# Risk Assessment Methodology

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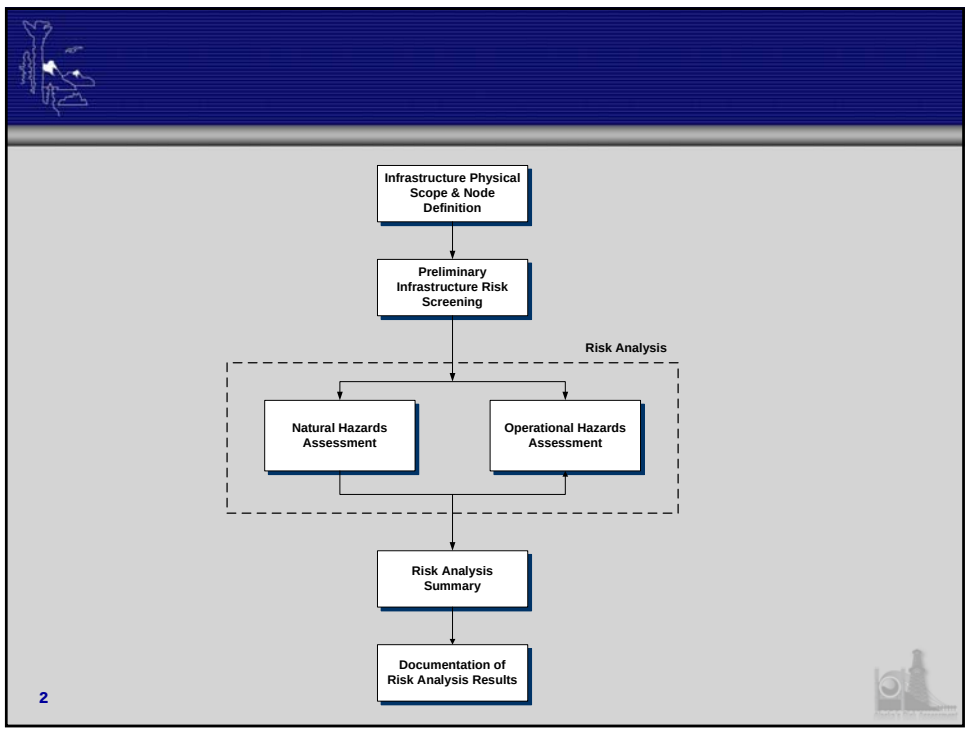


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# Presentation Outline

- Operational Hazard Risk Assessment - Montague
- Natural Hazard Risk Assessment - Harris
- Risk Presentation/Summary Approaches – Montague
- Questions

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# Operational Hazards Risk Assessment

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# Types of Operational Hazards

- Fires and explosions (which can result from hydrocarbon releases)
- Spills and leaks (e.g., due to natural aging process – corrosion, abrasion, wear and fatigue)
- Equipment malfunctions
- Loss of infrastructure support systems (e.g., power)
- Human errors

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# Special Issues

- Changes in process conditions (e.g., composition – heavy oil, increased quantities of solids produced, and throughput decline)
- Effect of integrity management standards and practices

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# OHRA Approach

- Data will be gathered from published references and from meetings or workshops with owners/operators of the infrastructure
- Facility-specific information will have to come from owner/operators
  - Impact of major equipment or system loss (e.g., level of redundancy)
  - Alternate operating modes
  - Restoration times
- Scenario frequencies will be estimated using standard models and approaches

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# Safety Risk

- Estimate potential harm to:
  - workers on site at infrastructure facilities and
  - the public in nearby communities/facilities
- The expectation is that safety risks to the outside community/facilities will be very limited

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# Safety Risk Focus

- The quantity and duration of the hydrocarbon material released
- The release distance and form of the released material
- Distance affected
- Once the magnitude of the hazardous event has been determined, the potential impact on local operations personnel and/or the public will be determined based on relevant staffing and population data

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# Safety Risk Consequences

- Modeling of release events and mitigations to protect people from such incidents will either be obtained from:
  - Facility siting studies requested from facility owners/operators, or
  - Analyses performed using software and specific infrastructure and hydrocarbon release data

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## Safety Risk Frequency Analyses

- The likelihood analysis is comprised of two tasks:
  - estimation of the frequency for component failures or other initiating events
  - analysis of the scenario frequency for initiating events that result in significant hazards

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## Data Analysis

- When necessary generic industry-wide reliability data and facility-specific data will be combined
- Bayesian updating analysis will be used

