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THE CITY OF CALGARY

COMMUNITY CLIMATE RISK INDEX

SUMMARY REPORT

JULY 29, 2021

PREPARED BY

WSP CANADA INC.

ABOUT THE PROJECT

Climate change is causing increasingly severe impacts on communities, built infrastructure, and the natural environment in Calgary. The city has experienced several destructive and costly climate-driven events, such as the 2013 floods, the 2020 hailstorm, and increasing incidences of extreme heat and drought-like conditions.

Climate change creates unequal and disproportionate impacts across the city – with some people, places and systems facing far greater risk than others. Geospatial differences in socioeconomic, ecological, and built systems can lead to inequitable vulnerability and an inequitable experience of climate risk across Calgary.

The City of Calgary has been working to advance the goals of the Climate Resilience Strategy and Council's 2018 mandate to reduce risk associated with climate hazards. In implementing this mandate, The City recognized the need to better understand how climate risk is distributed across communities, and which communities and systems are most at risk. Not only is it vital to understand *where* the highest risks occur across the city, but *why* these risks are occurring - what is making some people, infrastructure, natural areas or systems more vulnerable than others?

To understand community-scale climate risk and vulnerability, a Community Climate Risk Index (CCRI) was completed in 2020-2021. The CCRI is a geospatial index of climate risk in all 309 communities, to six climate hazards. More than 50 indicators of climate hazard exposure and vulnerability were analyzed, and current and future risk scores were developed for each community. The results are an index climate risk in all 309 communities, and a tool that The City can use to compare risk across communities and understand the biggest drivers of risk and resilience at the neighbourhood scale.


St. Patrick's Bridge – Peggy Frakenberger

PROJECT OBJECTIVES

The objectives of the Community Climate Risk Index project included:

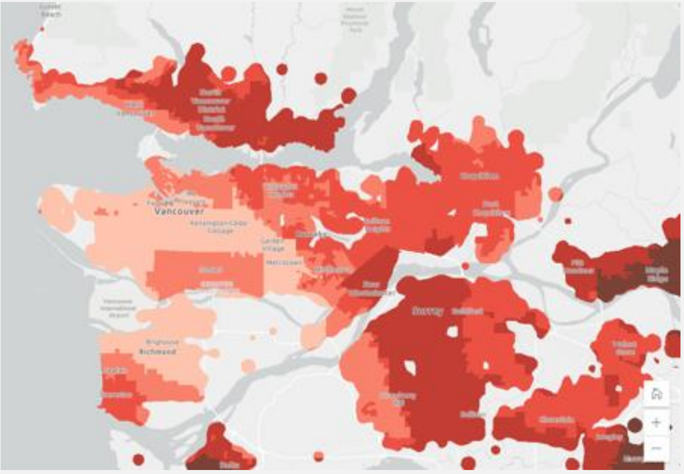
1. Understand **where** in the city is most exposed to climate hazards.
2. Understand **what** makes certain communities vulnerable to climate hazards, by examining key drivers of vulnerability and risk in each community.
3. Implement a system to **rate and compare** or community climate risk level, today and in the future.
4. Produce practical tools that support the use of Risk Index for City projects and decision-making.

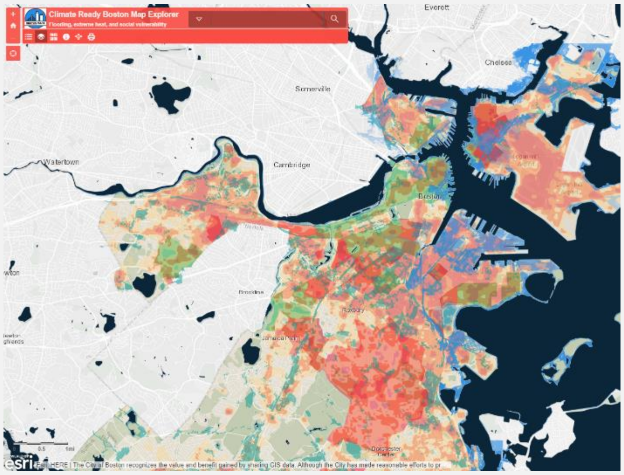
Where in the city are we most exposed to certain hazards, where are we most vulnerable to certain hazards, and why?

What is a community climate risk index?

A Community Climate Risk Index is a relative ranking system for climate risk across all communities in Calgary. The index includes exposure, vulnerability, and risk scores for six climate hazards. The index can be used to find the highest risk communities and compare levels of risk across communities. It can also be used to measure change in community risk scores over time.

Community climate risk and resilience indices are an emerging trend and best practice for climate adaptation. Similar projects have been completed in Edmonton, Montreal, and in other countries such as the US, Norway, Italy, and Korea. Climate risk indices are tools that help cities, regions and nations investigate the landscape of climate risk across large geographic areas. By studying risk drivers, tailored adaptation interventions and programs can be deployed in the most vulnerable areas. As there are often limited resources for adaptation, the risk indices help prioritize investment in the assets, places, and people who are most vulnerable.





THE PROCESS

The core steps of the project are described below.

1. **Climate hazard likelihood** was determined by analyzing historical and future climate projections for several climate variables (e.g. wind speed, maximum summer temperature, summer precipitation, etc.). The change in hazard variables and the likelihood of each climate variable informed the hazard likelihood scores.

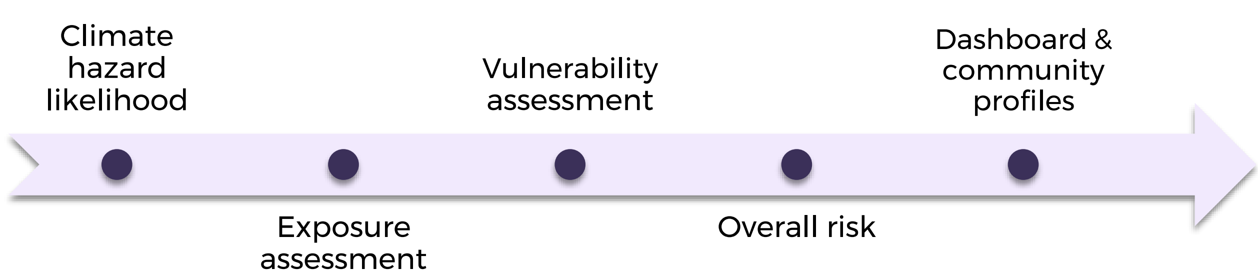
2. **Exposure** to each climate hazard was scored based on the amount of people, natural areas and built assets and infrastructure in each community. Future exposure was determined using future (2050) population projections for each community. Each community was given an exposure score for each climate hazard.

3. **Vulnerability** was also assessed for each community and each climate hazard. Vulnerability scores were generated by analyzing 40 indicators of sensitivity and adaptive capacity within built, natural and social systems in each community.

4. **Overall risk** was calculated for the present day and for the 2050s. The current hazard likelihood score, current exposure score, and vulnerability score were multiplied to generate a risk score for each hazard. Similarly, the future hazard likelihood, future exposure, and vulnerability scores were multiplied to generate future risk scores.

5. **A results dashboard** was created to visualize risk scores and drivers. For each community, the dashboard presents relative exposure, vulnerability and risk scores, a comparison to citywide averages, and highlights the community-specific drivers of risk in each social, built and natural system.

