Assessing the Risks of Climate Change on Solid Waste Infrastructure Using the PIEVC Process

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PIEVC CVIIP

PIEVC is a structured method for assessing and reporting vulnerability of infrastructure, buildings to climate risks.

Since 2008, **PIEVC** has assessed climate risks and vulnerabilities across a wide range of infrastructure systems in Canada including: buildings (residential, commercial and institutional); storm water/wastewater systems, roads and associated structures (e.g. bridges and culverts), water supply and management systems, electricity distribution, airport infrastructure and **Solid Waste Facilities.**

PIEVC is freely available, at no charge, for public infrastructure in Canada.
pievc.ca

PIEVC CVIIP

The Public Infrastructure Engineering Vulnerability Committee (**PIEVC**) was created in August 2005 to conduct an engineering assessment of the vulnerability of Canada's public infrastructure to the impacts of climate change. Between August 2005 and June 2012 the committee's activities were co-funded by Natural Resources Canada (NRCan) and Engineers Canada.

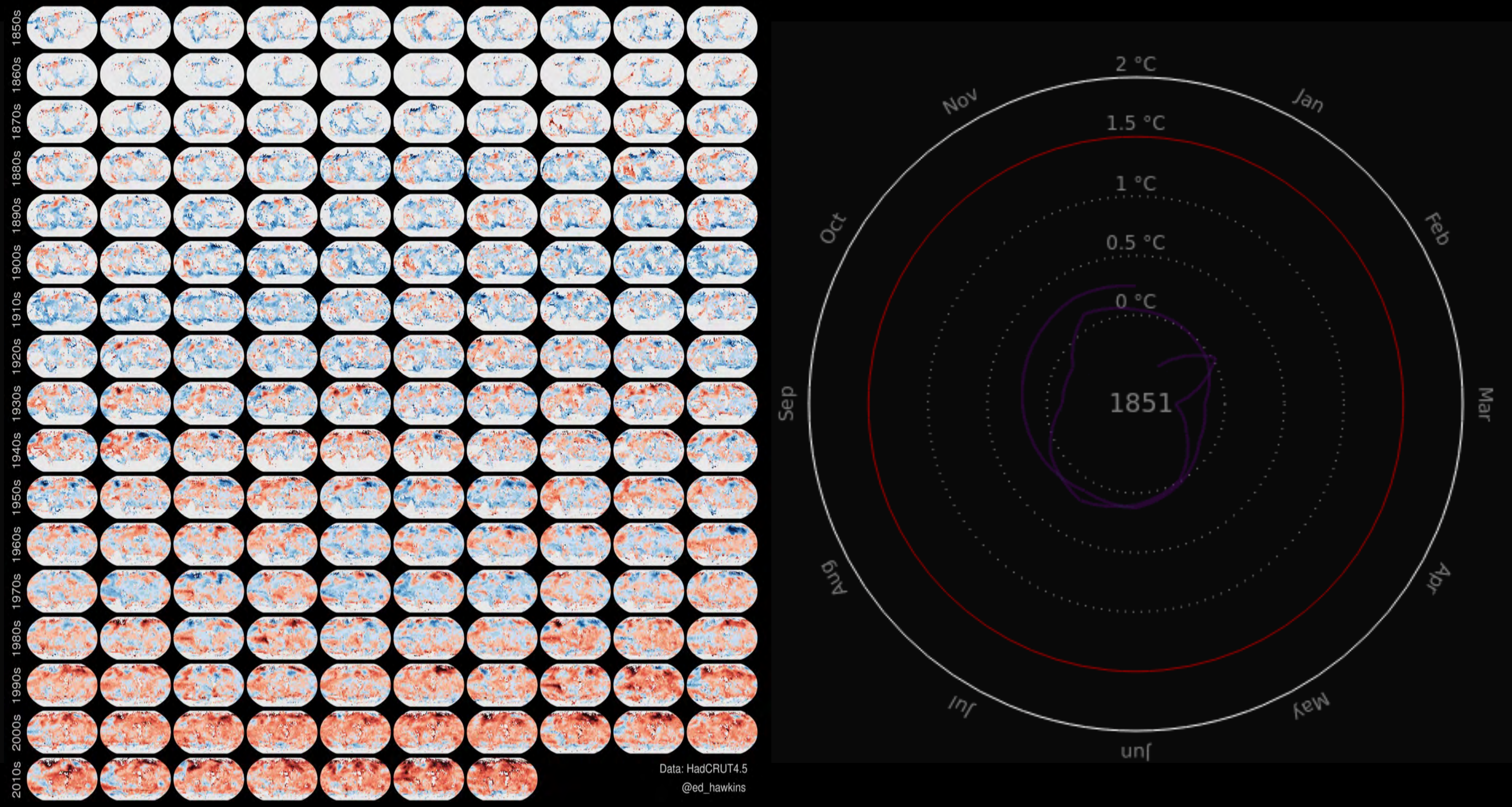
In 2020, operations of the PIEVC Protocol and PIEVC Program have been assumed by the PIEVC Program Alliance, consisting of the Institute for Catastrophic Loss Reduction (**ICLR**), the Climate Risk Institute (**CRI**) and Deutsche Gesellschaft für Internationale Zusammenarbeit (**GIZ**) GmbH.

PIEVC CVIIP

Climate Change Resilience Assessment

Understanding impact of global climate change on Infrastructure allows you to reduce your local risks!

Impacts from extreme events and slow onset changes



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Data: HadCRUT4.5
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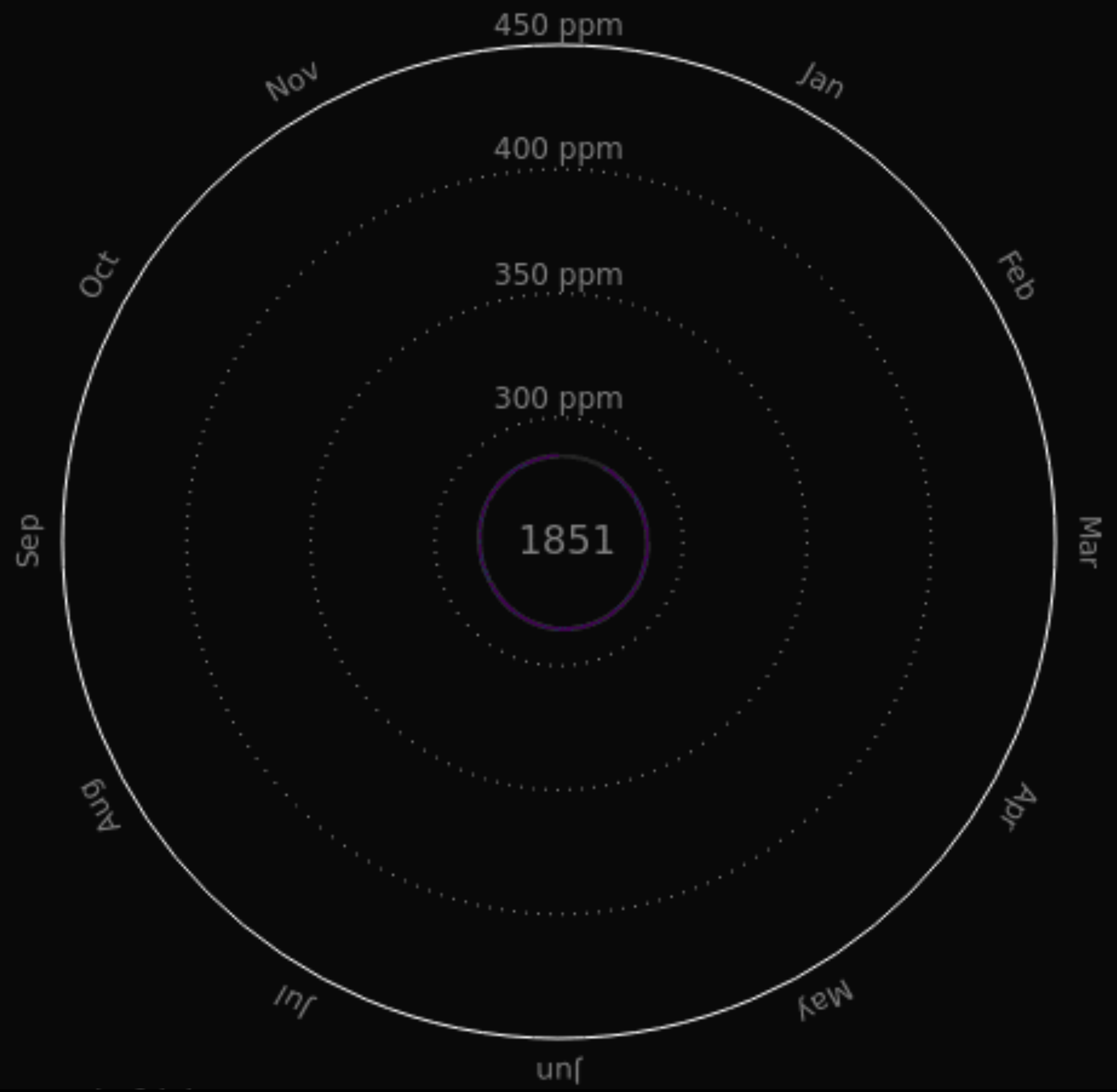
450 ppm
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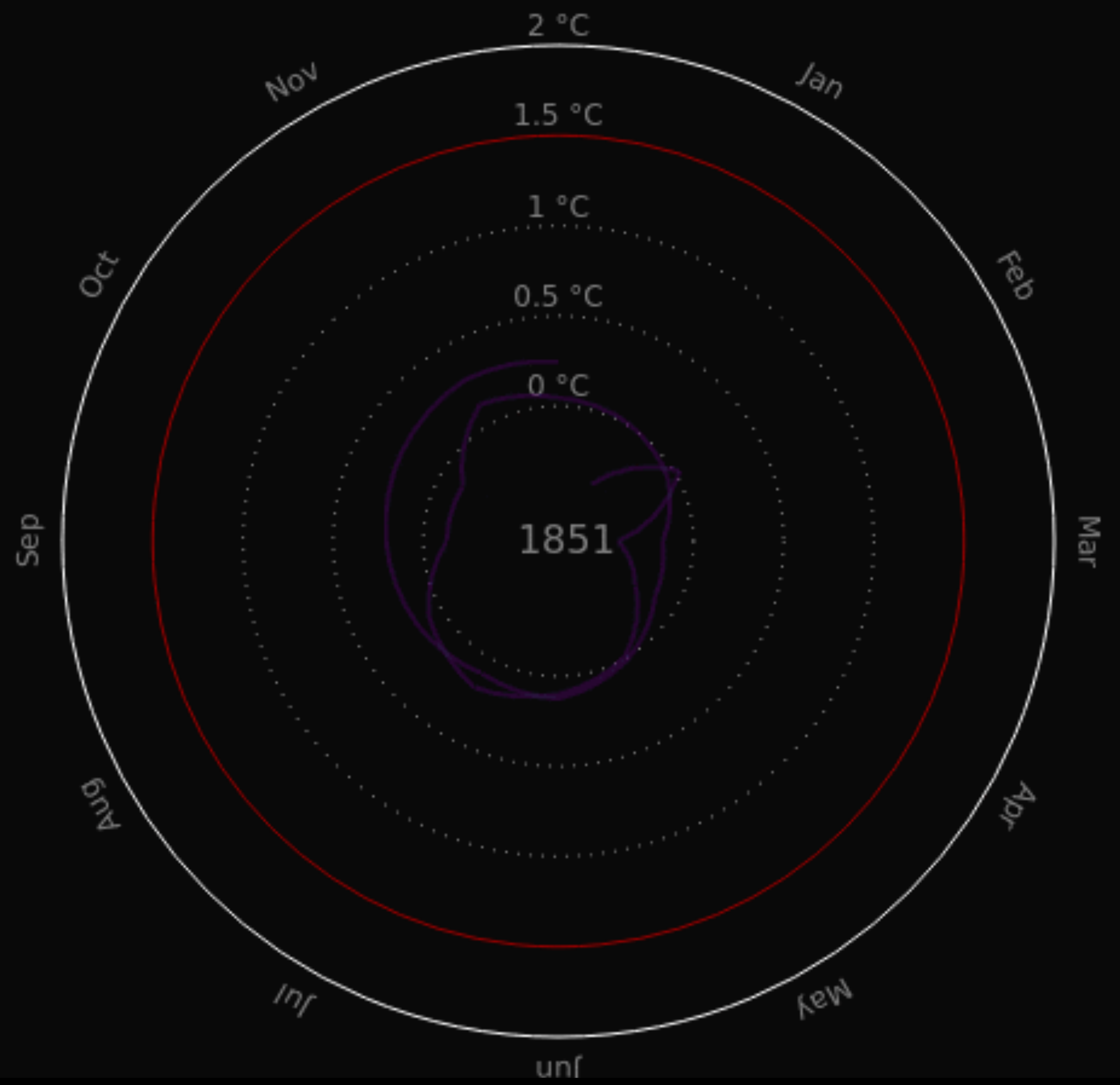
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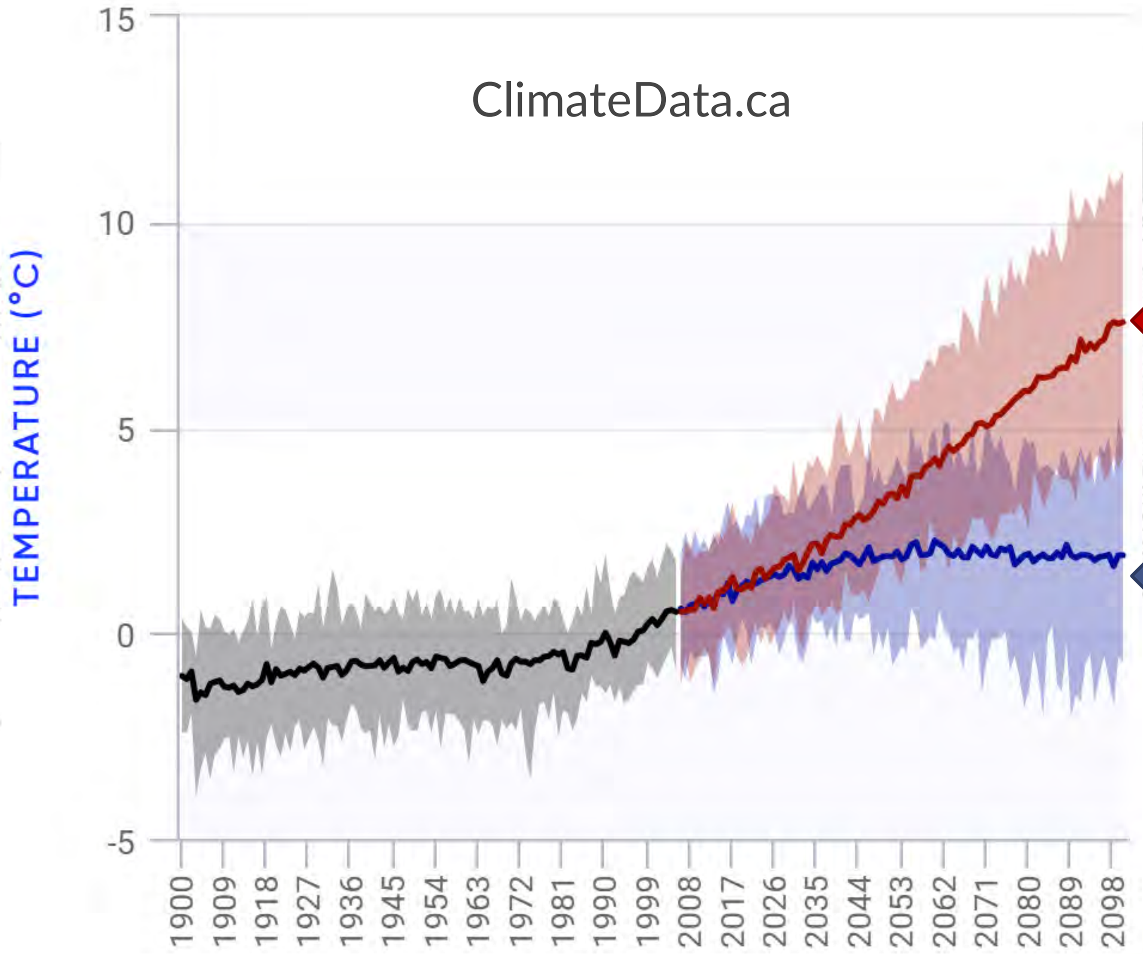
Emission Scenarios and Climate Projections



