
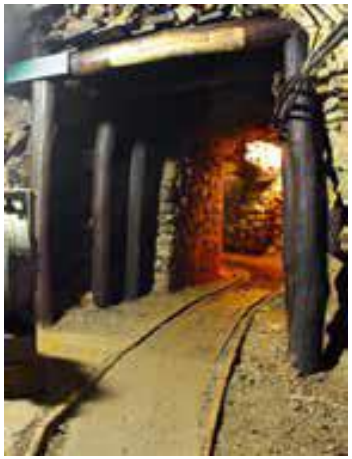


Mining Climate Change Adaptation Canadian Experience

Sean Capstick, Golder Associates

Climate Change Webinar

March 24, 2015

Organized by the

International Association of Impact Assessment

Golder Associates

Setting the Stage

Carbon Services

Energy Services

Climate Services

Climate Change Mitigation focus is on reducing emissions and increasing energy efficiency.

Climate Change Adaptation focus is on identifying and avoiding potential impacts of changing climate.

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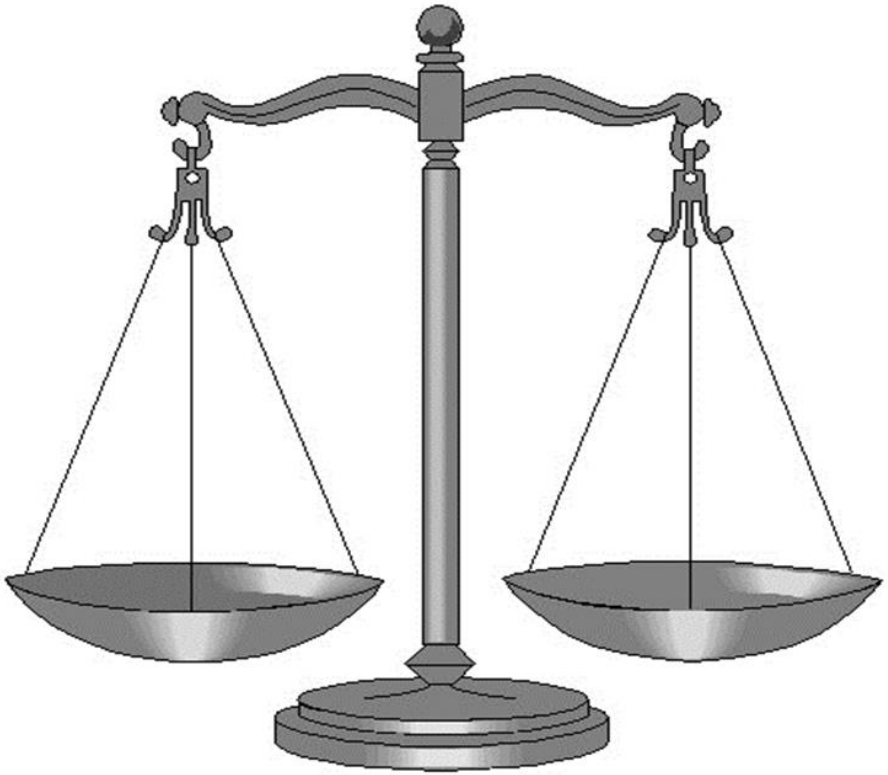
Climate Change Adaptation



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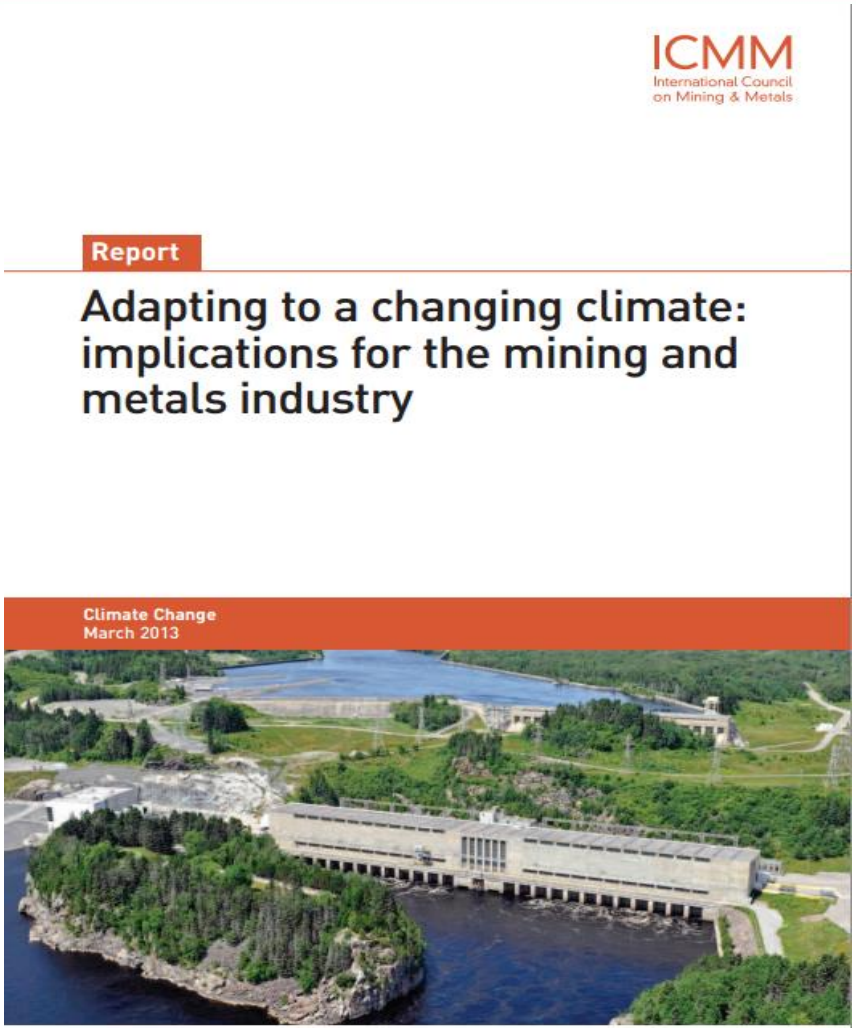
Industry Recognition of the Problem



- 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

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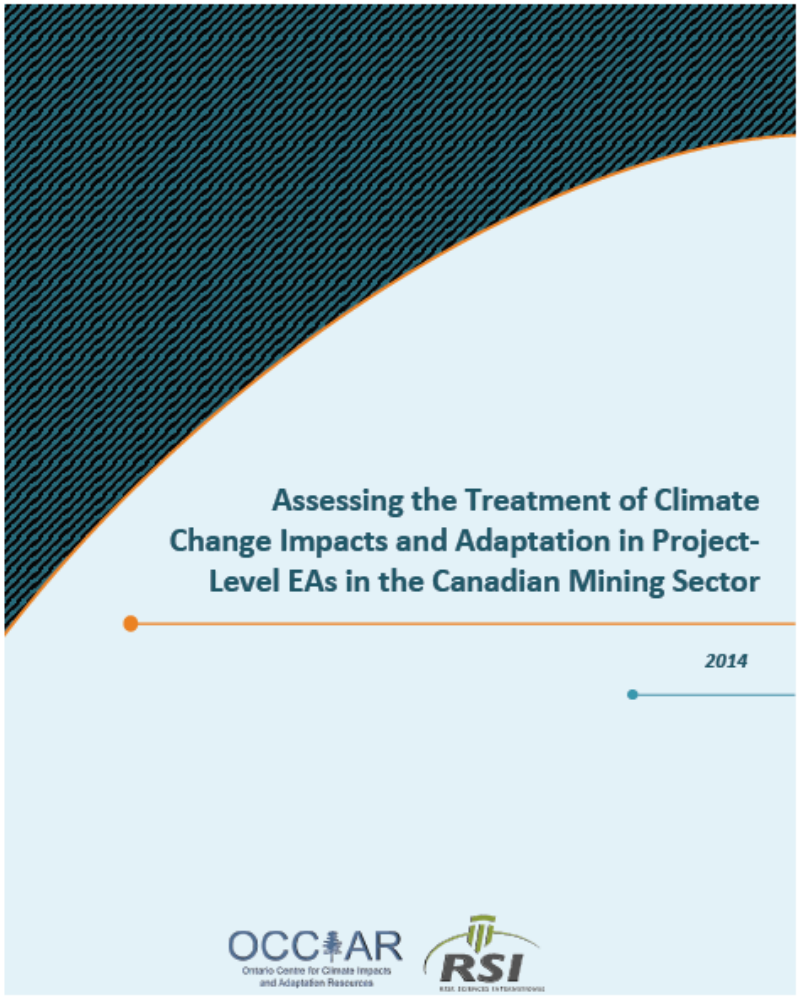
Canadian Specific Guidance



- Report on actions being taken to reduce climate change-related risks at the mining project level
- Describes the strengths and weaknesses of current approaches to factoring climate change adaptation into project ESIAs
- Recommends Best Management Practices to support climate adaptation decision-making in Canada's mining sector