   Community profiles were also created for two multi-community planning areas, Heritage and Westbrook. The community profiles are pilot projects that use the results of the CCRI to inform planning processes. The profiles include risk results and maps for each community in the planning area, analyze results by community, and discuss recommendations to address top risks through planning considerations.



COMMUNITY CLIMATE RISK INDEX QUICK FACTS

2020s

2050s

Present day risk scores were calculated as the baseline for the assessment. Risk scores for the 2050s were also generated so that current and future risk can be compared for all communities and climate hazards. The baseline for future climate projections was 1960-2014.

309

The project assessed all 309 communities in Calgary. Of the 309 communities, approximately 45 communities are undeveloped or residual. These communities were assessed, but the results focus on developed communities.

6

Six climate hazards were studied:

Meteorological drought, higher average temperatures, extreme heat, severe storms, river flooding, and short duration high intensity precipitation.

50

Indicators of vulnerability and exposure were analyzed to generate overall risk scores. Indicators were grouped by system (social, built, natural) and by exposure, sensitivity, or adaptive capacity.

CLIMATE HAZARDS

Climate hazard likelihood is the first component of the three main inputs in the overall risk score (hazard likelihood, exposure, and vulnerability). Six climate hazards were selected for inclusion in the CCRI project: higher average temperatures, extreme heat, meteorological drought, severe storms, river flooding, and short duration high intensity precipitation (SDHI). To feed into the overall risk score calculation, the baseline likelihood and future likelihood of each hazard was determined.

Future climate projections were analyzed for the 2050s and 2080s. Future climate projections are based on the output of climate models, using the RCP8.5 scenario (a high emissions scenario that projects a high-risk future). All climate data was obtained from the *Climate Data for Hydrologic and Hydraulic Analysis Technical Memorandum #2: Time Series Datasets and Typical Year Analysis* completed in 2020 by GHD for The City of Calgary and the Calgary Airport Authority. Where climate data was not available, peer reviewed literature was used to investigate trends in climate variables.

Multiple climate variables were evaluated to determine the trends and current and future probability of each hazard. For each climate variable, low, mean and high values from the climate data were observed. The evolution of each climate variable, the likelihood of the variable changing, the level of confidence in the dataset, and overall likelihood of each climate hazard were calculated.

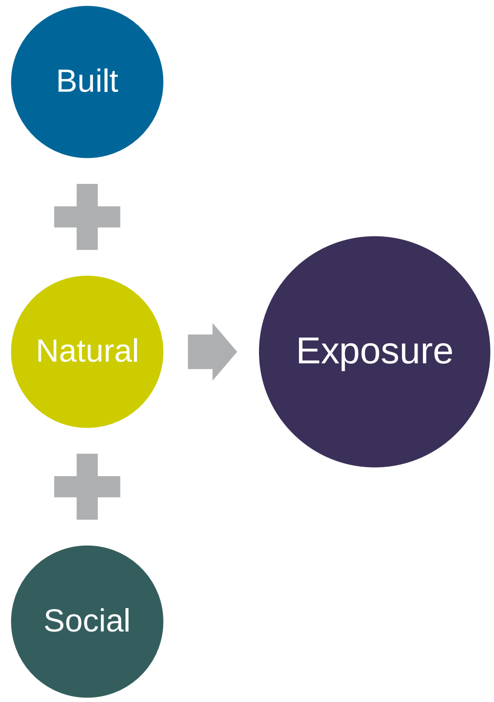
The hazard analysis results included a baseline (historical) and future (2050s) hazard likelihood score for each climate hazard. Each hazard likelihood score is summarized on the following page.

Table 1: Climate hazard likelihood scores

Climate hazard	Baseline (1960-2014) likelihood	Future (2050s) likelihood
Meteorological drought A meteorological drought episode has been defined as a period of longer than 2 weeks where the value of Precipitation-Evapotranspiration (water budget) falls below the 10th percentile.	1 Least likely: <1 episode every 50 years	3 Possible: Once every 10 years
Extreme heat Extreme heat is defined as 2 or more days where the maximum temperature is higher than 29˚C and minimum temperature is higher than 14˚C.	2 Unlikely - Once every 2-10 years	5 Most likely: More than 3x/year
Higher average temperatures The higher average temperature hazard is intended to capture slow on-set, chronic impacts of gradually rising temperature such as ecosystem shifts and long-term wear on infrastructure.	5 Most likely: Increase in average annual temperature is already occurring, and is almost certain to continue.	5
Severe storms Events that consist of heavy precipitation, strong wind gusts, lightning, and/or hail, to a degree which may cause damage to built or natural infrastructure, or hazardous conditions for communities.	3 Possible: Once every 2 years	4 Likely: More than 1x every year
River flooding A 1:100-year river flooding event based on historical values (as of 2015). Future streamflow rates were used to estimate the increase in 1:100-year level flood events.	2 Unlikely: 1% chance of this event happening in a given year (1:100)	3 Possible: Possible: 1.4% chance of the event happening in a given year (1:70 event)
Short duration, high intensity precipitation A short period of heavy rainfall (mm/h). A 1:100-year event based on historical rainfall estimates.	2 Unlikely: 1% chance of this event happening in a given year (1:100)	5 Most likely: There is a 5% chance of an event with the same rainfall volumes happening in a given year (1:20 event)

EXPOSURE

Exposure is the second component of the overall risk score calculation. Exposure is defined as the presence of something of value in a place or setting that could be impacted by a climate hazard (IPCC, 2014). For the CCRI project, exposure represents the amount of people, built assets, and natural areas in each community that could be affected by climate hazards. Exposure does not consider *how* each community's built, social or natural systems will be affected by climate hazards. Rather, exposure provides an estimate of *how many* people and assets are present (and therefore, exposed) in each community.



Exposure was analyzed and scored in three system categories: social, built and natural.

- **Built system exposure** includes the amount of buildings and paved land cover in each community.
- **Social exposure** represents the population (people) in each community.
- **Natural system** exposure refers to unpaved and natural land cover areas, parks, trees, water bodies and other aspects of the natural environment.

Geospatial data was provided by The City of Calgary to evaluate the amount of built infrastructure, natural areas, and population size per community. Using Census data and GIS datasets, counts of people, built and natural assets per community were generated and assigned a relative exposure rating using percentiles (nearest rank method). Some climate hazards incorporated unique exposure indicators, such as river flood maps to measure geospatial river flood exposure. Storm pipe length per community was measured as part of exposure to short duration high intensity precipitation.

The results are presented as current exposure rankings on a scale of 1 (very low) to 5 (very high) for each climate hazard, and a combined all-hazards exposure score. The exposure scores portray relative exposure of each community to each climate hazard. Future exposure scores were also calculated using population projections for 2050.

VULNERABILITY

Vulnerability is the third component feeding into the community risk score. **Vulnerability** is defined as the degree to which a system may be adversely affected by a climate hazard, encompassing a variety of concepts including sensitivity to harm and capacity to cope or adapt.

Sensitivity estimates the degree to which a system could be affected by a climate hazard. Sensitivity is driven by the predisposition of humans, society, infrastructure, and ecosystems to suffer harm as a consequence of intrinsic and contextual conditions.

Adaptive Capacity represents a system's capacity to respond and/or change in response to, and in expectation of, the impact of climate-related hazards. The adaptive capacity inherent in a system represents the set of resources available for adaptation, as well as the ability or capacity of that system to use these resources effectively in the pursuit of adaptation (Levina and Tirpak, 2006).

