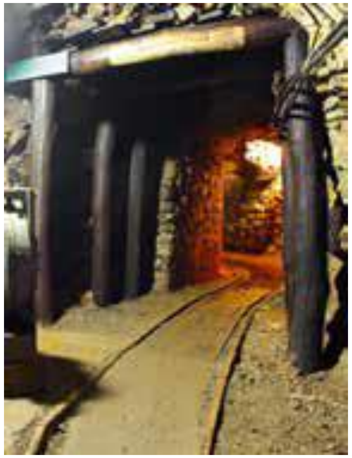


# An Assessment of the Costs and Benefits of Climate Change Adaptation in Mining

Sean Capstick, Golder Associates

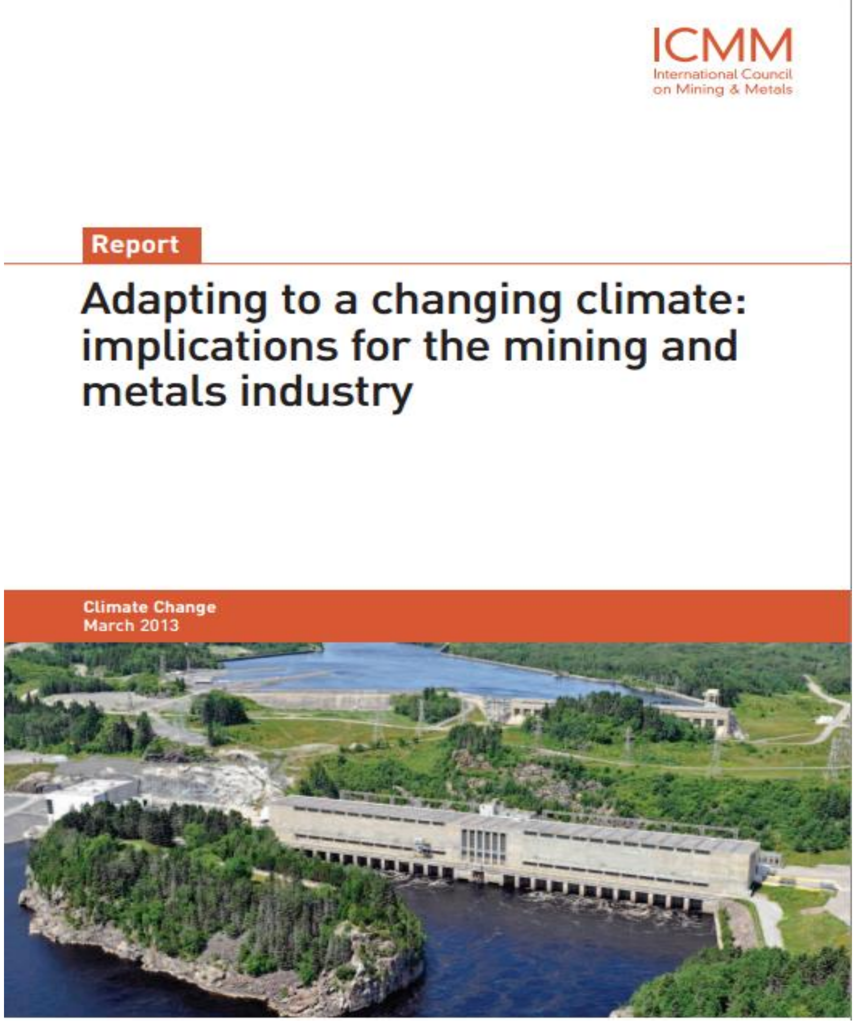
Climate Change Webinar

December 15, 2016

OCCIAR

Golder Associates

# Industry Recognition of the Problem


ICMM
International Council
on Mining & Metals

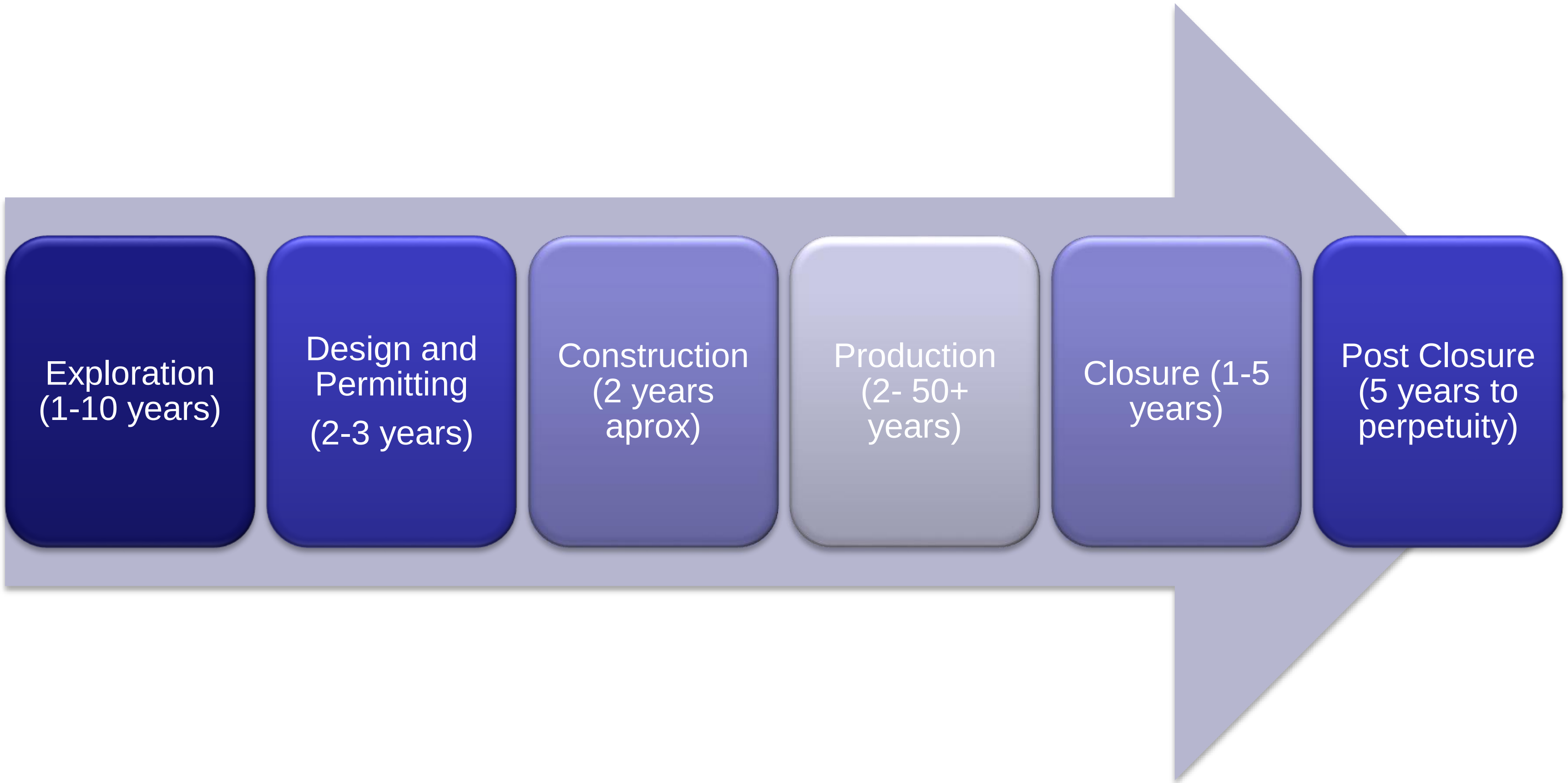
Report

Adapting to a changing climate: implications for the mining and metals industry

Climate Change
March 2013

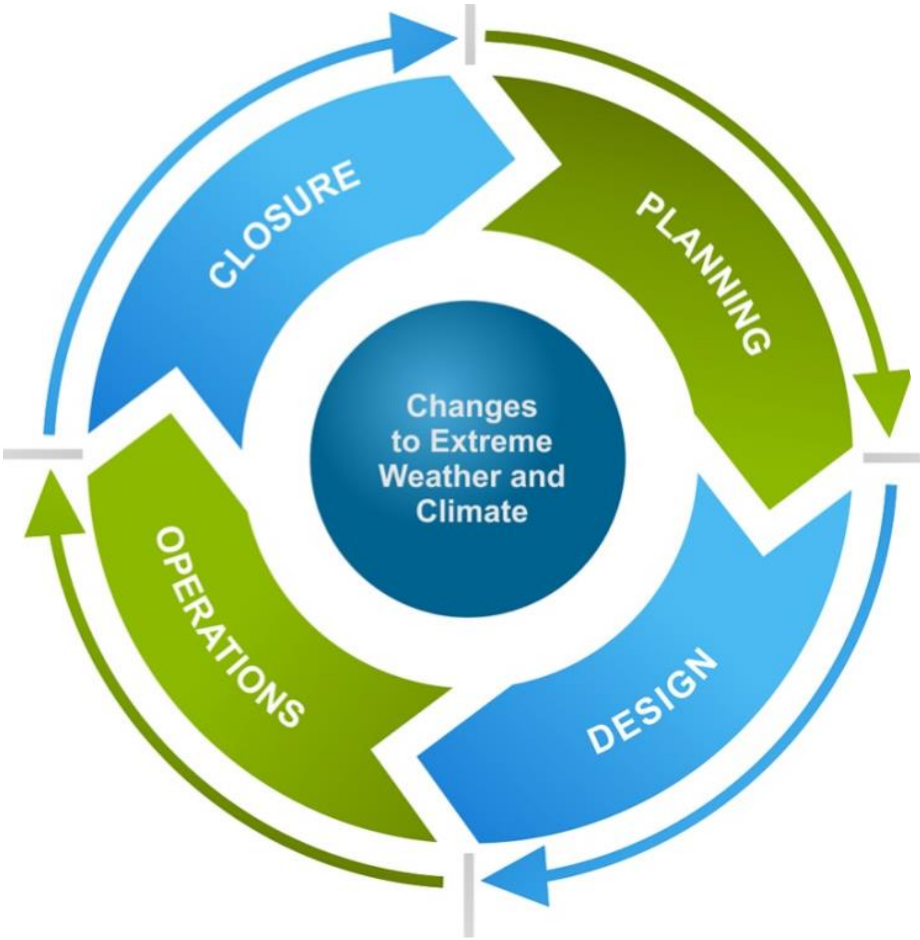
- Mines are often located in areas with extreme weather and challenging conditions
- ICMM identified a growing awareness that a changing climate and its impacts can affect the mining industry
- Report identifies potential climate impacts and how mining and metals companies can evaluate risks
- Provides available options for adapting to climate change impacts

# Typical Mine Life Cycle



# Incorporating Climate Change into Project Life Cycle

- Climate data is incorporated in most facets of Mining Projects and Infrastructure Design
- Design is generally based on historic climate data
  - Foundation Design
  - Material Specification
  - Tailings Dam Design
  - Outflow structures
  - Dewatering Requirements
  - Power Requirements
  - Water Supply / Water Balance
  - Closure Design
  - Transportation



# Assessment Reports

- Provide current state of knowledge on climate change


- Fifth Assessment report was finalized in late 2014



Stocker, Thomas and Dahe, Qin (2014). *The WGI Contribution to the IPCC 5th Assessment Report* [PowerPoint slides]. Retrieved from https://www.ipcc.ch/report/ar5/wg1/