RCP 8.5 Representative Concentration Pathway 8.5
"A scenario of comparatively **high greenhouse gas emissions**"

RCP 2.6 Representative Concentration Pathway 2.6
"The scenario with the most **stringent climate policy**"

Shared Socio-Economic Pathways (SSPs) *further refine previous RCPs to also consider societal changes*

PIEVC CVIIP

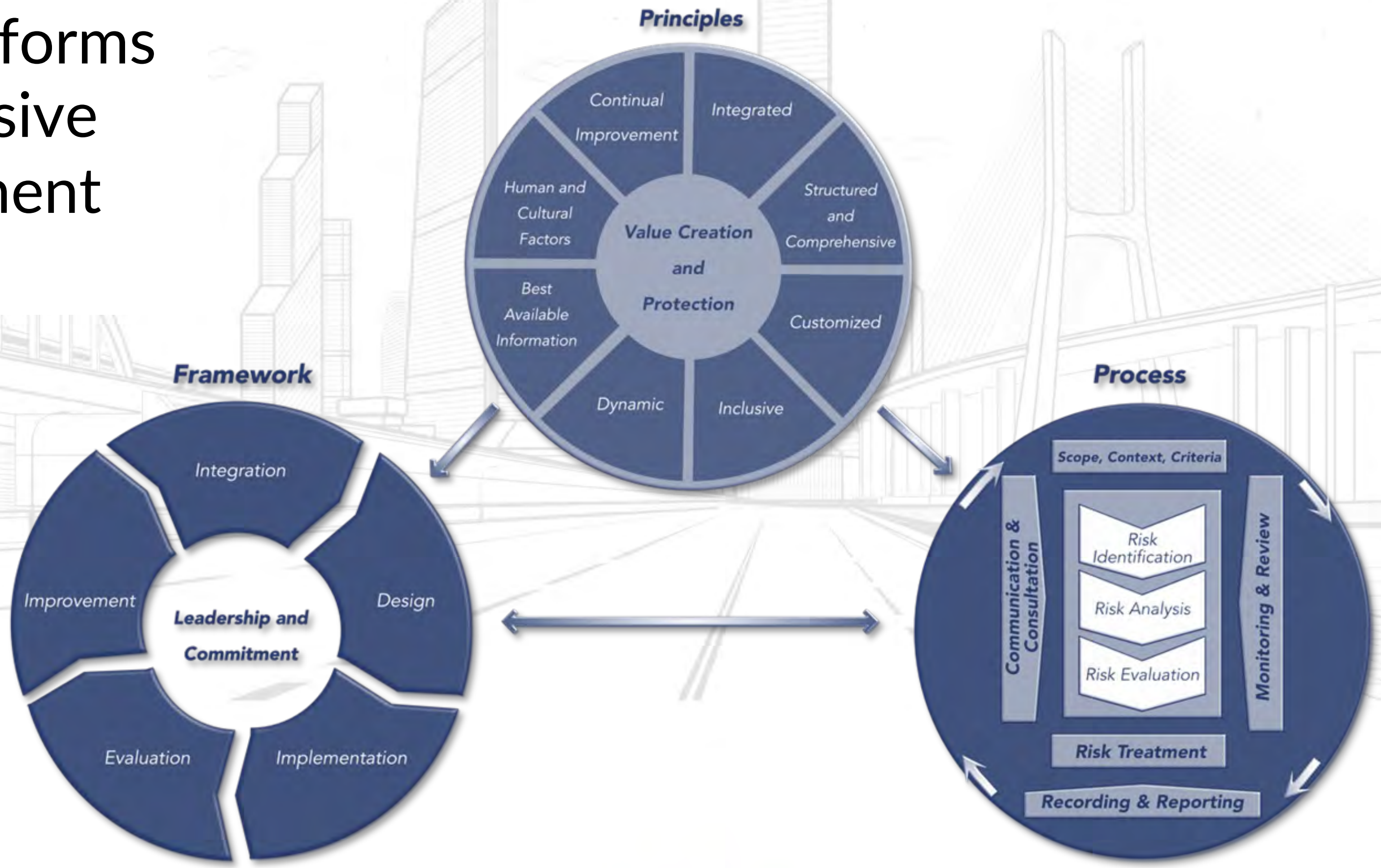
Climate Change Resilience Assessment

- Applications:
  - Asset management
  - Asset portfolio assessment and evaluation
  - Capital and master planning
  - Operations and management evaluation and review
  - Resilience assessment for funding programs (Climate Lens)
  - Concept and preliminary engineering design
  - Green and natural infrastructure assessments
  - Application requiring ISO 31000 and ISO 14090