Vulnerability scores were calculated for each community for all six climate hazards, by observing 40 unique indicators of sensitivity and adaptive capacity for people, built assets and the natural environment.

To determine vulnerability scores, each indicator was analyzed and given a sensitivity or adaptive score in each community. Then, a vulnerability score was generated for each system (social, built and natural) using a vulnerability matrix. Applying the appropriate hazard weighting, the social, built and natural vulnerability scores were averaged for each climate hazard. To generate an all-hazard vulnerability score, all six hazard vulnerability scores were averaged. Like exposure, the hazard-specific vulnerability scores were used to calculate hazard-specific risk scores, and the overall vulnerability score plugged into the overall risk score. The process is shown in the image below.

VULNERABILITY INDICATOR SELECTION

To ensure a holistic and equity-driven understanding of climate risk in communities, 40 unique indicators were used to estimate the **sensitivity** and **adaptive capacity** of social, built and natural systems. The project team studied peer reviewed literature and climate risk indices completed in other communities, regions and countries to select commonly used and evidence-supported indicators.

Depending on the system (built, natural, social), vulnerability can be observed by looking at a wide range of indicators. Assessing social vulnerability is an important step in identifying communities that, while equally exposed to climate hazards, might experience climate impacts disproportionately. Studying social vulnerability indicators allows The City to work towards equitable solutions that consider the needs of more vulnerable populations.

- Social vulnerability to climate hazards is related to the characteristics of humans, communities, and society, and is influenced by many physiological and social factors. Age, gender, race, family, and home conditions can make particular groups more susceptible to harm from climate-related hazards (Islam and Winkel, 2017). For example, individuals living alone are vulnerable because they may not be able to access immediate support in an emergency. In some cases, they may have less social and financial capital to get the resources needed to respond to climate hazards (i.e. if they are the sole person responsible for all household expenses).

- Social vulnerability is also driven by socioeconomic barriers that effect communities' access to healthcare, resources and social supports. Groups that are systemically disadvantaged by society's structures and biases include low income individuals, individuals with low education, one parent families, people of colour and Indigenous people, and elderly people (among others) (Islam and Winkel, 2017). The result of inequitable distribution of resources and access to health care, social support and social capital are important drivers of sensitivity to all hazards - climate hazards included.

- Built system vulnerability is influenced by the predisposition of the infrastructure to experience damage or failure due to a climate hazard. Infrastructure age, condition, and the standards to which the infrastructure was designed are all drivers of sensitivity. Existing stressors to the system such as damage or past events where the assets exceeded capacity are also drivers of vulnerability.

- Natural system vulnerability is influenced by the inherent characteristics of the system. Species type, location, and ecological condition influence sensitivity. Existing stressors to the system such as human disturbance are also drivers of vulnerability (Berry et al., 2014).

The list of vulnerability indicators and the associated climate hazards are presented in the table on the following pages. Detailed descriptions of each indicator are included in the Technical Report.

Indicator	Meteorological drought	Higher average temperatures	Extreme heat	Severe storms	River flooding	SDHI
Age (elderly >65 and youth < 5)						
Gender – Identified as female						
Visible minority population						
Indigenous status/Aboriginal Identity						
One parent families						
Living alone						
Mobility status (Movers to community from 2015-2016)						
Recent immigrant (2011-2016) and non-permanent residents						
Language – Neither French nor English						
Low education - No certificate, diploma or degree						
High household income (>$150,000)						
Low household income (based on the Low-income cut-offs, after tax)						
Low income and aged 65+						
Unemployment						
Public transit access						
Area of tree canopy						
Human disturbance index						
Underperforming parks						
Parks irrigation requirements						
Riparian management zone classification						
Riparian health scores						
Percentage of natural surface cover						
Tree canopy area						
Public tree condition rating						
Water demand						

Percentage of built/paved surface cover			■			
Age of homes – Built before 1960	■	■	■	■	■	■
Age of facilities	■	■	■	■	■	■
Housing condition – Major repairs needed		■	■	■	■	■
Facility condition		■	■	■	■	■
Bridge condition		■	■	■	■	■
Average condition of signals				■	■	
Average condition of streetlights				■	■	
Average condition of pavement		■	■		■	■
Average condition of sidewalks		■			■	■
Signals in poor/very poor condition				■	■	
Streetlights in poor/very poor condition				■	■	
Pavement in poor/very poor condition		■	■		■	■
Sidewalks in poor/very poor condition		■			■	■
Age of stormwater infrastructure					■	■

RISK

The final step of the Community Climate Risk Index was to determine the risk score for each climate hazard in each community, as well as an overall risk score combining all climate hazards. In the context of the CCRI project, climate risk is the result of the interaction between climate hazard probability, the exposure, and vulnerability (sensitivity and adaptive capacity) of each community to each hazard. This combined approach is consistent with the Intergovernmental Panel on Climate Change Fifth Assessment Report (AR5) where risk is the product of hazard probability, exposure and vulnerability.

Current (2020s) risk scores were calculated by multiplying the baseline hazard likelihood by the hazard exposure and vulnerability scores. The process was repeated to generate future (2050s) risk scores, multiplying the future hazard likelihood, future exposure score and the vulnerability score.

A combined overall risk score was generated by calculating the average of each hazard risk score for the current time period. The same process was repeated for a future combined risk score.

The current and future risk scores were assigned a qualitative rating using the scale below. The scale was developed by grouping the range of resulting risk scores (for current and 2050 risk) into five risk levels.

