Climate Vulnerability and Adaptation Report for Butte-Silver Bow

2022

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Introduction

The effects of climate change are already being experienced in Butte-Silver Bow (BSB) and will continue for decades to come. These changes include higher average temperatures and more extreme heat, changes in precipitation intensity and seasonal distribution and increased risk of flooding, more frequent and severe droughts, and more frequent wildfires and a longer fire season. Climate-related impacts, coupled with pre-existing challenges such as poverty, houselessness and lack of affordable housing, demographic shifts, environmental contamination, and aging infrastructure have significant implications for the people, infrastructure, and environment of BSB.

The purpose of this report is to improve understanding about local climate change impacts and vulnerabilities and present adaptation responses that can help reduce community vulnerability and/or increase resilience. The report synthesizes the results of a 2-day, in-person workshop held in June 2022. This workshop brought together 28 stakeholders from across Butte-Silver Bow to evaluate community vulnerability and develop adaptation strategies for three focus areas of importance to the community: (1) public health, (2) water resources, and (3) contaminated sites protection and redevelopment.

The subsequent sections in this report are described below:

- **Project Methods and Workshop Activities** – Provides an overview of the climate adaptation planning process, workshop series, and selection of pre-existing conditions and climate stressors.
- **Overview of Climate Projections and Impacts** – Presents a summary of current and projected climate changes for the community.
- **Vulnerability Assessment and Adaptation Planning Results** – Summarizes vulnerability and adaptation information for each of the three focus areas.
- **Conclusions** – Highlights common concerns, impacts, and adaptation strategies across the different focus areas.

Project Methods and Workshop Activities

Climate Adaptation Planning Overview

Climate change adaptation refers to how we prepare for, respond to, and recover from changes we are already experiencing and/or are expected to experience. *Adaptation*, which focuses on managing the impacts of climate change, can be distinguished from *mitigation*, which refers to efforts intended to decrease the potential for climate change itself (e.g., by reducing greenhouse gas emissions or enhancing carbon sequestration). The adaptation planning process (Figure 1) intentionally integrates the consideration of climate change into plans, programs, projects, and operations and is meant to be iterative.

While there are many different climate adaptation planning frameworks, they generally consist of the same steps: (1) project scoping, (2) assess vulnerability, (3) identify adaptation strategies, (4) implement those strategies, and (5) monitor, evaluate, and adjust strategies, as needed.

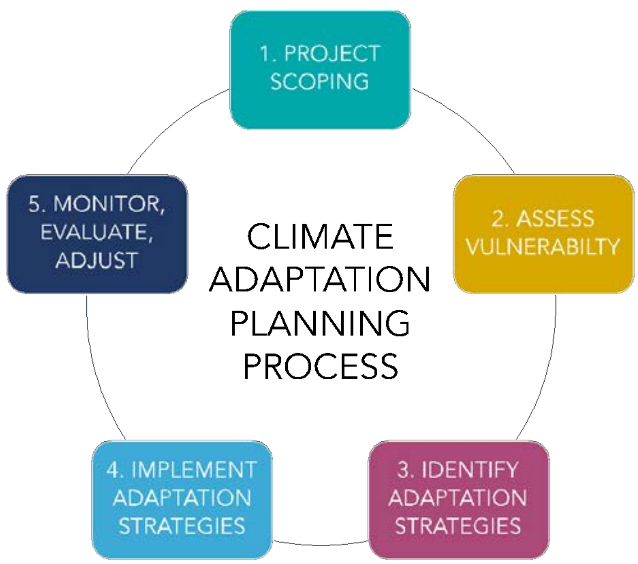

Figure 1. Steps in a basic climate adaptation planning process.

These steps are described below:

(1) **Project scoping**. This step includes identifying goals and desired outcomes of the process, establishing the geographic boundaries and timeframe of interest (i.e., near-term= 0–20 years; mid-term= 25–50 years; long-term= 50+ years), identifying and engaging with key stakeholders and partners, and identifying key climate stressors and pre-existing conditions (i.e., stressors that already impact a

community). Completion of this step is critical to provide the foundation for a clear and efficient adaptation planning process.