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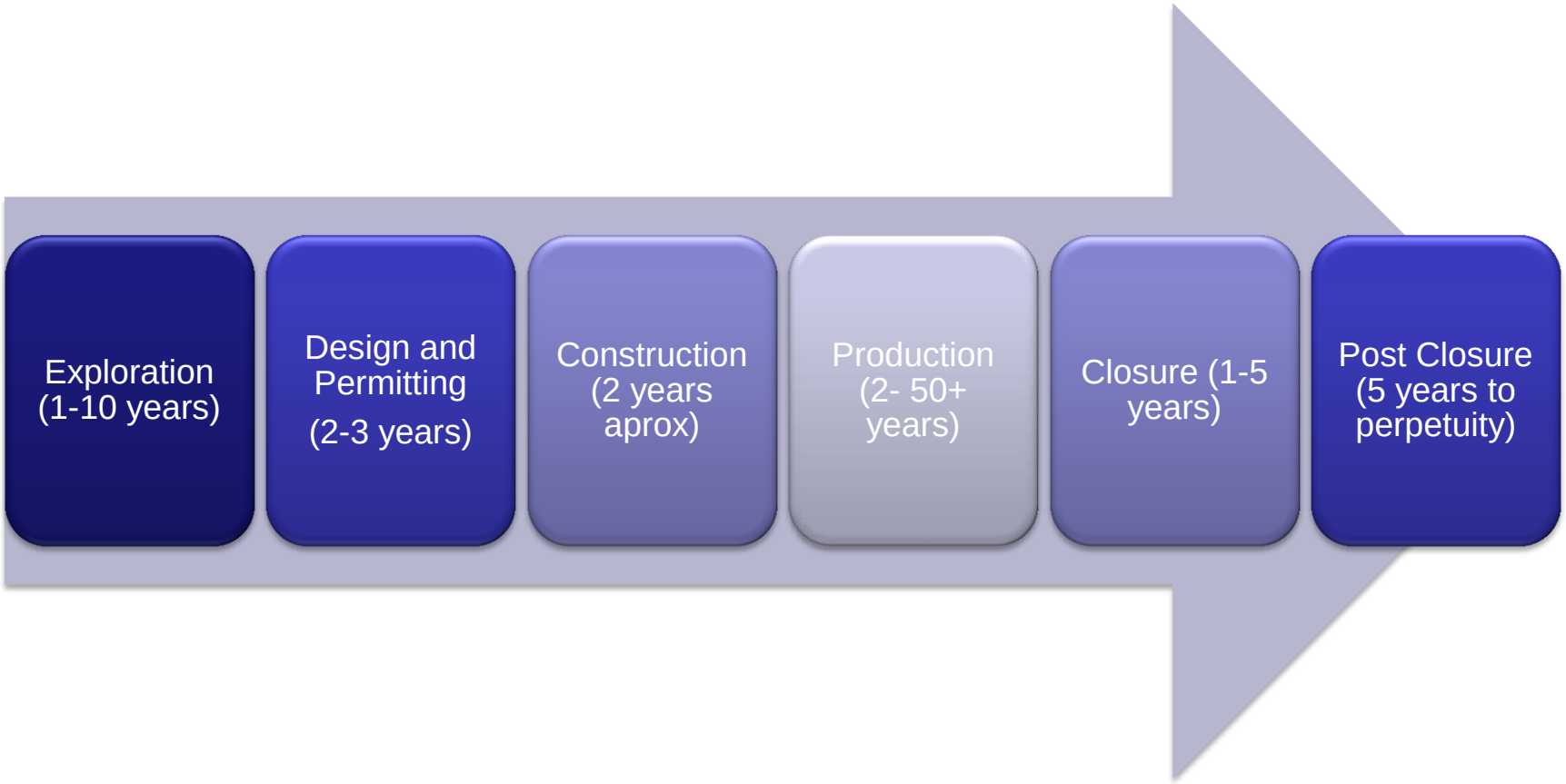
Typical Mine Life Cycle



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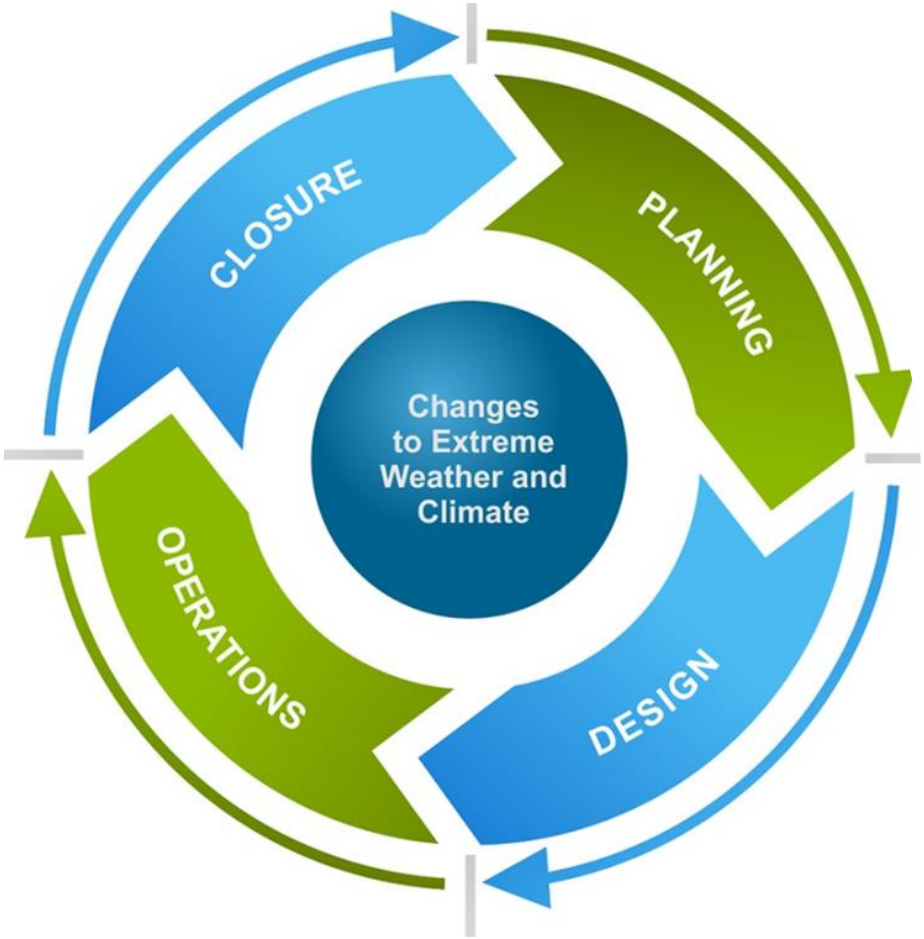
Incorporating Climate Change into Project Life Cycle

- 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



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Assessment Reports

- Provide current state of knowledge on climate change

1990

1995

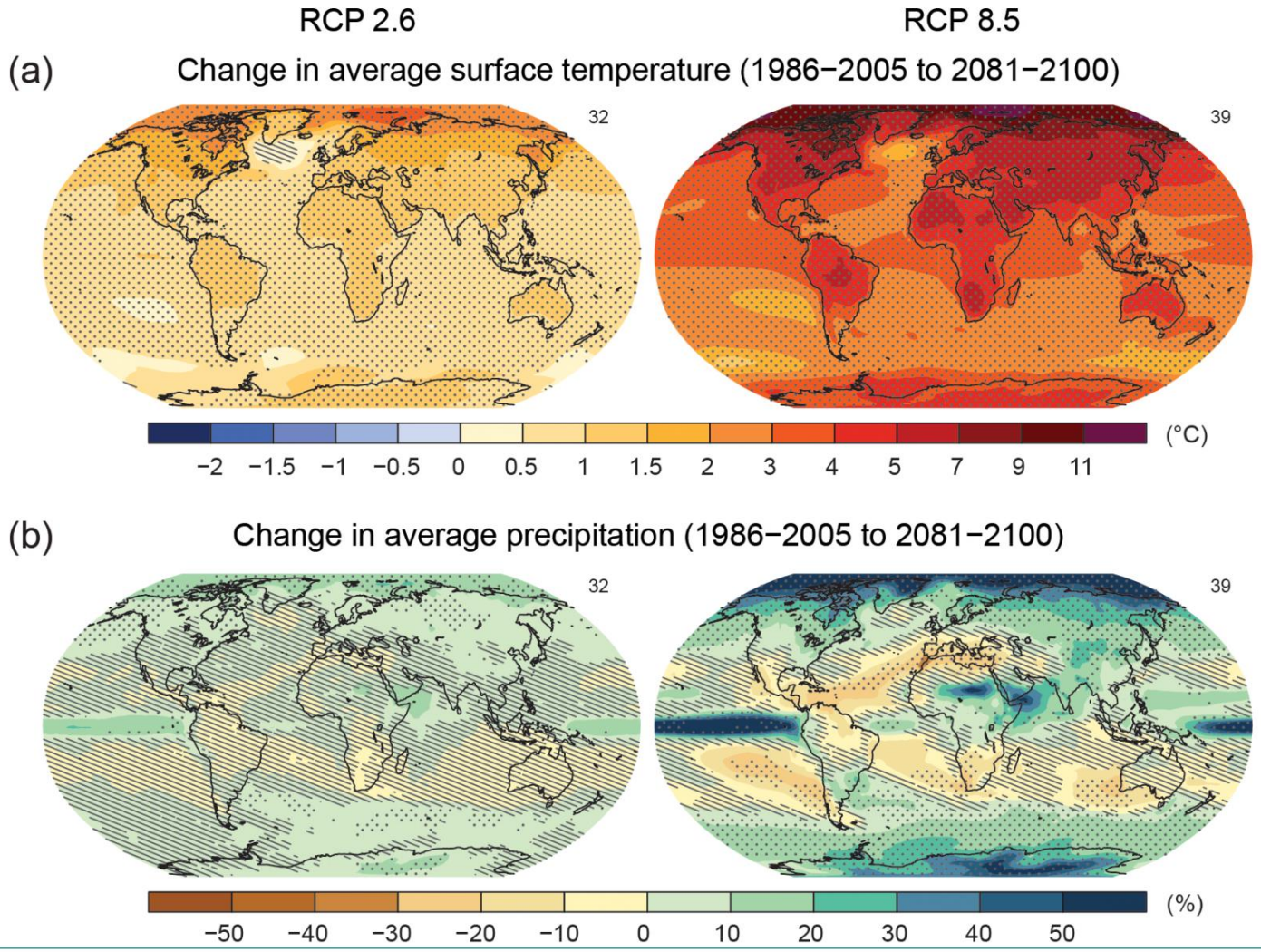
2001

2007

- 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/

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.