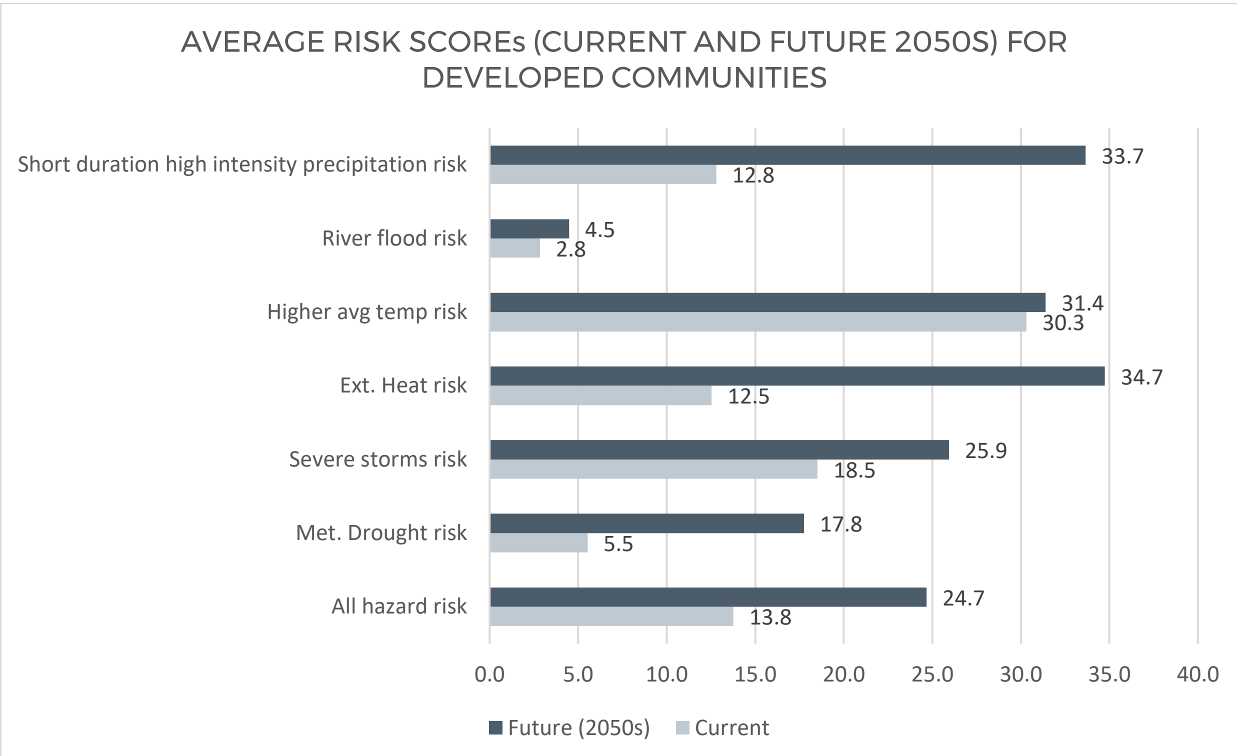
Risk Score Legend

Risk Score Range		Risk Rating
0	17	Very low
18	35	Low
36	53	Moderate
54	71	High
72	90	Very high

RESULTS

The average risk scores for developed communities in Calgary are shown in the graph below. The average risk score for all hazards is very low. By the 2050s, the risk score increases to approximately 25.

Figure 1: Current and Future Average Risk Scores (developed communities only)



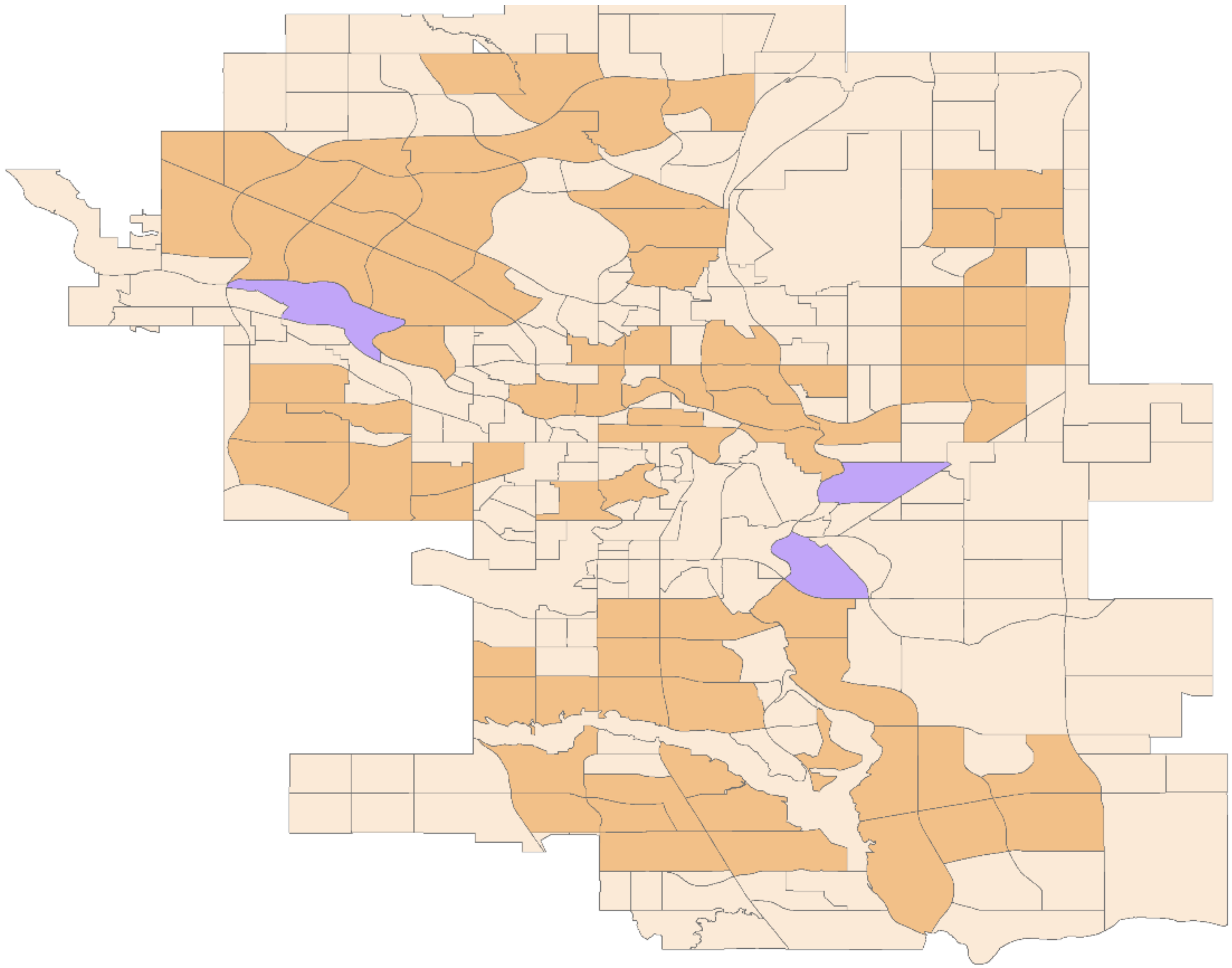
Currently, the top-risk hazards are higher average temperatures and severe storms. In the future, the highest-risk hazards are shown to be **extreme heat, higher average temperatures, and short duration high intensity precipitation.** These hazards are expected to have the greatest increase in the future, and exposure will increase as the population continues to grow.

Risk maps

Community climate risk maps were created using the all-hazard risk scores, as seen on the following pages. The northwest quadrant and southeast quadrants in Calgary have the highest overall risk scores today and in the 2050s. These areas include some of Calgary's oldest communities, meaning infrastructure and homes may be aging and more sensitive to climate-related impacts. Some communities in these quadrants are in close proximity to the Bow River, increasing exposure and vulnerability to river flooding.

Risk in each community is caused by various drivers. In general, risk scores tend to be higher in denser communities with larger concentrations of vulnerable populations, such as elderly and youth, low income, or individuals living alone. Communities adjacent to the Bow or Elbow rivers also tend to be more vulnerable, especially those with riparian areas in poor condition or that require restoration.