(2) **Assess Vulnerability**. Vulnerability assessments improve understanding of how climate change is likely to impact a community and its ability to respond to those impacts. Vulnerability assessments include consideration of the likelihood of exposure to climate change, the consequence of that exposure, and the community's capacity to adapt to those impacts. These assessments include consideration of the following three components of vulnerability:
- **Likelihood** is the degree to which a community is exposed to significant changes in climate and considers both the anticipated direction and magnitude of change.
- **Consequence** is the degree to which a community is affected by exposure to a changing climate and considers both the anticipated impacts of climate stressors as well as the impacts of pre-existing conditions.
- **Adaptive capacity** is the ability to adjust to climate change to minimize potential damages, take advantage of opportunities, or cope with consequences.

Likelihood and consequence together give an estimation of risk that, when combined with adaptive capacity, provides an overall picture of vulnerability (Figure 2). It is important to evaluate all three components – likelihood, consequence, and adaptive capacity – to gain a holistic perspective of the factors that are driving vulnerability.

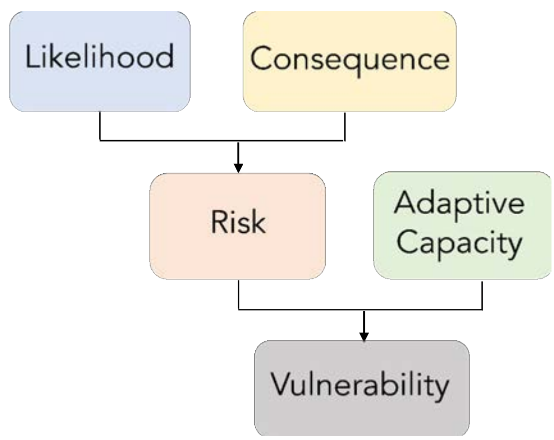

Figure 2. Components of vulnerability.

The vulnerability assessment step of the adaptation planning process includes evaluating the impacts of climate change on a community; characterizing the community's ability to minimize or cope with impacts; assigning likelihood, consequence, and adaptive capacity rankings; and summarizing overall vulnerability based on rankings, impacts, and adaptive capacity information. The resulting level of vulnerability is assessed using risk matrices that incorporate these components (Figure 3).

RISK CALCULATOR MATRIX

Likelihood	Consequence			
	Negligible	Moderate	Major	Catastrophic
Rare	Low	Low	Low	Low
Unlikely	Low	Moderate	Moderate	High
Likely	Low	Moderate	High	Extreme
Almost Certain	Low	High	Extreme	Extreme

VULNERABILITY CALCULATOR MATRIX

Risk	Adaptive Capacity		
	Low	Moderate	High
Low	Low	Low	Low
Moderate	Moderate	Moderate	Low
High	High	Moderate	Moderate
Extreme	High	High	Moderate

Figure 3. Matrices for assessing level of risk and vulnerability.

(3) **Identify Adaptation Strategies**. Adaptation strategies aim to reduce the negative effects or take advantage of the opportunities provided by climate change. The goal of this step is to identify adaptation strategies that reduce risk (limit exposure or minimize consequence) and/or enhance resilience (increase adaptive capacity). Understanding what drives vulnerability to climate change (likelihood, consequence, adaptive capacity, or some combination of these) provides a good starting point for identifying possible adaptation strategies. General types of adaptation strategies that may be considered include programmatic; capital improvements and infrastructure; coordination and/or collaboration; knowledge and evaluation; and plans, regulations, and policies. To help decide which actions to prioritize for implementation, it can be helpful to articulate co-benefits (e.g., greenhouse gas reduction, public health improvement, water quality improvement, etc.) and conflicts or challenges (e.g., unintended consequences on people or community assets).