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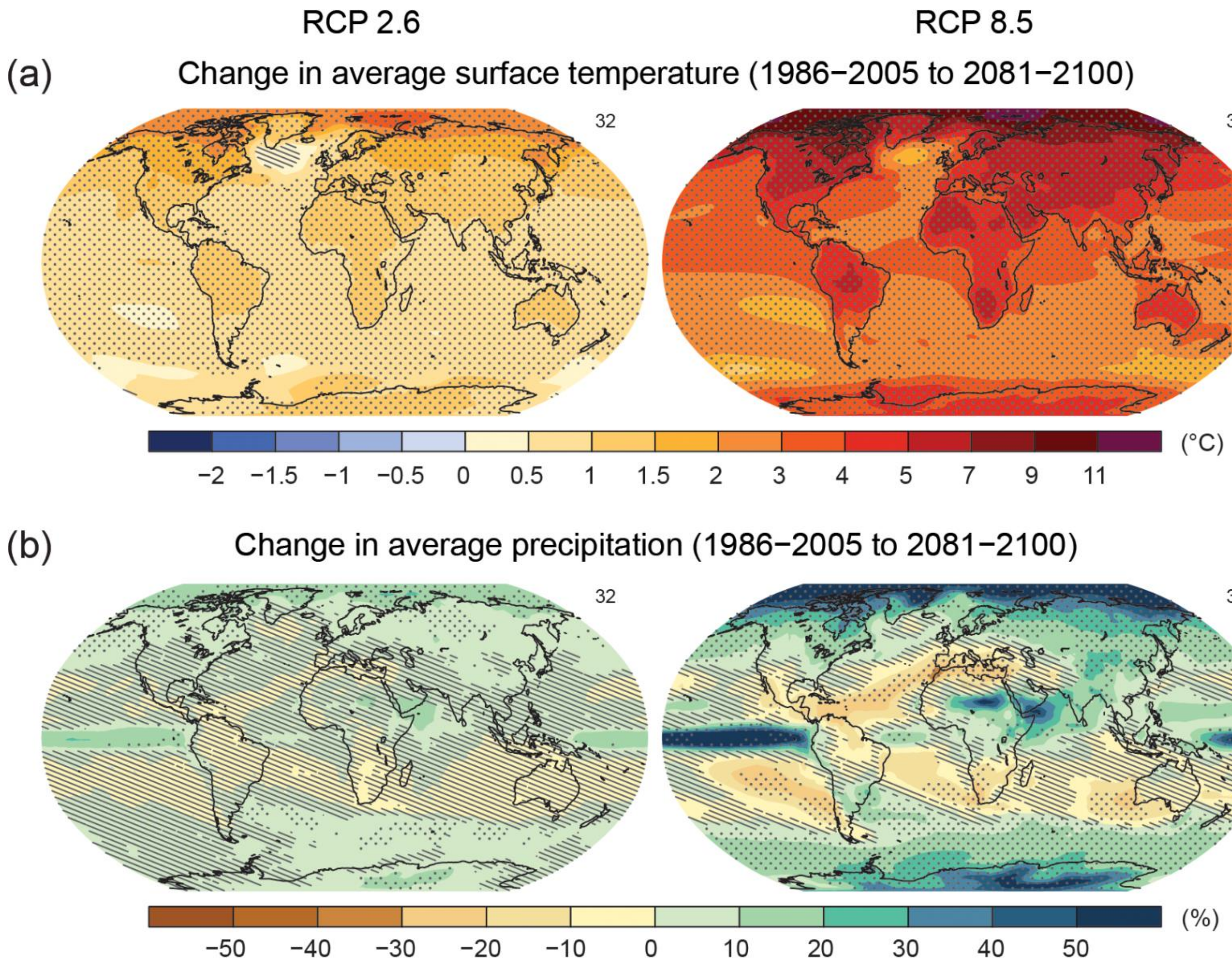
# Climate-Related Risk: Adapting to What?






IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

# Vulnerability Assessments

- Risk Assessment performed on existing Facilities to assess vulnerabilities and develop action plans
- Lessons learned on existing mines can focus ESIA assessments.
- Selected mining case studies located at:

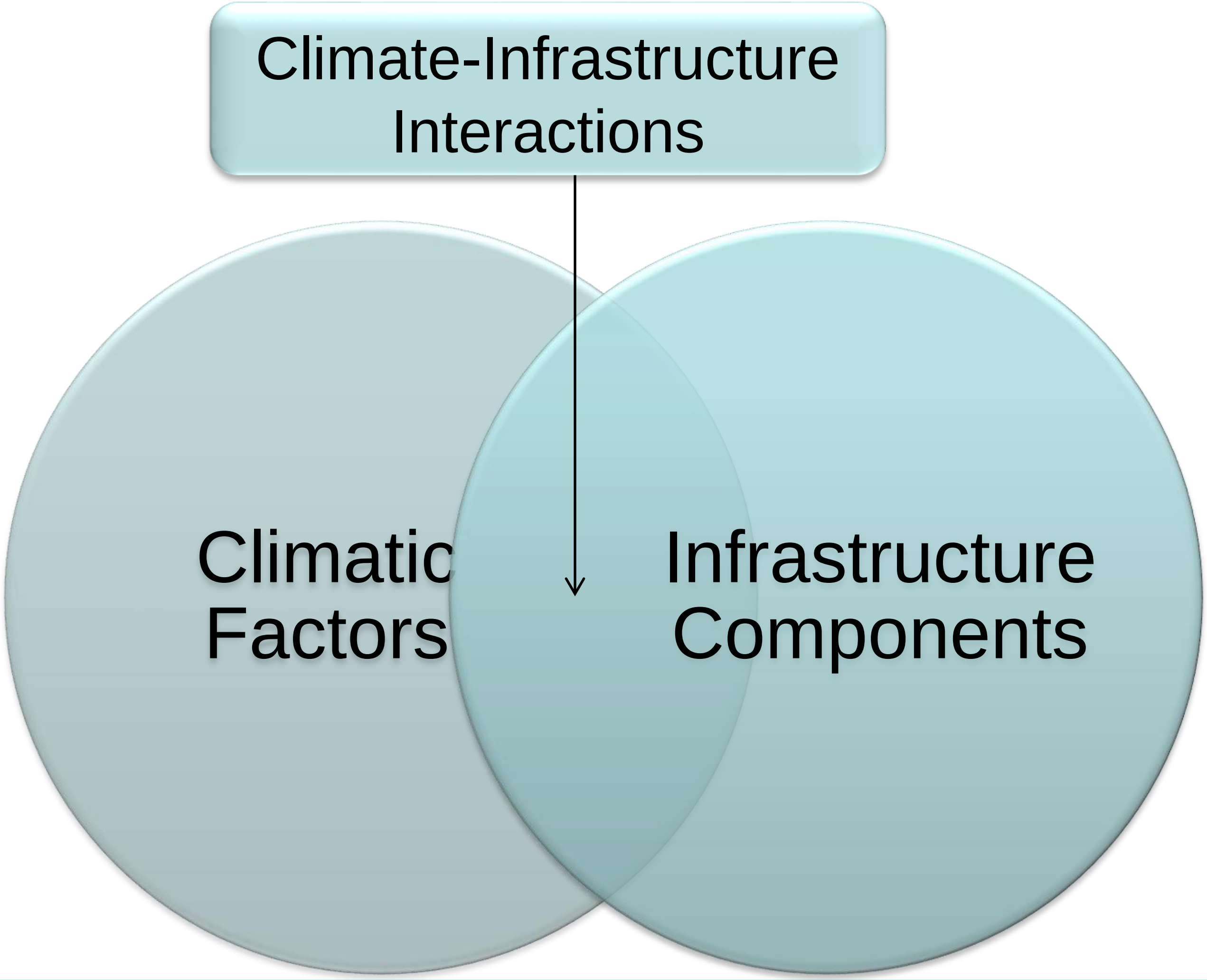
http://www.retooling.ca/climate change case studies

