RISK ASSESSMENT AND EVALUATION OF INCIDENT REPORTS IN ALBERTA OIL SANDS OPERATIONS

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INTRODUCTION

- Previous research by Kathleen Baker, M.Sc., E.I.T., regarding the Creative Sentencing project
  - Identified tailings-specific hazards, threats, consequences, and control
  - Interviewed frontline workers, contractors, and leaders
  - Promoted collaboration between oil sands owner companies and regional contractors
  - Presented research to various interdisciplinary audiences across Canada
- Current research takes a quantitative approach to analyzing incident reports

METHODOLOGY – RISK MATRIX

Consequence

Likelihood		A Negligible	B Minor	C Moderate	D Significant	E Severe
E	Very Likely	Low Med	Medium	Med Hi	High	High
D	Likely	Low	Low Med	Medium	Med Hi	High
C	Possible	Low	Low Med	Medium	Med Hi	Med Hi
B	Unlikely	Low	Low Med	Low Med	Medium	Med Hi
A	Very Unlikely	Low	Low	Low Med	Medium	Medium

Figure 1. Sample Risk Matrix[1]

[1]https://www.thereliabilityblog.com/2017/09/13/beyond-the-risk-matrix/

METHODOLOGY – RISK MATRIX PROCESS

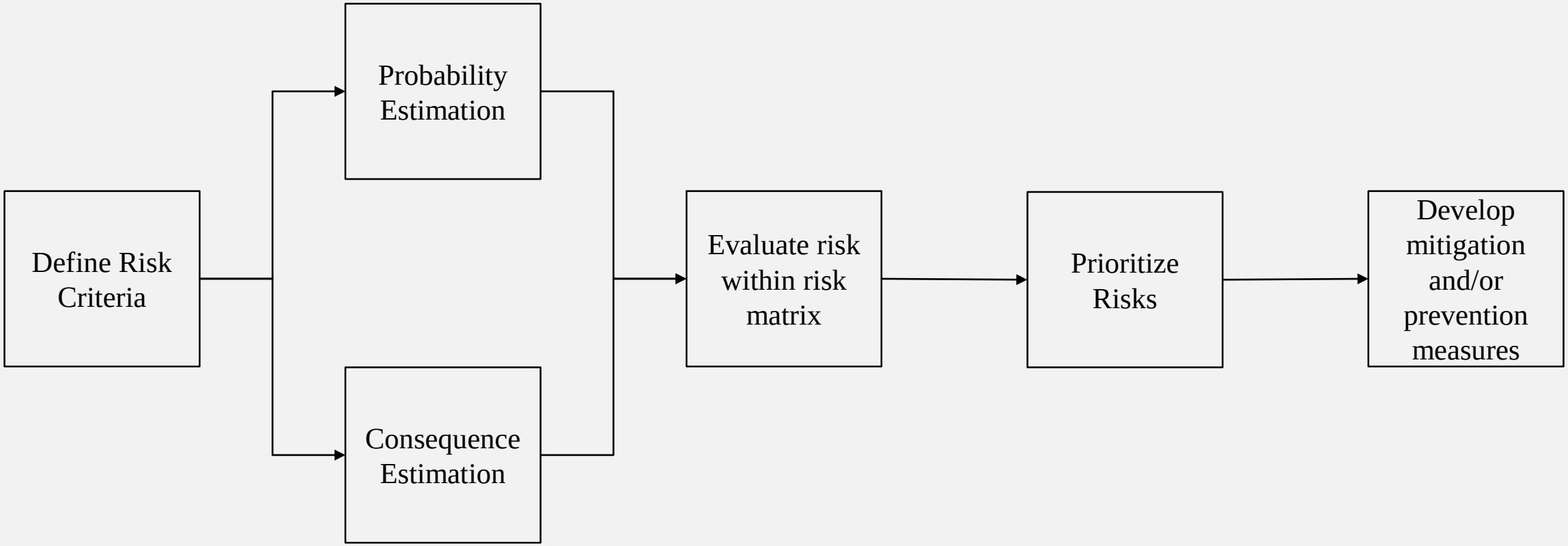


Figure 2. Process of using a risk matrix[2]

[2]Jay B. Clare and Louis Armstrong, "Comprehensive Risk Evaluation Approaches for International E&P Operations," SPE Projects, Facilities & Construction, 1(03), pp.1-6, 2006.