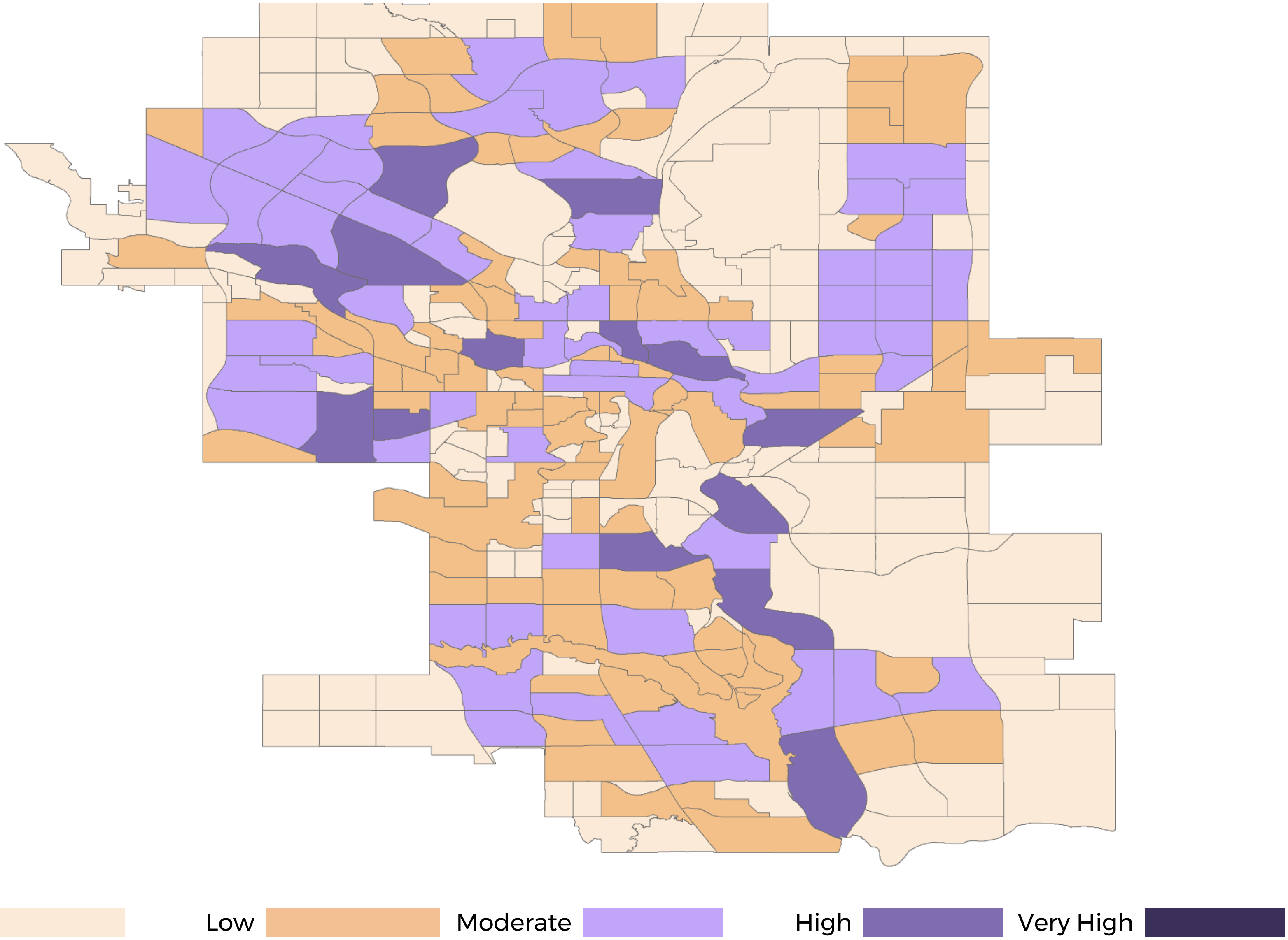
Figure 2: Current climate risk map (all hazards combined)



Very Low | Low | Moderate | High | Very High

Risk results are shown relative to all developed Calgary communities

Figure 3: Future climate risk map (all hazards combined)

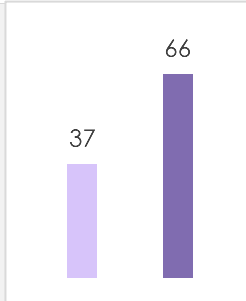
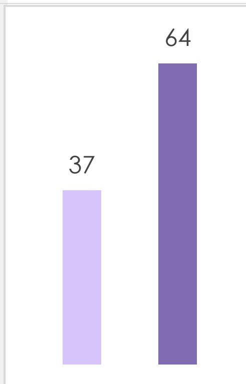
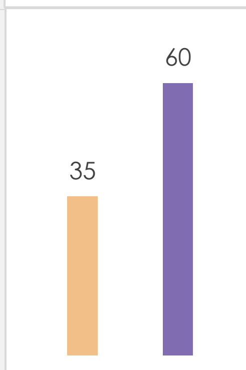
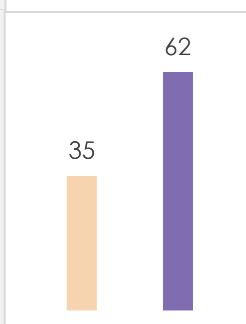


Risk results are shown relative to all developed Calgary communities

Communities with the highest risk scores

The communities with the highest overall risk scores are Ogden, Bowness, Bridgeland/Riverside, and Dover. The risk drivers listed below are named based on Census data (for social indicators) and other datasets that were analyzed. Each indicator is explained in detail in the Technical Report.

Table 2: Top Risk Communities and Risk Drivers

COMM.	CURRENT	FUTURE	RISK SCORE CHANGE	TOP RISK DRIVERS
Ogden	Current risk: Moderate Highest risk: Higher average temperatures (Very high)	Future risk: High Highest risk: Extreme heat (Very high)		— Large underperforming park area — Low riparian health score — Large tree canopy (improves adaptive capacity to extreme heat, but also drives sensitivity to storms, higher average temperatures) — 20% of the population are elderly or youth — 19% have no certificate, diploma or degree
Bowness	Current risk: Moderate Highest risk: Higher average temperatures (High)	Future risk: High Highest risk: Extreme heat (Very high)		— Over 1400 homes built before 1960 — Almost 400 homes in need of major repair — Average public tree condition rating is relatively low compared to other communities — Low riparian health scores — Parks and fields require irrigation — Large population — 20% of the population are elderly or youth — 20% of the population are newcomers to the community — 14% of residents live alone
Dover	Current risk: Low Highest risk: Severe storms (Moderate)	Future risk: High Highest risk: Extreme heat (Very high)		— Majority of community is natural land cover (improves adaptive capacity to extreme heat and heavy precipitation, but can also be sensitive to drought and higher average temperatures) — Natural areas have high human disturbance — Parks and fields require irrigation — 22% of the population are elderly or youth — 27% of population are visible minorities — 25% of population have no certificate, diploma or degree
Bridge-land/ Riverside	Current risk: Low Highest risk: Higher average temperatures	Future risk: High Highest risk: Higher average temperatures		— >900 homes built before 1960 — Large riparian area — Large tree canopy area — Majority of riparian area has been developed — Large underperforming park area — 25% of the population are elderly or youth — 25% of the population are living alone — 3% of population low income and over age 65

From the present day to the 2050s, community risk scores are increasing by 110% on average.

The greatest increase in risk occurs for extreme heat, meteorological drought, and short duration high intensity precipitation. Risk is increasing the most for these hazards because their likelihood is rising drastically from the historical trends to the future projections. Exposure is also expected to increase for these hazards due to population growth and continued development. Vulnerability scores do not change from current to future (due to data limitations), but the indicators of sensitivity and adaptive capacity have an influence on both current and future risk scores. The percentage increase of each risk score is shown in the table below.