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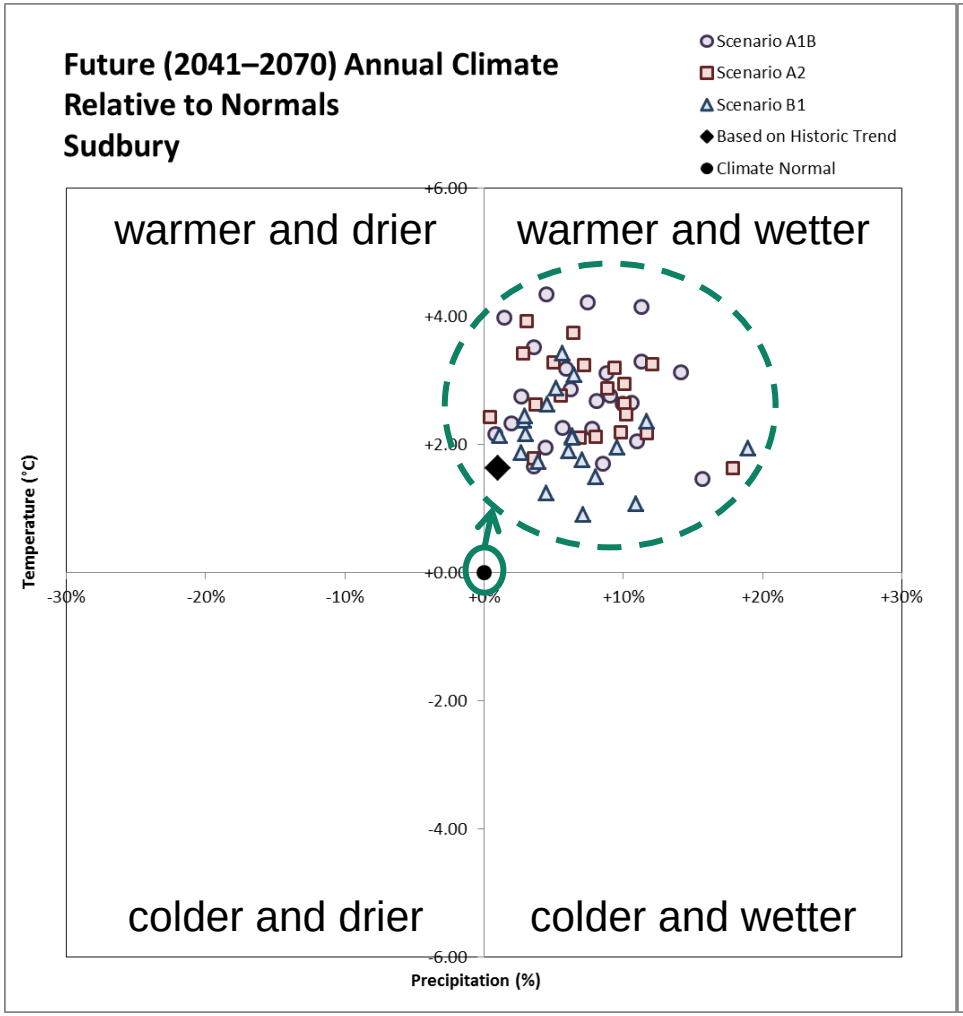
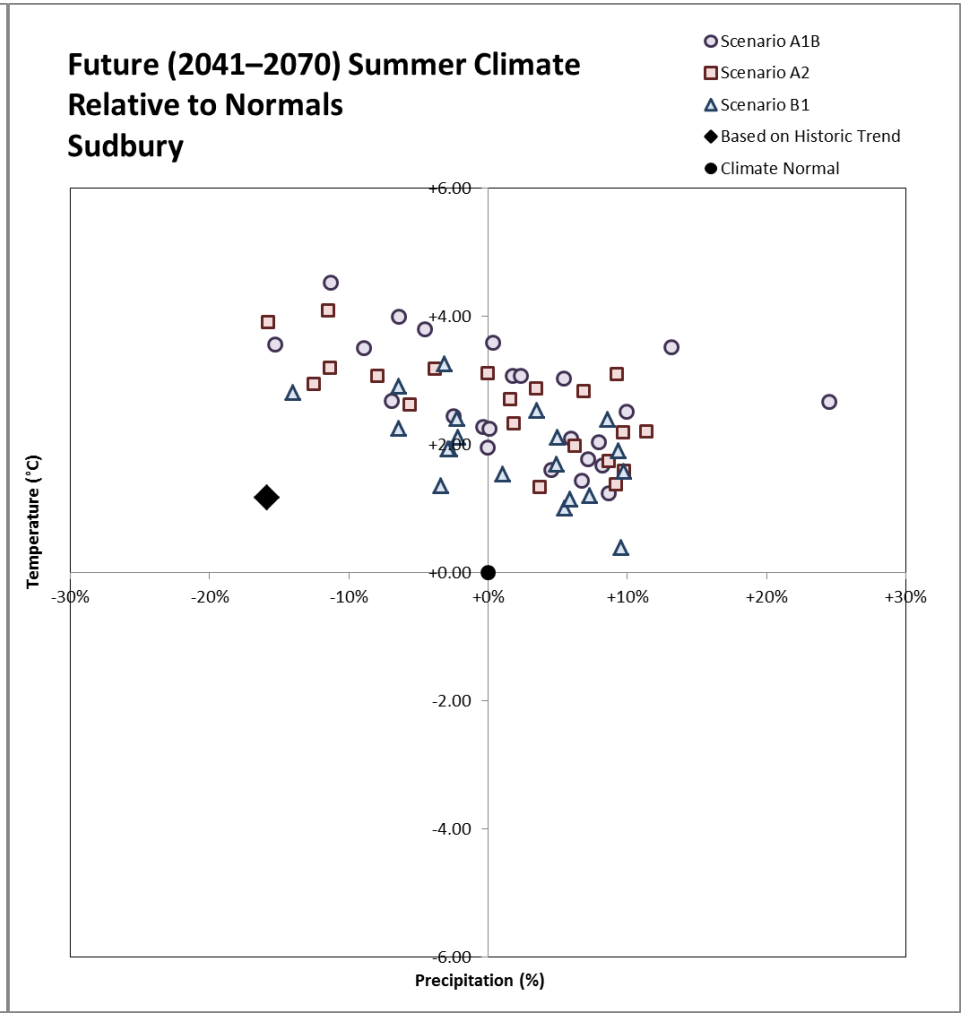
Future Climate: Scatterplot





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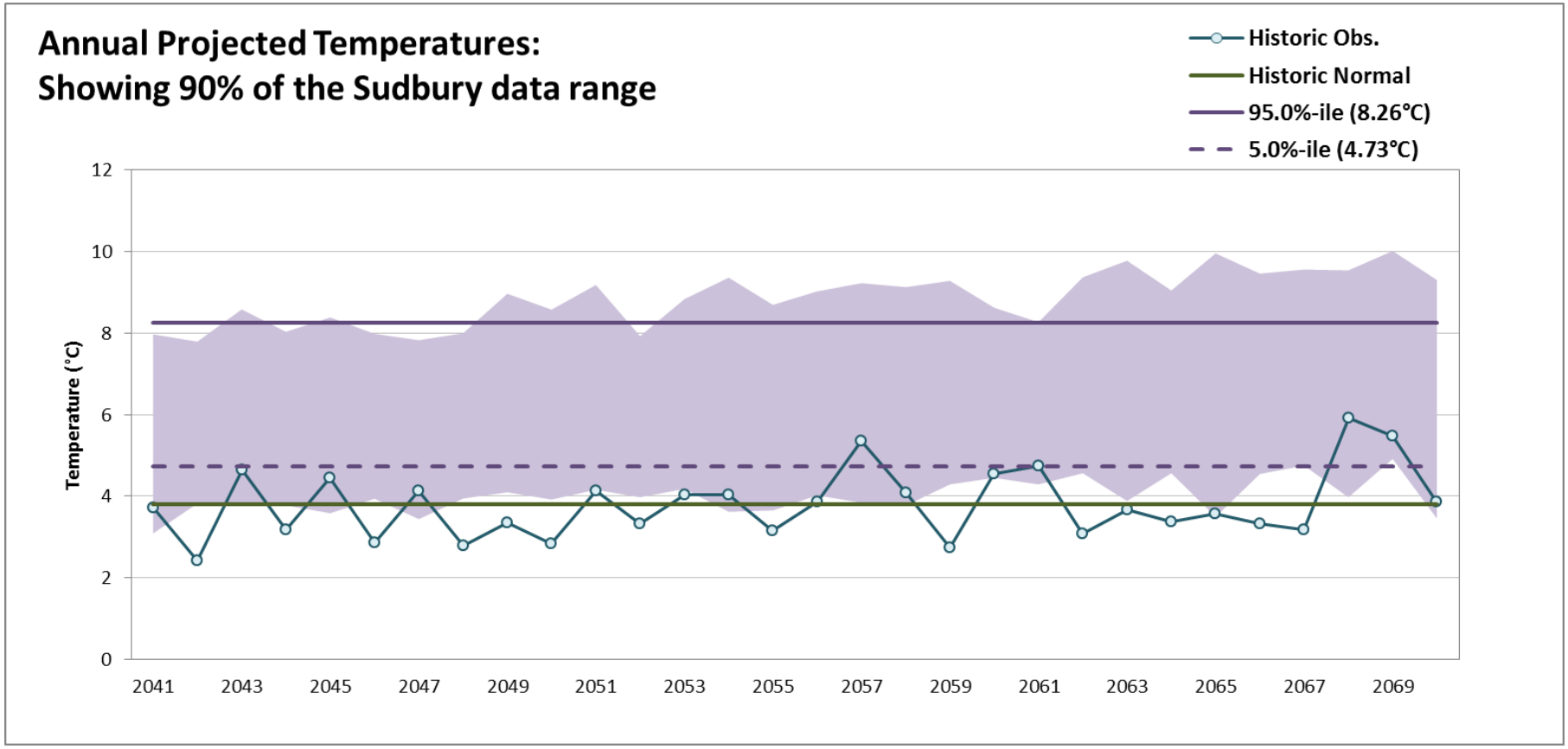
Future Climate: Cloud Graph