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# Methods Employed

- For pipeline segments, a scoring method will also be used (based on Muhlbauer)
- For more complex event scenarios, event tree techniques will be used as required to identify and estimate the frequency of significant operational event outcomes

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# Safety Risk Examples

- Facility served by fuel gas
  - Assess potential for fuel gas explosion
  - Event tree for release scenarios – immediate ignition (fire), confinement or congestion, delayed ignition
  - Delayed ignition with confinement or congestion – assess distances to populations (control rooms, offices, accommodations, public)
  - Will also require evaluation of downtime (reliability) and environmental impact (unlikely to be severe)
  - Example event – Recent fuel gas release at Pump Station 1

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# Safety Risk Examples (cont.)

- Facilities involving flammable liquids
  - Examine scenarios that can result in threats to populations in high risk locations (badly sited office locations or sleeping accommodations) or with limited ability to evacuate (e.g., platforms)
  - Examine scenarios that allow physical restrictions to limit personnel egress from area of fire

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# Environmental Risk

- Focuses on the likelihood, size and type of spills of hydrocarbon and seawater streams to the external environment
- Requires identification of significant spill scenarios
- Will use failure modes and effects analyses to organize nodal review

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## Environmental Event Contributing Factors

- Failure mechanisms
- Additional local threats (from operational activities)
- Sensitivity of the surrounding external environment
- Composition/type of fluid stream that is released
- Release quantity
- Recoverability of spill

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## Environmental Risk

- Consequence scores will be calculated for each of the release events that are considered, based on the index values discussed previously
- Likelihood analysis will be performed similar to the safety likelihood analysis

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# Relative Index Used for Environmental Consequence

- Model addresses several environmentally-related factors
  - Release Material Composition
  - Release Quantity
  - Recovery/Remediation Capabilities
  - Environmental Sensitivity

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# *Release Material Composition Categories*

| Composition | Category Index Number | Explanation |
|---|---|---|
| Crude oil or other liquid hydrocarbon (such as diesel) | **3** | A heavy hydrocarbon such as crude oil can have persistent impacts when released to the environment, making it the highest impact of the categories of materials being considered. |
| Seawater or Produced water (including contamination with small amounts of hydrocarbon) | **2** | Seawater and produced water are assumed to present a lower level of environmental impact than crude oil, but can still have extensive impacts on the environment due to their salinity as well as the small percentage of hydrocarbon present in produced water after treating (from a volumetric perspective). |
| Natural gas liquids (NGLs) | **1** | Spills of these materials are expected to have little environmental impact since they are highly volatile and would be expected to disperse quickly into the environment. |

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# Release Quantity Categories

| Release Quantity | Category Index Number | Explanation |
|---|---|---|
| Large release (>10,000 barrels) | 6 | Release quantities will be assessed based on normal process flow, the nature of the worst-case release considered, and the expected detection and isolation time. |
| Medium Release (1,001 to 10,000 barrels) | 5 | |
| Small Release (10 to 1,000 barrels) | 4 | |

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# Recovery/Remediation Capabilities

| Recovery/Remediation Capabilities | Category Index Number | Explanation |
|---|---|---|
| Little to no ability to recover/remediate this type of release | 1 | This category includes:<br>• Direct spills to moving bodies of water other than contained entirely on ice (such as ocean/sea, river systems, and tributaries)<br>• Spills to subsurface areas<br>• Other situations assessed as difficult to recover |
| Limited to moderate capability to recover/remediate this type of release | 2 | This category includes:<br>• Spills to land and tundra in other than frozen conditions<br>• Spills to unprepared surfaces (i.e., prepared surfaces include gravel pads which have been laid for remediation ease)<br>• Other situations assessed as limited to moderate to recover (including requiring input from State and remediation experts) |
| Very effective capability to recover/remediate this type of release | 3 | This category includes:<br>• Spills in winter conditions contained on ice or recovered from frozen land or tundra (i.e., limited migration)<br>• Spills to gravel pads or other prepared surfaces where recovery can be accomplished by direct removal of contaminated materials. |

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# Environmental Sensitivity

| Type of Environment | Category Index Number | Type of Environment |
|---|---|---|
| Waterways | **3** | This category includes:<br>•Waterways or direct pollution routes to waterways that support commercial fishing, aquaculture, or subsistence activities |
| Sensitive Lands (including surface and subsurface areas) | **2** | This category includes:<br>•A land area that supports unique flora and fauna or wildlife breeding and migratory areas, which may support subsistence hunting activities (e.g. tundra or wetlands)<br>•An area that encompasses a cultural or historical site<br>•A Recreational Area (defined as an area that supports hunting, fishing, hiking or other outdoor recreational activities)<br>•Areas that have been branded based on pristine conditions and which support tourism activities |
| Other Lands | **1** | This category includes:<br>•A land area (surface or subsurface) not defined as "sensitive" in Category 2 above. |