Table 3: Risk score increase by hazard

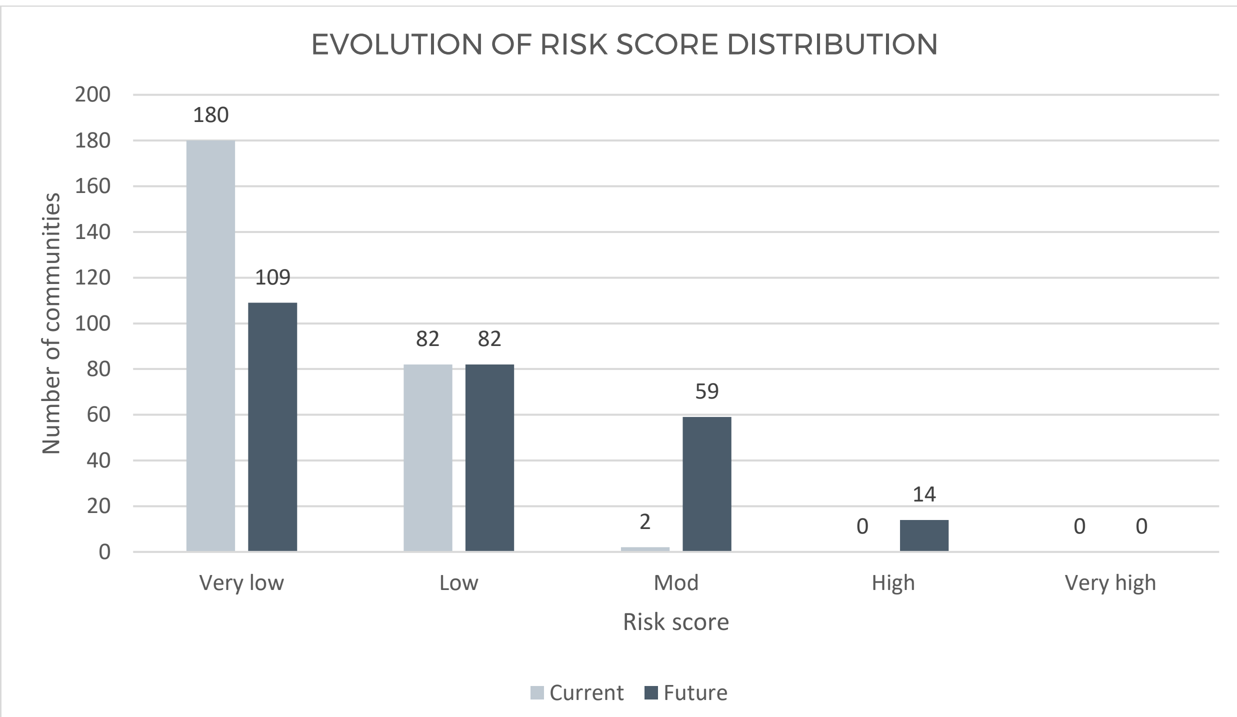
	All hazards	Met. drought	Severe storms	Extreme heat	Higher avg. temps	River flooding	SDHI
Current	13.8	5.5	18.5	12.5	30.3	2.8	12.8
Future (2050s)	24.7	17.8	25.9	34.7	31.4	4.5	33.7
Increase	80%	221%	40%	177%	4%	58%	163%

Over time, risk appears to increase for all climate hazards (assuming no further measures to reduce vulnerability or exposure). Risk scores increase mainly due to the increase in hazard likelihood and exposure (driven by population growth). Some communities which had very low risk will see an increase to low risk, for example. At present, there are no communities with very high- or high-risk scores, but **by the 2050s, 14 communities will fall within the high scoring risk category.**

It is important to remember that the CCRI risk scores are static numbers that depict relative community risk based on the data used for the CCRI project. Risk scores are expected to evolve over time, and will not necessarily increase in the manner predicted in the CCRI. Risk levels may increase due to population growth and development, disasters that damage infrastructure and ecosystems, or shifts in climate hazard probability or exposure due to climate change. If and when adaptation measures are undertaken by The City, risk levels may decrease.

The change in relative risk scores is shown in the figure below.

Figure 4: Evolution of Risk Scores from Present to Future (2050s)

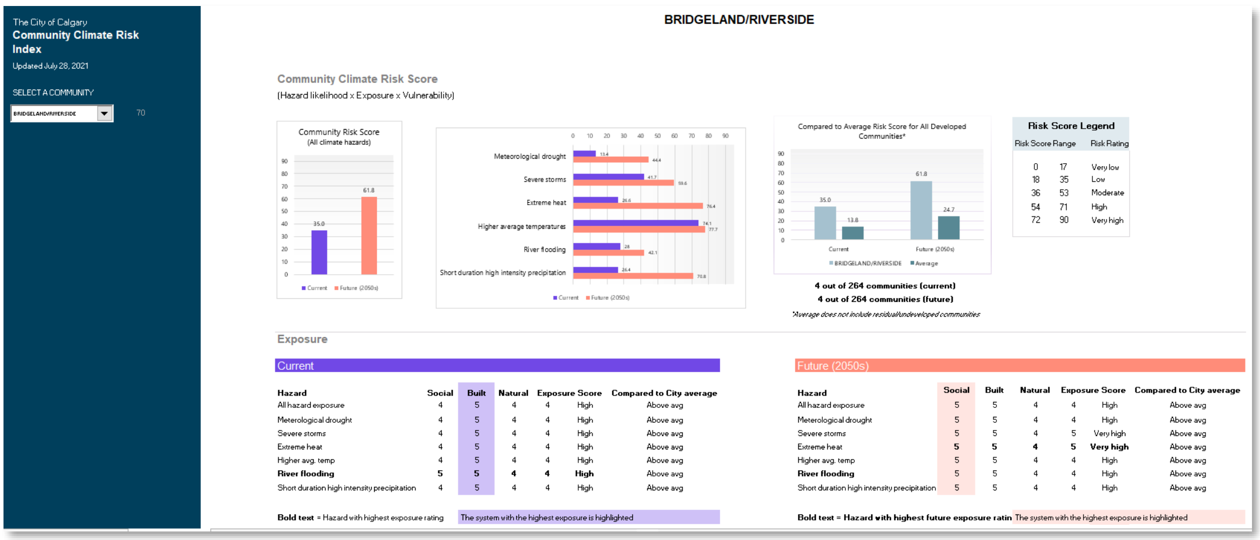


PROJECT OUTPUTS

Dashboard

An Excel dashboard was created to visualize the results of the CCRI project. The dashboard helps users visualize the CCRI results by community, and see the results of exposure, vulnerability and risk components by system and by hazard. The dashboard also includes the data for each individual vulnerability indicator and its influence on the overall risk score.

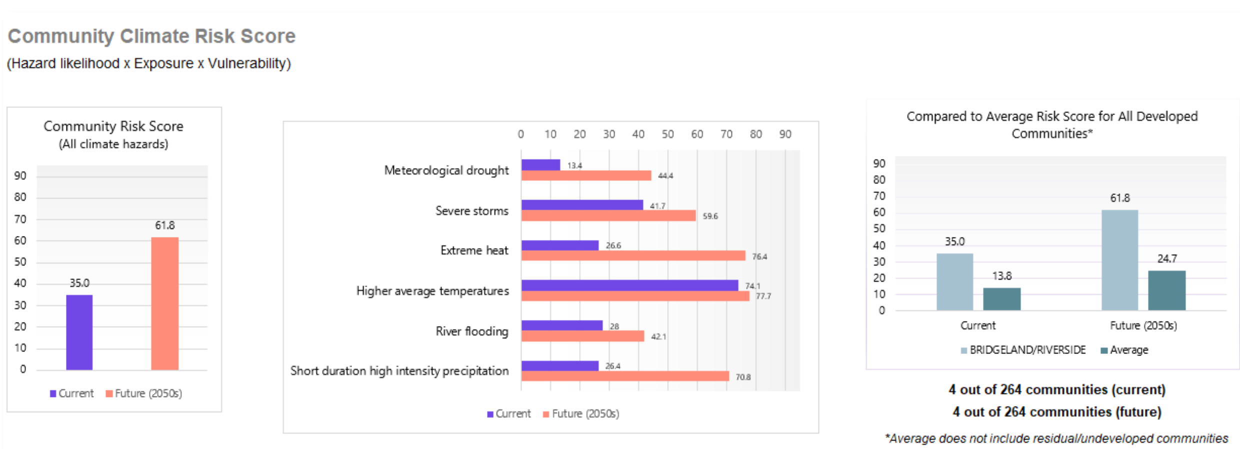
Figure 5: Screenshot of CCRI Results Dashboard



The dashboard contains five main sections.

