompany this break-even analysis with a discussion of how the estimated frequency of future spills and oil spill risk reduction influence the benefits of the rule. We likewise include an analysis of how the oil spill risk reduction affects a benefits estimate.

Break-Even Analysis. We look at how many barrels of oil spilled need to be avoided as a result of the rule so that its benefits match its costs. To conduct this break-even analysis, we used lower and higher estimates (see Appendix) of the social cost of a barrel of spilled oil in the Arctic. These BOEM (2016a) social cost estimates include cleanup costs, ecological

damages, subsistence impacts, and fatal and nonfatal injuries caused by a catastrophic oil spill. These social cost figures were estimated using the *Exxon Valdez* and *Deepwater Horizon* oil spill settlements as well as models for oil spill damages (BOEM 2015a).

We simply divided the 10-year undiscounted costs of the rule by the lower and higher estimates of the social cost of a barrel of oil spilled to get the avoided barrels of spilled oil that match the benefits of the rule to the costs. The results are in Table 5. Using a worst-case daily spill rate (averaged between the Beaufort and Chukchi Seas), the low social cost break-even spill duration would range between 22 and 37 days. The high social cost spill duration would be between 4 and 6 days. (For context, the Deepwater Horizon oil spill released 3.19 million barrels over 87 days.)

These results show that if the rule reduces an oil spill's duration by 4 to 37 days (or if it avoids between 75,000 and 757,000 bbl of spilled oil), then the rule's benefits will have matched its costs. But it is important to note that for the 10-year benefits of the rule to match the costs, such a spill would have to occur in the next 10 years, and such large oil spills tend to have extremely low frequencies. Table 6 shows BOEM's (2016a) estimates of the frequencies for different oil spill sizes. Using the break even spill sizes from Table 5 and the Table 6 frequencies, we provide some context for the likelihood of the above spills. Focusing on the lower social cost spill sizes, between about 23,700 and 28,000 wells would have to be drilled for a spill for a spill to be certain (i.e., a probability of 1). Focusing on the higher social cost spill sizes, the number of wells would be have to be smaller, but still in the thousands or tens of thousands—BOEM does not provide spill frequency estimates for spills below 150,000 bbl. The RIA predicts that in the first 10 years of Arctic drilling, only 6 wells will be drilled. Thus once the frequency of a spill is brought into the analysis, the expected benefits fall dramatically.

TABLE 5. BREAK-EVEN AVOIDED BARRELS OF SPILLED OIL

	Baseline	Longer Drilling Season	Shorter Drilling Season	Higher Rig Costs
Low Social Cost	542,814	447,720	607,056	756,668
High Social Cost	90,556	74,692	101,273	126,232

TABLE 6. PER-WELL SPILL FREQUENCY BY SPILL SIZE

Hypothetical Spill Size (bbl)	Per Well Frequency	Frequency (1 in X wells)
150,000	0.00005641	17,729
500,000	0.00004221	23,691
1,000,000	0.00003572	27,994
2,000,000	0.00003023	33,078
5,000,000	0.00002425	41,243
10,000,000	0.00002052	48,734

Source: BOEM (2016a).

To get to an estimate of the benefits, we have to look at the benefits of reducing the risk of an oil spill and the benefits from reducing the amount of oil spilled if a spill does occur as a result of the rule. But because we do not know how effective the rule will be at reducing the frequency of spills or the amount spilled, we cannot accurately measure the benefits of the rule. So we chose to calculate the benefits of the rule for risk reduction levels between 1 percent and 100 percent. With these estimates, we assume that the risk reduction from the rule (i.e., its effectiveness) will be the same for reducing the occurrence of spills and their size if they do occur. We discuss this calculation in more detail in Appendix A. We also note that our calculation considers only the benefits of reducing the risk and size of spills between 150,000 and 10 million bbl; we do not look at other benefits of the rule (i.e., reducing pollution and reducing spills below or above that range). The results of our analysis are displayed in Table 7.