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# Calculating Environmental Index

$$\mathcal{N}_i = M_i * (Q_i - R_i) * S_i$$

Where:

$N_i$ = Environmental Consequence Index for Event i
(Value: 3 to 45)

$M_i$ = Material Composition Index (1 to 3)

$Q_i$ = Release Quantity Index (4 to 6)

$R_i$ = Recoverability/Remediation Index (1 to 3)

$S_i$ = Environmental Sensitivity Index (1 to 3)

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# Example Application of Environmental Index

- A significant release of crude oil (M = 3) that is 2,000 barrels in size (Q = 5) in an area of very high sensitivity (S = 3), but where recovery and remediation efforts can be highly effective (R= 3), would be scored as:

$$N = 3 \times (5-3) \times 3 = 18$$

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# Proposed Categories Based on Environmental Index

| Category Number | Environmental Impacts | Consequences Score |
|---|---|---|
| 3 | **Catastrophic** – A significant release to an area of extremely high environmental consequence that causes large-scale, widespread, non-recoverable, irreversible, and long-term damage that is severe. The damage would be considered to be extensive enough that the area would be considered unusable for the foreseeable future. The loss would prevent a return to normal life support and access for the conduct of normal activities that were once supported by the area's resources. | Greater than or equal to 30 |
| 2 | **Challenging** – A significant release to an area of high environmental consequence that causes widespread and persistent damage to the area, which would cause a disruption in life support and would limit normal use and activities in the area for some time. Remediation would be required and some damage to the area may be irreversible. | Greater than 15, but less than 30 |
| 1 | **Manageable** – A release to an area of some environmental consequence that results in localized and reversible effects on the environment. Results in some initial disruption of activities in the area, but normal usage can resume in a very short time frame once remediation/recovery activities have been completed. | Less than or equal to 15 |

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## Use of Environmental Index

- Initial use of the index model will likely require adjustment as experience is gained
- The objective is to prioritize potential events by frequency and environmental index

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## Reliability (Revenue) Risk Assessment

- Purpose - analyze the potential for oil and gas production losses that are significant enough to materially affect state revenue
- Provide an estimate of production outages (defined by barrels of production lost)
- Can subsequently be used by the State to quantify dollar impacts to the State using the Department of Revenue's (DOR) State Revenue Forecast model

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## Reliability (Revenue) Risk Methodology

- Frequency of the initiating event will be estimated like discussed for safety events
- Factors unique to reliability (revenue) analyses
  - estimated production impacts (e.g., percent of production lost)
  - event durations

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## Analytical Approach

- Reliability block diagrams documenting production process flows
- What-if analysis to identify scenarios
- Scenario frequency estimates as discussed before

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## Reliability/Revenue Consequences

- The consequence measure will be barrels of oil (or barrels of oil equivalent) not produced
- Calculation of these consequences will require understanding of:
  - Type of event (e.g., spill, mechanical failure, support system outage)
  - Normal production rate and fraction lost
  - Potential alternate operating modes and time required to implement
  - Total event restoration time

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## Reliability/Revenue Consequences (cont.)

- Assumption is that daily production lost cannot be replaced
- Secondary impacts of production losses will be noted but not analyzed (e.g., impacts on refinery production, natural gas supply to Alaskan users)

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## Operational Hazards Risk Example

Storage Tank Failure

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## OHRA Example - Steps

- Select Node
- Reasonable worst case operational event
- Preliminary risk screening
- Detailed analyses for node/consequences that pass screening threshold
- Event frequency estimation
- Event consequence estimation
- Risk results