# Case Study: Vulnerably Assessment, Sudbury INO ON, Canada

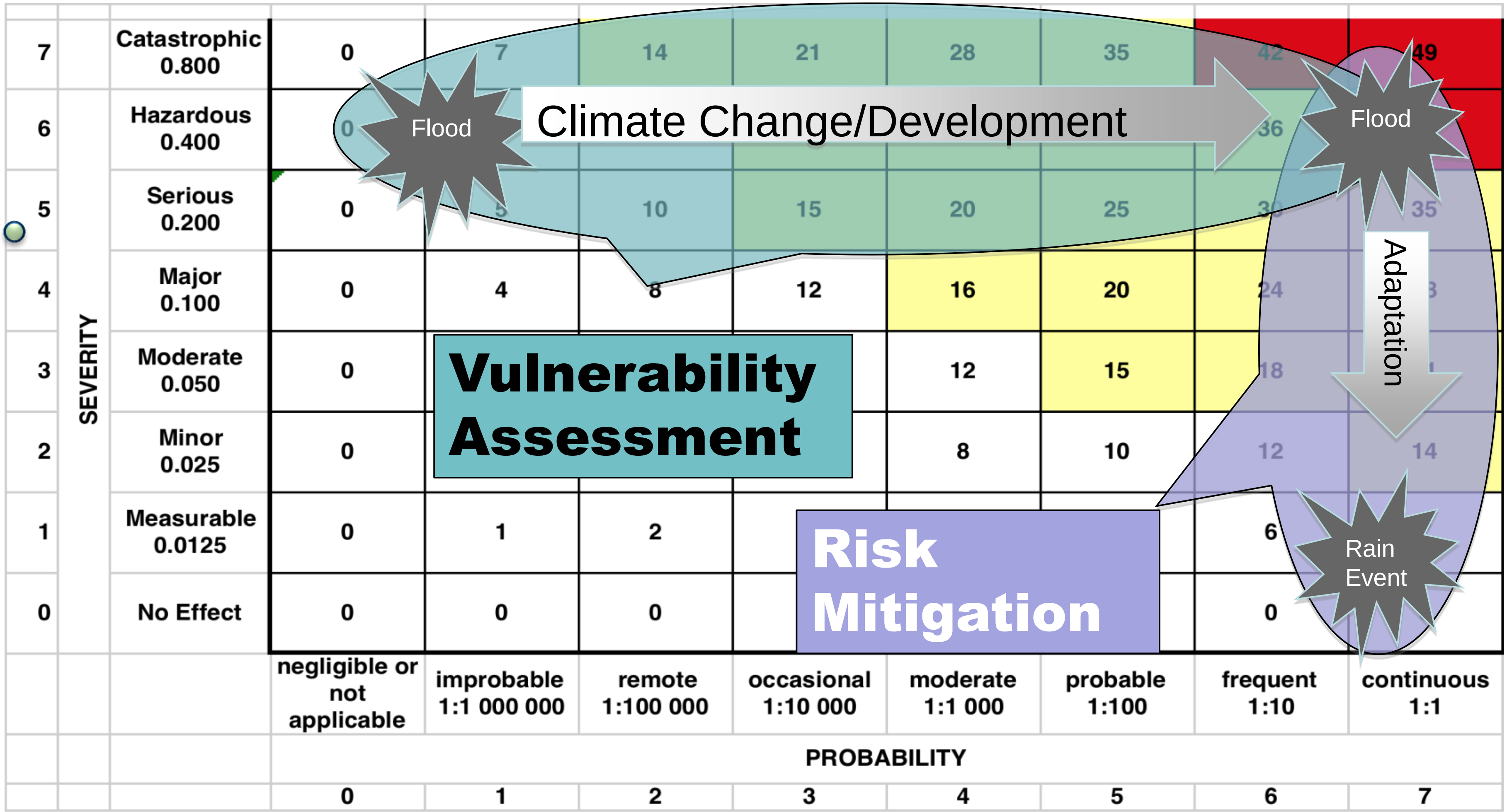
# Vulnerability Assessment Goals

- What are the climate change issues that are reasonably likely to impact the business and operations in the foreseeable future?
- How can these be integrated into the existing Risk Framework?
- How can we plan to build our adaptive capacity and make operations more robust in the future?
- What actions, if any do we need to take right now to minimize unacceptable risks or collect more information to better assess risks?

