

# **A Forensic Investigation of Crude Oil and Saline Spills: Detecting Fiction, Determining Facts**

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## **Summary and Abstract**

### Background and Questions

Understanding of the global connectedness of economic, social, political, and environmental systems has grown in concert with the scientific knowledge of the global impact of human activities. Anthropogenic change driven in large part by the release of greenhouse gases, conversion of a large portion of the Earth's ecosystems to human uses, over-exploitation of resources, and widespread pollution have led to rising concerns about ecological tipping points and the threats posed to global security in a world experiencing unprecedented changes.

As governments grapple with how to transform to ecologically sustainable economies, the energy industry has come under increasing pressure to improve its practices. Concerns regarding governance and regulatory oversight, climate change, human and environmental health, water supplies, and First Nations and Metis rights have increased significantly in recent years. Concerns over the routing of pipelines and the risks of spills have increased societal resistance to proposed energy projects.

The ability of an industry to operate depends upon an unwritten social license that society grants to those activities it believes benefit the public interest. That social license depends upon the provision of accurate information to the public and their elected representatives. Alberta's economy is dominated by the energy sector and is overseen by an energy regulator mandated to gather energy-related information. Alberta thus presents a case study to examine (1) whether information pertaining to energy industry spills is accurate, reliable, available to the public in a timely manner, and supportive of a social license; and (2) whether energy industry spills result in detectable and persistent environmental impacts.

Crude oil and saline water spills have been common in Alberta for decades and continue to occur frequently. The high frequency of energy industry spills raises several important questions: (1) Are the regulator's reported spill and recovery volumes accurate? (2) After cleanup operations, is there evidence of residual contamination and biological effects? (3) Are Alberta Energy Regulator data on spill cleanup efficiency and rates of environmental damage credible and supported by science? (4) Is the Alberta Energy Regulator protecting the environment?

This study examined five lines of evidence pertaining to crude oil and saline water spills: (1) a statistical and forensic audit of the Alberta Energy Regulator's crude oil and saline spill incident data for the province of Alberta; (2) field evidence of post-spill and natural soil and water chemistry; (3) field evidence of post-disturbance and natural vegetation, flora, and animal populations; (4) in-depth evidence pertaining to an oil spill in northwestern Alberta; and (5) findings and data from the scientific literature.

### Results

Over a 42.1-year period, 1 January 1975 to 6 February 2017, 70,088 energy industry spills were reported in Alberta. Of those spills, 24,948 reported crude oil as the primary substance spilled and 15,803 reported saline/produced water as the primary substance spilled. Over that period, on average, there were 1.62 crude oil primary spills/day and 1.03 saline primary spills/day in Alberta.

For crude oil spills, a reported 29,293 primary, secondary, and tertiary spills (total rate 1.90 spills/day) released a total volume of 285,498 m<sup>3</sup> (1.80 million petroleum barrels). For saline spills, a reported 25,410 primary, secondary, and tertiary spills (total rate 1.66 spills/day) released a total volume of 943,422 m<sup>3</sup> (5.93 million petroleum barrels). Total reported saline water spilled volume was 3.3 times that of crude oil. On average, 117 barrels of crude oil and 386 barrels of saline water have spilled each day over last 42.1 years. These total volumes spilled are gross underestimates of actual volumes due in large part to large spills that are missing from the regulator's data. One spill in 1948 southwest of Edmonton spilled 1.5 million barrels of crude oil.

The median spill volume was 2 m<sup>3</sup> for crude oil primary spills and 5 m<sup>3</sup> for saline primary spills. Based on the median spill volume observed to cause environmental harm in Oklahoma, if similar volume/harm relationships exist in Alberta, harmful crude oil primary spills occur at a rate of 0.87 spills/day and harmful saline spills at 0.40 spills/day. These harm rates would be conservative because they do not include secondary and tertiary spills, the toxicologic effect of complex spills, missing and unreported spills, and the tendency to underestimate spill volumes.

Exposure to complex mixtures was common in Alberta spills. Of the 24,948 crude oil primary spills, 35 % contained other spill components; 26 % contained saline water as the second component. Of the 15,803 saline water primary spills, 26 % contained other spill components; 17 % contained crude oil as the second component. The complex contaminant burden placed on the biota at spill sites constitutes an unassessed ecological risk.