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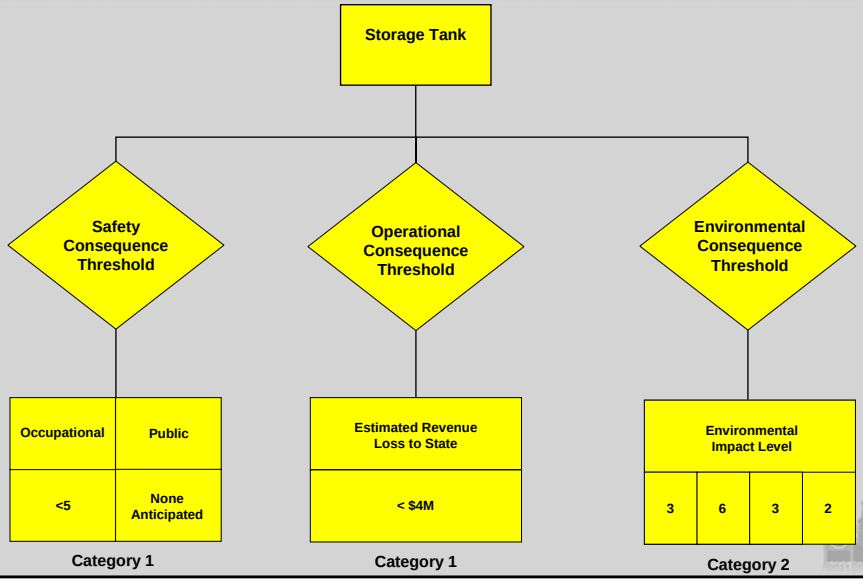
# OHRA – Screening Process




# OHRA – Likelihood Estimate

- Obtain tank rupture failure rate from industrial data bases
- Obtain failure history from Operator, if available
- Bayesian update

# OHRA – Environmental Consequence

Environmental Consequence Category

N = M * (Q – R) * S
= 3 * (6 – 3) * 2
= 18

Category 1: N less than or equal to 15

Category 2: 15 < N < 30

Category 3: N > 30

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# OHRA – Risk Results

- Risk Matrix – Event fits into a likelihood X consequence bin
- Risk Histogram – Event contributes to the estimated frequency of Environmental Consequence Y type risk

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# Natural Hazards Risk Assessment

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# RISK ASSESSMENT RESULTS AND SUMMARIES

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# Uses for Risk Data

- What risk management initiatives should be pursued?
- What risk management initiatives should not be pursued?
- How much money should reasonably be spent on risk management?
- How should that money be spent to obtain the most value?

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# Risk Summary Formats

- Risk Matrices- shows the number of events by risk level (based on frequency and consequence)
- Risk Histograms - shows total estimated frequency for events assigned to each of the consequence categories
- Risk Summaries- shows percentages of safety and reliability risk based on characteristics of the scenario and node

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## Risk Summary Formats (cont.)

- Risk matrices and histograms apply to all three classes of consequence (safety, environmental, and reliability/revenue)
- Risk estimates only apply to safety and reliability risks

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## Risk Matrices

- Risk matrices display the number of scenarios that have been assigned to each combination of frequency category and consequence category
- Risk data in this format is often used to identify which events to focus on in mitigation planning

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# Risk Matrix

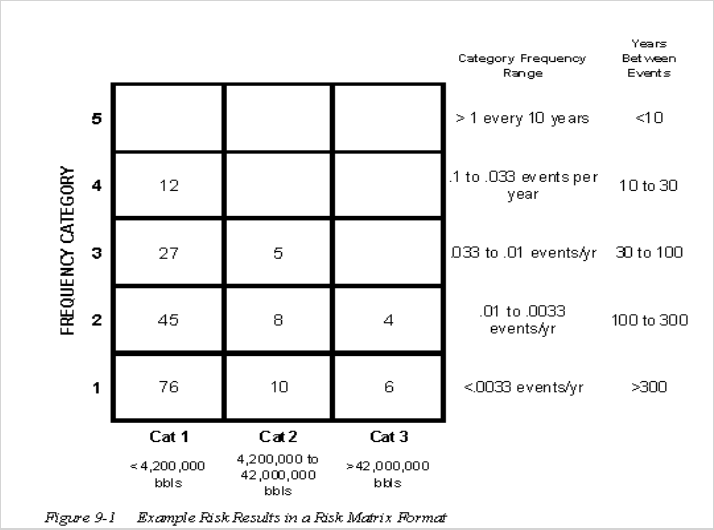


*Figure 9-1 Example Risk Results in a Risk Matrix Format*

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# Risk Histograms

- Sum the frequency of all of the events that contribute to each consequence category
- Help to compare actual experience to the risk assessment results