TABLE 7. BENEFITS ESTIMATES FOR VARIOUS LEVELS OF RISK REDUCTION (2014$)

Risk Reduction	Costs Avoided (Low Social Cost)	Costs Avoided (High Social Cost)
1%	$53,443	$320,327
10%	$534,431	$3,203,267
20%	$1,068,863	$6,406,535
30%	$1,603,294	$9,609,802
40%	$2,137,725	$12,813,070
50%	$2,672,157	$16,016,337
60%	$3,206,588	$19,219,605
70%	$3,741,020	$22,422,872
80%	$4,275,451	$25,626,140
90%	$4,809,882	$28,829,407
100%	$5,344,314	$32,032,675

Table 7 shows that the estimated benefits, for any level of risk reduction, are quite small when compared with the costs of the rule, which range from $1 billion to $2 billion. Even with a 100 percent risk reduction and a high social cost of oil spilled, $32 million, the cost of the rule outweighs the benefits by over $900 million. An important caveat here, however, is that almost every input to this benefits estimate is effectively unknown, as drilling has never occurred in the Arctic. The social costs of oil spilled are estimated from information on the Deepwater Horizon and *Exxon Valdez* incidents, which could result in an over- or underestimate of impacts. The *Exxon Valdez* spill, for example, occurred in the Prince William Sound and affected a large extent of shoreline, while in the Arctic, the oil could disperse easily with currents or could be trapped by sea ice and moved toward shore. Also, given the lack of drilling experience in federal waters in the Arctic, BOEM's estimated frequency of oil spill incidents is taken from data that largely covers the Gulf of Mexico from 1964 to 2014. Given the challenges of drilling in the Arctic—a lack of nearby infrastructure, sea ice, cold temperatures, extreme weather, and a lack of familiarity on the part of oil companies—the frequency of spills there might be larger.

The fact that this rule went forward implies that BSEE and BOEM placed a high premium on reducing the risk of catastrophic oil spills. In other words, the high costs of the rule could reflect the public's willingness to pay to reduce even small risks of a catastrophic oil spill in the Arctic. Society often places a "risk premium" on low-frequency, high-consequence events like catastrophic oil spills. For example, the willingness to pay for reducing mortality risk from electricity generation has been estimated to be 60 times higher for nuclear disasters than for routine fossil-fuel generation deaths (Itaoka et al. 2006). The risk premium for avoiding a catastrophic oil spill in the Arctic may therefore be quite large, regardless of the expected value of the benefits that will materialize over the first 10 years of its implementation.

The key takeaway from this analysis is that BSEE and BOEM should conduct more research to better assess the benefits from maintaining and the forgone benefits from repealing this rule. One way to do this is by using expert elicitation (a technique for interviewing experts and quantifying their responses as well as uncertainty) to assess risk reduction from the rule and expected spill frequency, following the methodology outlined in Colson and Cooke (2018). BSEE and BOEM could alternatively conduct a study of Americans' willingness to pay to prevent Arctic oil spills, similar to Bishop et al. (2017), to assess the risk premium the public places on avoiding catastrophic spills in the Arctic. Such an estimate would better capture values than would legal settlements or model estimates (as done in BOEM 2015a). With this information, assessing the costs and benefits of implementing, repealing, or modifying the Arctic rule could be a matter of assessing a risk reduction range and applying that to the estimate of willingness to pay to avoid a spill. Without that information, however, the impacts of modifying or repealing the Arctic rule are essentially unknown.

5.5. Modification Scenarios

BSEE and BOEM might choose to modify the Arctic rule a number of different ways. We include only modifications that have been suggested in comments and that we are able to quantify. Most of the suggestions for modifications either were adopted by BSEE and BOEM or were not possible to quantify in our analysis. We examined two possible changes: one that makes the rule more stringent and one that makes the rule less stringent.

First, we look at the inclusion of a 10-day buffer period between when operators would be able to complete and abandon a relief well and the expected return of sea ice, as suggested by Harvard Law School's Emmett Environmental Law and Policy Clinic (ELPC 2015). The change would effectively extend the shoulder season by 10 days and would add 10 more days of costs incurred by operators (from 34 to 44 days).[21] This change would increase the costs of the rule by around $360 million to $440 million, as shown in Table 8.

Second, we consider Shell's (2015) recommendation to remove the same-season relief rig requirement, which requires that a second rig be on standby to be able to drill a relief well within 45 days. The costs of this provision result entirely from the shoulder season requirement, as other costs are assumed to be in the baseline. This change reduces the costs of the rule by more than half (over $1 billion).

Of course, we cannot assess the benefits lost from these two changes. From a qualitative perspective, risks to the environment would probably be reduced from extending the shoulder season. ELPC (2015) argued that drilling, completing, and abandoning relief wells can be complex and can take longer than expected, also noting that if a spill were to occur just before ice encroachment, it would continue for several months, a potentially disastrous outcome. However, Shell argued that a relief well is not the best available and safest technology for well control—implying that a longer shoulder season would not result in an increase in safety—and that capping stacks, for example, would be better able to respond to a well control issue.