The foregoing spill rates and volumes are minima for five reasons: (1) Pre-1975 spills are not included in the Alberta Energy Regulator (AER) database. Approximately 2500 to 3000 crude oil and 1000 saline pre-1975 spills are estimated to be missing. (2) Documented spills post-1975 are missing from the database. (3) The AER database does not include spills under federal jurisdiction. (4) The AER database does not include spills reported to Alberta Environment but not to the regulator. (5) Unreported spills noted as “oil or saltwater staining” are not included in the database.

The AER lists 48 different sources of crude oil and saline spills. For crude oil, the three most common sources of spills were multiphase pipelines, crude oil group batteries, and oil wells. By volume of crude oil released, the three largest sources were crude oil group batteries, crude oil pipelines, and multiphase pipelines. For saline water, the three most common sources of spills were water pipelines, crude oil group batteries, and multiphase pipelines. By far the largest volume of saline water was spilled from water pipelines followed by crude oil group batteries and oil wells.

Although spill-related concerns typically focus on pipelines, pipelines are responsible for only a portion of spills. Pipelines account for 32 % of crude oil primary spills and 37 % of the volume spilled, and for 52 % of saline primary spills and 59 % of the volume spilled.

AER data on spill volumes, recovered volumes, recovery efficiency, and environmental effects are neither accurate nor credible. AER spill and recovery volumes are not measured quantitative values, they are non-empirical decisions influenced by human biases. Scatter plots of the relationship between spill volume and recovery efficiency assume the form of a pointillism-rendered falcon with its wings swept back, stooping onto its prey. The “falcon effect” is a false measurement effect and results from recovery volumes that are subjective judgments constrained by choosing preferred fractions of the spill volume. This constraint imposes smooth, arcuate structures to the scatter plots that produce the falcon-like patterns.

Although the majority of spills in Alberta reported perfect recovery, no scientific studies were found that document perfect recovery of spilled oil or saline water. Because neither spill volumes nor recovery volumes are measured quantitative values, the volumes of crude oil and saline water remaining in the environment after cleanup remain unknown.

Based on the regulator’s publically-available classification of “sensitive”, the AER designated 0.21 % of crude oil spills and 0.27 % of saline water spills as occurring in sensitive areas. Privately owned lands were three times more likely to be designated sensitive areas than were public lands. The tendency to designate spills on privately owned lands as “sensitive” more often spills on public land suggests that undisclosed, non-ecological considerations influence “sensitivity”. No spills on First Nations lands and Metis Settlements were designated as sensitive areas. The low rate of sensitive area occurrence in energy industry spills is not scientifically credible. In late 2016, the AER decided to classify all spills as occurring in non-sensitive areas. Significantly, an internal AER scientific assessment found that 60 % of pipeline spills in Alberta in 2015 occurred in sensitive habitats.

The regulator’s data indicated that habitat was rarely affected and animals were rarely injured or killed as a result of spills. Crude oil and saline spills had “no affect” in 98.73 % and 99.06 % of spills, respectively. Habitat was affected in 1.18 % of crude oil spills and animals were injured or killed in 0.09 % of crude oil spills. Similarly, habitat was affected in 0.92 % of saline spills and animals were injured or killed in 0.02 % of saline spills. Scientific studies demonstrate that AER data on environmental and wildlife damage rates are not credible. It is significant that: (1) No scientific studies were found that document an absence of ecological effects after crude oil and saline water spills. (2) Industry-reported impact rates from outside of Alberta were 30-50 times higher than those reported in Alberta. (3) Evidence demonstrates that AER is failing to record animal deaths or injuries in its incident database.

