REX2024
PRCI Research Exchange

Operator Experience on the Implementation of Quantitative Risk Assessment Framework and Safety Risk Thresholds in Annex B of Z662-23

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PRCI LEADING PIPELINE RESEARCH

Pipeline Research Council International

Overview

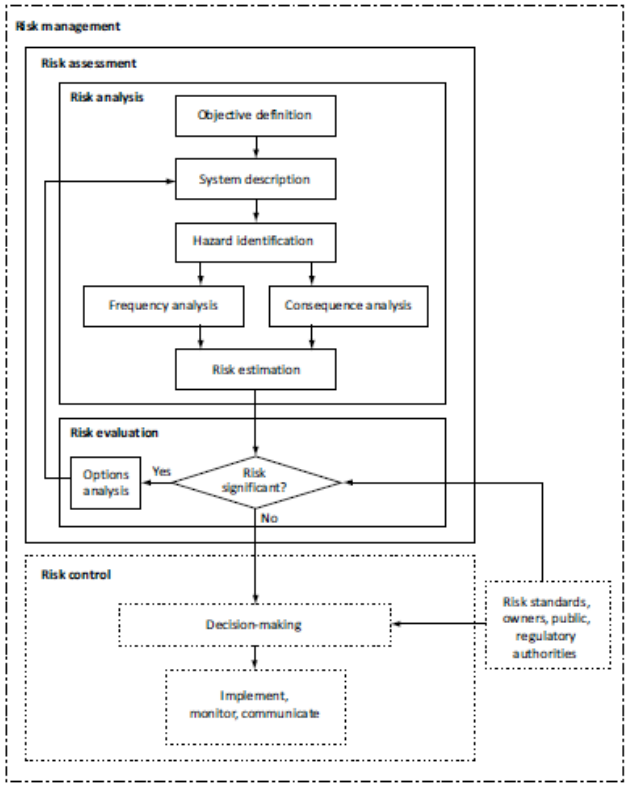
- **CSA Z662 Annex B (informative) guidelines for risk assessment of pipelines**
  - Pre-2023: an informative/non-mandatory Annex of the Canadian Standard that used to provide only high-level guidance to pipeline risk assessment.

- **Risk Management Task Force (RMTF) was formed in 2017 to transform Annex B into a more useable risk assessment tool**
  - Ensure clarify and consistency of concepts and definitions
  - Support the development and use of risk criteria
  - Provide more detailed guidance on the risk assessment process
  - Provide a stronger link to a risk management framework