1 The first charts in the dashboard present the overall community risk score, risk scores by hazard, and a comparison of the community to the citywide risk score.

Figure 6: Screenshot of community risk scores from CCRI Dashboard



2 Current and future exposure scores are presented by hazard and by system (social, built and natural).

Figure 7: Screenshots of exposure scores from CCRI Dashboard

Exposure

Current

Hazard	**Social**	**Built**	**Natural**	**Exposure Score**		**Compared to City average**
All hazard exposure	5	5	4	4	High	Above avg
Meterological drought	5	5	4	4	High	Above avg
Severe storms	5	5	4	5	Very high	Above avg
Extreme heat	**5**	**5**	**4**	**5**	**Very high**	Above avg
Higher avg. temp	5	5	4	4	High	Above avg
River flooding	4	1	3	2	Low	Average
Short duration high intensity precipitation	5	5	4	5	Very high	Above avg

Bold text = Hazard with highest exposure rating

The system with the highest exposure is highlighted

Future (2050s)

Hazard	**Social**	**Built**	**Natural**	**Exposure Score**		**Compared to City average**
All hazard exposure	5	5	4	4	High	Above avg
Meterological drought	5	5	4	4	High	Above avg
Severe storms	5	5	4	5	Very high	Above avg
Extreme heat	**5**	**5**	**4**	**5**	**Very high**	Above avg
Higher avg. temp	5	5	4	4	High	Above avg
River flooding	5	1	3	3	Moderate	Above avg
Short duration high intensity precipitation	5	5	4	5	Very high	Above avg

Bold text = Hazard with highest future exposure rating

The system with the highest exposure is highlighted

3 Community vulnerability scores are presented by hazard and by system.

Figure 8: Screenshot of vulnerability scores from CCRI Dashboard

Vulnerability

Current

Hazard	Soc	Built	Nat	Vulnerability Score		Compared to average
All hazards	3	4	4	3	Moderate	Above avg
Met. Drought	3	5	3	3	Moderate	Above avg
Severe storms	3	3	4	3	Moderate	Above avg
Extreme heat	3	3	4	3	Moderate	Above avg
Higher avg. temp	**3**	**4**	**4**	**4**	High	Above avg
River flooding	3	3	3	3	Moderate	Above avg
Short duration high intensity precipitation	3	4	3	3	Moderate	Above avg

Note: River flood vulnerability is 0 for communities that are not exposed.

Bold text = Hazard with highest vulnerability rating

The system with the highest exposure is highlighted

4 Each climate hazard is defined, and the current and future likelihood scores are provided in the dashboard for reference. Hazard weighting for the overall risk scores is also included in a table.

Figure 9: Screenshot of climate hazard likelihood ratings from CCRI Dashboard

Climate Hazards

Note: Hazard likelihood is the same across all communities except for river flooding.

Meteorological drought	Present likelihood	Future likelihood (2050s)
A meteorological drought episode has been defined as a period of longer than 2 weeks where the value of Precipitation-Evapotranspiration (water budget) falls below the 10th percentile.	1 Least likely: <1 episode every 50 years	3 Possible: Once every 10 years

Extreme heat	Present likelihood	Future likelihood (2050s)
Extreme heat is defined as 2 or more days where the maximum temperature is higher than 29°C and minimum temperature is higher than 14°C.	2 Unlikely: Once every 2-10 years	5 Most likely: More than 3x every year

5 A Community Indicators & Drivers table lists each of the vulnerability indicators used for the CCRI. The raw data from each indicator is included (e.g. number of elderly people per community, condition rating of pavement in the community, area of underperforming parks, etc.). The table identifies whether the indicator was used as a sensitivity or adaptive capacity metric, and provides the sensitivity or adaptive capacity score on a scale of 1-5. For each indicator, the influence on the risk score is also identified. Indicators that scored particularly low or high and had a greater pull on the final risk score and can be quickly identified.

Figure 10: Screenshot of Community Indicators & Drivers table from CCRI Dashboard

Community Indicators & Drivers

SELECT A HAZARD All hazards

Note: Blank values mean no data was available. 0 in S or AC columns also means no data was available.

Social

Indicator	Community	S or AC Rating		Influence on risk score
Current population	10351	5	S	High
People aged over 65 and under 5 years old	22%	5	S	High
Visible minority population	27%	4	S	Medium
Indigenous status/Aboriginal identity	7%	5	S	High
Living alone	14%	5	S	High
One parent families	6%	5	S	High
Women identified	48%	1	S	Low
Newcomers to community	19%	1	AC	High
Recent immigrant (2011-2016) and non permanent residents	7%	2	AC	Medium
Home language is neither FR or EN	3%	1	AC	High
Low education (No certificate, diploma or degree)	25%	1	AC	High
Low income over age 18	12%	1	AC	High
Low income and aged 65+	2%	1	AC	High
Unemployed	6%	1	AC	High
High income household	1%	2	AC	Medium
Number of public transit stops (LRT and BRT)	45	5	AC	Low

Community Profiles

A key output of the CCRI project was a pilot project to create Community Profiles for two Local Area Planning projects in Calgary.

Community Climate Risk Profiles are summary reports of climate exposure, vulnerability and risk to six climate hazards relevant to Calgary. Exposure, vulnerability and overall risk can be explored within individual communities and compared across planning areas and the city as a whole. The Community Climate Risk Profiles also provide insight into the geographic and community-specific indicators that drive climate risk, such as geographical features, demographics, and the condition of existing built and natural environments.

The intent of the Community Climate Risk Profiles is to help decision-makers understand how climate change hazards may affect Calgary communities, which factors are driving community exposure and vulnerability, and how the driving factors may be addressed through policies, investments, and/or other measures to reduce risk.

The Profiles are intended to be used internally by community planning teams to understand community scale climate risks and integrate measures to increase climate change resilience within planning processes. Specifically, they can aid planners in selecting climate resilience measures for inclusion in Local Area Plans, as a means to address the key drivers of climate risk at the community scale.

Figure 11: Screenshots from Community Profiles

NEXT STEPS

FURTHER STUDIES

Throughout the CCRI project, opportunities for additional climate change risk studies were identified. Such projects can help The City address data gaps and better understand some of the more complex indicators of climate resilience. Examples of potential further studies may include:

1. A study to assess vulnerability and risks to critical infrastructure, infrastructure interdependencies and cascading climate risks across built, social and natural assets.
2. A study or survey of adaptive capacity of social and built systems at The City and within communities (e.g. a qualitative survey of community/City response capacity).
3. The City may consider adding additional climate hazards such as forest fires to the Risk Index, however, differentiating forest fire risk by community may be challenging.