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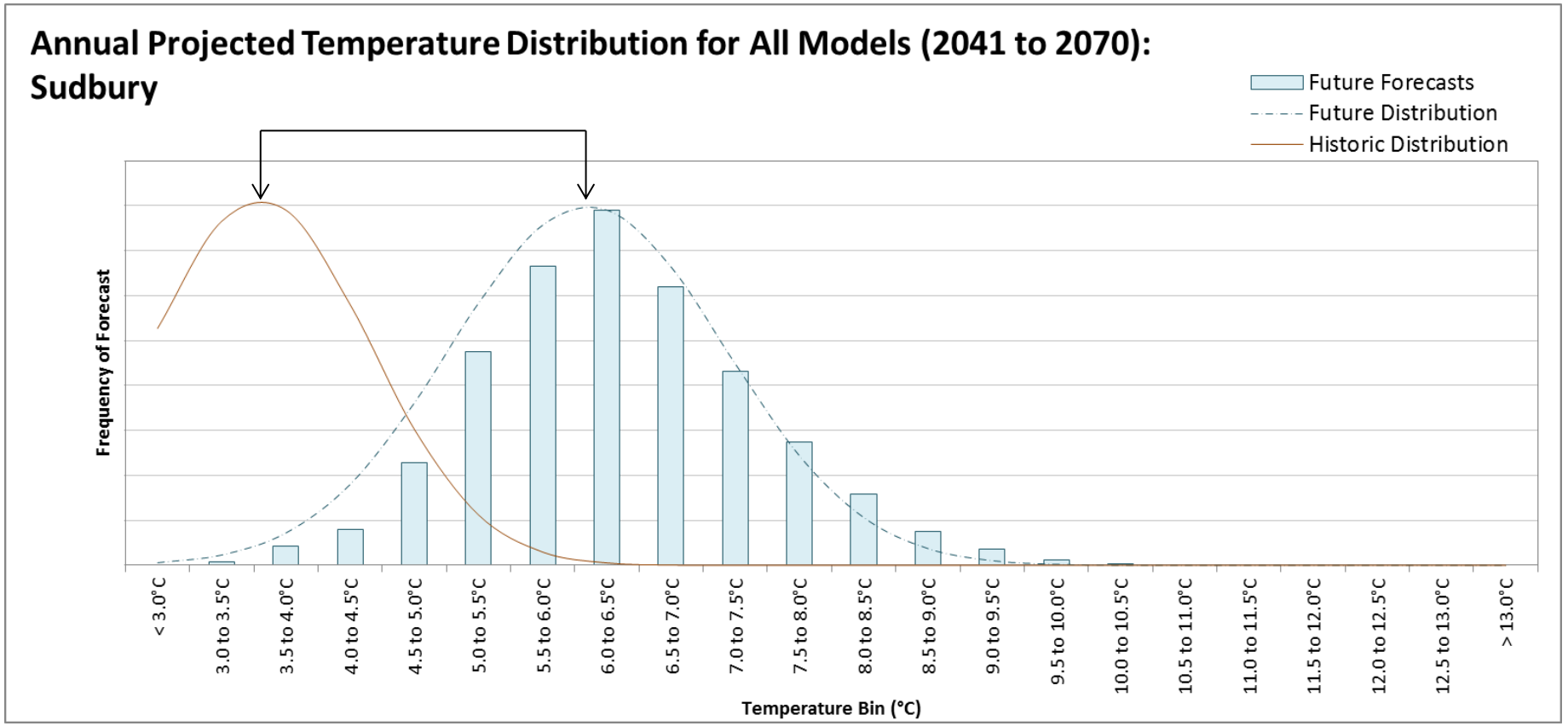
Future Climate: Histogram



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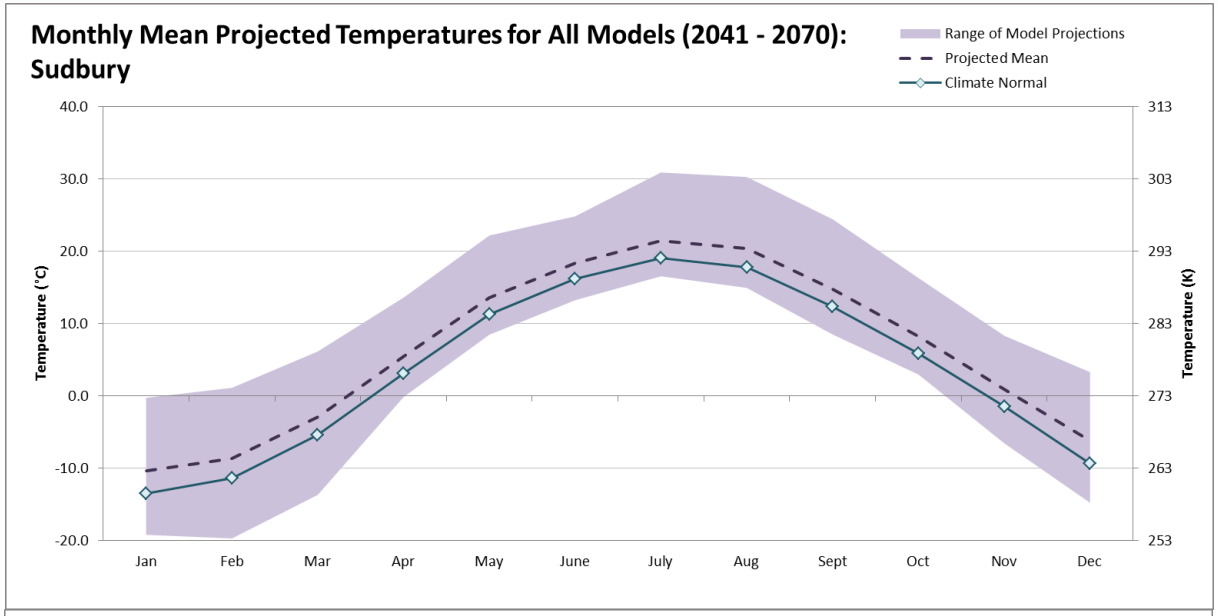
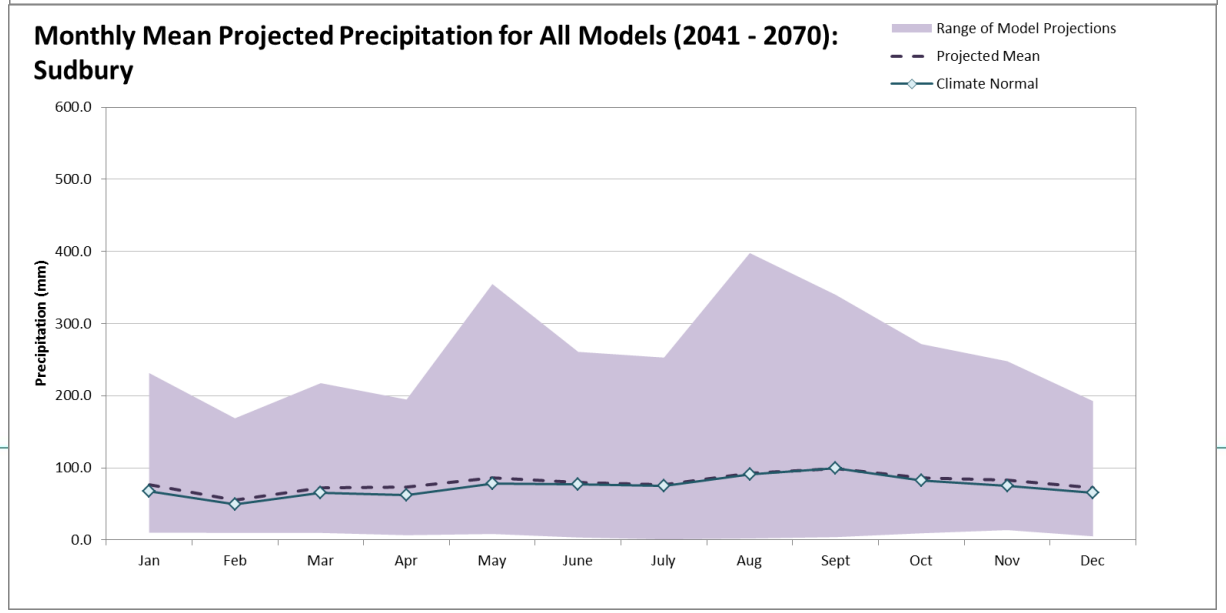
Future Climate: Monthly Analysis





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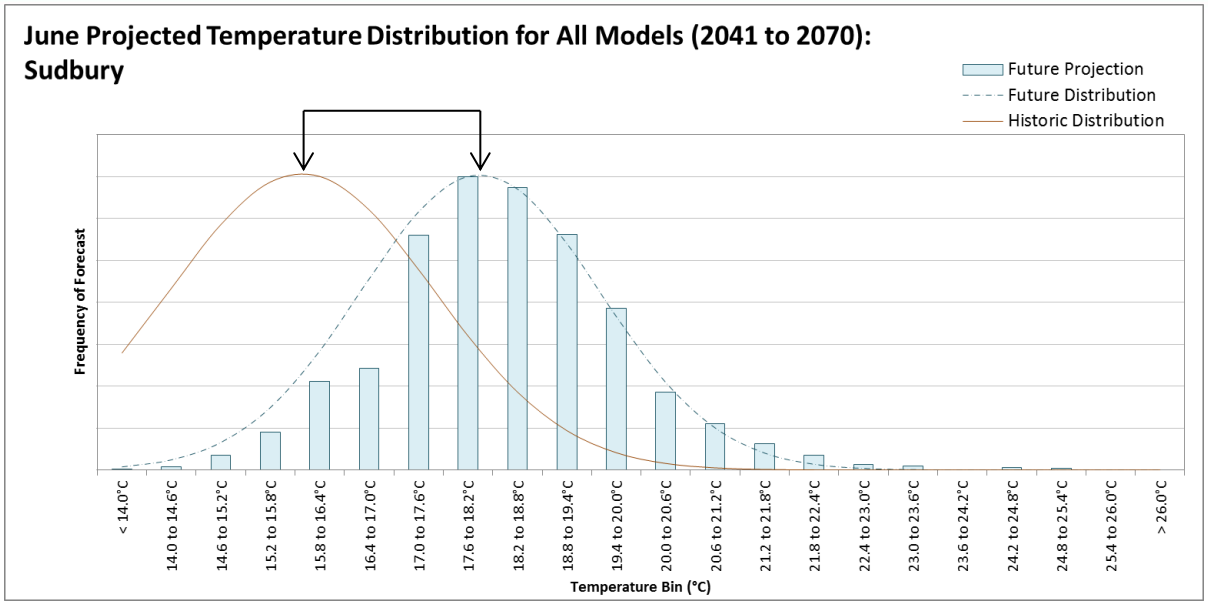
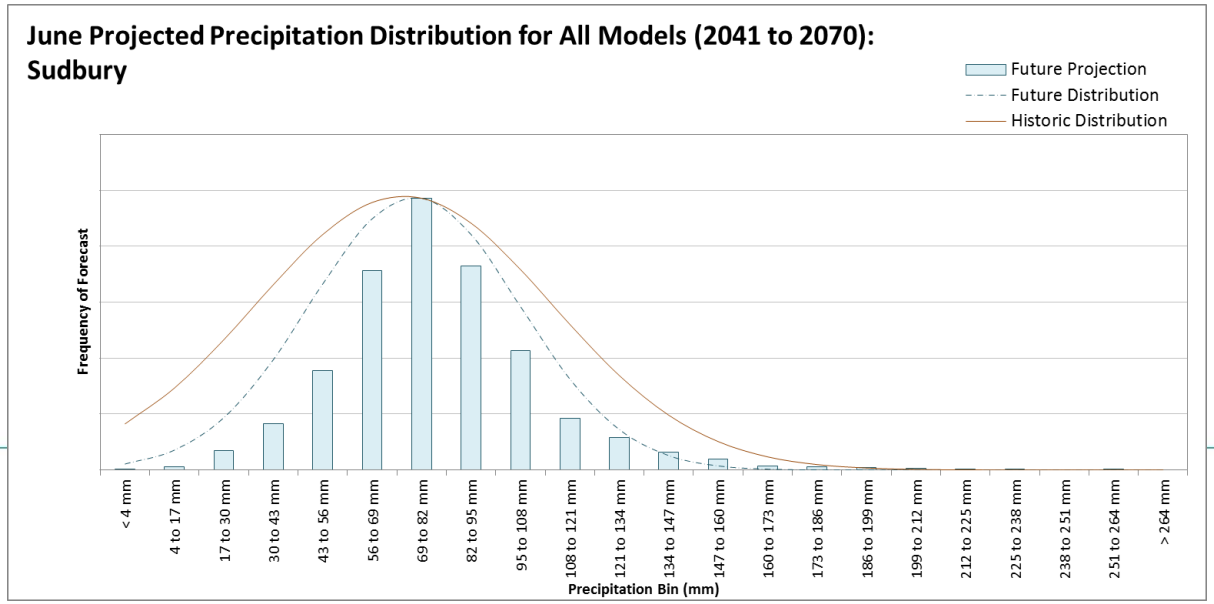
Future Climate: Monthly Analysis