# Identifying Risks



# Adaptation Planning



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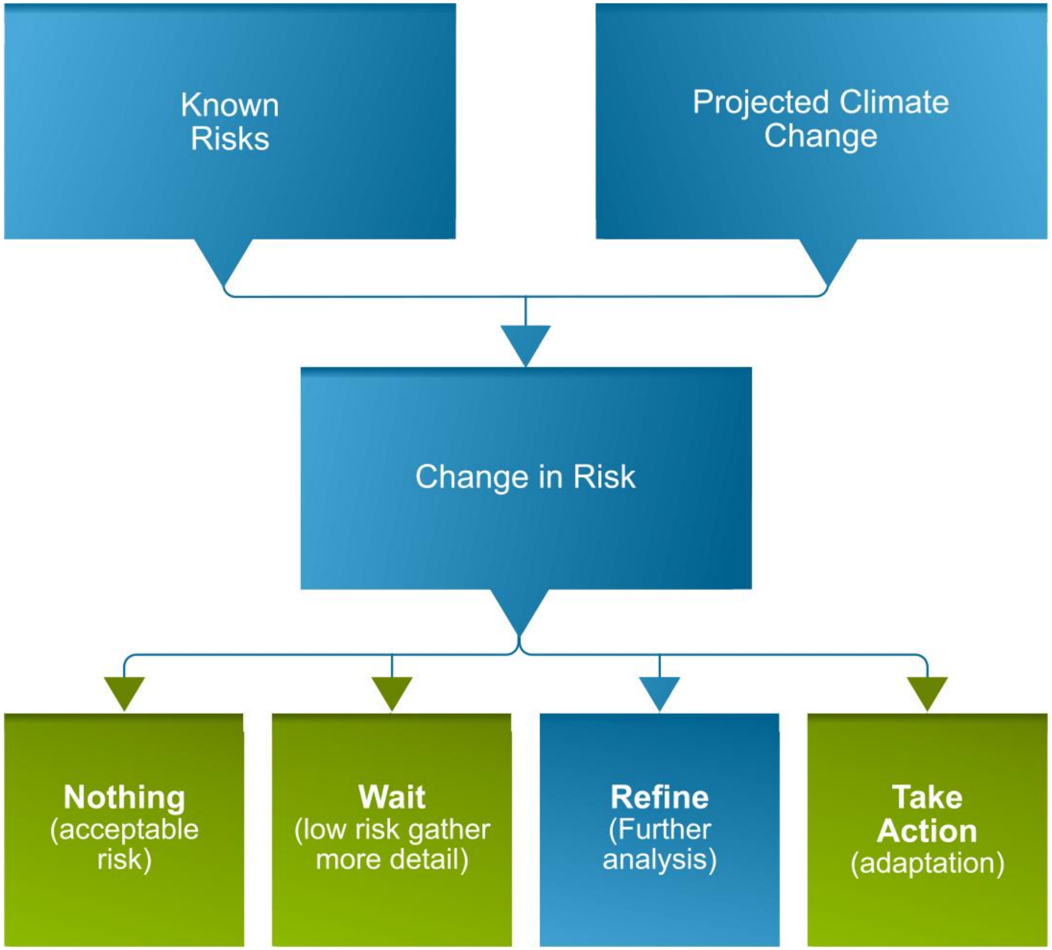
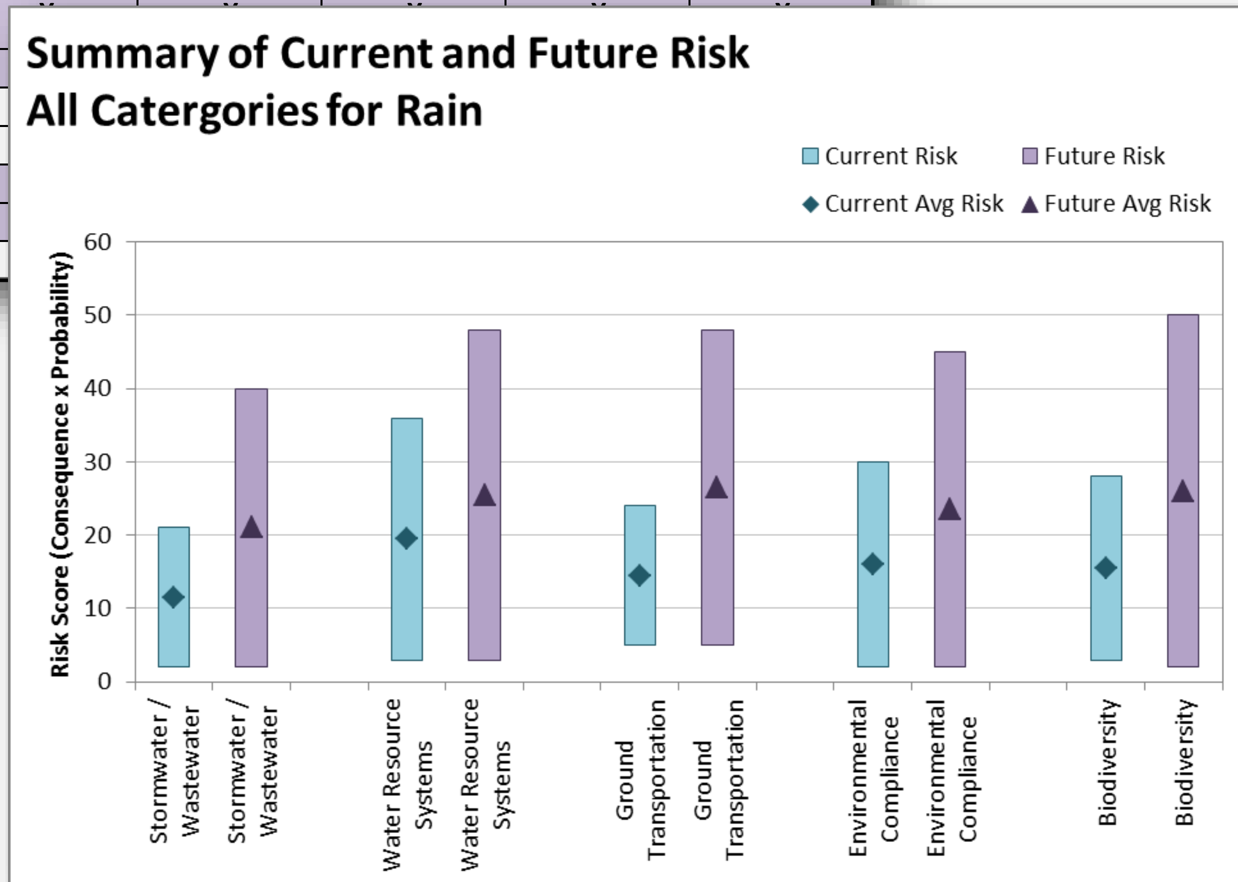
# Operations and Closure



# Vulnerability Assessment Studies

| Infrastructure Component | Climate Factor | | | | |
|---|---|---|---|---|---|
| | Temperature | Rain | Snow | Wind | Mixed Events |
| Stormwater, Wastewater Treatment and Collection Systems | | | | | |
| Water Resource Systems | | | | | |
| Ground Transportation | | | | | |
| Buildings and Infrastructure | | | | | |
| Environmental Compliance | | | | | |
| Biodiversity | | | | | |
| Public Infrastructure | | | | | |