UPDATING THE COMMUNITY CLIMATE RISK INDEX

It will be important to update the CCRI to incorporate new data as it becomes available. Doing so will help ensure an up-to-date snapshot of community climate vulnerability and risk. As further projects are completed, results can be periodically incorporated into the CCRI analysis and dashboard. Examples of potential updates to CCRI data include the forthcoming provincial flood maps (estimated in 2023-2024), the 2020 Census, and new asset management data as the Infrastructure Status Report is periodically updated.

COMMUNITY EDUCATION AND ENGAGEMENT

The CCRI represents a snapshot in time of climate risk in Calgary. The CCRI results were largely informed by publicly available data that was applicable to the scope and methodology of the project (such as the Census and geospatial data of buildings and land use). It is important to note that the data used to generate the risk scores may not paint the full picture of climate change vulnerability and risk in Calgary. To fully understand the extent of community climate risk, engaging directly with communities who experience climate change firsthand is crucial. As plans are developed to share the results of the CCRI more broadly, it is recommended to consider the inclusion of community-driven data. Gathering climate information from the “ground up” can help establish a more nuanced and holistic understanding of sensitivity and adaptive capacity, validate the results of the CCRI, and help The City target adaptation measures in vulnerable communities and systems.

USING THE RESULTS OF THE COMMUNITY CLIMATE RISK INDEX

The intent of the CCRI is to help integrate climate resilience into citywide decision-making, and inform targeted adaptation and resilience actions that advance The City's Resilience Strategy. The results are also intended as a baseline against which the City can measure its progress on reducing climate related risks to built, natural, and social systems.

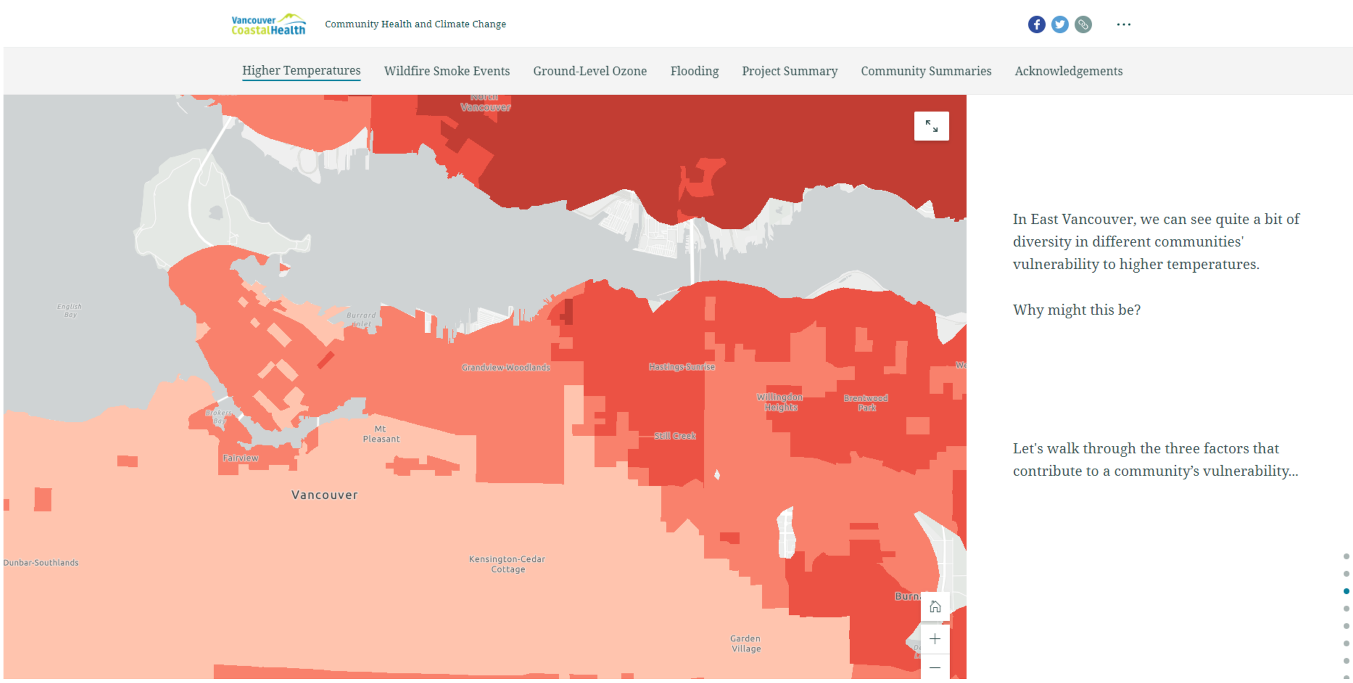
The City's Adaptation Team will use the CCRI results internally, to inform future climate adaptation and resilience initiatives. Tailored programs and projects will be designed to support communities that have higher risk levels, targeting specific risk drivers. Outside of the Climate Adaptation Team, the results will continue to be used to develop Community Profiles for all multi-community growth areas in Calgary. The Adaptation Team also intends to use the results to support other business units at The City of Calgary. The City is now able to provide project teams with relevant climate hazard, exposure and vulnerability data, as well as information on key risk drivers at the community scale, tailored to the nature of the project. The results of the CCRI can be used in other ways, such as:

- Developing a strategy to integrate the CCRI results into other hazard risk indices and risk management initiatives conducted by the Calgary Emergency Management Agency (CEMA).
- Using the CCRI data to guide climate-informed asset management processes, and to continuing exploring the linkages between critical infrastructure and climate risk.
- Using the CCRI data to support The City's parks teams in identifying climate-related risks to park assets, and planning appropriate interventions for communities with vulnerable natural systems.
- The results can help The City determine when more detailed and site-specific risk assessments may be appropriate, applying The City's existing climate resilience assessment templates. For example, communities with particularly sensitive riparian areas, parks or road infrastructure may be selected.
- The City may use the climate risk scores to advance climate risk disclosure, utilizing frameworks such as the Task Force for Climate-related Financial Disclosure. Municipal risk disclosure has been identified as an emerging good practice aligned with the direction of major financial intuitions and real asset owners.

Disseminating results

The City will determine the appropriate format to share the community risk scores publicly, while ensuring that the results can be accurately interpreted by a lay audience. Community-facing results could include online climate profiles and interactive maps, which can be used as tools to inform the Calgarians about climate risks in their communities. The City will also explore adapting the multi-community profiles into public facing resources that can be used as outreach and education tools as more Local Area Plans are developed.

Finally, The City intends to develop an internal GIS database using the results from the CCRI project. The GIS databases can be tailored to internal or public facing purposes and could offer users an opportunity to visualize climate risk by hazard, system and by community, similar to the City's existing disaster explorer maps or the maps created by the research organization Climate Central. The example below is an interactive online risk map created by Vancouver Coastal Health.



CONCLUSION

While climate hazards and exposure are largely outside of the control of The City, there is a great deal that can be done to reduce vulnerability and overall risk in Calgary. Communities can be supported through tailored initiatives that help vulnerable groups overcome barriers and access resources to help prepare and respond to climate hazards. Adaptive capacity can increase through education and engagement of City staff and communities on climate risks and resilience measures. Natural systems can become more resilient through continued protection and enhancement of ecosystems, especially those in need of restoration and conservation. Vulnerabilities in built infrastructure can be reduced by adapting assets that are sensitive to climate hazards, such as older infrastructure or heavily paved areas with poor drainage. The Community Climate Risk Index offers infinite possibilities for exploring the dimensions of climate risk at the sub-city scale. Further, it provides The City of Calgary with a decision-making tool to advance adaptation in the pockets and systems within Calgary which may benefit the most.

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