OBJECTIVES

- Create a risk matrix system for aggregating incident reports
- Increase the efficiency of reporting incidents in the oil and gas industry
- Support the design of more sensitive risk prevention and mitigation strategies

INCIDENT REPORTS (SAMPLE)

01-03-2013	2:30 PM	After completion of RCW tie-in; operators were safeing in equipment openining RCW water slowly to ensure water flow through condensers was established. After starting up booster pump was started, operators noticed water was leaking from the line downstream to RCW pond. Split in the line is about a foot and a half.
09-25-2015	1:47 PM	Pond dredge booster pumphouse unable to run for more than 10 minute duration. Contractor's second stage booster pump tripping out on low suction pressure. Dredge operators on 2 shifts attempted multiple ways to bring up the dredge and were unsuccessfull in maintining the pump and transfering the required material to the pond.
10-17-2016	8:35 AM	Operators were alerted to a leak on system 1 by the plant 5 emergency dump pond, upon inspection operators discovered that the expansion barrell past the isolation valve was holed out, and had formed a roughly 5 foot discharge hole underneath the pipe. Ops were unable to verify size of the hole, and determine exactly where the leak was coming from due to the line being partially submerged, but it was on the discharge side of the expansion barrell

ANALYZING RISK – CONSEQUENCE

- Consequences are rated based on impact to Health/Safety, Environment, Finance, and Reputation[3]
- Consequence scale was developed using the average values from risk matrices of participating companies
- Consequences are also classified by type: Operation, Leak/Spill, Communication, Vehicle, Weather, Health/Safety, and Miscellaneous

[3]W. Kent Muhlbauer, Pipeline Risk Management Manual - Third Edition. Burlington, MA, USA: Gulf Professional Publishing, 2004.

ANALYZING RISK – CONSEQUENCE

Degree of Severity	5	4	3	2	1
Health/Safety	Minor injuries or illnesses that do not require first aid treatment or may require basic first aid treatment	One or more injuries or illnesses requiring medical treatment or resulting in restricted work.	One or more injuries or illnesses resulting in lost time	Single fatality or one or more long term disabilities	Multiple fatalities
Environmental	Inconsequential or no adverse effects, clean up confined to site or close proximity	Minor adverse effects, local emergency response, 0-6 months clean up	Medium adverse effects, local emergency response, short to medium term effects, 7-12 months clean up	Medium to significant adverse effects, intermediate emergency response, 1-4 years clean up	Off property impact requiring remediation taking 5 years or more. Major emergency response with significant adverse effects.
Reputation	No media coverage. Single stakeholder involvement with concerns addressed in the normal course of businesses. Temporary side road closure.	Local media coverage. Multiple stakeholders involved with concerns addressed in the normal course of business. Secondary road closure lasting < 24 hours	Extended local media coverage or one-time national media coverage. Key stakeholder involvement. Extended secondary road closure > 24 hours	National media coverage. Involves multiple key stakeholders. Operations interrupted. Major road closure < 24 hours.	International media coverage. Multiple key stakeholders involved. Operations shutdown and/or potential of future operations being prevented. Extended closure of major road.
Financial	Cost < $1M	$1M < Cost < $10M	$10M < Cost < $100M	$100M < Cost < $500M	Cost > $500M

ANALYZING RISK - LIKELIHOOD

- Count occurrences of an incident within a certain time period
- Calculate ratios of one incident type vs total incident count

MACHINE LEARNING PROCESS

Input Variables	Output Variables
• Date • Time • Incident report	• Actual risk score • Potential risk score • Descriptive Label (Operation, Leak/Spill, Communication, Vehicle, Weather, Injury/Illness, Miscellaneous, Uncategorized)