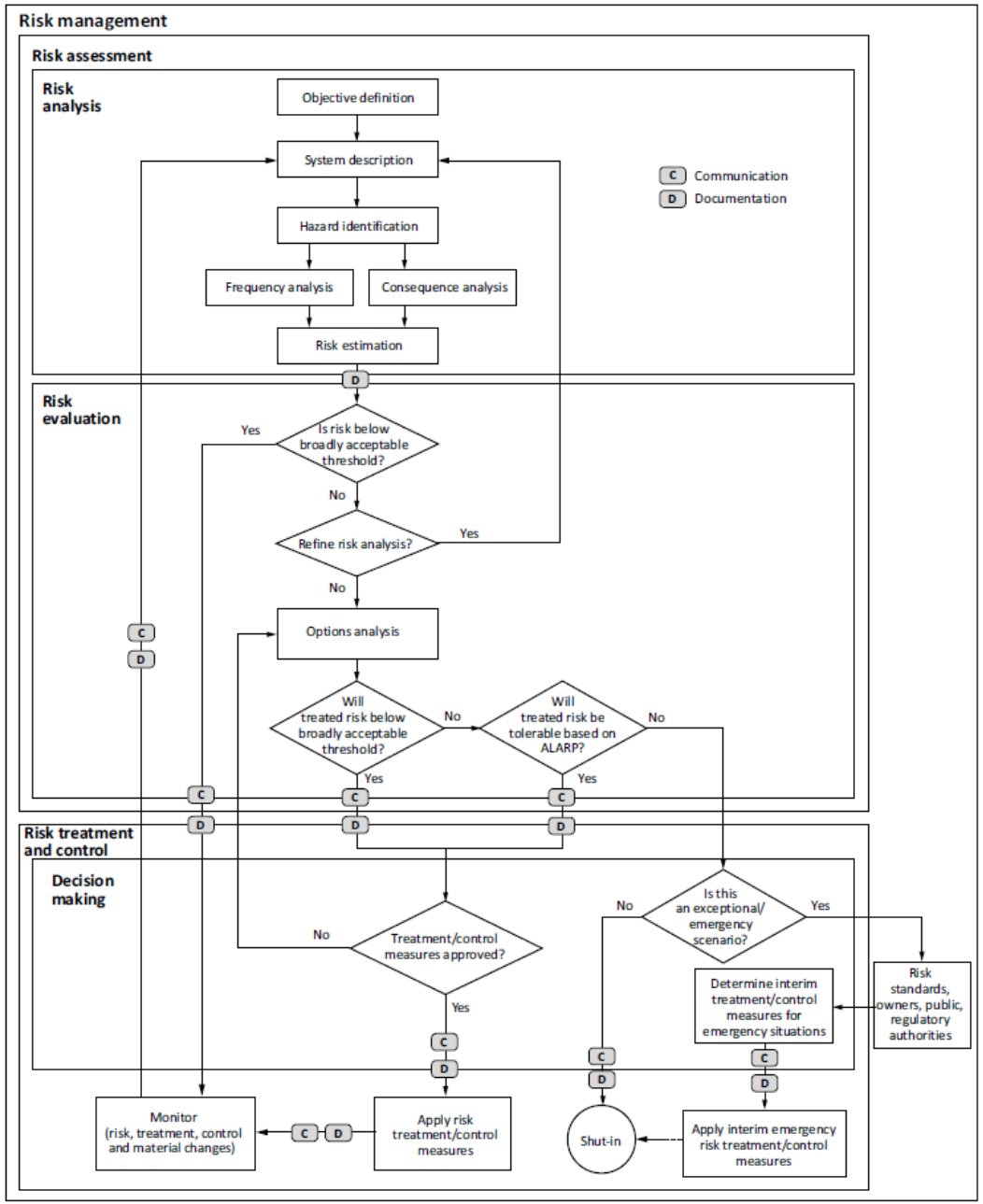
- **Form of Z662 Risk and Reliability Technical Sub-Committee**
  - CSA Z662 Executive and Technical committee approved the form of a new technical sub-committee entitled “Risk and Reliability” that replaces existing task forces to manage Annex B risk management guidelines, Annex C limit state design and Annex O reliability-based design and assessment