(4) **Implement Adaptation Strategies**. When a list of adaptation strategies has been generated and prioritized, they must be put into action. Developing an

adaptation implementation plan for each prioritized strategy helps communities articulate how and when (e.g., immediately, within the next 5 years, etc.) the strategy should be implemented, leads and partners responsible for implementation, existing resources and those that are still needed, and potential barriers to implementation.

(5) **Monitor, Evaluate, and Adjust**. Climate change adaptation planning should be an iterative process, and monitoring and evaluation are essential components that allow communities to make progress while also adjusting actions based on project outcomes and new information. For instance, post-implementation monitoring of adaptation strategies helps to determine whether the strategies are having their intended effect and when or where adjustments might be needed. Developing a monitoring and evaluation plan is critical to minimize wasted time, money, and effort. These plans should include identification of desired outcomes, parameters to monitor and the method to do so, thresholds that may signal desired outcomes are not being met, and possible alternative strategies to pursue if these thresholds are crossed.

Tools Used in the Workshop

Climate Change Adaptation Certification Tool

The Climate Change Adaptation Certification Tool (CCAC)[1] is intended for use during regulatory or procedural review processes being carried out as part of routine community functions. The CCAC can be applied to decisions about any project or proposal that will involve the use of public funds, has a life cycle of greater than 5 years, and can impact public good (e.g., fiscal expenditures, capital planning, permitting, infrastructure design, and siting). Applying the CCAC to these decisions allows explicit evaluation of future conditions on project function and longevity, increases understanding of the long-term sustainability of a project at the funding or permitting phase and considers how to reduce community risk that could arise from actions that become a liability under future conditions. The CCAC process includes three steps:

1. Identification of climate change risk factors
2. Evaluation of climate impact on a project
3. Determination of project review

[1] http://ecoadapt.org/data/documents/EcoAdaptCCAC_BSB2022_Fillable.pdf

Rapid Vulnerability and Adaptation Tool[2]

The Rapid Vulnerability and Adaptation Tool (RVAT) for Climate-Informed Community Planning was developed to make climate adaptation planning a simple, direct, and feasible process for communities. The purpose of the tool is to improve understanding of community vulnerability to climate impacts and to develop implementable solutions that reduce vulnerability and/or increase resilience. The RVAT is designed to cover the major steps of a basic climate adaptation planning process, which include:

1. Project scoping,
2. Vulnerability assessment,
3. Adaptation strategy development, and
4. Adaptation implementation.

Workshop Series Overview

The Butte-Silver Bow Climate Change Adaptation Workshop series[3] was held on June 8 and 9, 2022. The first day of the workshop focused on discussing climate impacts and assessing vulnerability, and the second day focused on developing adaptation strategies and an introduction to network mapping. Workshop activities for each day are discussed in more detail below.

Climate Adaptation Workshop Activities: Day 1

The first day focused on orienting participants to the workshop series, introducing climate adaptation planning and the steps involved, identifying and prioritizing pre-existing conditions (i.e., stressors that currently impact the community), presenting climate change projections and discussing impacts, introducing and completing the first step of the CCAC, and completing the first two steps of the RVAT (project scoping, including prioritizing pre-existing conditions and climate stressors and evaluating adaptive capacity, and conducting the vulnerability assessment).

Workshop activities were divided between presentations, large group discussions, and breakout group activities. Workshop participants were divided into groups to address three focus areas:

- Group 1: Public Health
- Group 2: Water Resources
- Group 3: Contaminated Sites Protection and Redevelopment

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[2] http://ecoadapt.org/data/documents/RVAT_BSB.pdf

[3] The workshop support page (http://ecoadapt.org/workshops/bsb-june2022-workshop) includes links to presentation slides and all other workshop materials.

Workshop participants, including affiliations and group assignments, can be found in Appendix A.