PIEVC CVIIP

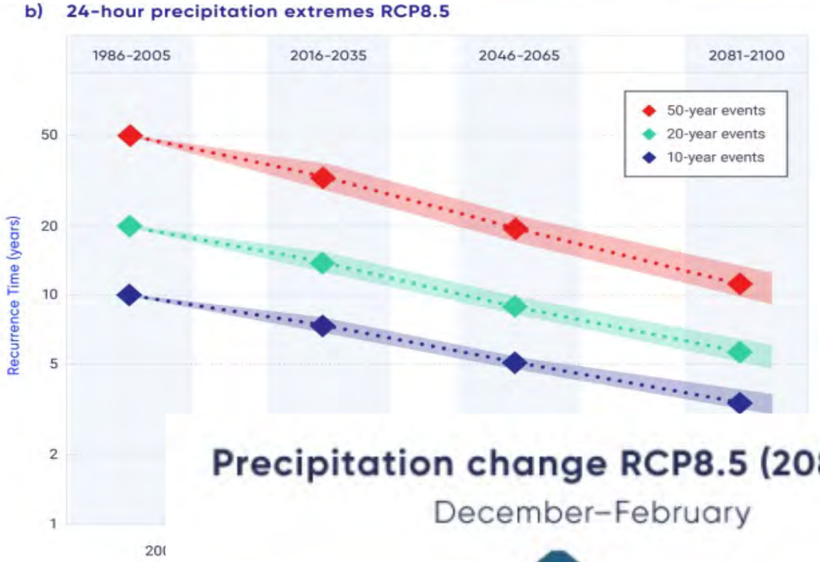
Climate Change Resilience Assessment

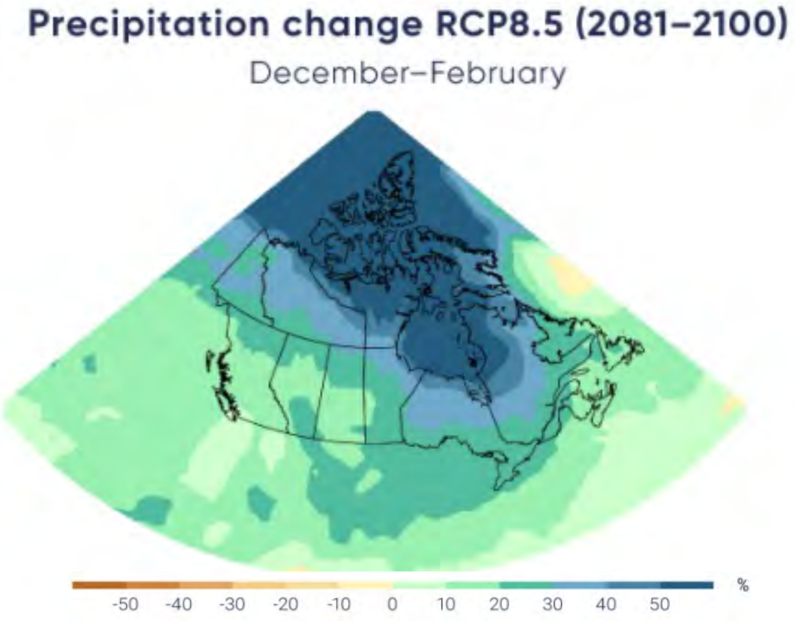
- ISO 31010 informs a comprehensive risk management process



PIEVC CVIIP

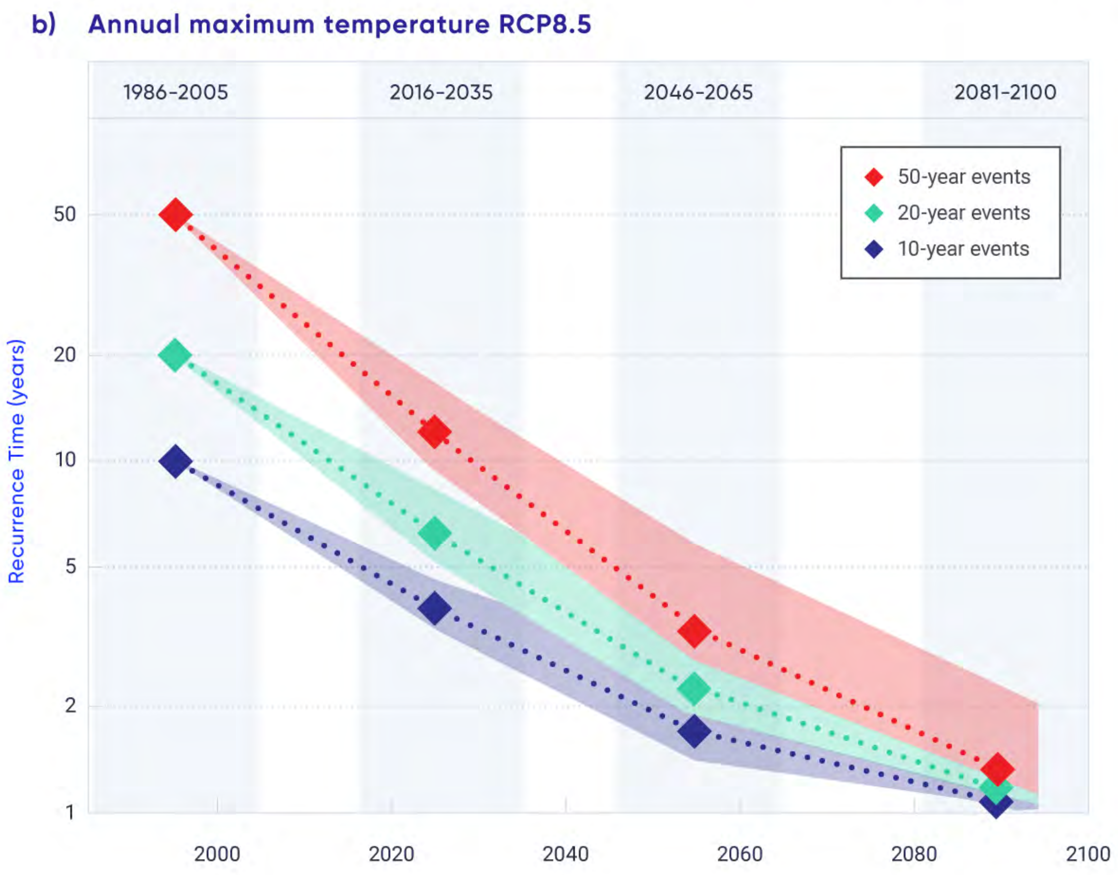
Potential Impacts



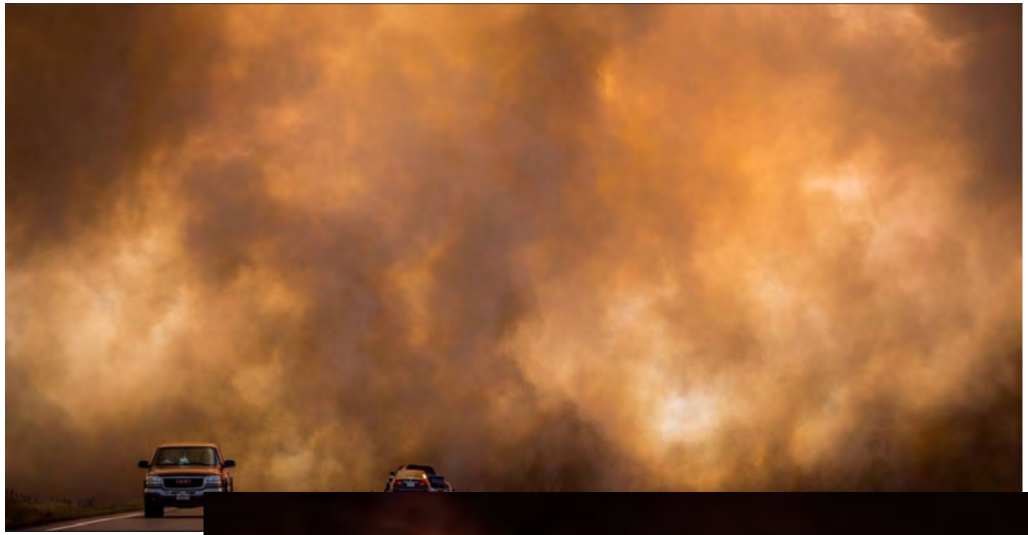


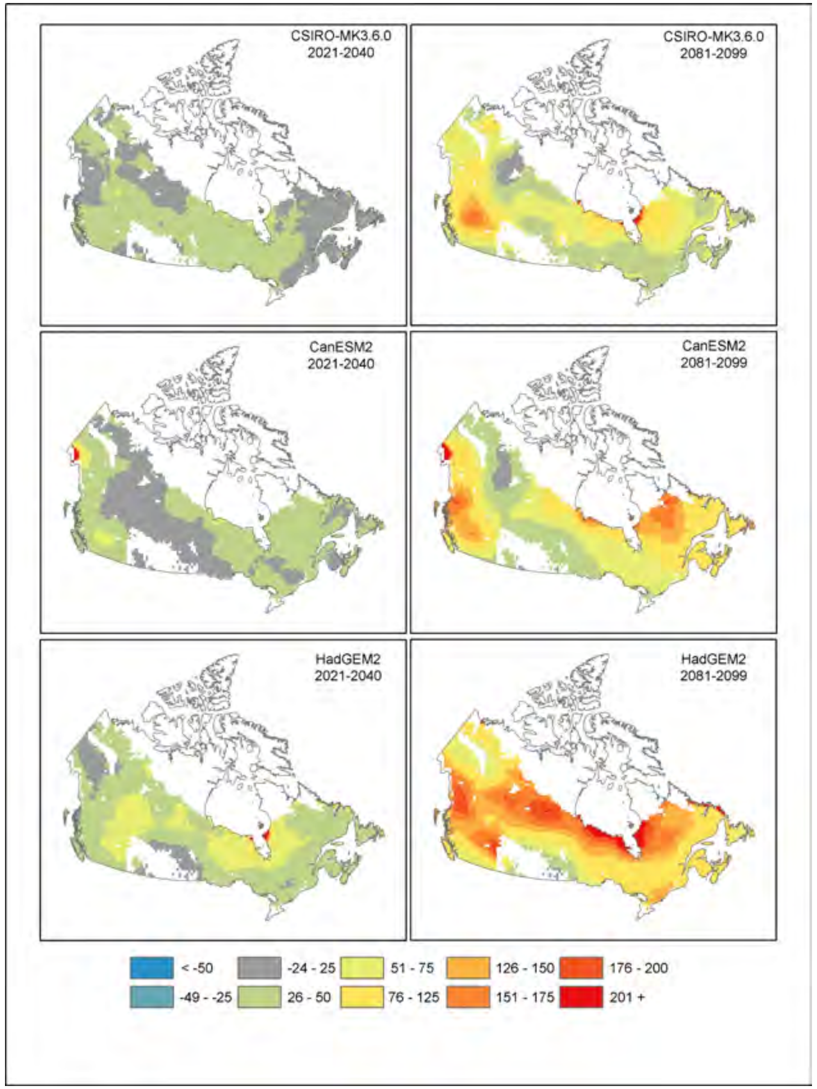
Potential Impacts

Potential Impacts



Potential Impacts





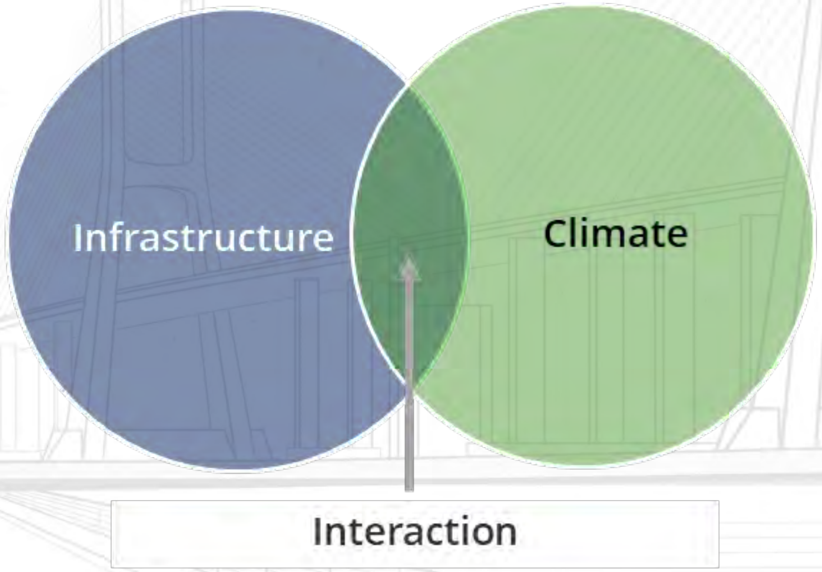
Potential Impacts

Potential Impacts

PIEVC Process

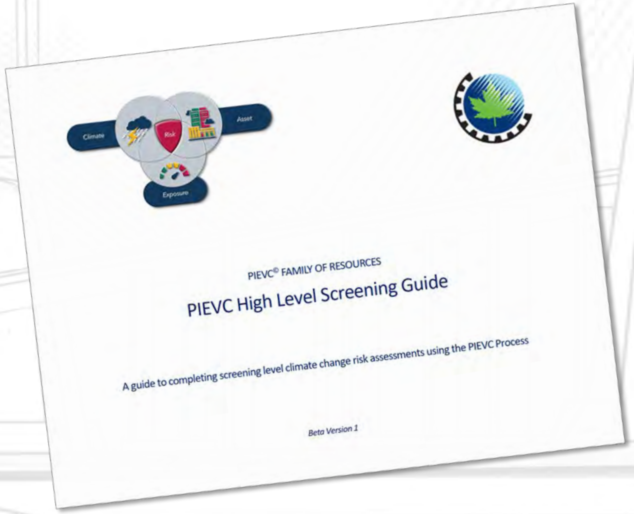
- Process to assess **consequence** and **likelihood** of future climate changes and events on infrastructure to inform on infrastructure planning, design, operation and management.