Major Changes to Annex B

Introduction of a comprehensive risk management framework



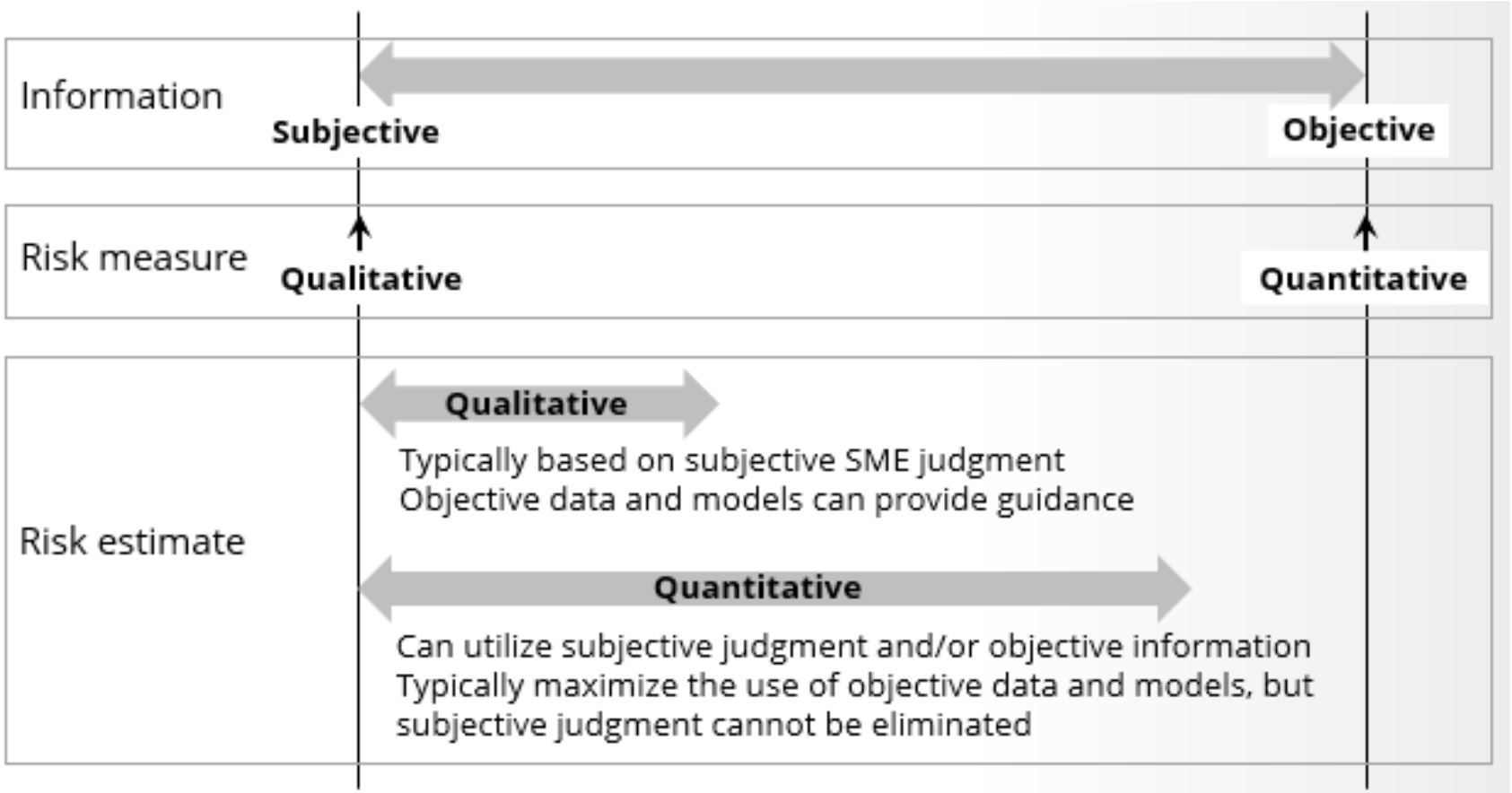
Z662-19



Z662-23

Major Changes to Annex B

Clarity and consistency on risk assessment concepts and definitions



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Major Changes to Annex B

Introduction the ALARP principle

- Broadly acceptable threshold – a risk level that is so insignificant that it is not “a cause for concern”
- Maximum tolerable threshold – a risk level that is so high that must not be allowed to exceed
- Risk levels in between must be ALARP
  - Evaluate all possible risk mitigation options
  - Implement risk mitigation unless cost is grossly disproportionate to benefits (i.e., not reasonably practicable)

Risk matrix — Quantitative risk display
(See Clauses B.5.2.6.2 and B.5.3.3.)

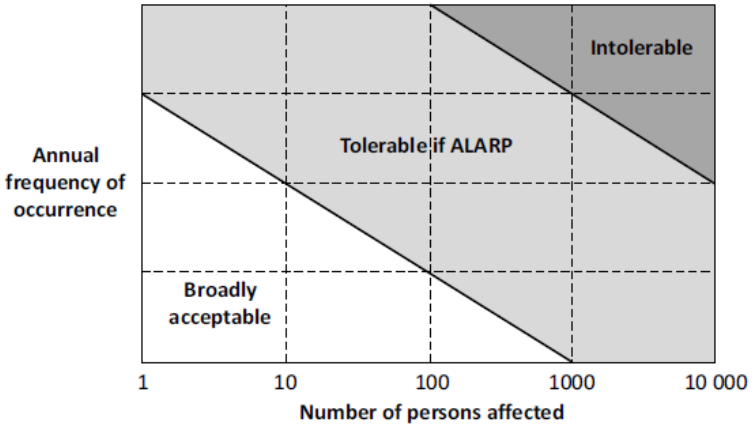
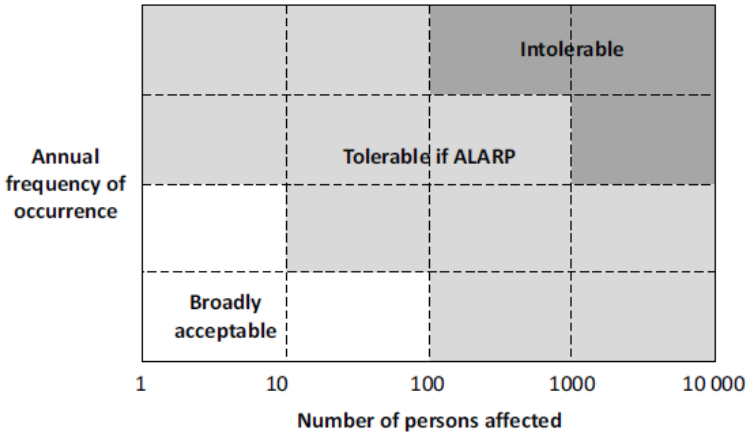