TABLE 8. COSTS BY MODIFICATION SCENARIO (2014$)

	3%			7%		
	KEEPING RULE					
	Costs	Benefits	Net Benefits	Costs	Benefits	Net Benefits
Baseline	2,064	—	—	1,752	—	—
Longer Shoulder Season (HLS ELPC)	2,502	—	—	2,112	—	—
% Difference	*21%*	—	—	*21%*	—	—
No Same-Season Relief Rig Requirements	842	—	—	749	—	—
% Difference	*-59%*	—	—	*-57%*	—	—

[21] This adjustment assumes a 116-day drilling season (as does the baseline). With a 44-day shoulder season, the share of the drilling season lost is 38 percent.

6. Discussion

6.1. Public Comments

Industry's comments on the rule argue in favor of taking a performance-based approach to the regulation, while NGOs and think tanks often argue for more prescriptive regulations. More specifically, industry argues that requiring operators to have a rig nearby for drilling a relief well within 45 days and prior to sea ice encroachment is unnecessarily burdensome and would not result in improved environmental outcomes (API, USCC, and NOIA 2015; AEX 2018; Shell 2015). API, USCC, and NOIA (2015) note that a capping stack was used to control the Deepwater Horizon Macondo well, though the drilling of a relief well was initiated. Industry maintains that other technology may provide less risky means of controlling a well (such as a capping stack, already required under the rule), as drilling a relief well poses risks of its own (Shell 2015). Industry groups have also stated that the pollution prevention requirements should be removed and have argued in favor of performance-based standards rather than the source control and containment requirements, which prescribe specific technologies for shortening the duration of an oil spill (AEX 2018).

Pew Charitable Trusts (2015), on the other hand, points out that a reliable backup for controlling a well is needed in case the other methods of control fail. The organization therefore supports the same-season relief rig requirement in addition to the source control and containment requirements. ELPC argues furthermore that "a purely performance-based relief rig standard is inadequate. For low-probability, high-consequence events such as a loss of well control, it is impossible for an operator to demonstrate its ability to meet such a standard in practice before a spill occurs" (2015, 2). ELPC (2015) argues in favor of the prescriptive relief rig requirement but suggests including a performance-based standard as a backstop. The comment is also supportive of the source control and containment requirements so that operators do not have to rely on in situ burning, mechanical recovery, and chemical dispersants, which can be less effective during winter months.

6.2. Nonmonetized or Indirect Impacts

The RIA notes that though BSEE and BOEM cannot predict when development might occur, the Arctic rule could affect the pace and scale of production, particularly if, as a result of the rule, the amount of production in the Alaska region is insufficient to keep the Trans-Alaska Pipeline System open. Such impacts could affect royalty revenue and jobs in the region and eliminate the option of using the pipeline later. The RIA does note that other factors, such as oil prices, could well have a larger impact on the pace and scale of Arctic oil production. While the rule may affect employment in Alaska once drilling does begin, preventing an oil spill would potentially offset those impacts. Alaska natives, for example, rely on subsistence whaling for food and their cultural identity, which would be negatively affected by an oil spill.

7. Conclusion

While we find evidence that the costs of the Arctic rule may be large enough to outweigh benefits, we likewise find that any benefits measures are too uncertain to accurately assess whether repealing or modifying the rule would in fact be beneficial. Given the lack of information, regulators should not make any adjustments that could potentially increase the risk of a spill in the Arctic, in light of the potentially catastrophic consequences. The large costs of the rule warrant further examination, as they could potentially be reduced without increasing oil spill risk. Large changes to relax the rule would, in our view, require further study to understand and estimate the added risks such a relaxation would pose. We suggest expert elicitation and stated preference methods as a promising way forward.

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Appendix. Benefits Measurement Methodology

Our goal was to measure the sum of the benefits from (1) reduced risk of spill occurrence and (2) reduced spill damages (i.e., smaller spill volumes when spills do occur) from this rule.