## Significance and Implications

The energy industry disturbance signature takes the form of persistent changes in vegetation and soils relative to natural controls. The vegetation signature can be characterized by attributes such as: increased meadow vegetation; increased grass, agricultural, forage, weedy, exotic, or planted species; increased pollution-tolerant and halophytic species; reduced forest or shrub vegetation, reduced native species and vegetation type diversity; reduced lichen and moss species occurrence and abundance; reduced vegetation cover and litter cover (and therefore increased bare ground); and reduced vegetation biomass, density, and stature. The soil signature can be characterized by attributes such as: elevated hydrocarbons, sodium, chloride, calcium, magnesium, potassium, electrical conductivity, pH, and sulfates; increased bulk density and soil compaction; reduced fertility, nitrogen, phosphorus, organic carbon, and nutrient cycling, and loss of soil structure; and increased depth of the active layer on permafrost soils. The causes of the industrial disturbance signature at any location are site-specific and may include the direct effects of the spill, the pre-spill disturbance history, and the post-spill responses.

Depending on the circumstances, spills of saline water can have more persistent effects on ecosystems than do oil spills. Oil spills undergo physical and biodegradative changes that, over time, lead to a reduction in toxicity. In contrast, salts cannot be broken down or degraded. Unless they are leached, flushed from the system, rendered unavailable, or removed from the site, excessive salts can persist indefinitely. Unlike oil spills, which leave visible accumulations, saline spills are essentially invisible. This invisibility can make saline spills more insidious than oil spills.

Given the tens of thousands of spills and the fact that spill volumes and recovery volumes are non-empirical estimates, the absence of scientific evidence for perfect spill recovery is salient. Issuances of cleanup recovery dates, indicating completion of spill cleanup, were found to be managerial decisions unjustified by the available scientific data. The lack of scientifically credible post-spill monitoring presents a major environmental uncertainty. The impact of spills, contaminated sites, and industrial disturbances upon native species and ecosystems requires study.

Significant and persistent ecological impacts and residual contamination were observed after crude oil and saline spills and energy industry disturbances. Chemistry, vegetation, floristic, and wildlife data indicate that the ecological effects could be pervasive. Soil remediation standards used by the Alberta Energy Regulator are insufficient to prevent ecosystem salinization. The multiplier effect of climate change exacerbates the stresses posed by the energy industry.

An Alberta energy industry footprint of 12 thousand km<sup>2</sup>, landscape-level effects on ecosystem function, and the failure of reclamation to achieve healthy soils and vegetation lead to an inescapable conclusion: The energy industry is causing wholesale, long-term damage to ecosystems.

The regulator misinforms the public by: (1) providing non-empirical human-biased estimates of spill volumes and recovery volumes; (2) overestimating spill recovery efficiency; and (3) failing to provide credible assessments of spill rates and spill effects on the environment, soils, and wildlife. The misinformation is exacerbated by missing information, by the inordinate delay between information request and delivery, or by failing to provide the information requested.

Lack of access to credible, accurate, complete, unbiased, and timely information undermines the regulator's claim of transparency, constitutes information distortion, and debars the scientific community and the public from participating in environmental monitoring and protection. Organizations tend to distort information to meet organizational needs by selectively producing, sustaining, and distributing information that is favorable to the perception that their behaviors, actions, and decisions are responsible, reasonable, and justified. Information distortion does not require willful deceit, it simply requires that an individual accept the role of a functionary whose responsibilities are limited to completion of assignments.

Pervasive and persistent spill effects coupled with distorted information present significant social and environmental liabilities. The deficiencies reported here demonstrate that concerns over pipelines and spills are justified. The regulator's data are of poor quality; spill reports are absent, fail to address environmental impacts, or are unavailable; transparency is inadequate; and third party review and scientific scrutiny have not been applied. The regulator's consistent failure to protect the environment undermines the integrity of government, industry's social license, and environmental quality.

Federal and provincial performance and scientific audits of the regulator and of industry should be conducted from the standpoint of data and environmental protection. Based on the findings of those audits, a new energy regulator should be constituted within government, and the environmental protection mandate

removed from the regulator. Failing that, the energy industry could work pro-actively with an independent third party scientific panel that would audit, review, and report on spills in order to provide a true account of the impacts of energy industry activities.

Globally, a paucity of publically-available data on non-marine spills and their environmental effects suggests that inadequate reporting and environmental assessment of spills may be a widespread problem. The social and environmental liabilities resulting from non-marine spills in other jurisdictions merit attention.