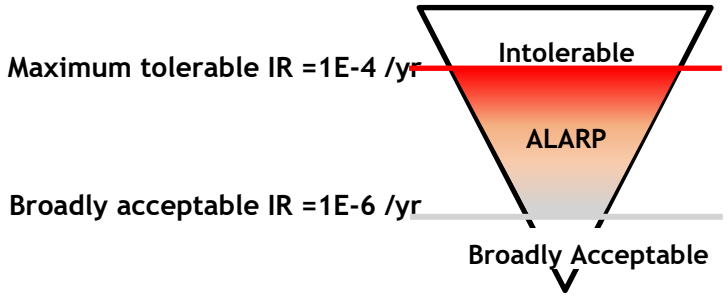
Figure B.4 b)
Risk matrix with quantified boundaries
(See Clauses B.5.2.6.2 and B.5.3.3.)



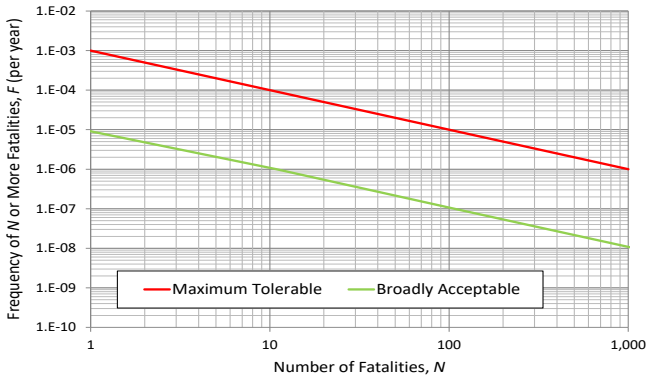
Major Changes to Annex B

Quantitative safety and environmental risk criteria

Safety



Individual Risk



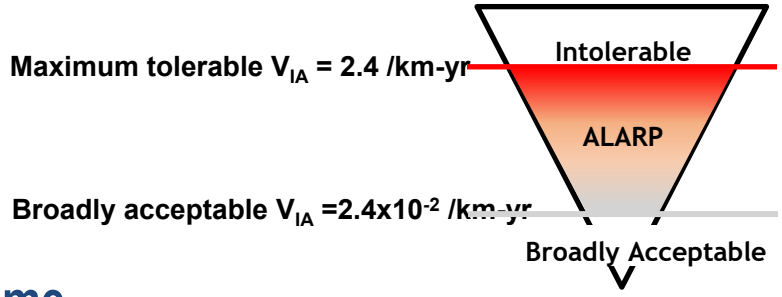