Project Scoping: Identifying Pre-Existing Conditions and Climate Stressors

As part of the first step of the RVAT (project scoping), workshop participants were asked to identify pre-existing conditions for Butte-Silver Bow (i.e., stressors that already impact the community). Participants collectively identified more than 25 pre-existing conditions that, through discussion and ranking in each breakout group, were narrowed down to top priority conditions (bolded items represent top three conditions selected by the group):

- Group 1, Public Health: **High poverty rates, pre-existing health conditions, mental health issues,** lack of access to medical care, contamination, substance abuse, low quality and quantity of housing stock, houselessness, demographics and older population, and population growth
- Group 2, Water Resources: **Surface and groundwater contamination**; challenges of a closed basin; limited water sources; **aged and aging infrastructure**; **water rights issues, including first-in-use rights, and utilitarian versus conservation approaches to water use**; water use, particularly agricultural and industrial use; and utilitarian versus conservation approaches to water use
- Group 3, Contaminated Sites Protection and Redevelopment: **Contaminated air and soil**, s**oil quality and low native biodiversity**, airborne contaminants, **risks associated with ongoing mining activities and remedial actions**, novel ecosystems and invasive species, high elevation and associated short growing season, and steep slopes and aspects and associated complex microclimates

Major climate stressors for Butte-Silver Bow were identified by workshop facilitators (Appendix B) and included increasing wildfire risk and air quality impacts, extremes in precipitation/precipitation shifts, extreme temperatures, and drought.

Conducting the Vulnerability Assessment

The identified pre-existing conditions and climate stressors provided the basis for the second step of the RVAT (vulnerability assessment). Each breakout group explored the intersection of these conditions and climate stressors to identify the impacts of greatest concern for their focus area. For each of these impacts, the groups assessed the primary components of vulnerability:

- *Likelihood* of the impact occurring
- C*onsequence* to the community were the impact to occur

- The consequent *risk* resulting from the product of likelihood and consequence
- *Adaptive capacity* of the community in terms of the staff and resources that the relevant jurisdictional and/or community groups have available to address the impact

These rankings were then used to determine risk (resulting from the intersection of likelihood and consequence) and overall vulnerability for that impact, based on matrices provided within the RVAT worksheets. The results of this vulnerability assessment formed the foundation for the adaptation solutions work during Day 2 of the workshop.

Climate Adaptation Workshop Activities: Day 2

On Day 2, the breakout groups focused primarily on identifying adaptation strategies that would reduce impacts of greatest concern for each focus area and then developing implementation plans for priority strategies (the third and fourth steps of the RVAT, respectively).

Workshop participants were also introduced to a network mapping tool (https://network-mapping-41fb1.web.app/). This tool, developed by Virginia Tech staff based on registration and pre-workshop planning, shows participants the existing relationships among local government departments/agencies and/or community organizations and how each links to different focus areas. The tool is designed to help participants think about the connections and partnerships that can support Butte-Silver Bow in implementing adaptation solutions developed in the workshop as well as moving forward on community collaboration for climate change adaptation.

Overview of Climate Projections and Impacts

The following summaries provided foundational information for the workshops about current and projected future climate changes. A table of observed and projected climatic changes can be found in Appendix B.[4]

Air Temperature and Extreme Heat

By 2050, average daily minimum temperatures (minimum daily temperatures averaged across the whole year) in Butte-Silver Bow are projected to increase by 4.3°F above the historical average of 23.8°F from 1961–199, and average daily maximum temperatures

[4] Projections for air temperature, extreme heat, and annual precipitation were obtained from the U.S. Climate Resilience Toolkit Climate Explorer (https://crt-climate-explorer.nemac.org), generated using the high-emissions scenario for 2050/mid-century (average of 2035–2064) and 2100/late-century (average of 2070–2099) time periods compared to average conditions between 1961–1990.

are projected to increase by 4.8°F above the historical average of 49.9°F. By 2100, minimum and maximum temperatures are likely to have increased by 10.4°F and 11.0°F above historical averages, respectively.

Extreme heat events are also likely to increase significantly. The number of days with maximum temperatures over 90°F are likely to increase from the historical average of 0.8 day per year to 9 days per year by 2050 and just over 39 days per year by 2100 (representing a 1,025% and 4,800% increase, respectively).