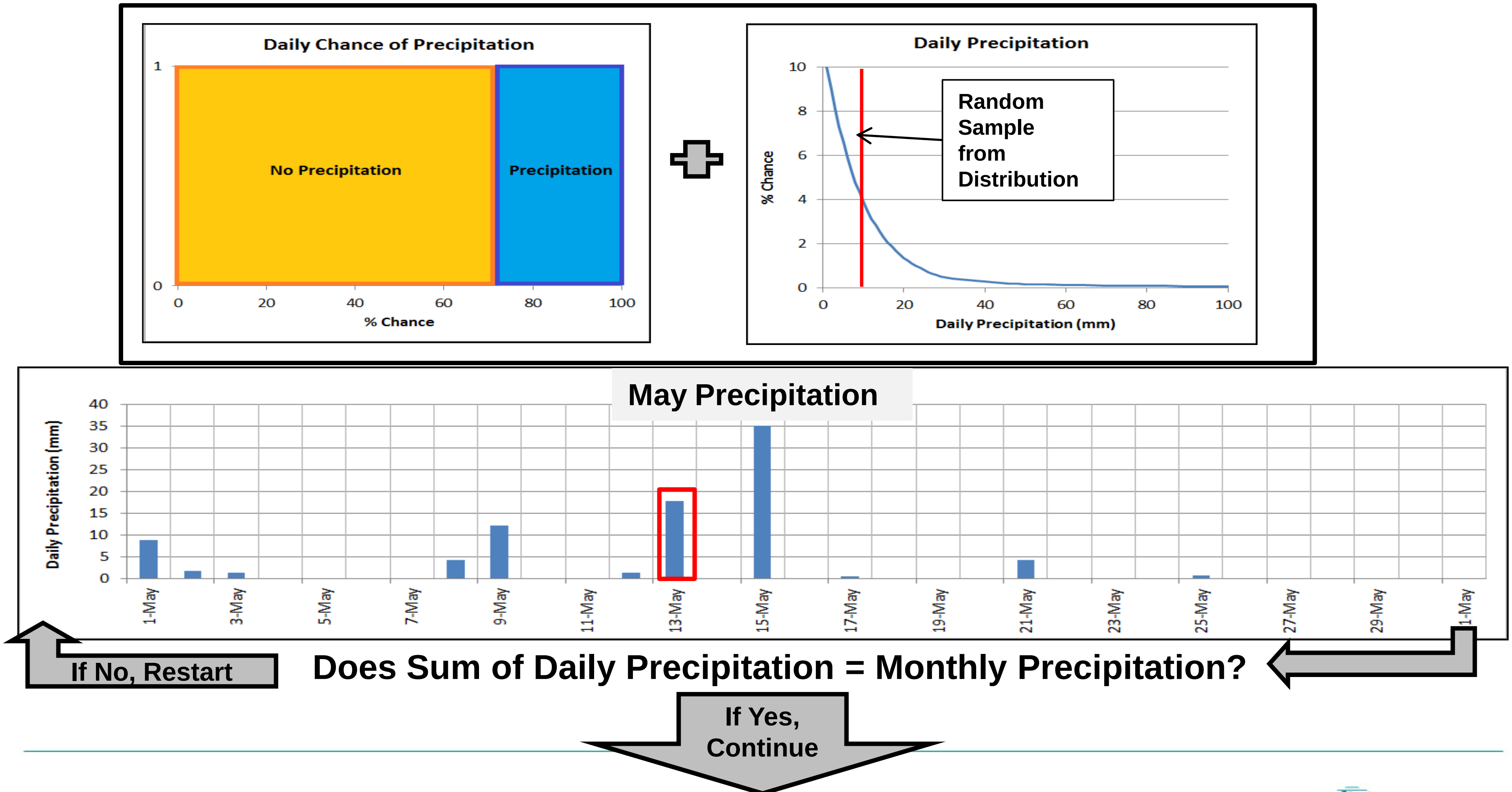

R = C x P

R = Risk
C = Consequence
P = Probability

# Sudbury INO – Water Balance

- One item for follow-up was potential operational risks due to ongoing changes in water management
- Changes in seasonal patterns of precipitation and evaporation are projected to change over the lifetime and closure of the project
- Modifying structures to cope with increasing fluctuations in water levels are very expensive
- Golder developed a GoldSim model to assess the range of projected changes in water availability
  - Evaluate impact on water management system
  - Highlights areas vulnerable to changes in climate
  - Decision-making tool for effective capital expenditures