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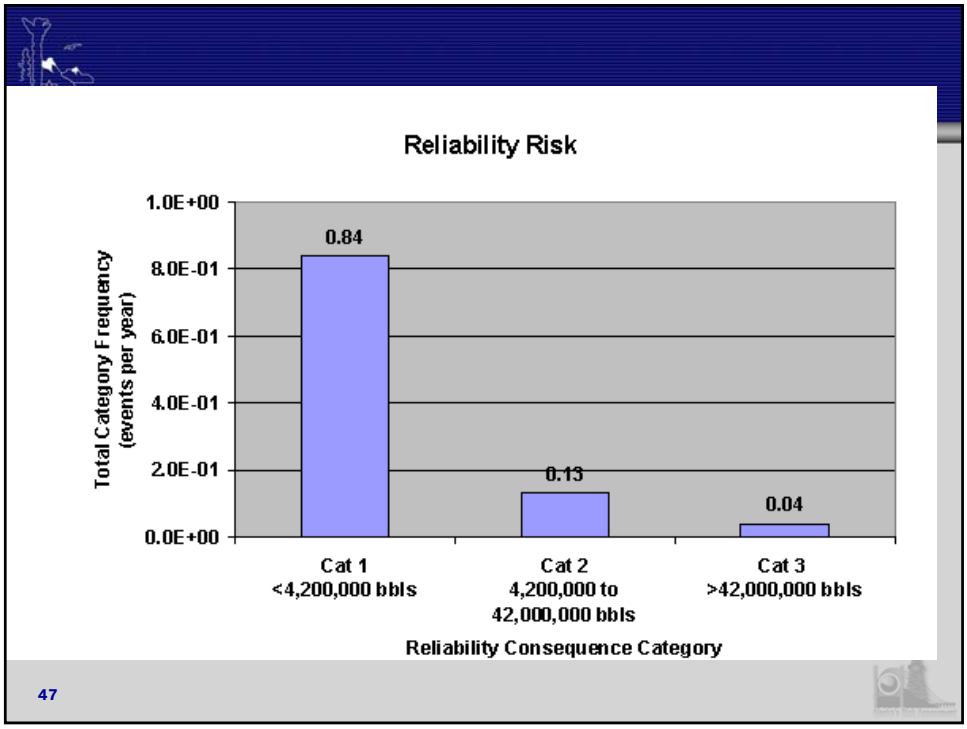


# Risk Estimates

- Involves calculating a specific risk using the classical risk equation. For the example of reliability risk, this equation is:
  - Risk (barrels per year) = Frequency (events per year) X Consequence (barrels per event)

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# Risk Summaries

- Risk totals can be summed for a collection of scenarios to calculate risks for groups of:
  - Nodes
  - Facilities
  - Facility types
  - Operating areas
  - Owners/Operators
  - Natural hazards (when applicable)

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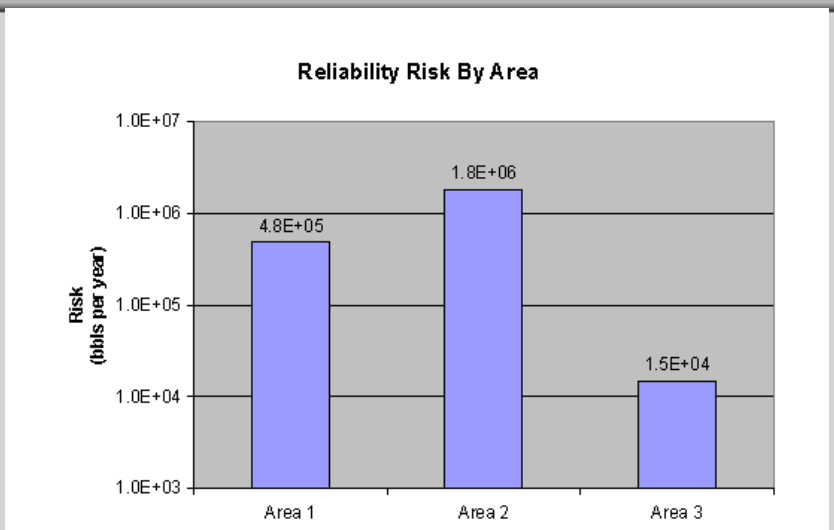
# Risk Estimates by Area

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# Risk Summations

- Can aid the State in answering questions such as:
  - Which nodes are the largest contributors to the estimated reliability risks?
  - What fraction of the estimated reliability risk is associated with nodes that are part of TAPS?
  - What fractions of the estimated reliability risk are associated with each infrastructure owner/operator?

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# Risk Comparisons

- Within a consequence class, different scenarios can be compared by frequency, or consequence, or their estimated risk
- It is much more difficult to compare risks across consequence classes, because they are represented in different risk units
- Direct comparisons of different categories of risks are not being made in this project

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# QUESTIONS?

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