- **Consequence x Likelihood = Risk**

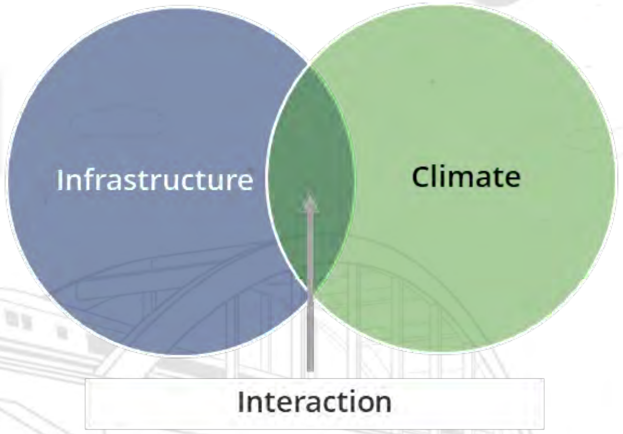


PIEVC Process

- The High Level Screening Guide (HLSG) tool was developed to provide a more streamlined, rapid or a screening level assessment approach to climate change resilience assessments.



PIEVC CVIIP

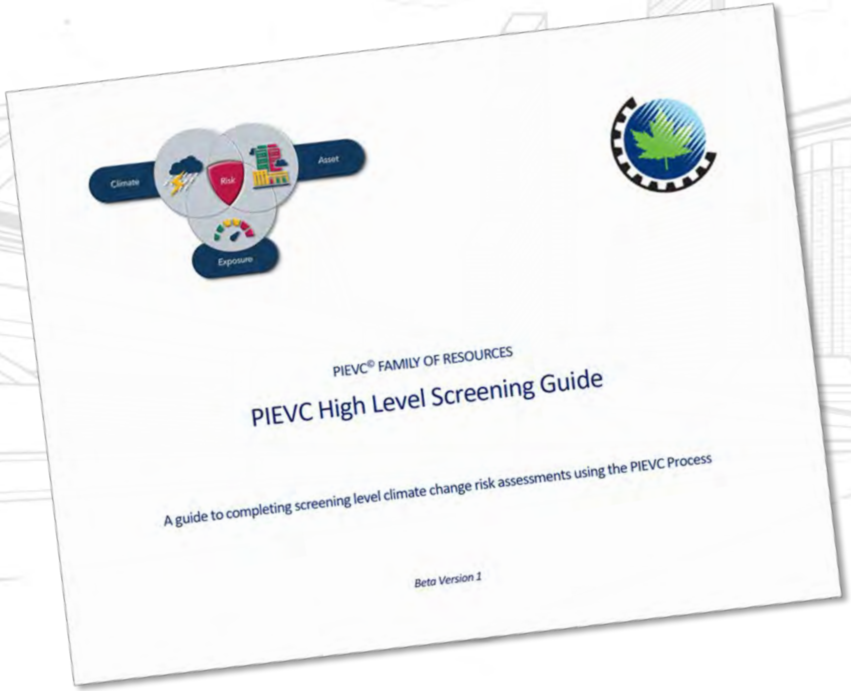


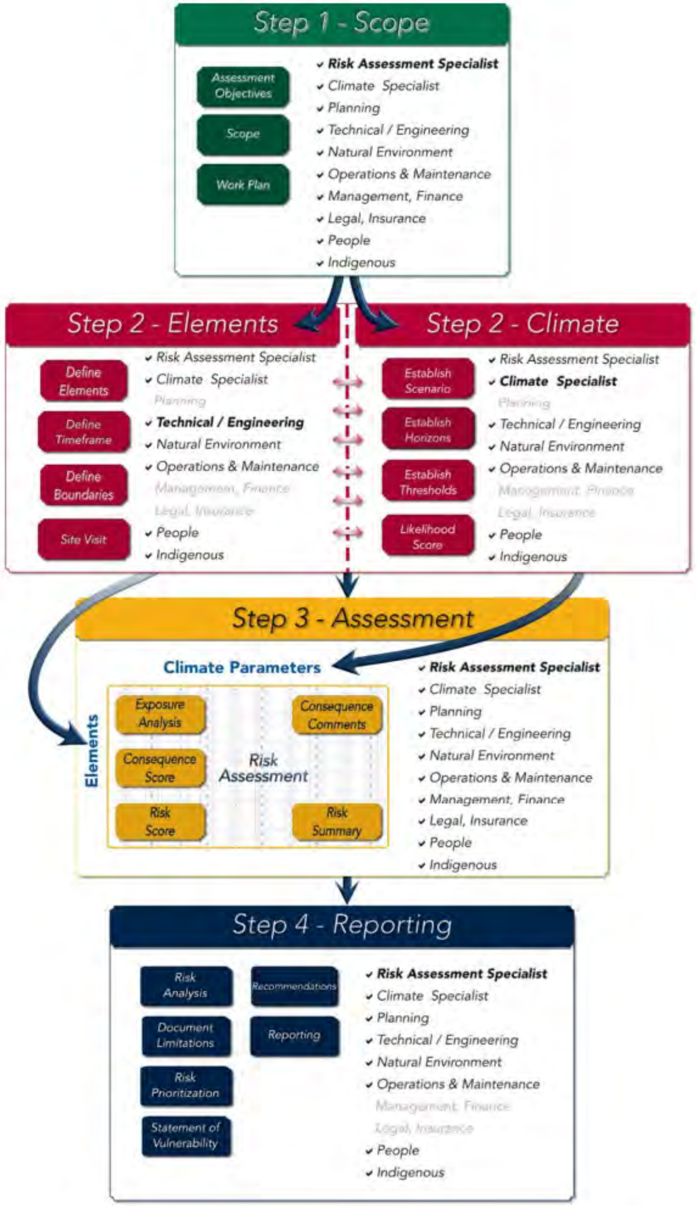
5	CONSEQUENCE	Catastrophic	0	[illegible]	10	[illegible]	[illegible]	[illegible]
4		Major	0	4	8	12	16	[illegible]
3		Moderate	0	3	6	9	12	[illegible]
2		Minor	0	2	4	6	8	10
1		Insignificant	0	1	2	3	4	5
0		No Effect	0	0	0	0	0	0
			Negligible Not Applicable	Highly Unlikely Improbable	Remotely Possible	Possible Occasional	Somewhat Likely Normal	Likely Frequent
			LIKELIHOOD					
			0	1	2	3	4	5

FLOOD
Climate Change
FLOOD
Adaptation
FLOOD

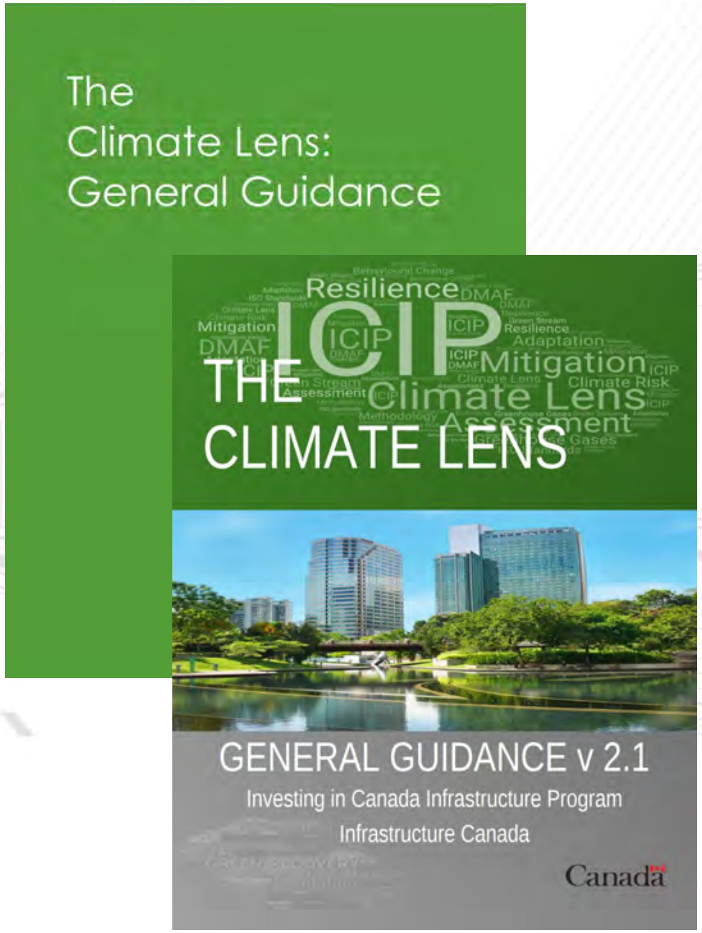
PIEVC CVIIP

PIEVC PROGRAM






Step 1 - Scope / Context / Criteria
Objectives
Scope
Context
Work Plan
Risk Assessment Specialist
Climate Specialist
Planning
Technical / Engineering
Environment
Operations & Maintenance
Management, Finance
Legal, Insurance
People
Indigenous


The
Climate Lens:
General Guidance
THE
CLIMATE LENS
GENERAL GUIDANCE v 2.1
Investing in Canada Infrastructure Program
Infrastructure Canada
Canada

- **Risk Assessment:** The risk assessment specialist(s)* have in-depth knowledge of the fundamentals of risk and the PIEVC Process. They have strong skills in facilitation and communication that strengthen the knowledge and expertise of other team resources and guide the process.
- **Climate:** The climate specialist(s)* have a strong understanding of climate that is relevant to the local context. They can interpret climate data and communicate uncertainty effectively with other team resources.
- **Planning:** Individuals or groups with knowledge of community planning, land-use planning, infrastructure planning and other related expertise relevant to the scope of the assessment (like transportation) can provide a broader understanding of multi-stakeholder goals and relevant policy.
- **Technical / Engineering:** Professional Engineer(s)*, technical or engineering subject matter specialist(s) have relevant experience working with the infrastructure or systems being assessed.
- **Natural Environment:** Natural environment subject matter specialists have relevant experience working with and managing natural systems. Expertise needed will vary depending on the assessment scope but can include knowledge about sustainability, hydrology, landscape architecture, ecology, aquatic biology, or forest management.
- **Operation & Maintenance:** Individuals or groups involved in operations and maintenance can provide valuable insight into the system being assessed or similar systems they have worked with previously.
- **Management, Finance:** Individuals or groups involved with financing or managing the assets can assist with encouraging buy-in across the organization and aligning project objectives with the organization's goals and strategy.
- **Legal, Insurance:** Individuals or groups with legal and insurance expertise can provide insight on topics like liability, risk tolerance, the ability to acquire insurance, and relevant policy.
- **People**: Non-organizational stakeholders who rely on the services of the systems or assets being assessed have critical perspectives to contribute related to service disruptions and levels.
- **Indigenous:** Meaningful engagement with Indigenous communities and knowledge holders can improve understanding of climate conditions in the areas and communities being assessed.