Precipitation and Drought

Changes in annual precipitation in Butte-Silver Bow are expected to be relatively insignificant by mid-century, with model projections suggesting increases of 3.8% from the historical average of 18.5 inches per year (to 19.2 inches per year). By 2100, annual precipitation is projected to have increased by 8.2%, to 20 inches per year. More significant shifts are expected in how precipitation is distributed within the course of the year, with large increases expected in winter and spring precipitation (21% and 22%, respectively) by 2100. Slight decreases are likely in summer (-7%) and fall (-5%) precipitation.[5]

Snow

Over the past 80 years (1935–2015), southwestern Montana has experienced a 20% decrease in April snowpack, with more significant changes at lower elevations. By 2100, April snowpack is expected to decline by an additional 50%. In addition, spring snowmelt is likely to shift earlier in the year due to warmer temperatures, resulting in earlier spring peak flows and reduced late-summer stream flows.[6]

Extreme Precipitation and Flooding

Extreme precipitation, which is strongly associated with flooding, is likely to increase in terms of both frequency and amount. The number of days each year when at least 1inch of rain falls in 24 hours is expected to increase slightly, from 0.8 day to 0.9 day (+12.5%) by 2050, and then to 1.4 days (+75%) by 2100. An increase is also projected

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[5] J.R. Alder, J. R. and S. W. Hostetler, 2013. USGS National Climate Change Viewer. US Geological Survey (https://doi.org/10.5066/F7W9575T), county-scale projections generated using the high-emissions (RCP 8.5) scenario for the mid-century (average of 2025–2049) and late-century (average of 2075–2099) time periods compared to recent conditions (average of 1981–2010).

[6] C. Whitlock, W. F. Cross, B. Maxwell, N. Silverman, A. A. Wade, 2017. Montana Climate Assessment. (Montana State University and University of Montana, Montana Institute on Ecosystems, Bozeman and Missoula, MT, 2017), doi:10.15788/m2ww8w 88/m2ww8w.

in the amount of rain falling in a given extreme precipitation event, with rainfall totals within a 20-year storm event expected to increase 16% by 2100.[7]

Over the coming century, these trends are likely to continue. Although flooding projections are not available for Butte-Silver Bow, it is likely that increases in extreme precipitation frequency and amount will increase the risk of severe flooding. Flood risk will likely be highest in the spring when peak flows are also projected to be higher and average seasonal precipitation will likely increase.

Drought

The Butte-Silver Bow area is likely to see increasing periods of drought, both in terms of seasonal droughts and longer multi-year droughts.[6,8] This increase will largely be due to warmer temperatures, which increase evaporation and plant transpiration and results in less water remaining in the system.

Wildfire

The length of the fire season and the frequency of large fires have already increased significantly in the northern Rocky Mountains, due in large part to warmer spring temperatures.[9] Studies also show that annual area burned has increased significantly.[10] Over the coming century, these trends are likely to continue, with longer fire seasons, more large fires and increases in the annual area burned, and potentially more days of extreme fire weather.

Summary of Potential Impacts

Potential impacts of the projected climate changes described above are summarized below (note that the more specific intersection of these impacts with climate and pre-existing conditions that was discussed by workshop participants as part of the vulnerability assessment are described in subsequent sections of this report).

Likely impacts of projected climate changes on **public health** may include the following:

- Reduced air quality due to the impacts of heat and smoke from larger, more frequent wildfires, exacerbating respiratory and cardiopulmonary illnesses

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[7] U.S. Climate Resilience Toolkit Climate Explorer, op.cit.

[8] 5 B. I. Cook, J. E. Smerdon, R. Seager, S. Coats, Clim Dyn. 43, 2607–2627 (2014).

[9] A. L. Westerling, Phil. Trans. R. Soc. B. 371, 20150178 (2016)

[10] S. A. Parks, J. T. Abatzoglou, Geophysical Research Letters, 47, e2020GL089858 (2020).