Societal Risk

Environment

$$V_{IA} = \beta\, V^{0.8}$$

Environmental impact factor

Spill volume



Impact-adjusted spill volume

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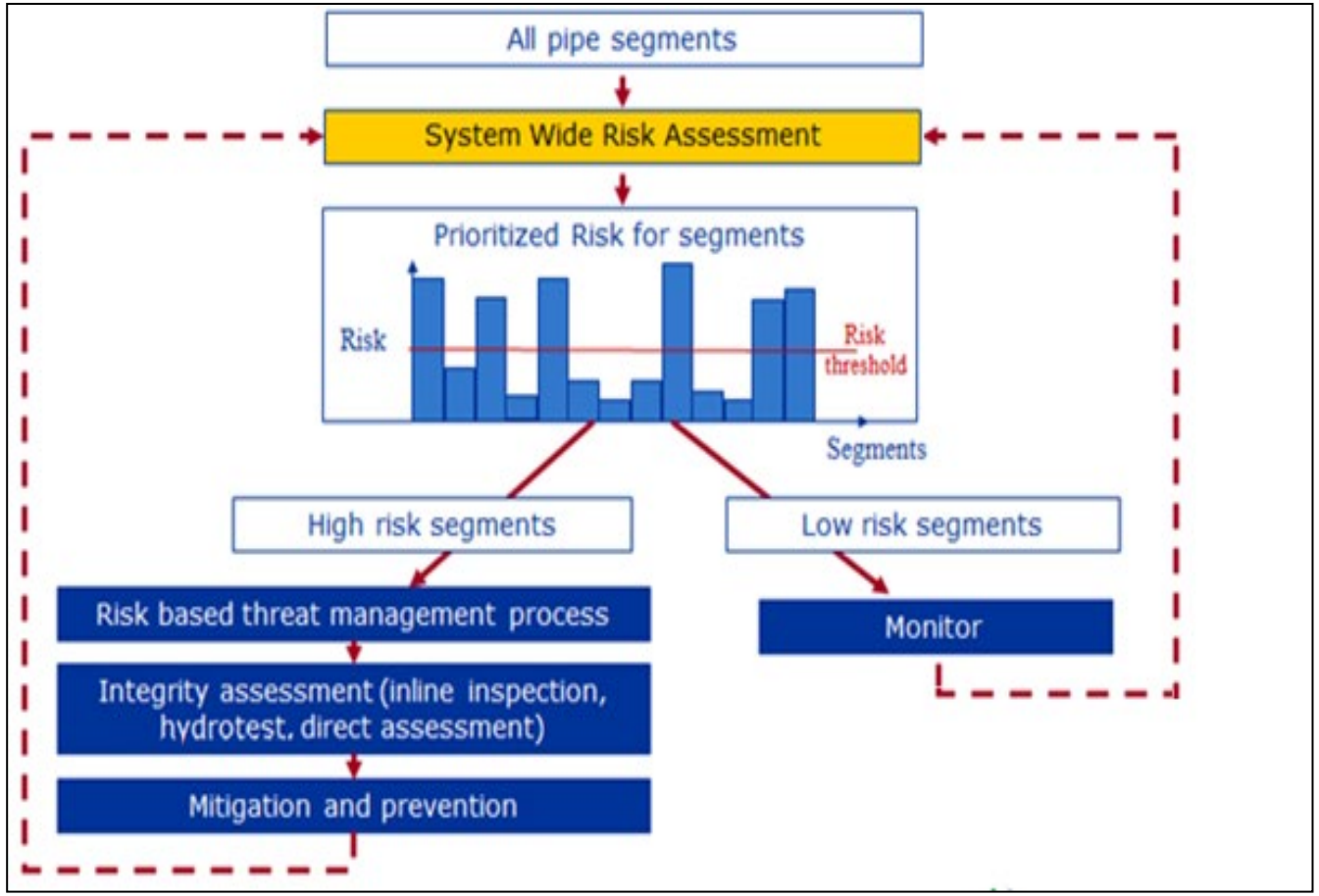
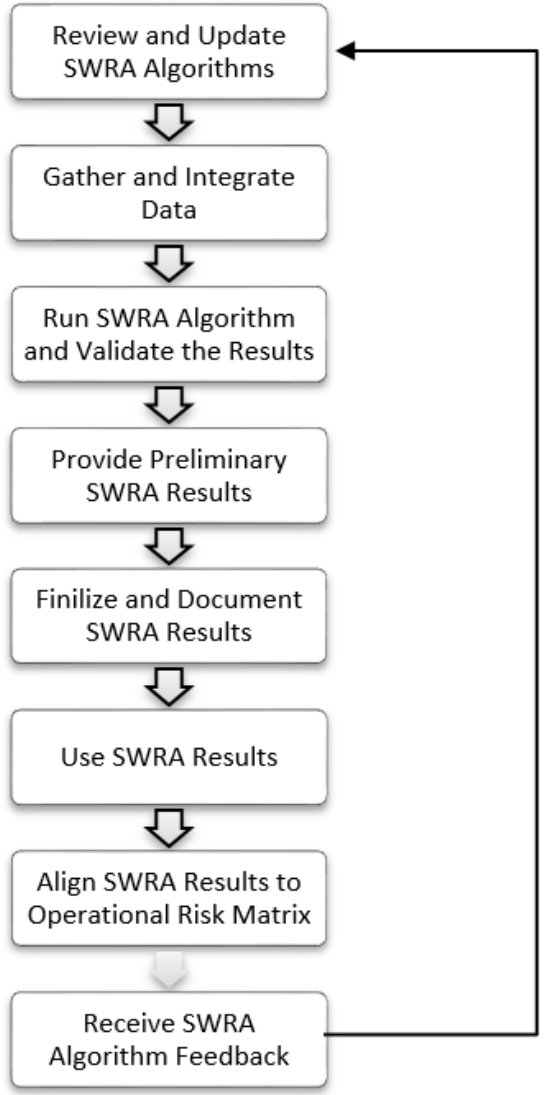
TC Energy Pipeline Risk Assessment Program