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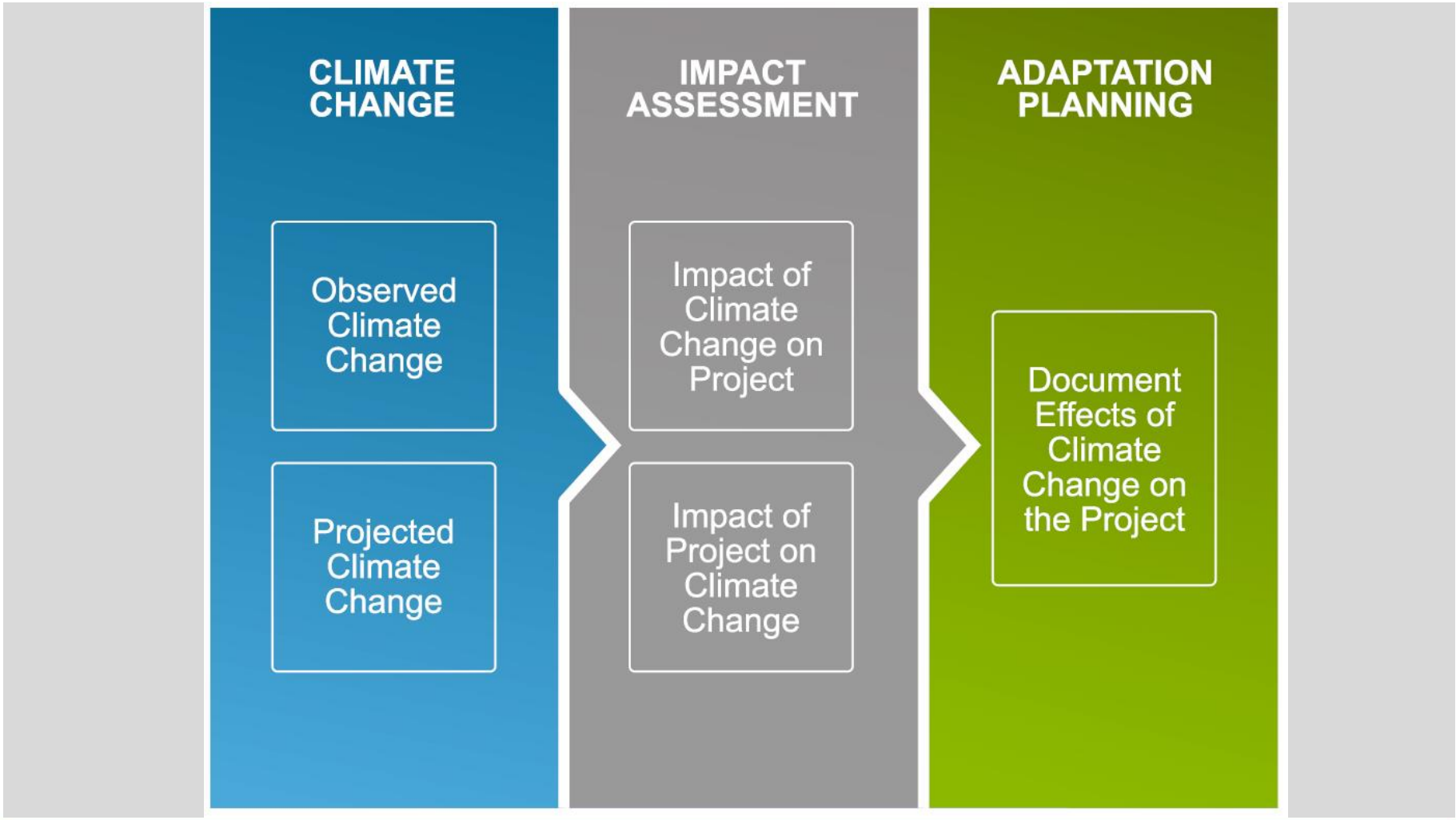
Planning and Design



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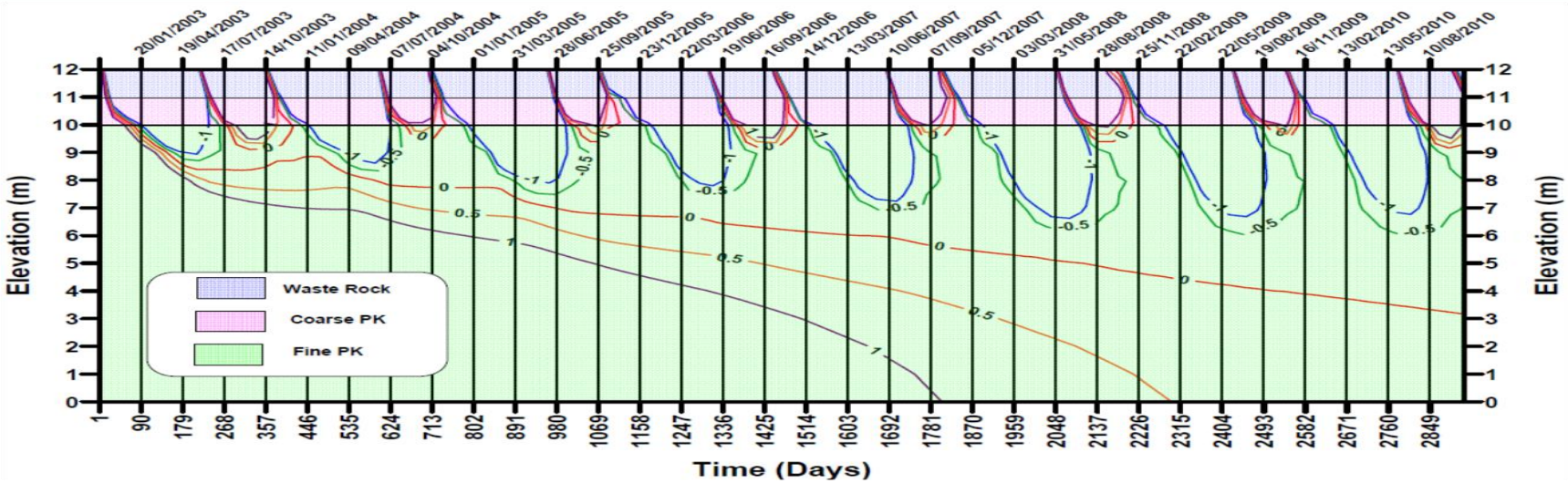
Canadian Environmental Assessment Agency

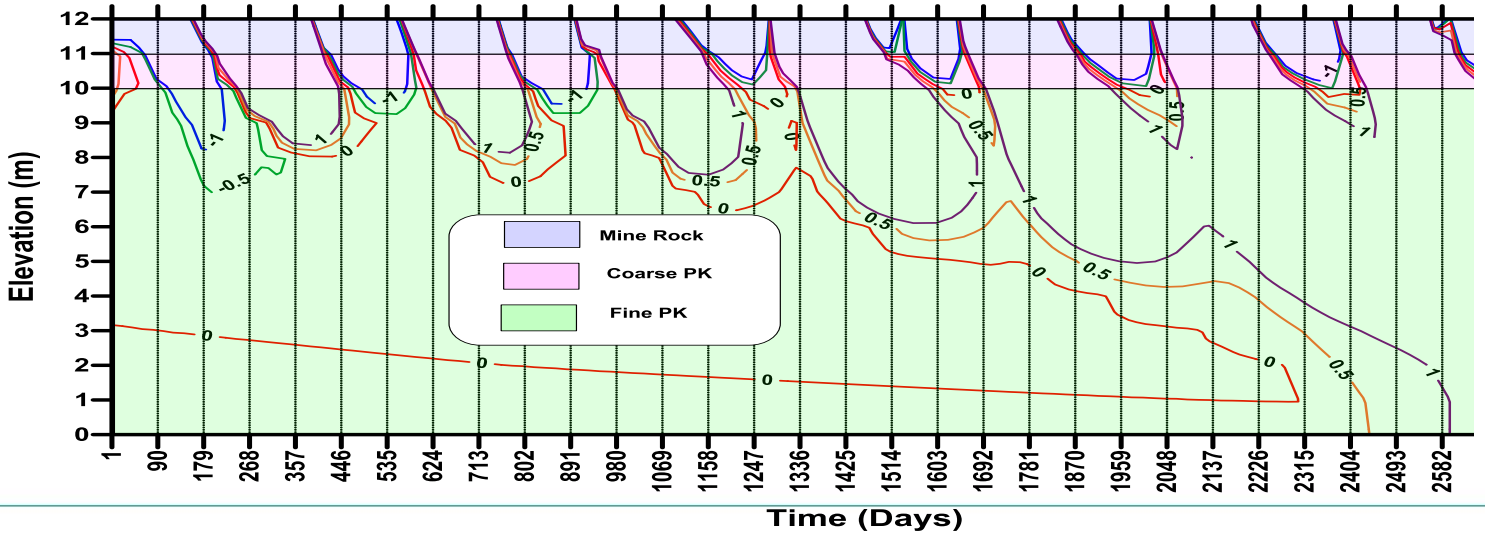
- Federal agency that overseas the review and approval of ESIA in Canada
- Typically requires an assessment of:
  - Effect of the project on GHG emissions
  - Effect of a changing environment on the project
- OCCIAR Report identified approximately 40 mining projects since 2004 for review as part of the study

Case Study: Meliadine Mine, Rankin Inlet, NU, Canada

- Meliadine gold project is one of Agnico Eagle's largest gold projects in terms of reserves and resources
- Golder completed a ESIA in 2013
- Climate Change impact assessment was an important Technical Supporting Document
- Hearings held in Nunavut in 2014

Case Study: Permafrost in waste rock piles





Simulation illustrating differences in the thermal regime inside waste rock piles under a +7°C temperature increase by 2071-2099.