MACHINE LEARNING PROCESS

- Data Preparation:
  - Properly format incident reports
  - Read incident reports into Python
  - Remove empty/null cells
  - Split data into training and test data
- Data Analysis (Classification of Incident Reports)
  - scikit-learn and NumPy (supervised learning)

MACHINE LEARNING PROCESS

- TfidfVectorizer
  - Tokenizing, text pre-processing, removing stop words
  - Builds a feature dictionary and transforms incident reports into feature vectors
  - Calculate frequency of word occurrence
  - Fits an estimator to the data and then transforms the count-matrix to a tf-idf representation.
- Train a classifier

TEXT TO NUMBERS LOGIC

- Example:
  - Incident 1: Gravel pushed outside stockpile limits.
  - Incident 2: Slipped outside and fell on ice outside P2 change room.

  - Vector 1: [1 1 1 1 1 0 0 0 0 0 0 0 0]
  - Vector 2: [0 0 2 0 0 1 1 1 1 1 1 1 1]

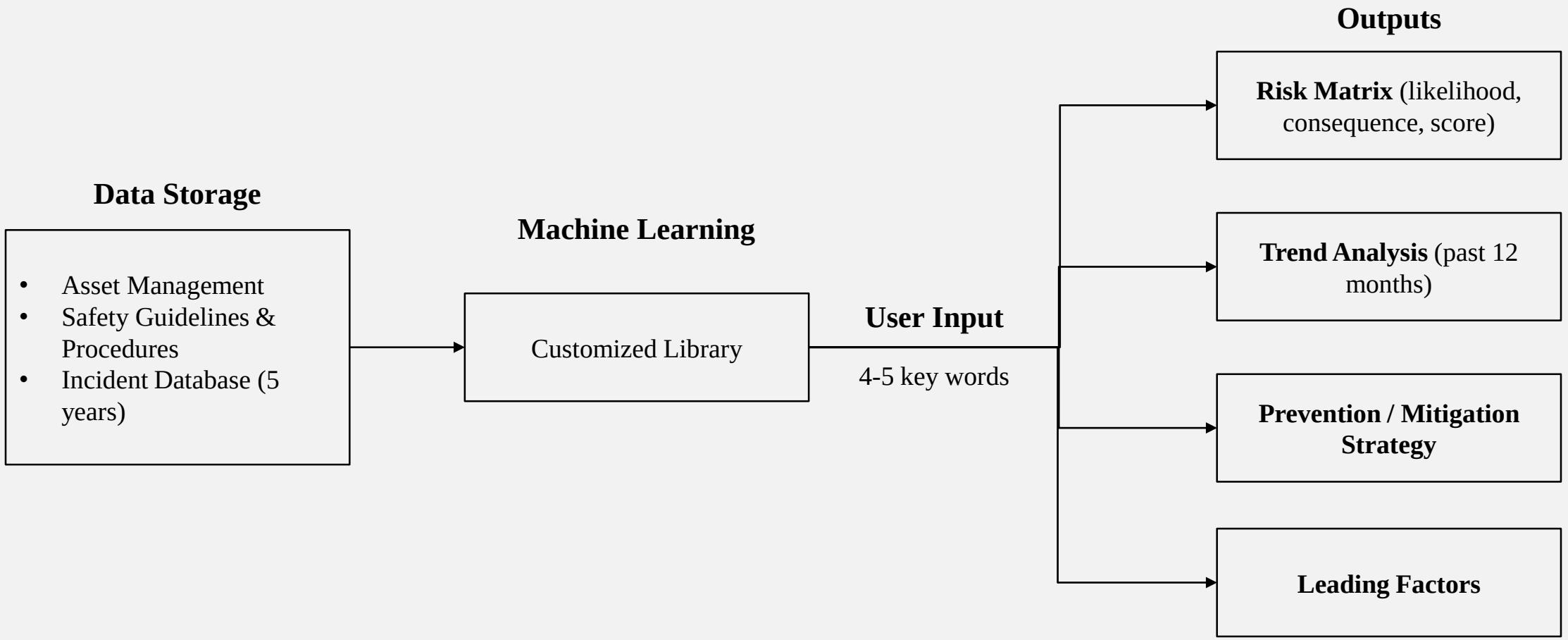
RESULTS: CLASSIFYING INCIDENT REPORTS

Classification Method	Accuracy
Support Vector Classification (SVC)	56.98%
Linear SVC	**88.48%**
MLP Classifier (Neural Network)	85.50%
Nearest Neighbors	73.56%
Decision Tree	75.95%
Random Forest	75.80%
Adaboost	63.21%
Multinomial Naïve Bayes	66.76%
Logistic Regression	84.37%

RESULTS: CLASSIFYING INCIDENT REPORTS

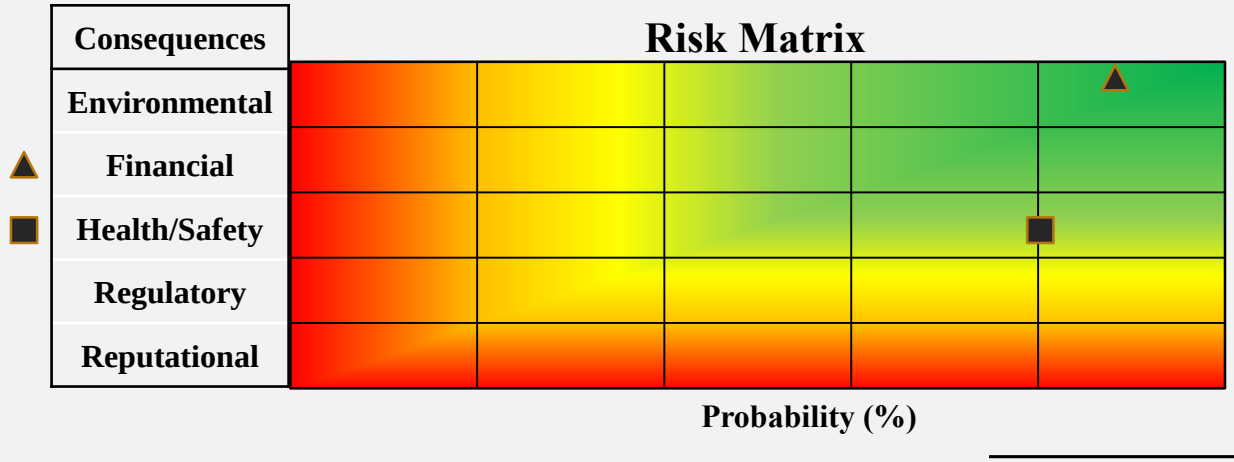
		Predicted						
		Comm.	Health/S	Leak/Spill	Misc.	Operation	Uncat.	Vehicle
Actual	Comm.	62	2	0	1	9	0	0
	Health/S	0	709	4	0	110	0	20
	Leak/Spill	0	2	241	0	48	0	4
	Misc.	0	1	1	43	10	1	0
	Oper.	2	68	14	5	2571	4	51
	Uncat.	0	16	0	4	38	43	2
	Vehicle	0	31	7	2	91	1	547