Considerations when building your team

1. *Not all assessment will require a full team with the resources suggested. In many assessments, several roles may be filled by one or several qualified individuals.*
2. *Who is interested in participating? Do they have the capacity, time, and expertise?*
3. *Who will be responsible for project management, establishing timelines, setting up meetings and following up? Will this be one person, or multiple?*
4. *Are there any existing organizations or groups that you could leverage to champion this process?*
5. *Do you require any internal/external expertise to analyze or derive climate data or better understand the elements you are assessing?*
6. *Does the project team represent broad and diverse perspectives from the organization or community that you are working with?*
7. *How will you solicit team resources? Do you need to establish any formal agreements (like a terms of reference) to participate?*
8. *Are there other areas of expertise or stakeholders to include?*

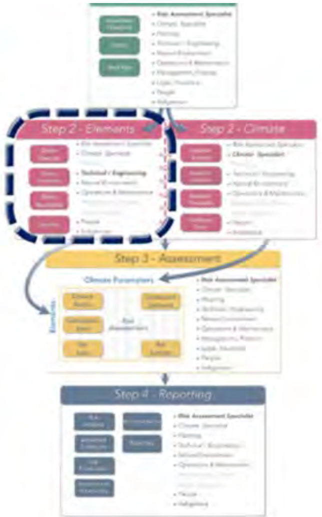
PIEVC Training

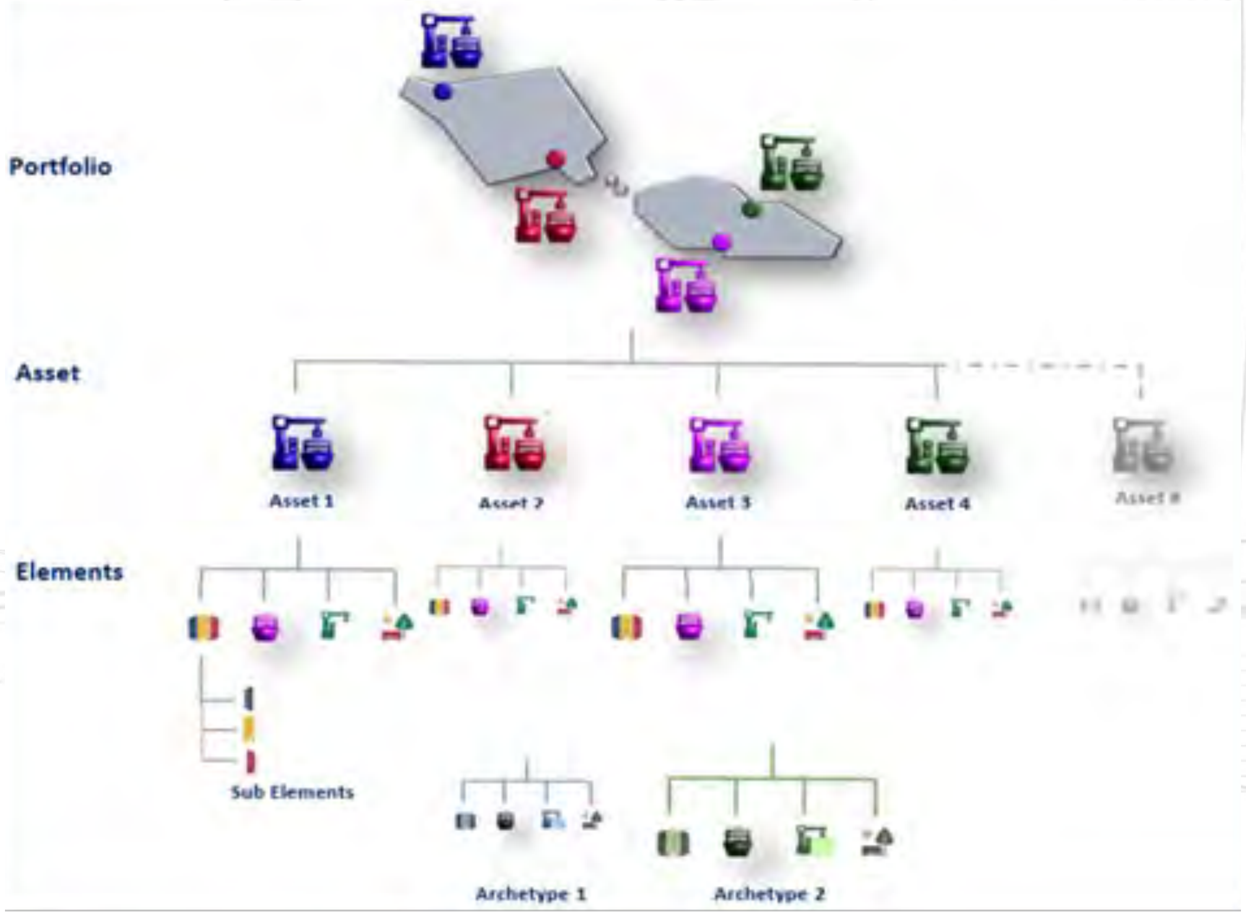
The ***infrastructure Resilience Professional (IRP) Training Program*** *has been designed to help infrastructure practitioners strengthen the knowledge and competencies they require to advance more climate-resilient approaches for the planning, design, and management of infrastructure.* ***https://climateriskinstitute.ca/irp-page/***

PIEVC PROGRAM

	Tasks	Timeframe	Assessment Team (shaded Team Members may not be required in that step of the project)	
Scope	**Project Overview** ▪ Project Initiation ▪ Understand assessment objectives ▪ Confirm scope of assessment ▪ Confirm work program and Schedule (Work Plan) ▪ Designate roles and initiate information collection (Assessment Team)	**1 - 2 weeks** ▪ Kick off meeting: 2 - 3 hours	✓ **Risk Assessment Specialist (Lead)** ✓ Climate Specialist ✓ Planning ✓ Technical / Engineering ✓ Natural Environment	✓ Operation & Maintenance ✓ Management, Finance ✓ Legal, Insurance ✓ People ✓ Indigenous
Data	**Elements** ▪ Defining Elements ▪ Define Timeframe ▪ Site Visit ▪ Orientation Sessions (Presentation, Primers, Questionnaire)	**2 weeks** ▪ Site Visit (half day - optional but recommended) ▪ Orientation Sessions or Meetings (2 - 4 hours)	✓ Risk Assessment Specialist ✓ Climate Specialist Planning ✓ **Technical / Engineering (Lead)** ✓ Natural Environment	✓ Operation & Maintenance Management, Finance Legal, Insurance ✓ People ✓ Indigenous
	Climate ▪ Identify and Evaluate Climate Change and Climate Hazards and establish Climate Parameters ▪ Establish Likelihood Scores	**2 weeks - may overlap with above** ▪ Engagement / Meetings (2 - 3 hours)	✓ Risk Assessment Specialist ✓ **Climate Specialist (Lead)** Planning ✓ Technical / Engineering ✓ Natural Environment	✓ Operation & Maintenance Management, Finance Legal, Insurance ✓ People ✓ Indigenous
Assess	**Risk Assessment** ▪ Establish Consequence Scores ▪ Risk Assessment Workshop ▪ Summarize and Classify Risk	**1- 2 weeks** ▪ Half Day Workshop or Meeting (2 - 3 hours) depending on assessment approach	✓ **Risk Assessment Specialist (Lead)** ✓ Climate Specialist ✓ Planning ✓ Technical / Engineering ✓ Natural Environment	✓ Operation & Maintenance ✓ Management, Finance ✓ Legal, Insurance ✓ People ✓ Indigenous
Report	**Recommendations Reporting** ▪ Develop conclusions and recommendations for Identified risks ▪ Review and Reporting	**1 - 4 weeks** ▪ Engagement / Meetings (2 - 3 hours)	✓ **Risk Assessment Specialist (Lead)** ✓ Climate Specialist ✓ Planning ✓ Technical / Engineering ✓ Natural Environment	✓ Operation & Maintenance Management, Finance Legal, Insurance ✓ People ✓ Indigenous


Step 2 - Elements
Define Elements
Define Timeframe
Define Boundaries
Site Visit
✔ Risk Assessment Specialist
✔ Climate Specialist
Planning
✔ Technical / Engineering
✔ Environment
✔ Operations & Maintenance
Management, Finance
Legal, Insurance
✔ People
✔ Indigenous




Portfolio
Asset
Asset 1
Asset 2
Asset 3
Asset 4
Elements
Sub Elements
Archetype 1
Archetype 2

PIEVC CVIIP

Asset Category	Example
Built Infrastructure	▪ Buildings, Transportation Infrastructure, Energy and Electrical Infrastructure, Water Resources and Drainage, Water Supply, Treatment, Communication Infrastructure, Infrastructure, etc.
Natural Environment	▪ Green Infrastructure, Soils, Tree Canopy, Bioswales, etc. ▪ Natural Systems ▪ Natural Assets
People	▪ Includes all employees of an organization, also includes contractors, vendors, clients, customers, and other people that the organization chooses to classify in this category. In general, the term includes internal and external stakeholders of the organization that may be directly affected by the organization's risks and adaptation measures.

PIEVC PROGRAM

Infrastructure	Components
Waste and Recycling Operations	• Staff – Outdoor only • Pickup Trucks • Sideload Trucks • Read Load Trucks • Overhead Trucks • Crane Truck • W&R Garage • Yard Waste Site + Wood Chippers + Recycling Station • Carts, Otto Carts • Bins (Garbage, Steel, Demo)
Waste and Recycling Centre	• Staff • Undeveloped / Agricultural / Buffer Land • Dual Scales and Scale House • Class 2 Landfill and Contaminated Soil Cell • Waste Transfer Station and Baler • Contracted Equipment – Landfill Heavy Equipment (Primary and Secondary) • Material Recovery Facility + SCADA • Class 2 Composting Facility • Public Drop Off and C&D Drop Off • Surface Water Management System • Groundwater & Subsurface Gas Monitoring Systems • Landscaped Area • Roads, Fences and Site Infrastructure • Mesh Network Infrastructure

PIEVC CVIIP

Developing Climate Parameters, Hazards and Indicators

As previously noted, the terms climate parameter, climate hazard, and climate hazard indicator are central to the **PIEVC HLSG** process. Parameters describe the overall climate “categorization”, whereas the hazards and indicators describe more specific impactful events and the intensity thresholds at which impacts can be expected to occur on the elements under assessment.

Each climate parameter is assigned one or multiple associated hazards and hazard indicators that are specific to the infrastructure and elements under assessment.