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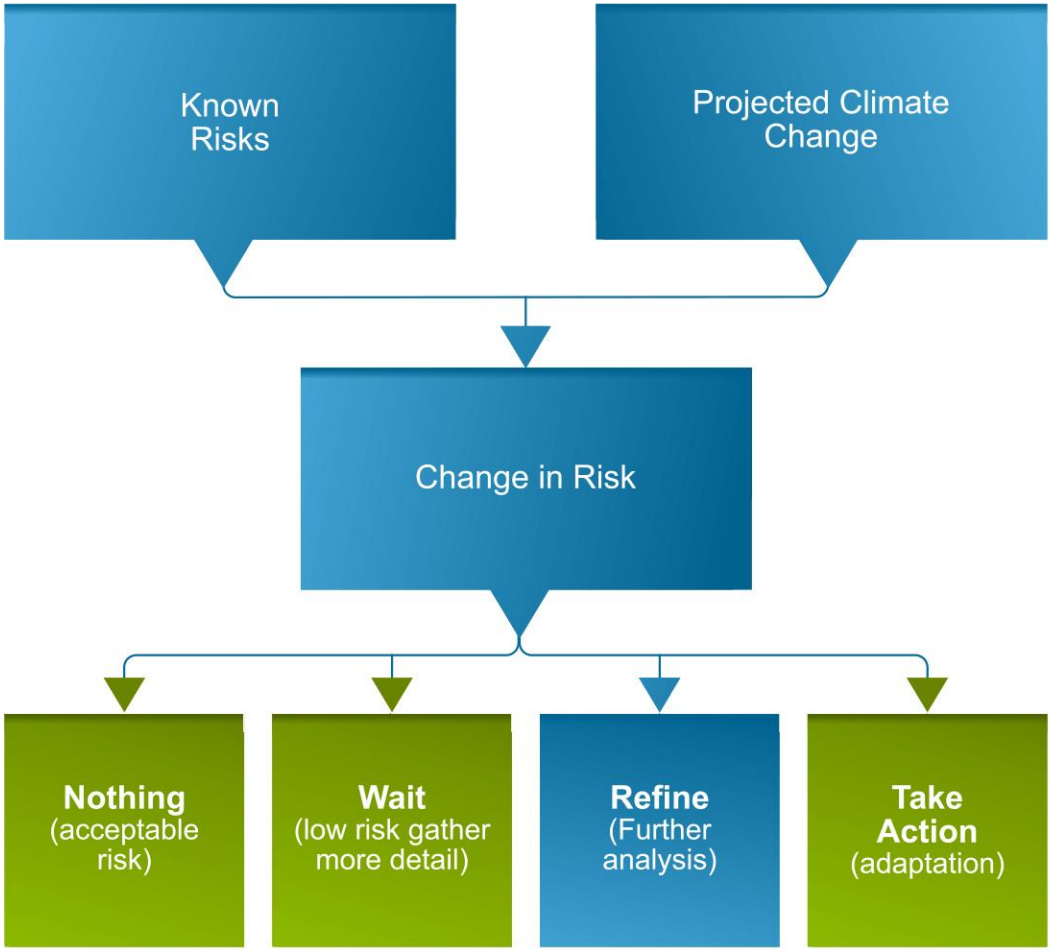
Operations and Closure



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

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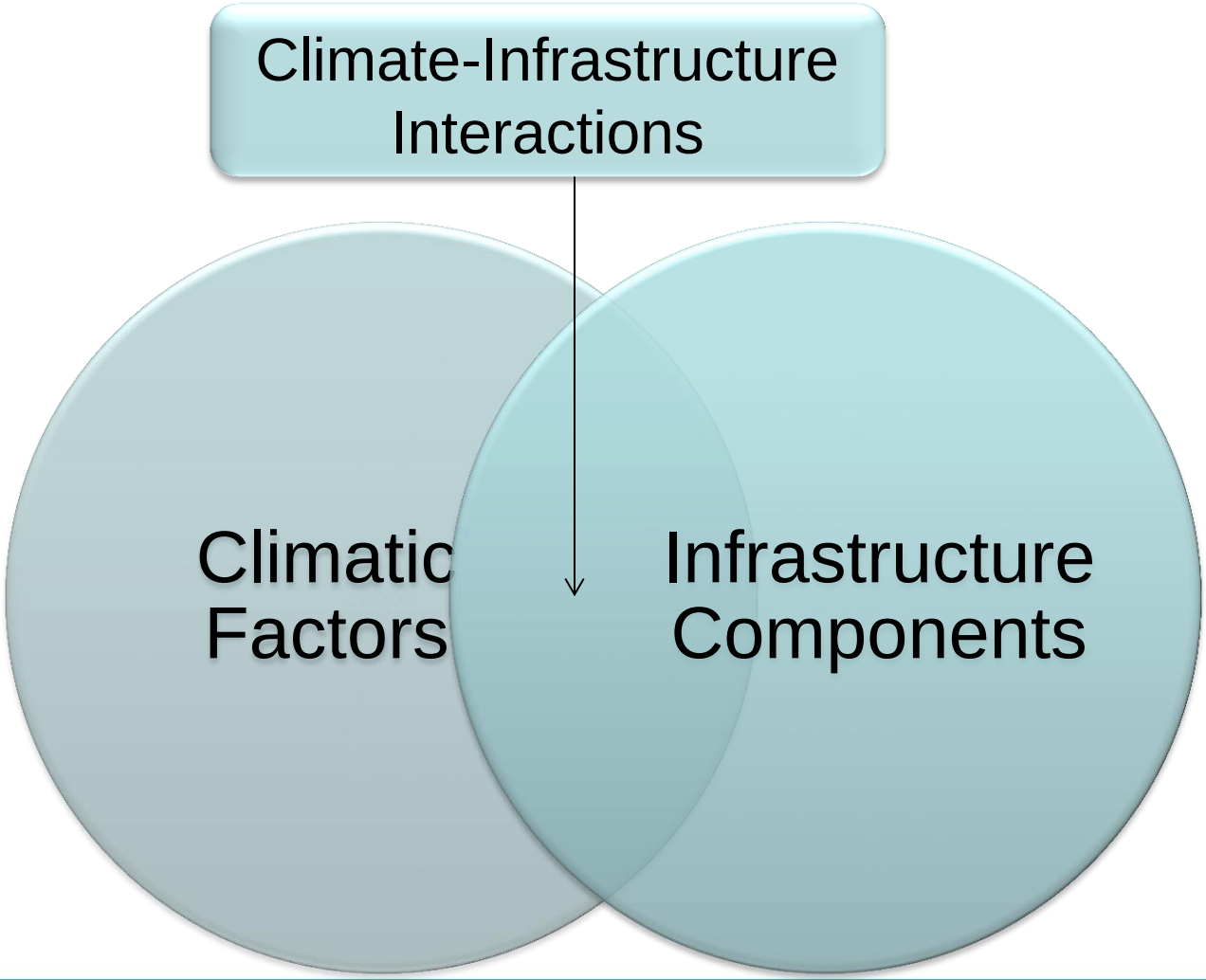
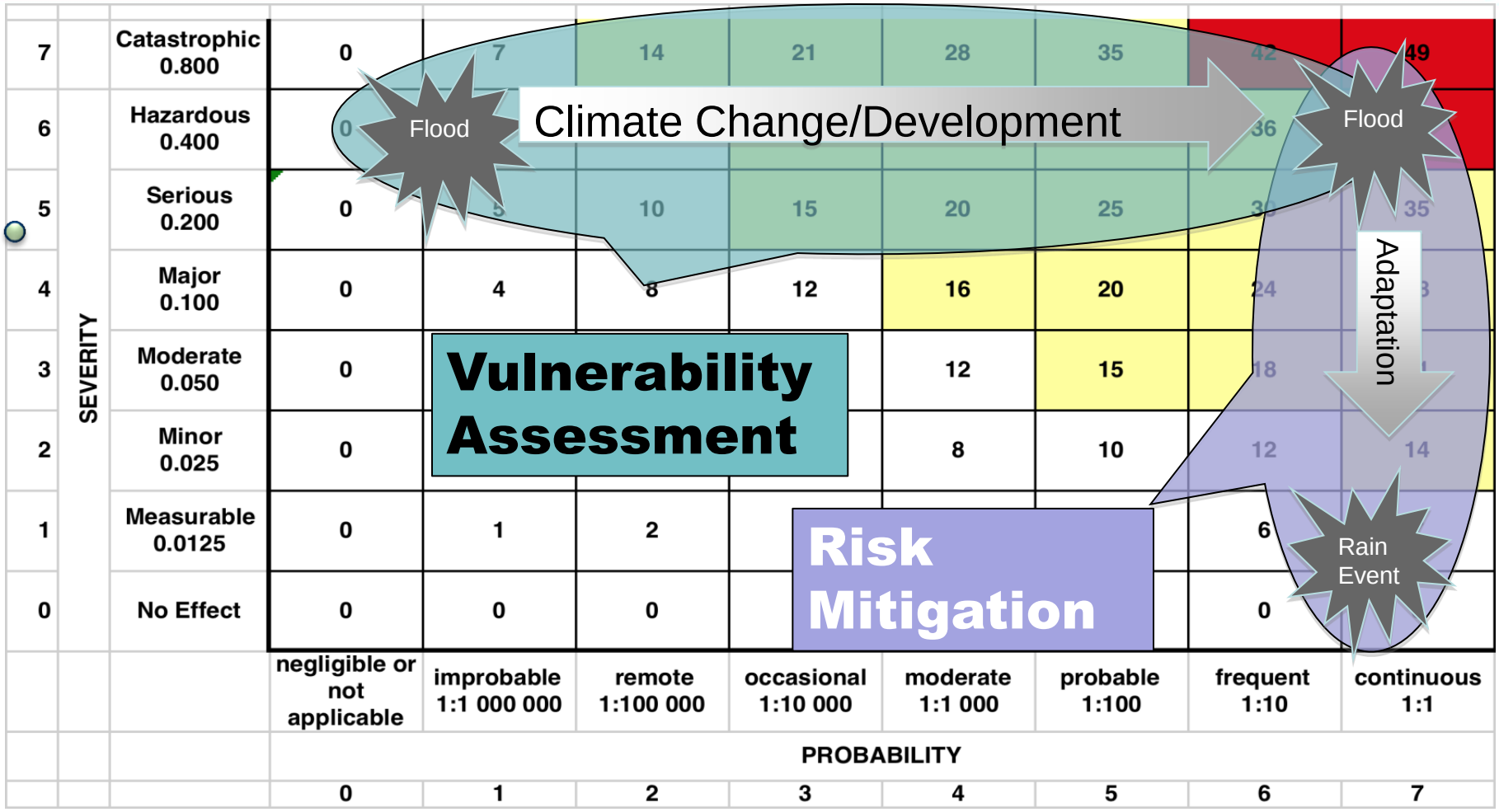
Vulnerability Assessment Goals