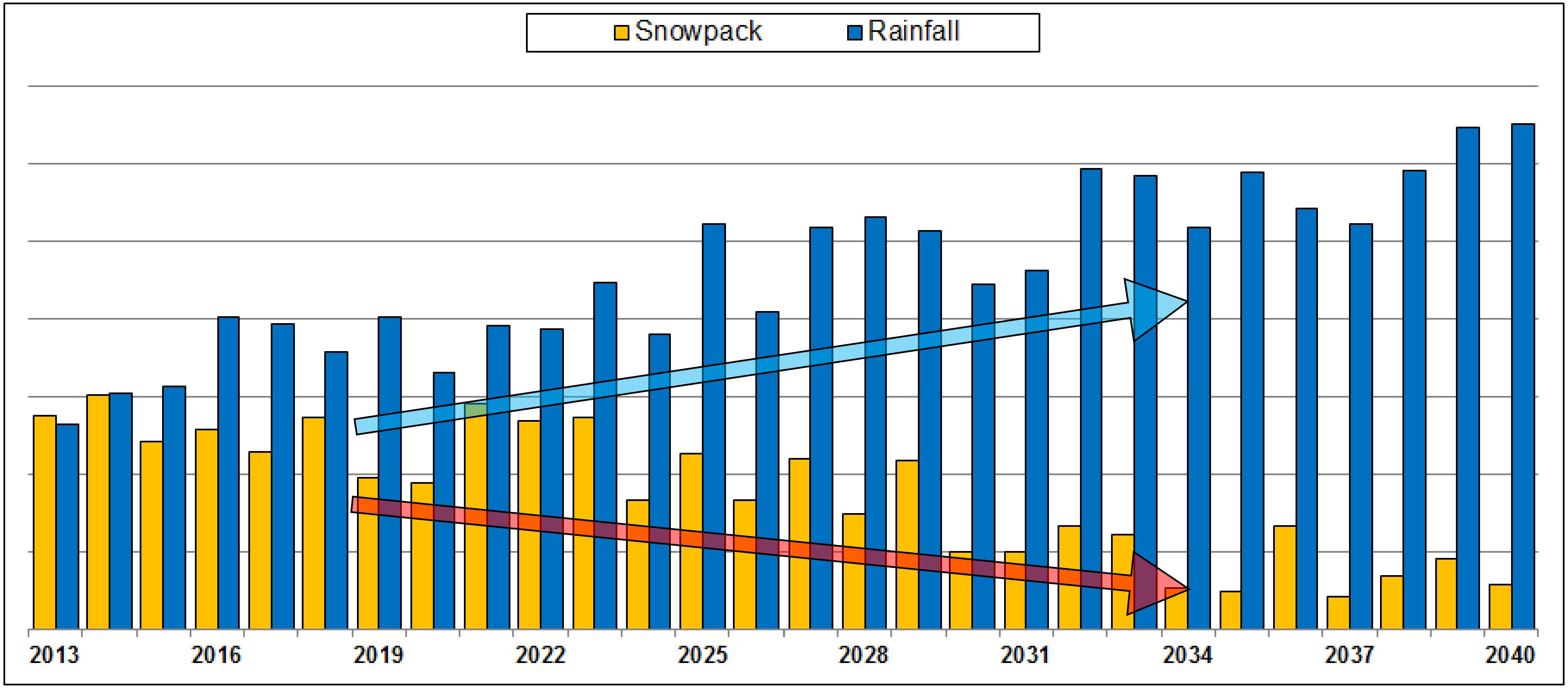
# Innovation – Probabilistic Assessment



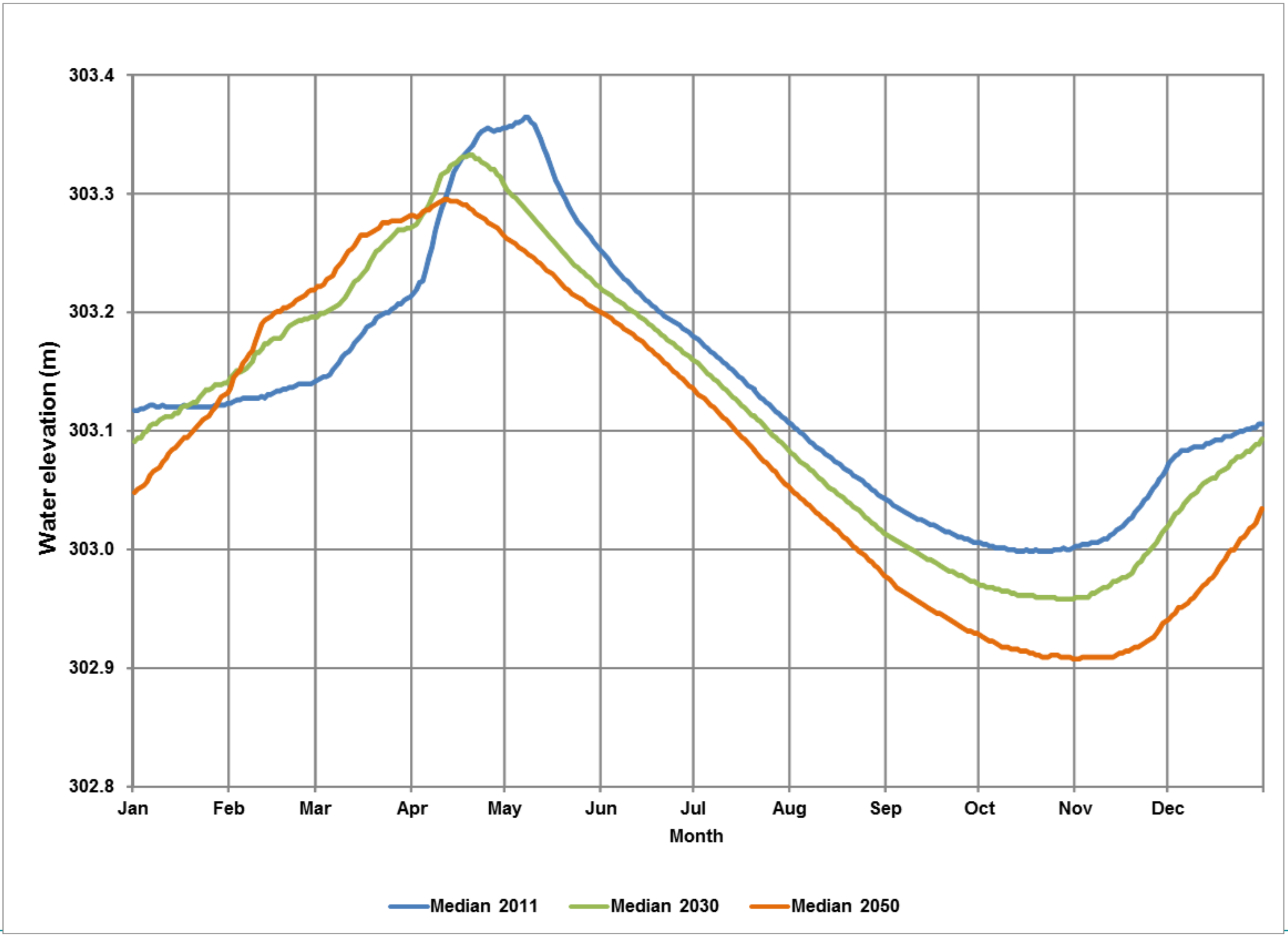
# Applications Model: Adding Climate Change

Results show…
-Decreasing Trend in Snowmelt Events
-Increasing Trend in Rainfall Events