Indicators can be identified using a variety of sources, including design standards, operational standards, rules of thumb, maintenance guidelines, codes of practice, literature, past impacts to the infrastructure under assessment, experience, and professional judgement. For each climate hazard, the team should define one or more corresponding indicator values associated with the performance thresholds of the infrastructure and provide these to the climate specialists for tailored climate analysis. When the **PIEVC HLSG** is applied to an asset in the design phase, historical climate of the site or region and prior impacts of climate on similar existing assets should be considered.

New data from the IPCC Sixth Assessment report (AR6) *is now available, including a new set of GHG emissions scenarios. These scenarios correspond well with the current emissions scenarios from IPCC AR5, but should be reviewed by the team to determine the relevance of any new parameters and projections during the project timeline. New scenarios from AR6 are named Shared Socioeconomic Pathways (SSP) and combine the GHG forcing on the atmosphere with alternative pathways of socioeconomic development to include the effects of possible global strategies for mitigation, adaptation, and the impacts of climate change.*

At the screening level, it may be possible to use pre-set climate indicators available from a series of climate portals. A list of potential climate indicator variables is available in the appendices.

Climate Portal Name	Source	Link
Climate Data Canada	Environment and Climate Change Canada/ OURANOS/ CRIM/ PCIC/ Prairie Climate Centre	https://climatedata.ca
Downscaled Climate Scenarios	Environment and Climate Change Canada	https://climate-change.canada.ca/climate-data/#/
Climate Atlas of Canada	Prairie Climate Centre	https://climateatlas.ca
PCIC Plan 2 Adapt	Pacific Climate Impacts Consortium	https://www.pacificclimate.org/analysis-tools/plan2adapt
PCIC Climate Explorer	Pacific Climate Impacts Consortium	https://www.pacificclimate.org/analysis-tools/pcic-climate-explorer
Ouranos Climate Portraits	Ouranos Consortium	https://www.ouranos.ca/climate-portraits

Step 2 - Climate

Establish Scenario	✔ Risk Assessment Specialist ✔ **Climate Specialist** Planning
Establish Horizons	✔ Technical / Engineering ✔ Natural Environment
Establish Thresholds	✔ Operations & Maintenance Management, Finance Legal, Insurance
Likelihood Score	✔ People ✔ Indigenous

Step 2 - Climate

- Establish Scenario
- Establish Horizons
- Establish Thresholds
- Likelihood Score

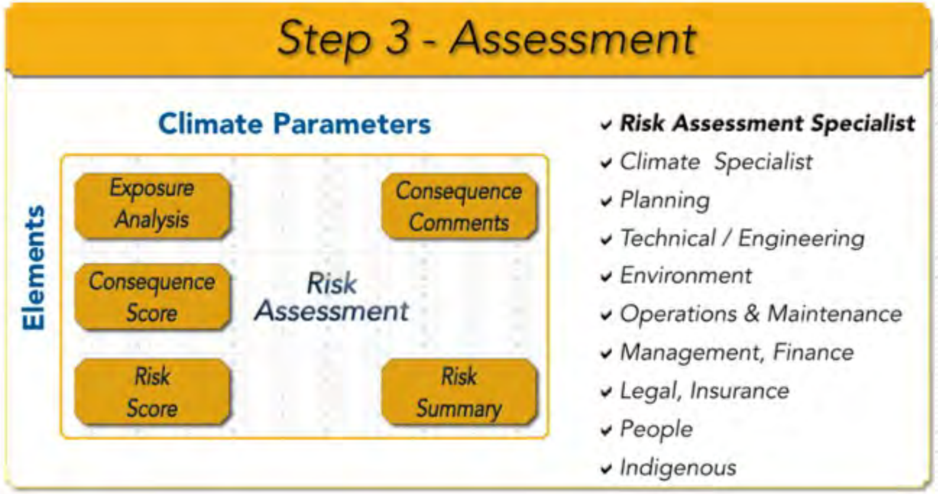
- ✔ Risk Assessment Specialist
- ✔ **Climate Specialist**
- Planning
- ✔ Technical / Engineering
- ✔ Natural Environment
- ✔ Operations & Maintenance
- Management, Finance
- Legal, Insurance
- ✔ People
- ✔ Indigenous

Likelihood Score (L)	Middle Baseline Approach - Establish Base	Method	Suggested Rational
1	▲	Likely to occur less frequently than current climate	50 – 100% reduction in frequency or intensity with reference to Baseline Mean
2			10 – 50% reduction in frequency or intensity with reference to Baseline Mean
3	Establish Current Climate Baseline Per Parameter	Likely to occur as frequently as current climate	Baseline Mean Conditions or a change in frequency or intensity of ±10% with reference to the Baseline Mean
4			10 – 50% increase in frequency or intensity with reference to Baseline Mean
5	▼	Likely to occur more frequently than current climate	50 – 100%+ increase in frequency or intensity with reference to Baseline Mean

PIEVC CVIIP

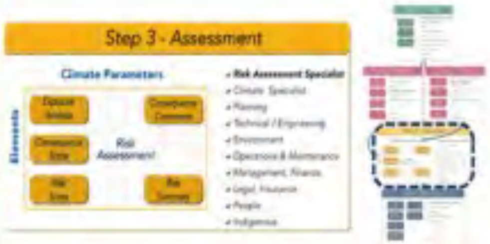
Climate Parameter (P)	Climate Hazard (H)	Indicator (I)	Present (1981-2010) Estimated Value	Baseline Likelihood Score (L)	2050s (2041-2070) Estimated Value	2050s Likelihood Score (L)	2080s (2071-2100) Estimated Value	2080s Likelihood Score (L)	Probability Score Methodology	Occurrence Definition	Climate Scenario	Parameter Source	Direction / Magnitude Confidence
Temperature	Extreme Heat	Days with Tmax > 35°C	0.2	3	1.6	4	6.5	5	Middle Baseline	Days per year	RCP 8.5	Climate Data.ca Observed Data and Projections	Increasing/High
	Extreme Cold	Days with Tmin < -30°C	2.3	3	0.5	2	0.1	1	Middle Baseline	Days per year	RCP 8.5	Climate Data.ca Observed Data and Projections	Decreasing/High
	Freeze Thaw Cycles	Annual Frequency	59.8	3	49.9	3	43	3	Middle Baseline	Cycles per year	RCP 8.5	Climate Data.ca Observed Data and Projections	Decreasing/High
Precipitation	Annual Precipitation	Average Annual Precip	410	3	450	3	550	4	Middle Baseline	Total Precip (mm)	RCP 8.5	Climate Data.ca Observed Data and Projections	Increasing/Moderate
	Extreme Rainfall	Occurrence of 50mm rainfall in 24 hours	0.02	3	0.04	4	0.05	4	Middle Baseline	Frequency per year	RCP 8.5	Climate Data.ca Observed Data and Projections	Increasing/Low-to-Moderate
	Drought	Length of Dry Spells	5.2	3	8.8	4	10.2	5	Middle Baseline	Consecutive days per year	RCP 8.5	Climate Data.ca Observed Data and Projections; Additional Calculations	Increasing/Moderate
Wind	Wind Gusts	Frequency of Wind Gusts > 90 km/hr	2.3	3	Likely increasing, up to 50%	3	Likely increasing, up > 50%	4	Middle Baseline	Frequency per year	RCP 8.5	Climate Data.ca Observed Data from Station; Literature and Research to support projected changes	Likely Increasing/Low
	Tornadoes	Occurrence of EF1 or stronger tornado	0.02	3	0.02	3	0.02	3	Middle Baseline	Frequency per year	RCP 8.5	ECCC Tornado Database; Literature and Research to support possible changes	Steady or Possibly Increasing/Very Low

Likelihood Score (L)	Middle Baseline Approach - Establish Base	Method	Suggested Rational
1		Likely to occur less frequently than current climate	50 – 100% reduction in frequency or intensity with reference to Baseline Mean
2			10 – 50% reduction in frequency or intensity with reference to Baseline Mean
3	Establish Current Climate Baseline Per Parameter	Likely to occur as frequently as current climate	Baseline Mean Conditions or a change in frequency or intensity of ±10% with reference to the Baseline Mean
4			10 – 50% increase in frequency or intensity with reference to Baseline Mean
5		Likely to occur more frequently than current climate	50 – 100%+ increase in frequency or intensity with reference to Baseline Mean



CONSEQUENCE		Negligible Not Applicable	Highly Unlikely Improbable	Remotely Possible	Possible Occasional	Somewhat Likely Normal	Likely Frequent
5	Catastrophic	0	5	10	15	20	25
4	Major	0	4	8	12	16	20
3	Moderate	0	3	6	9	12	15
2	Minor	0	2	4	6	8	10
1	Insignificant	0	1	2	3	4	5
0	No Effect	0	0	0	0	0	0
	PROBABILITY	0	1	2	3	4	5

PIEVC CVIIP



Risk Assessment Worksheet

Consequence Score (C)
1 - Very Low
2 - Low
3 - Moderate
4 - High
5 - Very High

Climate Parameters (P)

Climate Projections																									
	Present		L				L				L				L				L				L		
	2050		L				L				L				L				L				L		
	2080		L				L				L				L				L				L		
Elements (E)		Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R
1	Present		L		R		L		R		L		R		L		R		L		R		L		R
	2050		L		R		L		R		L		R		L		R		L		R		L		R
	2080		L		R		L		R		L		R		L		R		L		R		L		R
2	Present		L		R		L		R		L		R		L		R		L		R		L		R
	2050		L		R		L		R		L		R		L		R		L		R		L		R
	2080		L		R		L		R		L		R		L		R		L		R		L		R
3	Present		L		R		L		R		L		R		L		R		L		R		L		R
	2050		L		R		L		R		L		R		L		R		L		R		L		R
	2080		L		R		L		R		L		R		L		R		L		R		L		R
4	Present		L		R		L		R		L		R		L		R		L		R		L		R
	2050		L		R		L		R		L		R		L		R		L		R		L		R
	2080		L		R		L		R		L		R		L		R		L		R		L		R
5	Present		L		R		L		R		L		R		L		R		L		R		L		R
	2050		L		R		L		R		L		R		L		R		L		R		L		R
	2080		L		R		L		R		L		R		L		R		L		R		L		R
6	Present		L		R		L		R		L		R		L		R		L		R		L		R
	2050		L		R		L		R		L		R		L		R		L		R		L		R
	2080		L		R		L		R		L		R		L		R		L		R		L		R

Summary

	Low	Med	High	Consequence Comments
Present				
2050				
2080				
Present				
2050				
2080				
Present				
2050				
2080				
Present				
2050				
2080				
Present				
2050				
2080				
Present				
2050				
2080				

Risk Assessment:
1. Assess interaction (E and P) by performing an Exposure Analysis (Yes/No)
2. Assess consequence: For each (Yes) interaction assess a Consequence, Score (C)
3. Record why a score was chosen (Consequence Comments)
4. Calculate the Risk (R) for each interaction (R=C x L)
5. Review Risk Summary