REVISED METHODOLOGY



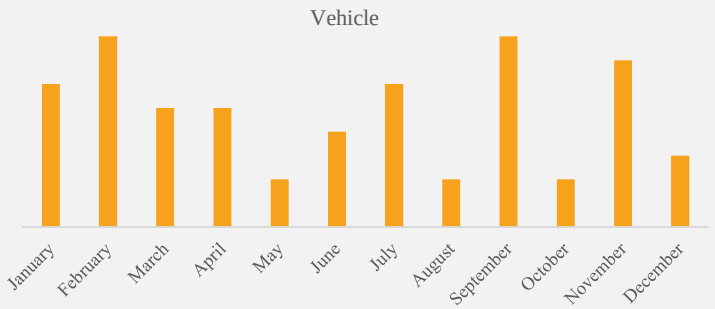
INCIDENT REPORTING USING CUSTOMIZED LIBRARY

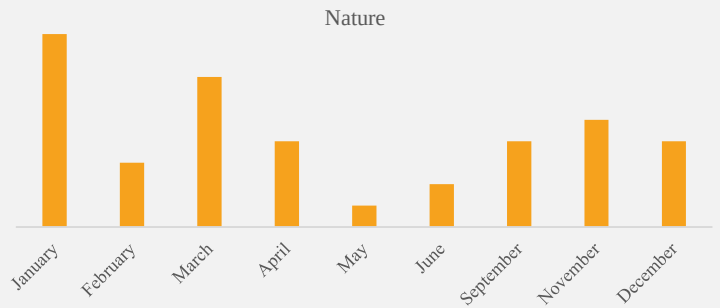
RESULTS: RISK MATRIX AND TREND ANALYSIS

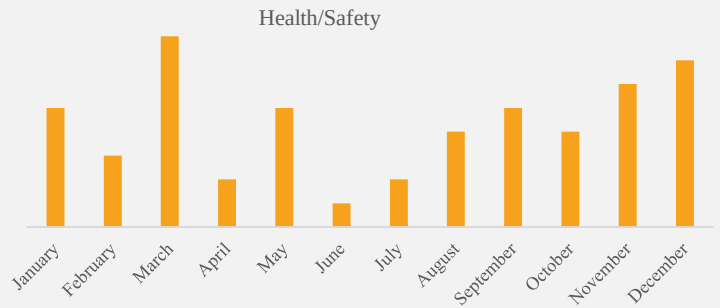


Risk Matrix (likelihood, consequence, score)

Trend Analysis (past 12 months)



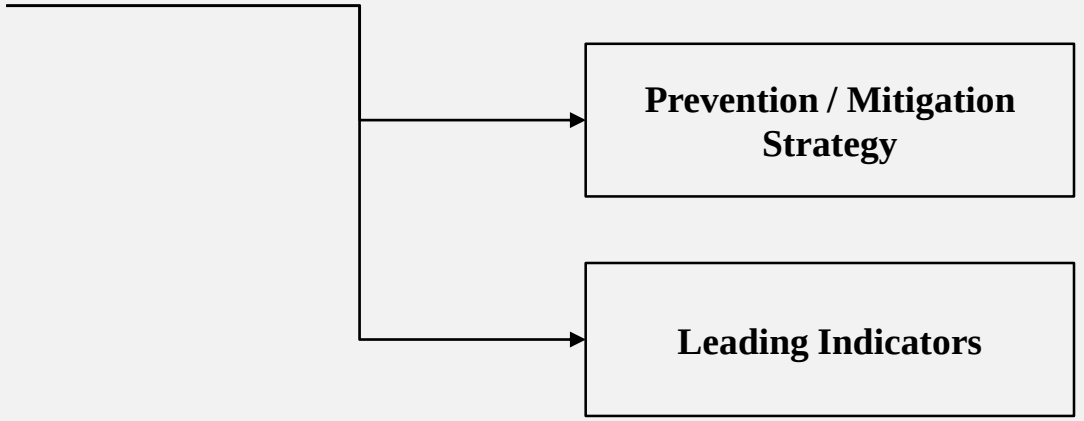




RESULTS: PREVENTION/MITIGATION STRATEGIES AND LEADING INDICATORS

- **Prevention / Mitigation Strategies**
  - Was the road salted / graveled?
  - Drive at a speed appropriate to road and weather conditions.
  - Provide employees with an option to take defensive driving (or training to drive in winter).

- **Leading Indicator**
  - Icy road conditions
  - Inadequate risk recognition
  - Factors to affect situational awareness



CONCLUSION

- Increase efficiency of reporting incidents in the oil and gas industry
- Assign risk scores, evaluate trends, suggest tailored improvements

THANK YOU!

QUESTIONS?