- 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



7	SEVERITY	Catastrophic 0.800	0	7	14	21	28	35	42	49
6		Hazardous 0.400	0	6	12	18	24	30	36	42
5		Serious 0.200	0	5	10	15	20	25	30	35
4		Major 0.100	0	4	8	12	16	20	24	28
3		Moderate 0.050	0	3	6	9	12	15	18	21
2		Minor 0.025	0	2	4	6	8	10	12	14
1		Measurable 0.0125	0	1	2	3	4	5	6	7
0		No Effect	0	0	0	0	0	0	0	0
			negligible or not applicable	improbable 1:1 000 000	remote 1:100 000	occasional 1:10 000	moderate 1:1 000	probable 1:100	frequent 1:10	continuous 1:1
			PROBABILITY							
			0	1	2	3	4	5	6	7

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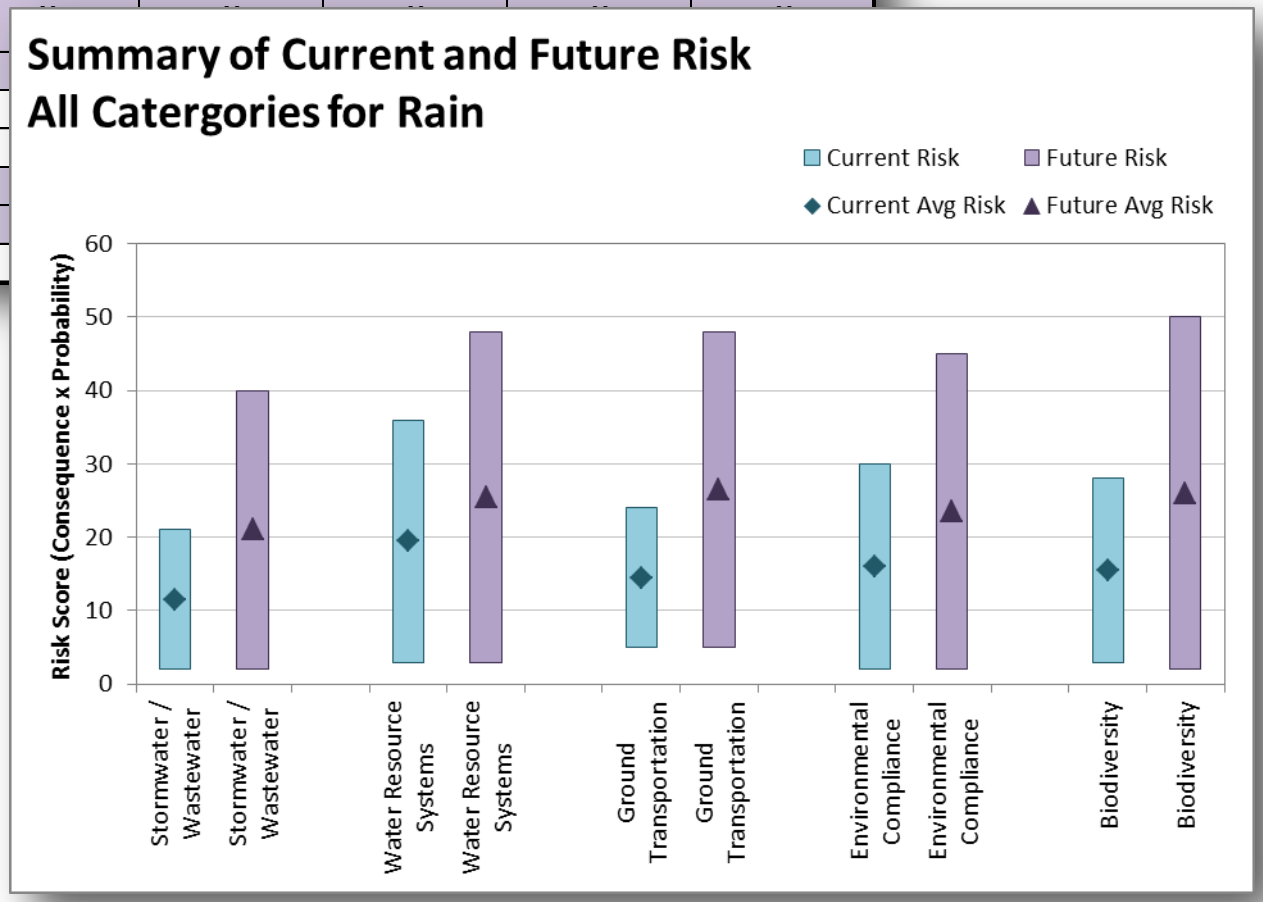
Vulnerability Assessment Studies

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					



$$R = C \times P$$

R = Risk
C = Consequence
P = Probability

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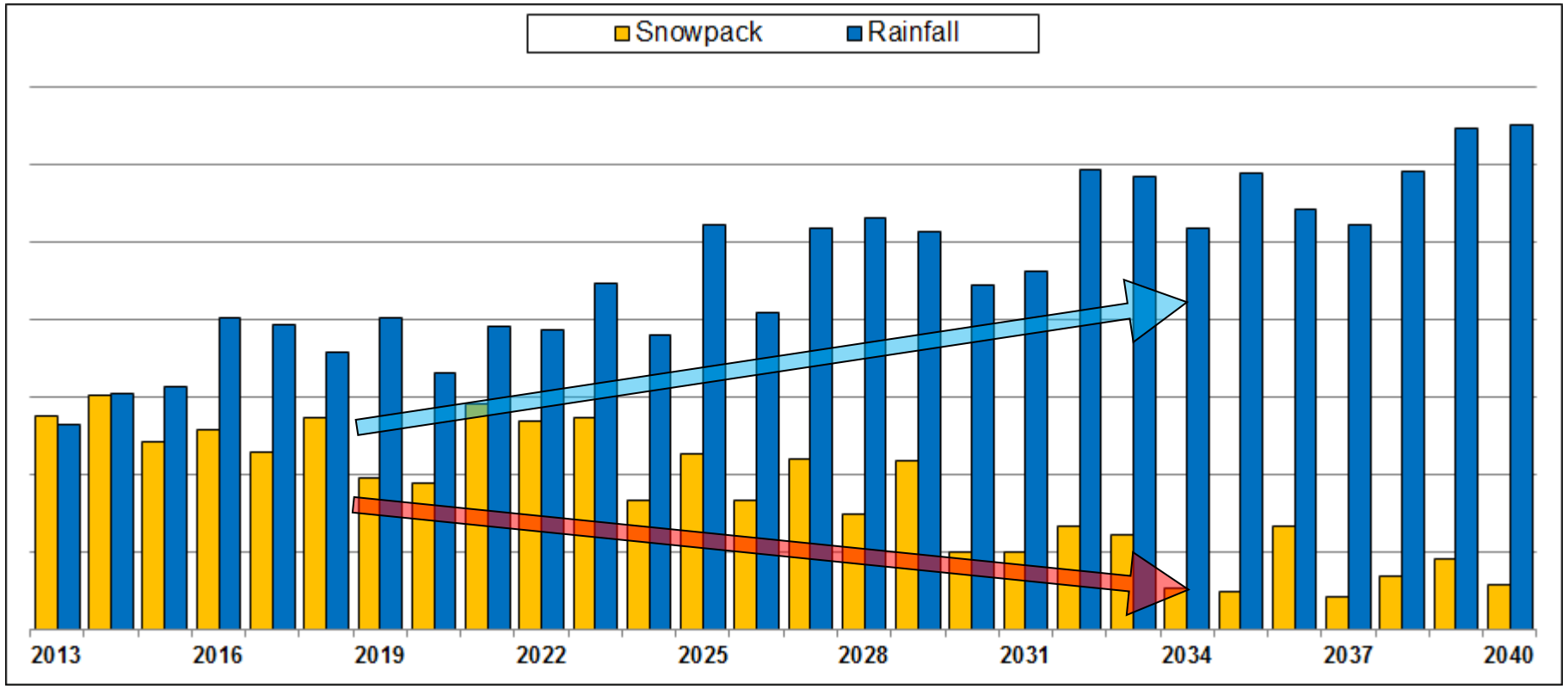
Sudbury INO – Water Balance