- Increased risk of injury or death due to severe flooding, as well as increases in gastrointestinal disease and other water-borne or mold related illnesses because of flood damage
- Likely increase in the incidence of West Nile virus because of increased summer drought, and potential for climate-driven changes in other vector-borne diseases
- Increases in the intensity/frequency of extreme events (e.g., flooding) that could overwhelm emergency systems, block emergency access or evacuation routes, or damage/disrupt emergency shelters
- Increased vulnerability among those with existing chronic health conditions as well as children, the elderly, pregnant individuals, low-income residents, and anyone lacking access to health services and/or adequate health insurance

Likely impacts of projected climate changes on **water resources** may include the following:

- Reduced late-summer surface water availability due to warmer temperatures, decreased snowpack, and earlier snowmelt, with more severe reductions occurring during periods of drought
- Likely increases in the demand for groundwater (i.e., for municipal or agricultural use) as traditional surface water sources dry up earlier in the season and during longer periods of drought
- Reduced water quality due to warmer water temperatures that increase the risk of pathogen growth and harmful algal blooms
- Increased runoff during heavy rainfall events that follow dry periods, resulting in greater risk of landslides and flash floods (particularly in burned or unvegetated areas)

Likely impacts of projected climate changes on **contaminated sites protection and redevelopment** may include the following:

- Altered contaminant transformation or degradation and volatility due to warmer temperatures and extreme heat, as well as increased sensitivity to contaminants in aquatic organisms experiencing heat stress
- Decreased contaminated runoff from sites and slowing of contaminant migration into groundwater during periods of drought, though these can also lead to higher concentrations of contaminants in receiving waters or a lack of water needed for treatment systems

- Potential for spread of contaminants by wildfires, which can also cut off site access and threaten critical on-site infrastructure, such as pump and treat systems, active monitoring systems, and power/data lines
- Increased dilution of contaminants due to wetter conditions, though this can also speed contaminant migration in groundwater and burden water containment and treatment systems
- Increased erosion and scour during more extreme precipitation events and flooding, which can undermine containment by rapidly transporting contaminants and exceeding treatment capabilities, increasing contaminant concentrations in waterbodies, cutting off site access, and damaging infrastructure

Vulnerability Assessment and Adaptation Strategies

The following sections summarize the vulnerability and adaptation information for each of the three focus areas addressed in this workshop series: Public Health, Water Resources, and Contaminated Sites Protection and Redevelopment. The information presented is based on the discussions and input of workshop participants during breakout group activities.

Public Health

This group focused on the goal of protecting Butte-Silver Bow residents' public health, which included discussion of physical health impacts as well as mental health. The time frame considered for this assessment was 10 to 50 years.

VULNERABILITY ASSESSMENT

Summary of observed and/or anticipated effects of pre-existing conditions and climate stressors

Pre-existing Conditions

High rates of poverty, pre-existing health conditions, and **mental health issues** were identified by participants as primary pre-existing conditions that impact public health.

High rates of poverty can drive houselessness, hunger, crime rates, and lack of medical access and insurance. Housing and energy costs are particularly difficult to bear for community members facing poverty. Poverty can exacerbate mental health issues and substance abuse and strongly affects the well-being of children. Poverty can also be self-reinforcing if it limits individuals' abilities to look for jobs and/or job training opportunities (e.g., if people are unable to obtain childcare to look for or secure work).

Pre-existing health conditions add to stress on the local healthcare system, including associated services such as hospice. Chronic or pre-existing health conditions can also be a significant cost burden for individuals.

Mental health issues add stress to the justice system and healthcare system and often intersect with and exacerbate poverty and substance abuse issues. Participants identified the lack of community-based services to address mental health care and mental health resources for children as significant challenges for the community.

Climate Stressors

Wildfire, extreme heat, and **air quality** were identified by group participants as the climate stressors that have the most significant impacts on public health in Butte-Silver Bow.

Wildfire is likely to have several impacts on public health, including increasing mental health stresses and restricting opportunities to get outdoors, especially for children. Heat stress could increase if windows must stay closed because of smoke, and power outages may be more frequent with wildfires. People may be displaced from their homes and lose community spaces and structures, and fire suppression resources and capacity may be reduced or exhausted.