Improvements to Individual Risk

- **Previous individual risk approach**
  - Assuming on 100% presence and 0 offset distance – conservative but could resulted in unnecessary integrity work at locations where the actual risk is not that high (e.g., remote locations)

- **Benchmarking and validation studies performed; IR factor introduced to account for the effect of likelihood of presence and offset distance**
  - Influencing factors: structures, roads, population density and land use types

In calculating the individual risk, offset from the pipeline, probability of the individual being present and access to shelter may be considered. In addition to the occupants of permanent structures and public spaces near the pipeline, other individuals who might be present shall be considered.

Improvements to Societal Risk Analysis

- **Roads previously not considered in the analysis**
  - PHMSA Mega Rule Part 1 – MCA: certain types of roads within PIR is one of the criteria for MCA
  - Z662-23 Annex C – including clauses for consequence considerations driven by roads

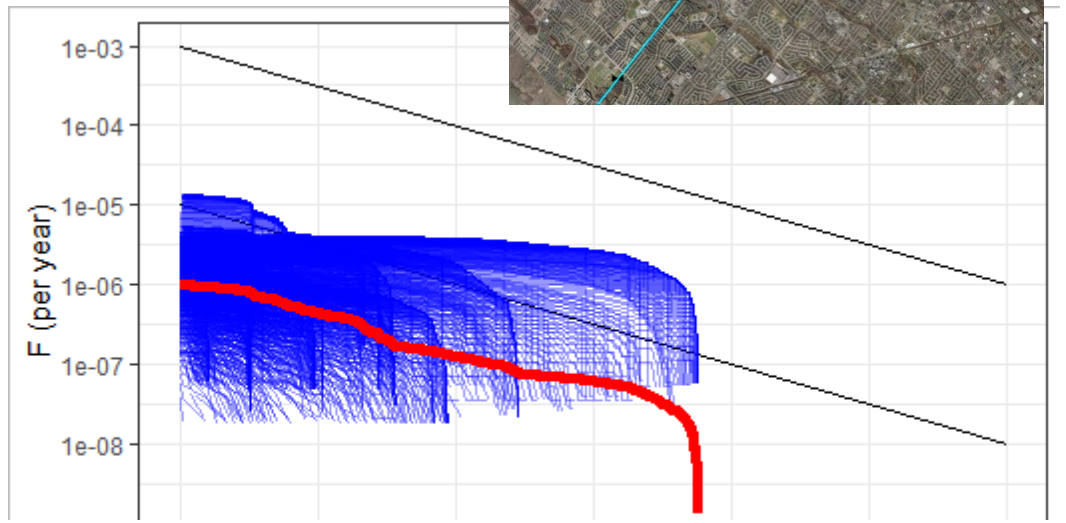
- R&D with PIPESAFE Group (PSG) and DNV (IPC2022-87251)
  - Considering unique characteristics of roadway users – fast travelling/escaping speed, restricted escaping routes, vehicle sheltering effect etc.

- Data collection and refinement
  - Over 37000 km of relevant road data

Incidents	Consequence
2007 CGT Line 100, Delhi, LA near I-20 [5]	One motorist killed and one injured
2009 Florida Gas Transmission, Palm City, FL, between I-95 and SR-91 [6]	Two motorists injured
2012 CPG SM80, Sissonville, West Virginia near I-77 [7]	Road closed for 19 hours and about 800 feet of road surface replaced.
2014 TransCanada Mainline 400-1, Otter-burne, Manitoba near highway 303 [8]	Fire lasted approximate 12 hours, highway 303 closed until the fire was off.