In theory, that would look like this:

$$\begin{aligned} &Benefits\ from\ Arctic\ Rule \\ &\qquad = (Risk\ Reduction_{Occurrence} \times Damages_{Occurrence}) \\ &\qquad + (Risk\ Reduction_{Severity} \times Damages_{Severity}\ ) \end{aligned}$$

where

$$Damages = Spill\ Size\ \times per\ bbl\ Social\ Cost$$

So we would measure the benefits of avoiding a spill of X size (for example, 150,000 bbl) minus the damages from the amount of oil that was spilled (for example, 5,000 bbl). We would multiply that by $Risk\ Reduction_{Severity}$. We would then estimate the damages from the remaining 5,000 bbl and multiply that by $Risk\ Reduction_{Occurrence}$.

One way to think of this more intuitively is to use an example. A spill of 5 million barrels has a per well-year frequency of 0.000024. The rule mandates use of a relief rig that can drill a relief well within 34 days of a well control incident. A well in the Chukchi Sea could discharge 25,000 bbl of oil according to the final RIA, meaning a well control incident could spill 850,000 bbl over the 34-day period under the rule. So if a well blowout did occur, an operator would avoid spilling 4.15 million bbl. We multiply the 4.15 million bbl times the $per\ bbl\ Social\ Cost$ to get $Damages_{Severity}$, which we would multiply by the risk reduction from the rule. But because the rule reduces the likelihood of a spill in the first place, the 850,000 bbl is avoided as well. We multiply that number by the $per\ bbl\ Social\ Cost$ to get the $Damages_{Occurrence}$, which we also multiply by a risk reduction figure. Adding both of those numbers gives us a benefits estimate.

But because we had no information regarding the risk reduction, we assumed the risk reduction level was the same for both parts of the rule.

To measure the per-well damages estimate, we use Table A-1 below (using frequency figures from BOEM 2016a). The low social cost and high social cost cases are per-barrel estimates of oil spill damages from BOEM (2016a). The low social cost estimate, $4,345 per bbl, uses the lower bound of values from Table 2-3 in BOEM (2016a), while the high social cost estimate, $26,045 per bbl, uses the upper bound. Both figures account for ecological damages, response costs, fatal and nonfatal injuries, and subsistence impacts in the Arctic region. The ecological damages are more than four times those in the Gulf of Mexico, while cleanup costs can be much larger or smaller than those in the Gulf. While the Gulf of Mexico social cost estimate accounts for commercial fishing, the Arctic social cost estimate instead accounts for subsistence impacts.

TABLE A-1. BENEFITS PER WELL FROM AVOIDED SPILL DAMAGES

Spill Size Avoided (bbl)	Freq. per well*	Statistical bbl reduced	Costs Avoided (Low)	Costs Avoided (High)
A	**B**	**C = A*B**	**D1 = C*Low Social Cost**	**D2 = C*High Social Cost**
150,000	0.000056	8	36,765	220,380
500,000	0.000042	21	91,701	549,680
1,000,000	0.000036	36	155,203	930,327
2,000,000	0.000030	60	262,699	1,574,681
5,000,000	0.000024	121	526,831	3,157,956
10,000,000	0.000021	205	891,594	5,344,434
Sum (benefits per well)**			**1,964,794**	**11,777,458**

*Frequency per well from BOEM (2016a).
**Note: Numbers are rounded so totals in columns may not sum properly.

The sums at the bottom of columns D1 and D2 are what we multiply against the number of wells drilled each year (as shown in Table A-2). The undiscounted totals are then multiplied by the risk reduction to get the total benefits for the low social cost scenario and the high social cost scenario. We can adjust the frequencies above or the risk reduction to conduct our break-even analysis by setting the total undiscounted costs of the rule equal to the total undiscounted benefits (sums of columns F1 and F2) times risk reduction.

TABLE A-2. TOTAL UNDISCOUNTED BENEFITS, NOT ACCOUNTING FOR RISK REDUCTION

Year	Wells Drilled	Benefits from Reducing Spills (Low Social Cost)	Benefits from Reducing Spills (High Social Cost)
	E	**F1 = E*SUM(D1)**	**F2 = E*SUM(D2)**
1	0	$0	$0
2	4	$7,859,176	$47,109,832
3	0	$0	$0
4	2	$3,929,588	$23,554,916
5	0	$0	$0
6	0	$0	$0
7	0	$0	$0
8	0	$0	$0
9	0	$0	$0
10	0	$0	$0
Undiscounted Total		**$11,788,764**	**$70,664,748**

This estimate is likely to be an underestimate of the benefits, the magnitude of which is a function of how much the rule reduces spills of less than 150,000 bbl or greater than 10 million bbl in size, as well as the benefits from preventing drilling waste.