Risk Summary

	Low	Med	High
Present			
2050			
2080			

Category	Structural Design	Functionality	Environmental	Operations & Maintenance	Emergency Response Risks	Insurance Considerations	Policies and Procedures	Social Effects	Period	Low	Med	High
Waste and Recycling Operations												
Staff - Outdoor only			•	•	•	•	•	•	Current	8	1	0
									2050	7	3	0
									2080	6	3	1
Pickup Trucks	•	•	•	•	•	•	•	•	Current	3	1	0
									2050	3	1	0
									2080	2	1	1
Sideload Trucks	•	•	•	•	•	•	•	•	Current	4	2	0
									2050	5	1	0
									2080	5	0	1
Rear Load Trucks	•	•	•	•	•	•	•	•	Current	3	2	0
									2050	4	1	0
									2080	4	0	1
Overhead Trucks	•	•	•	•	•	•	•	•	Current	4	2	0
									2050	5	1	0
									2080	5	0	1
Crane Truck	•	•	•	•	•	•	•	•	Current	4	2	0
									2050	5	1	0
									2080	5	0	1
W&R Garage	•	•	•	•	•	•	•		Current	2	0	0
									2050	3	0	0
									2080	2	1	0
Yard Waste Site + Wood Chippers + Recycling Station				•				•	Current	3	1	0
									2050	2	2	0
									2080	2	1	1
Carts, Otto Carts				•				•	Current	4	1	0
									2050	4	2	0
									2080	4	1	1
Bins (Garbage, Steel, Demo)				•				•	Current	4	1	0
									2050	4	2	0
									2080	4	1	1

Climate Parameter – Temperature

Category	Period	Mean JJA Temperature (High Average Summer Temperature)				Mean DJF Temperature (Low Average Winter Temperature)				# Days above 30°C (Extreme High Summer Temperature)				# Days below -30°C (Extreme Low Winter Temperature)				# Freeze/ Thaw Events (Freeze/ Thaw Events)			
		Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R
Staff - Outdoor only	Current		3		0		3		6		3		9		3		9		4		0
	2050		4		0	Y	2	2	4	Y	4	3	12	Y	2	3	6		3		0
	2080		5		0		1		2		5		15		1		3		2		0
Pickup Trucks	Current		3		0		3		0		3		0		3		6		4		0
	2050		4		0		2		0		4		0	Y	2	2	4		3		0
	2080		5		0		1		0		5		0		1		2		2		0
Sideload Trucks	Current		3		0		3		0		3		3		3		12		4		0
	2050		4		0		2		0	Y	4	1	4	Y	2	4	8		3		0
	2080		5		0		1		0		5		5		1		4		2		0
Rear Load Trucks	Current		3		0		3		0		3		3		3		12		4		0
	2050		4		0		2		0	Y	4	1	4	Y	2	4	8		3		0
	2080		5		0		1		0		5		5		1		4		2		0
Overhead Trucks	Current		3		0		3		0		3		3		3		12		4		0
	2050		4		0		2		0	Y	4	1	4	Y	2	4	8		3		0
	2080		5		0		1		0		5		5		1		4		2		0
Crane Truck	Current		3		0		3		0		3		3		3		12		4		0
	2050		4		0		2		0	Y	4	1	4	Y	2	4	8		3		0
	2080		5		0		1		0		5		5		1		4		2		0
W&R Garage	Current		3		0		3		0		3		0		3		6		4		0
	2050		4		0		2		0		4		0	Y	2	2	4		3		0
	2080		5		0		1		0		5		0		1		2		2		0
Yard Waste Site + Wood Chippers + Recycling Station	Current		3		0		3		0		3		0		3		0		4		0
	2050		4		0		2		0		4		0		2		0		3		0
	2080		5		0		1		0		5		0		1		0		2		0
Carts, Otto Carts	Current		3		0		3		0		3		0		3		9		4		0
	2050		4		0		2		0		4		0	Y	2	3	6		3		0
	2080		5		0		1		0		5		0		1		3		2		0
Bins (Garbage, Steel, Demo)	Current		3		0		3		0		3		0		3		9		4		0
	2050		4		0		2		0		4		0	Y	2	3	6		3		0
	2080		5		0		1		0		5		0		1		3		2		0

Climate Parameter – Precipitation

Category	Period	[illegible] (Drought)				1:100 24-hour Rainfall Accumulation (GEV distribution) (Extreme Rainfall)				Average Maximum 5-day Consecutive Precipitation (Persistent Precipitation)				Mean DJF Precipitation (Extreme Snowfall)				Severe Summer Hail Days (% Change Relative to Present) (Hail Days)				Annual Total Precipitation (Average Precipitation)			
		Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R
Staff - Outdoor only	Current		3		0		3		6		3		9		3		12		3		6		3		0
	2050		4		0	Y	4	2	8	Y	3	3	9	Y	4	4	16	Y	3	2	6		3		0
	2080		4		0		5		10		3		9		5		20		3		6		4		0
Pickup Trucks	Current		3		0		3		6		3		0		3		12		3		9		3		0
	2050		4		0	Y	4	2	8		3		0	Y	4	4	16	Y	3	3	9		3		0
	2080		4		0		5		10		3		0		5		20		3		9		4		0
Sideload Trucks	Current		3		6		3		3		3		0		3		12		3		9		3		0
	2050	Y	4	2	8	Y	4	1	4		3		0	Y	4	4	16	Y	3	3	9		3		0
	2080		4		8		5		5		3		0		5		20		3		9		4		0
Rear Load Trucks	Current		3		0		3		3		3		0		3		12		3		9		3		0
	2050		4		0	Y	4	1	4		3		0	Y	4	4	16	Y	3	3	9		3		0
	2080		4		0		5		5		3		0		5		20		3		9		4		0
Overhead Trucks	Current		3		6		3		3		3		0		3		12		3		9		3		0
	2050	Y	4	2	8	Y	4	1	4		3		0	Y	4	4	16	Y	3	3	9		3		0
	2080		4		8		5		5		3		0		5		20		3		9		4		0
Crane Truck	Current		3		6		3		3		3		0		3		12		3		9		3		0
	2050	Y	4	2	8	Y	4	1	4		3		0	Y	4	4	16	Y	3	3	9		3		0
	2080		4		8		5		5		3		0		5		20		3		9		4		0
W&R Garage	Current		3		0		3		0		3		0		3		0		3		6		3		0
	2050		4		0		4		0		3		0		4		0	Y	3	2	6		3		0
	2080		4		0		5		0		3		0		5		0		3		6		4		0
Yard Waste Site + Wood Chippers + Recycling Station	Current		3		0		3		3		3		0		3		0		3		0		3		0
	2050		4		0	Y	4	1	4		3		0		4		0		3		0		3		0
	2080		4		0		5		5		3		0		5		0		3		0		4		0
Carts, Otto Carts	Current		3		0		3		3		3		0		3		9		3		0		3		0
	2050		4		0	Y	4	1	4		3		0	Y	4	3	12		3		0		3		0
	2080		4		0		5		5		3		0		5		15		3		0		4		0
Bins (Garbage, Steel, Demo)	Current		3		0		3		3		3		0		3		9		3		0		3		0
	2050		4		0	Y	4	1	4		3		0	Y	4	3	12		3		0		3		0
	2080		4		0		5		5		3		0		5		15		3		0		4		0

Climate Parameter – Wind, River Flooding, Ice Accretion, Wildfire, Tornado

Category	Period	Wind: Mean # days/year with Daily Peak Wind >70 km/h (Maximum Wind Gust)				River Flooding: Precipitation as snow at Oldman Reservoir (Oldman River Flood Level)				Ice Accretion: 1:50 Year Annual max Horizontal Accretion (Extreme Ice Accretion (Freezing Rain))				Wildfire: Climate Moisture Deficit (Wildfire Risk)				Tornado: Convective Available Potential Energy Linear Trend Over Full 1960-2099 Period (Tornado)				Comments / Rationale For Consequence Score (from Risk Assessment Workshop)
		Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	Y/N	L	C	R	
Staff - Outdoor only	Current		3		9		3		0		1		4		3		0		0		0	
	2050	Y	4	3	12		2		0	Y	2	4	8		4		0	Y	1	4	4	
	2080		5		15		1		0		2		8		5		0		2		8	
Pickup Trucks	Current		3		0		3		0		1		0		3		0		0		0	
	2050		4		0		2		0		2		0		4		0		1		0	
	2080		5		0		1		0		2		0		5		0		2		0	
Sideload Trucks	Current		3		0		3		0		1		0		3		0		0		0	
	2050		4		0		2		0		2		0		4		0		1		0	
	2080		5		0		1		0		2		0		5		0		2		0	
Rear Load Trucks	Current		3		0		3		0		1		0		3		0		0		0	
	2050		4		0		2		0		2		0		4		0		1		0	
	2080		5		0		1		0		2		0		5		0		2		0	
Overhead Trucks	Current		3		0		3		0		1		0		3		0		0		0	
	2050		4		0		2		0		2		0		4		0		1		0	
	2080		5		0		1		0		2		0		5		0		2		0	
Crane Truck	Current		3		0		3		0		1		0		3		0		0		0	
	2050		4		0		2		0		2		0		4		0		1		0	
	2080		5		0		1		0		2		0		5		0		2		0	
W&R Garage	Current		3		0		3		0		1		0		3		0		0		0	
	2050		4		0		2		0		2		0		4		0	Y	1	5	5	
	2080		5		0		1		0		2		0		5		0		2		10	
Yard Waste Site + Wood Chippers + Recycling Station	Current		3		9		3		0		1		2		3		12		0		0	Grass fires are a concern.
	2050	Y	4	3	12		2		0	Y	2	2	4	Y	4	4	16		1		0	
	2080		5		15		1		0		2		4		5		20		2		0	
Carts, Otto Carts	Current		3		12		3		0		1		3		3		0		0		0	Cold is a concern as it can cause materials to become brittle and break.
	2050	Y	4	4	16		2		0	Y	2	3	6		4		0	Y	1	4	4	
	2080		5		20		1		0		2		6		5		0		2		8	
Bins (Garbage, Steel, Demo)	Current		3		12		3		0		1		3		3		0		0		0	
	2050	Y	4	4	16		2		0	Y	2	3	6		4		0	Y	1	4	4	
	2080		5		20		1		0		2		6		5		0		2		8	

Consequence Score

0 - No Effect
1 - Insignificant
2 - Minor
3 - Moderate
4 - Major
5 - Catastrophic

Develop Risk Score

- Calculate the **Risk (R)** for each interaction **Risk (R) = Exposure (E) x Consequence (C) x Likelihood (L)**, where **(E)** is either **Yes=1** or **No=0**

Summarize the Risks

Summarize and classify risk using the scales provided. Assessors may adjust the classification categories as appropriate to align with the infrastructure owner's risk appetite.