Develop Designs Accordingly



# Water Management



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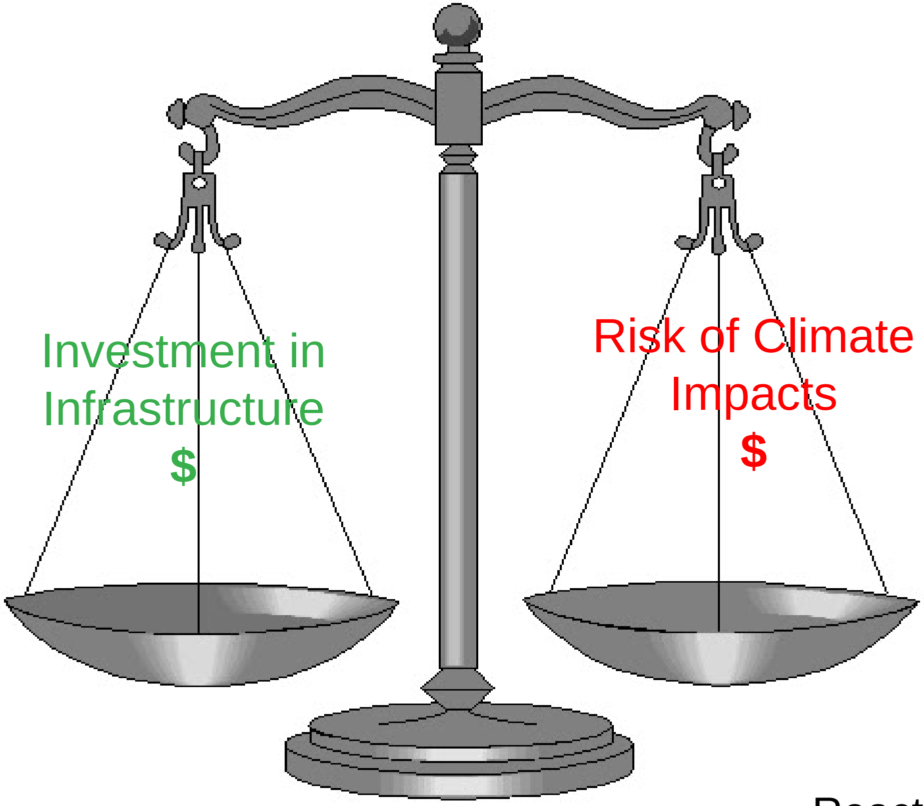
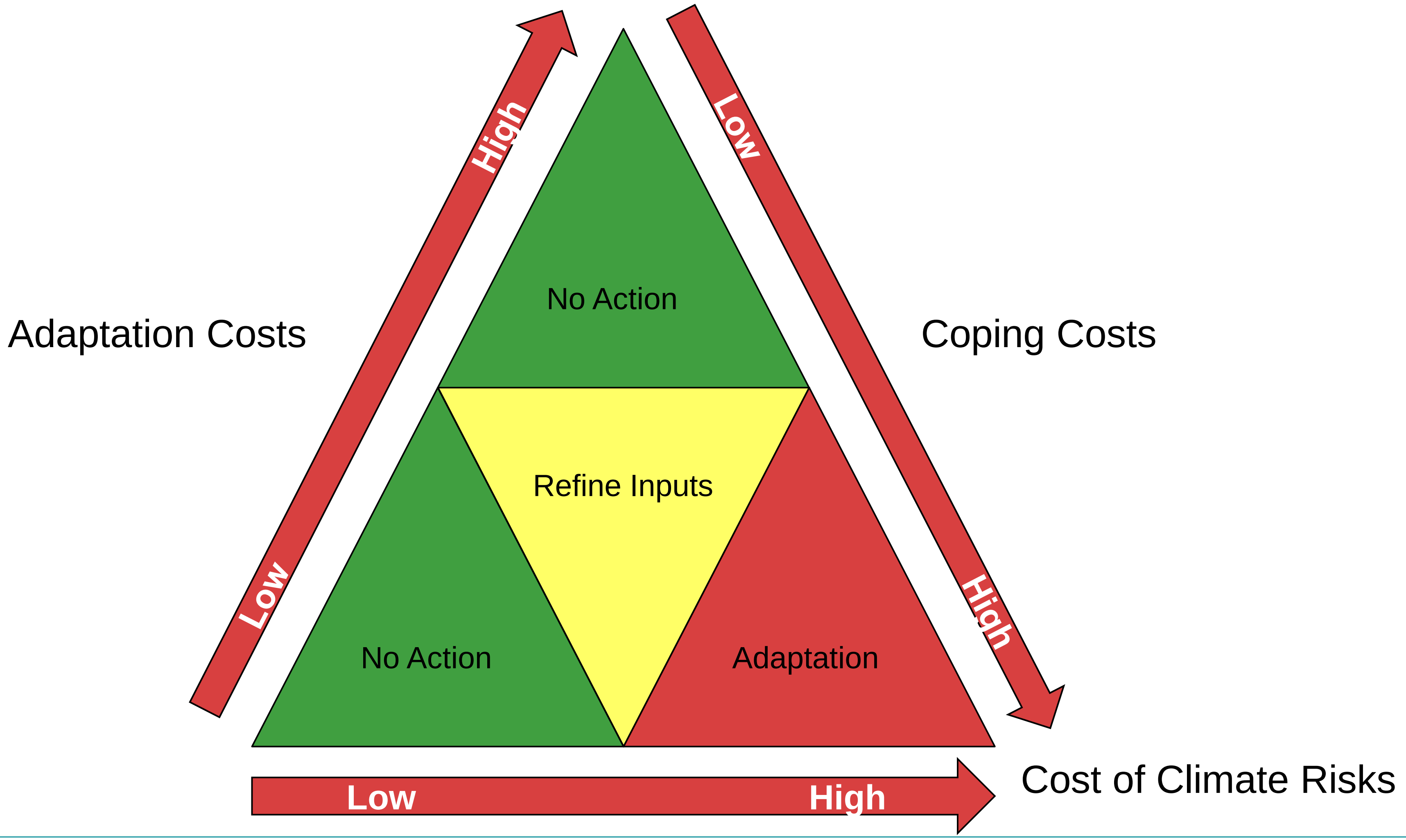
# Economic Models




Planning for Future

React to impacts of climate change

# CBA to Identify Adaptation Uncertainties



# Example Climate Infrastructure Interactions

| | Climate Event | Infrastructure Impacted |
|---|---|---|
| E1 | Significant 1:100 year 24-hour rainfall event | Overtopping of dams, breach of retaining structures, too much flow through water management system, flooding of pit |
| E2 | Significant 1:25 year 24-hour rainfall event | Overtopping of lined ponds, too much flow through water management system |
| E3 | Significant 1:50 year 15 min rainfall event | Localized flooding, culvert wash out, loss of production due to disruption of transportation |
| E4 | Flash flooding due to spring melt and increased snow accumulation | Overtopping of lined ponds, too much flow through water management system, flooding of pit |
| E5 | Hurricane | Flooding of pit (compromised ability to pump water out) |



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# Example Summary of Results – 10 year

| 10 Year Period | | Coping Preferred | Adaptation Preferred |
|---|---|---|---|
| | | Payback Not Achieved | Payback Achieved |
| E1 | Current Climate | 89.5% | 10.5% |
| | Future Climate | 86.4% | 13.6% |
| E2 | Current Climate | 13.2% | 86.8% |
| | Future Climate | 1.4% | 98.6% |
| E3 | Current Climate | 92.6% | 7.4% |
| | Future Climate | 44.5% | 55.5% |
| E4 | Current Climate | 100% | 0% |
| | Future Climate | 100% | 0% |
| E5 | Current Climate | 96.6% | 3.4% |
| | Future Climate | 71.8% | 28.2% |

# Example Summary of Results 39 year

| 39 Year Period | | Coping Preferred | Adaptation Preferred |
|---|---|---|---|
| | | Payback Not Achieved | Payback Achieved |
| E1 | Current Climate | 83.1% | 16.9% |
| | Future Climate | 79.2% | 20.8% |
| E2 | Current Climate | 0.2% | 99.8% |
| | Future Climate | 0% | 100% |
| E3 | Current Climate | 73.8% | 26.2% |
| | Future Climate | 4.3% | 95.7% |
| E4 | Current Climate | 100% | 0% |
| | Future Climate | 100% | 0% |
| E5 | Current Climate | 88.6% | 11.4% |
| | Future Climate | 30.8% | 69.2% |

# Summary

- A risk based framework for successfully integrating climate change for mining projects at both planning and operational stages has been developed which:
  - Clearly documents both baseline and future climate projections that will be used in the assessment
  - Use a multi model analysis to describe the range and uncertainties of the future climate projections
  - Clearly identifies the climate infrastructure interactions that are to be considered in the assessment
  - Identified the relevant risk for the identified interactions
  - Identify the proposed design features or adaptation measures (mitigation measures) that are proposed
  - Better documents Adaptive Management Strategies between coping and adaptation and rational why one is preferred over the other



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