Improvements to Societal Risk Analysis

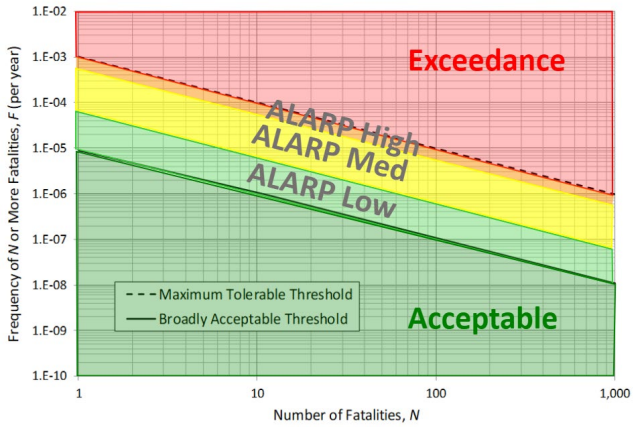
- **Inconsistent evaluation length**
  - Previously a rule-based evaluation length defined based on the so-called “developed areas”
  - Evaluation length varying between less than 100 m to more than 30 kms
  - Not reflecting the worst locations within longer evaluation lengths.
- **Implementation of sliding km evaluation**
  - Global implementation of SR calculation (regardless of population density)
  - Efficient numeric evaluation and more powerful computational infrastructure
  - IPC2020-9507

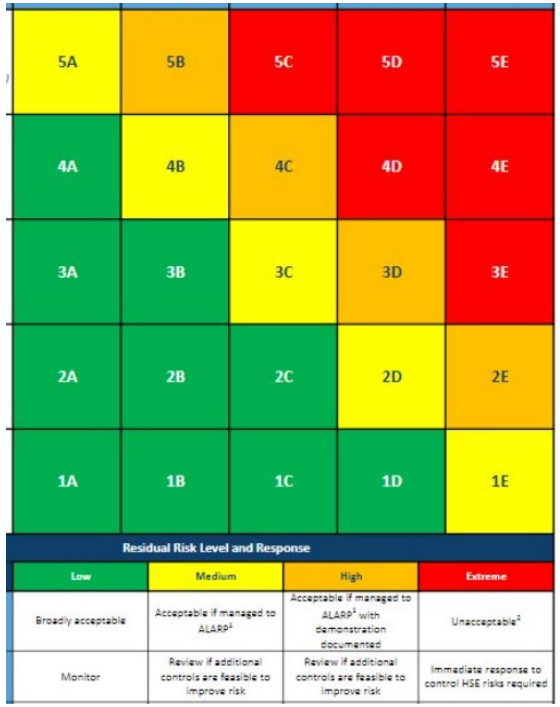


The F-N criteria in Figure B.7 shall be met for all developed areas along the pipeline route. The F-N criteria shall be met for the worst-case position of all 1 km evaluation lengths that overlap the pipeline length affecting the developed area. The pipeline length affecting the developed area shall include all failure locations for which the hazard zone can overlap the development, including those occurring beyond the ends of the developed area.

ALARP Review and Management

- **Challenges:**
  - Numerous locations with risk levels needs ALARP review
  - Cost benefit analysis tool in development and often requires SME inputs from multiple teams
- **Solution:**
  - Development and refinement of cost benefit analysis tool
  - Introduction of ALARP tiers to allow different review requirements and response criteria
  - Alignment to the corporation operational risk matrix (ORM) to ensure leadership visibility and oversight





Challenges, Impacts and Benefits

- **Challenges:**
  - Build and sustain a capable team with rich domain knowledge and advanced data analytical skills
    - Leadership support, adequate resources and investment, and team's commitment to excellence
  - Implementation of major algorithm and process changes while maintaining continuality of the annual risk assessment cycles
    - Risk assessment results are widely used at TCE in many business-critical decisions (budget allocations, integrity work prioritization, multi-year work planning etc.)
    - All major algorithm changes are planned and executed in phases, including pilot studies, off-cycle assessments, validation and impact analysis, before changes are officially incorporated
    - Prioritization of the changes and improvements discussed to ensure alignment with business needs.

Challenges, Impacts and Benefits

- **Impacts and Benefits**
  - Ensured TCE pipeline risk assessment program continue to follow the industry best practices and meet the latest requirements from the standards
  - Improved risk results provides more accurate risk profiles of the system and drives integrity work at right locations
  - Successful implementation of the changes demonstrated the maturity of the program, the teams strive to excellence and paved the path forward for the further integration of the program as part of TCE's enterprise risk management

thank you

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