- 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

Applications Model: Adding Climate Change

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

Develop Designs Accordingly



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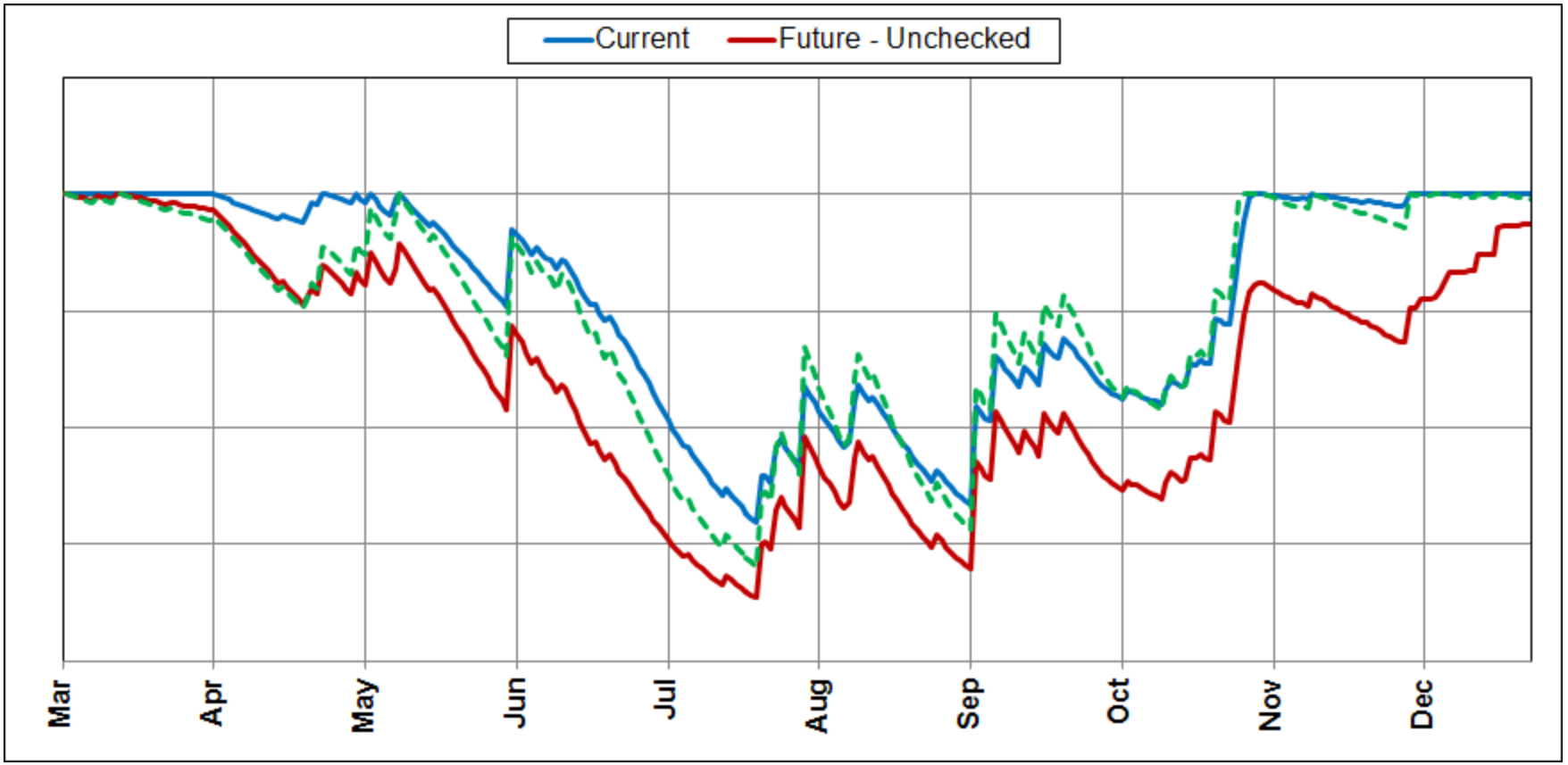
Applications Model: Gauging Effectiveness of Adaptation

Increased Evaporation may Extend Annual Dry Periods

Plan for New Patterns



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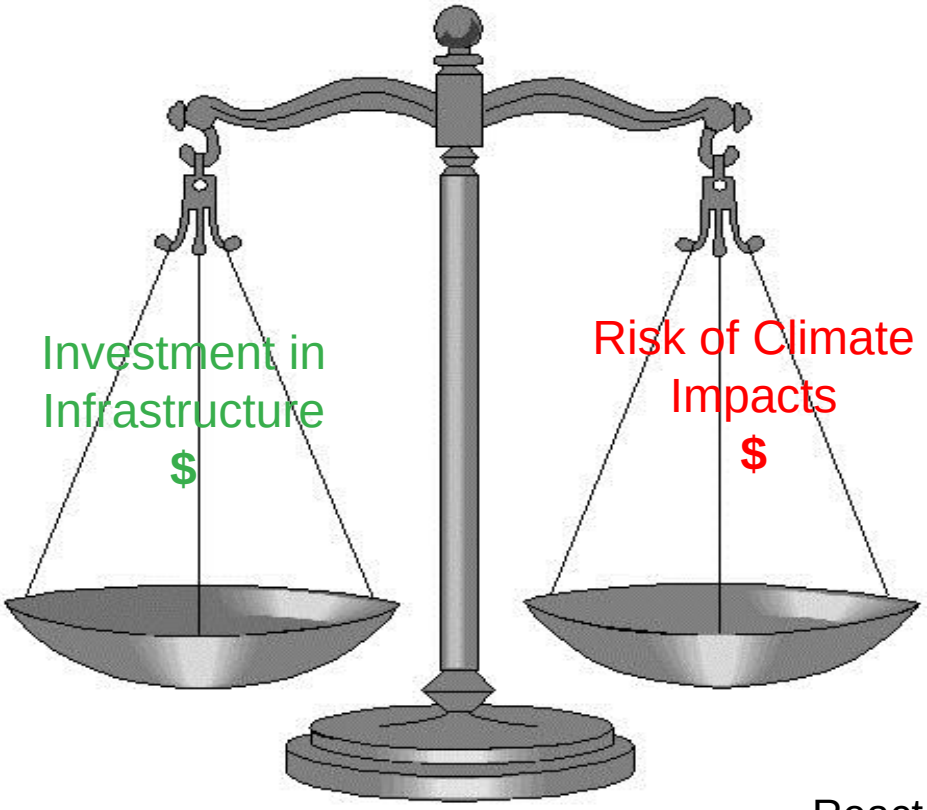
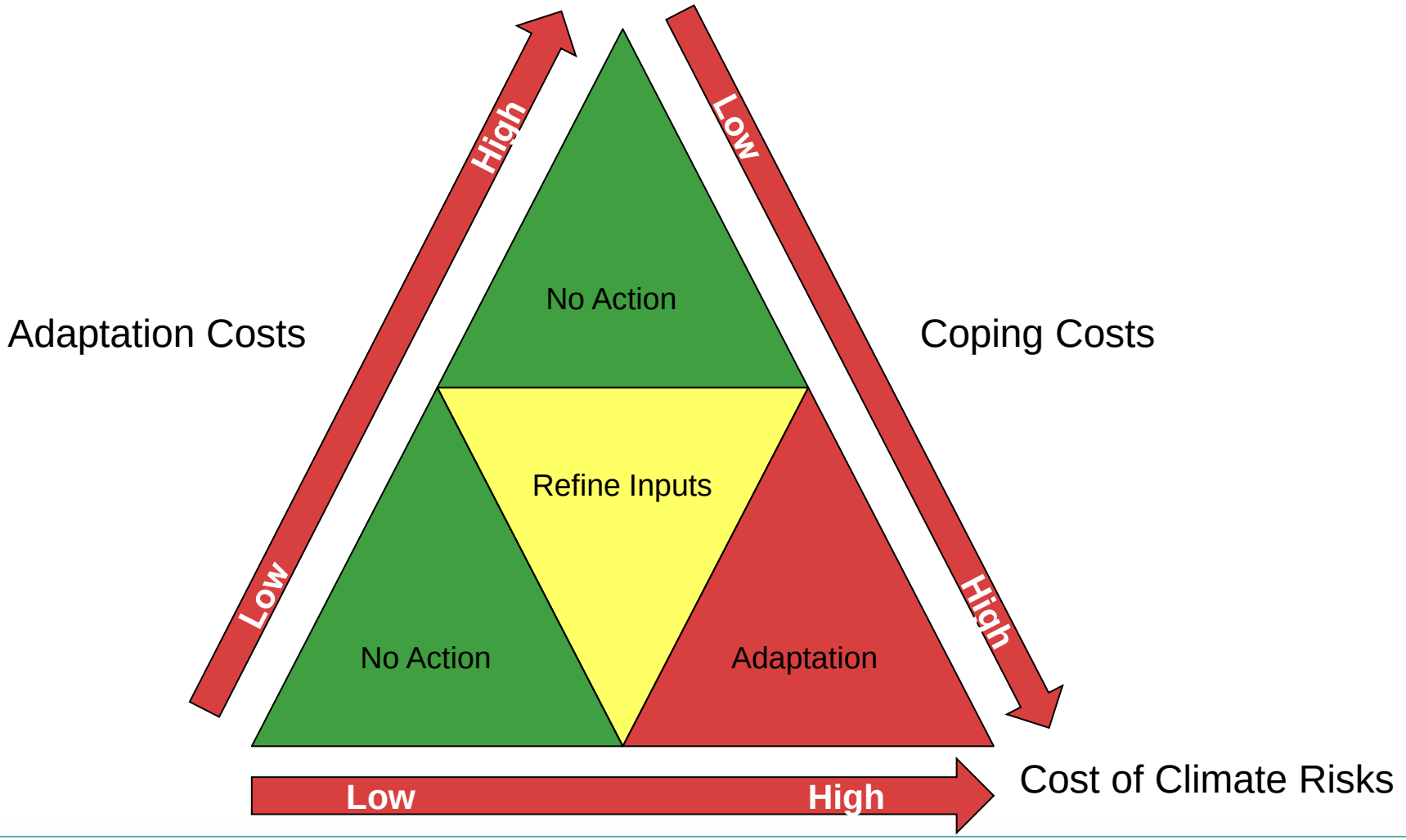
Economic Models



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)

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%

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Moving Forward

- Climate Change Impact Assessments should:
  - Clearly document both baseline and future climate projections that will be used in the assessment
  - Use a multi model and multiple concentration pathways analysis to describe the range and uncertainties of the future climate projections
  - Clearly identify the Valued Components and climate interactions that are to be considered in the assessment
  - Document the significance assessment for the identified interactions
  - Identify the proposed design features or adaptation measures (mitigation measures) that are proposed
  - Better document Adaptive Management Strategies between coping and adaptation

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