Risk Score (R)	Risk Classification		
1 - 9		Low Risk	Risks requiring minimal action
10 - 16	(yellow)	Medium Risk	Risk that may require further action
17 - 25	(red)	High Risk	Risks that require action

Consequence		Likelihood 1	2	3	4	5
5	5	5	10	15	20	25
4	4	4	8	12	16	20
3	3	3	6	9	12	15
2	2	2	4	6	8	10
1	1	1	2	3	4	5
		1	2	3	4	5
		Likelihood				

Figure 4-12: WRU - Waste Operations Risk Score for 2080s

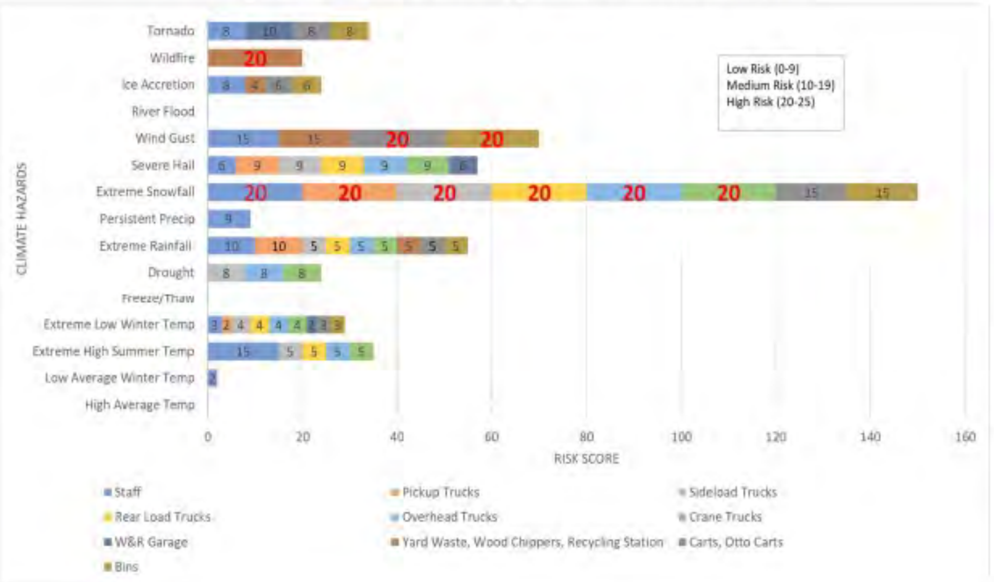
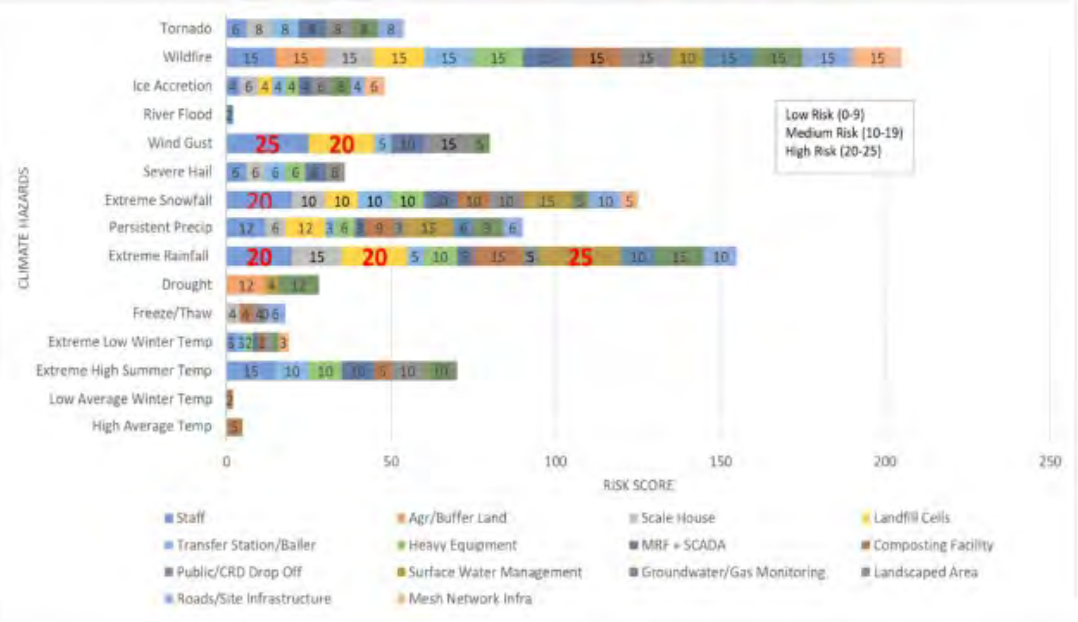


Figure 4-15: WRU - Waste Facilities Risk Score for 2080s



High Risk Impacts on WRU – Operations Components

High Scored Climate Hazards	Waste/Recycling Operations
Extreme Snowfall	• Road blockage due to heavy snowfall. Waste pick up service cannot be fulfilled.
Wind Gust	• Bins are blown away and damaged. Replacement required. • Damage to surrounding and public safety concerns.
Severe Hail	• Damage trucks and bins and required replacement.
Severe Rainfall	• Heavy rain causing overland flooding. Waste pick up service cannot be fulfilled.

High Risk Impacts on WRU – Facilities Components

High Scored Climate Hazards	Waste/Recycling Facilities
Wildfire	• Landfill waste cell, landscaped areas and drop off areas all have plenty of fuel that can exacerbate the dangers of wildfire. • Staff well being and safety concerns.
Extreme Rainfall	• Excess storm water runoff may impact the performance of the landfill leachate and stormwater collection system. • Staff well being and safety concerns.
Extreme Snowfall	• Blockage of access to the landfill facilities within the site. • High snow pack in the landfill which will increase moisture with the waste during spring snow melt thus increase the leachate generation.
Wind Gust	• Blown waste debris at the site, and beyond the landfill site made it difficult to retrieve. • Staff well being and safety concerns.
Extreme High Summer Temperatures	• Landfill waste cell fires (dry conditions). • Overheating of equipment. • Staff well being and safety concerns. • Odours.

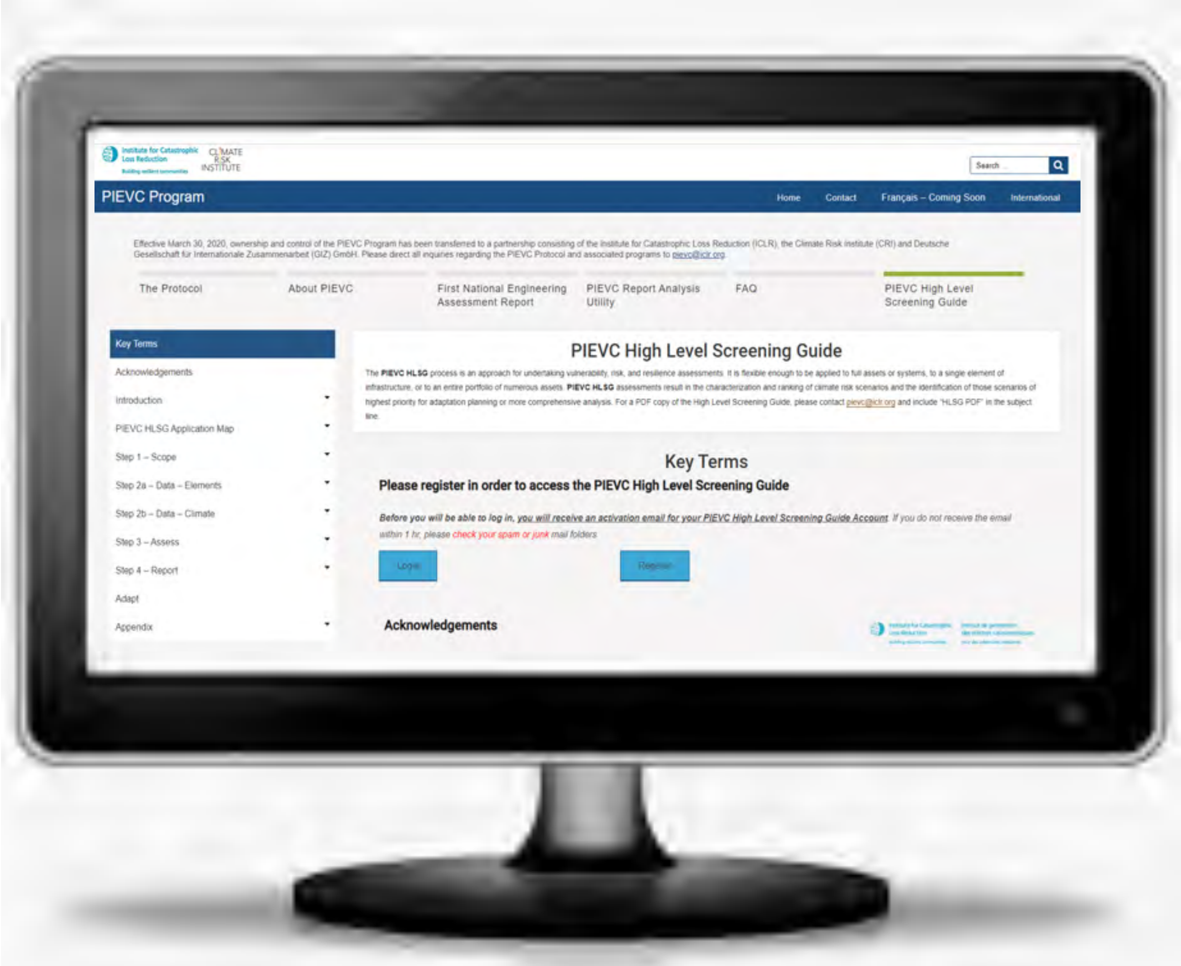
Develop Recommendations

- Develop recommendations for identified risks
  - Provide justification for each recommendation.
  - Incorporate, as much as possible, organization risk tolerance and acceptable residual risk.
- Categorize the recommendations according to for example:
  - Policy/procedural changes.
  - Remedial actions.
  - Further study or analysis.
  - Further comprehensive risk assessment.
  - Further engineering analysis or design changes.
    - Provide preliminary design criteria that may address the risk to guide engineering team.
  - Risk avoidance strategies.
    - Consider stopping activities in high-risk areas.

Climate Hazard / Parameter	Potential Adaptation Measures	Waste and Recycle Utility
Extreme High Summer Temperature/Drought	Develop a city-wide heat wave emergency preparedness and response plan	x
	Develop safety policy for staff when working under this extreme weather condition	x
	Replace electrical and control equipment to account for extreme heat.	x
	Provide sufficient circulation to the stormwater ponds to prevent stagnation.	
	Continue to implement water conservation and water use efficiency education and awareness programs.	
	Promote and provide incentives for water conservation in urban agriculture, including grey water recycling and water retention and storage technologies.	x
	Evaluate treatment effectiveness and its responses to high temperatures.	
	Investigate new asphalt mixes to reduce the heat island effect.	
	Conduct building envelop/energy audit to identify issues with ventilation and cooling.	x
	Develop species inventory and identify species that are susceptible to and tolerant of this extreme heat and drought.	
	Introduce drought resistant planting to help stabilize road and trail embankments.	

Climate Hazard / Parameter	Potential Adaptation Measures	Waste and Recycle Utility
High Average Summer Temperature (Increase Growing Season)	Develop a city-wide private tree inventory.	
	Develop and implement education and awareness programs for residents and businesses to support energy efficiency and small-scale renewable power projects.	x
	Enhance electricity storage capacity in public facilities.	
	Enhance slope stability monitoring on road embankments.	
	Implement electricity demand management strategies to reduce peak demand.	x
	Increase energy efficiency and renewable energy use (e.g. solar) across all public facilities and operations.	x
	Utilize xeriscaping techniques and native seed mixes on managed natural areas and lawns.	
	Plant trees throughout the city, using locally sources seeds, to provide shade, promote carbon sequestration and lessen the heat impact on concrete joints in sidewalks and trails.	x
	Develop a demonstration garden to begin experimenting with new food and plant types and varieties that may be grown in the future.	x
	Increase topsoil requirements for new development.	
	Promote permaculture techniques in the City to increase resilience and use resources more efficiently.	x
	Support private sector research to transition to more efficient and renewable energy and take advantage of new technologies.	x

Other Examples



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Assessing the Risks of Climate Change on Solid Waste Infrastructure Using the PIEVC Process

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Questions?

June 11, 2025

PIEVC CVIIP