Extreme heat is likely to cause increased heat stress and exhaustion and could also lead to overcrowding of public spaces that have cooling capacity, which could in turn drive increases in disease transmission. Extreme heat could also reduce both water quality and water availability in the community.

Air quality associated with wildfires as well as increased winds and consequent dust is likely to increase rates of asthma and cardiovascular and respiratory illnesses. Air quality impacts could reduce opportunities to get outdoors and restrict recreational opportunities, which have consequences for mental health as well as the local tourism economy. Reduced air quality can also lead to increased heat stress if windows need to remain closed.

Combined Impacts of Pre-existing Conditions and Climate Stressors

Climate change is likely to exacerbate the impacts of or be exacerbated by these pre-existing conditions. Participants identified several ways in which climate stressors and pre-existing conditions can intersect to affect connected communities:

Increasing wildfire risk is likely to intersect with pre-existing conditions to exacerbate impacts in several ways, including:

- Increased costs of cooling and air filtration when windows need to stay closed puts an additional economic burden on low-income residents and may increase risk of smoke exposure to unhoused people and residents who cannot afford filtration technology. The need for public shelters to accommodate more people and be open for longer periods may stretch community resources.
- Pre-existing health conditions such as asthma and cardiovascular issues may be exacerbated by smoke exposure and increase heat stress on these populations if windows need to be closed to reduce smoke. These health issues can drive

increased physician and ER visits, thus adding strain to healthcare systems and social services. Those with pre-existing health conditions also may experience increased anxiety due to their vulnerability to these stresses.
- Wildfire may impact mental health, as residents are less able to enjoy the outdoors. These restrictions can increase isolation, depression, and anxiety. There may also be increased mental stress from the economic burdens of additional costs such as cooling and filtration.

Impacts of *extreme heat* are likely to intersect with pre-existing conditions to exacerbate impacts in several ways, including:

- Increased costs of cooling, air filtration, and weatherization may be disproportionately impactful on low-income residents, who are more likely to live in poor-quality housing with no air conditioning.
- Extreme heat is likely to exacerbate most chronic pre-existing health conditions.
- Mental health issues and general irritability is likely to increase with extreme heat.
- Crime rates may be exacerbated by extreme heat.

Decreased air quality due to dust and smoke is likely to intersect with pre-existing conditions to exacerbate impacts in several ways, including:

- Increasing costs of air filtration may be disproportionately impactful on low-income residents, who are more likely to live in poor-quality housing with no air conditioning.
- Unhoused community members face greater exposure to smoke and contaminants, thus increasing the need for public shelters that provide safety from reduced air quality.
- Air quality issues are likely to exacerbate pre-existing health conditions, including asthma and cardiovascular issues. Heat stress may increase in these populations if they need to keep windows closed to reduce exposure to contaminants or smoke. These issues may drive increased physician and ER visits and lead to overburdening of health care systems and social services.
- Residents may be less likely to be able to enjoy months with nice weather due to smoke or dust impacts, and this can in turn increase isolation, depression, and anxiety. It also has impacts on jobs and livelihoods, particularly in the tourism economy.

Overall vulnerability

Participants selected five impacts of greatest concern for public health in Butte-Silver Bow and assessed vulnerability (see Figures 2 and 3 for the vulnerability assessment process) for each of these impacts, as described below.

Increased likelihood of people in poverty to live in poor-quality housing and **increased cost burdens for cooling and filtration and weatherization** were both ranked by breakout group participants as having **high vulnerability** due to extreme risk and low-to-moderate adaptive capacity to respond to the impact. **Exacerbation of chronic health conditions** received a **high vulnerability** ranking and moderate adaptive capacity. **Decreased ability to get outside, along with loss of social/recreational opportunities and associated impacts on the Butte-Silver Bow community** was ranked as having **high vulnerability** and viewed as high risk combined with low adaptive capacity. The **overburdening of health care and social service systems** was viewed as having **high vulnerability** due to extreme risk; the adaptive capacity of physical health care was ranked as moderate, while for mental health and social services, the adaptive capacity was rated as low (Table 1).

Table 1. Vulnerability Assessment Ranking Results for Impacts of Greatest Concern for Public Health

Effects/Impacts of Greatest Concern	Likelihood	Consequence	Risk	Adaptive Capacity	Vulnerability
Increased likelihood of people in poverty to live in poor-quality housing that is not equipped for extreme heat, smoke, or low air quality	Almost Certain	Major	Extreme	Low-Moderate	High
Increased cost burden for cooling/filtration (when windows can't be opened) and weatherization, especially for people in poverty	Almost Certain	Major	Extreme	Low-Moderate	High
Exacerbation of chronic health conditions due to wildfire, heat, and low air quality	Almost Certain	(Very) Major	Extreme	Moderate	High

Decreased ability to get outside, along with loss of social/recreational opportunities and associated economic impacts	Almost Certain	Major	Extreme	Low	High
Overburdening of health care and social service systems	Almost Certain	Major	Extreme	Physical Health Care: Moderate, Mental Health/Social Services: Low	High

PROPOSED ADAPTATION STRATEGIES AND IMPLEMENTATION PLANS

Adaptation strategies for effects of greatest concern

Participants identified several possible adaptation strategies for each of the effects of greatest concern selected for public health (Table 2). Time limitations meant that not all co-benefits and unintended consequences were identified by the breakout group for every effect of concern.

Table 2. Identified Effects of Greatest Concern and Possible Adaptation Strategies for Public Health. Starred (**) adaptations were those carried forward to discuss for implementation.

Effects of Greatest Concern	Adaptation Strategies to Reduce Vulnerabilities
Increased likelihood of people in poverty to live in poor-quality housing that is not equipped for extreme heat, smoke, or low air quality	● Adapt existing housing to be safe and energy-efficient during heat and smoke events**. ● Collaborate to improve housing. ● Ensure that agencies already working on this are communicating well, sharing resources and ideas, and not duplicating efforts. ● Find funding to include energy efficiency and weatherization/filtration in housing improvement efforts (e.g., LEED homes). ● Ask/advocate for University System Benefits funds to use for this, could also potentially use funds from MT Department of Environmental Quality, Department of Energy, Environmental Protection Agency ● Find funding to install solar for homes (e.g., community solar projects) to offset costs; consider for solar projects brownfields already being fenced off ● Collaborate with private sector partners already working in affordable housing to address housing quality issues.

	● BSB is currently going through a zoning rewrite; this could also play a role in funding and land donations. ● Collaborate with housing development/planning and other action agencies (e.g., National Center for Appropriate Technology [NCAT] for in-depth assessments and engineering, Action Inc. for assistance to low-income individuals in the context of climate change, Highland College for training opportunities). ● Create pilot project in specific neighborhoods**. ● Use "Circle of Parents" young adults (and similar groups with special healthcare needs) and the staff/volunteers who work with them to implement improvements in the summer months. ● Upgrade public buildings to serve as clear air and cooling shelters**. *Co-benefits:* Increased awareness and commitment to "housing is healthcare"; community revitalization; cooling center upgrades would benefit existing users (e.g., school, library). *Potential challenges/unintended consequences:* Increased exposure to contaminants/mold if houses are too airtight; potential for gentrification.
Increased cost burden for cooling/filtration (when windows can't be opened) and weatherization, especially for people in poverty	● Promote education on air quality (e.g., clean air room, DIY filters) ● Implement energy conservation measures with funding and retrofits (funding for filters and filtration systems) ● Add filtration, weatherization, cooling to residential metals, and abatement programs ● Tap into federal money for cooling assistance ● Seek infrastructure funding to improve HVAC in our schools ● Try to get solar panel or wind energy programs. *Co-benefits:* Increased walkability, access, health, and financial stability; prevention avoids cost of calamity, which increases durability and resilience (building to last). *Co-benefits:* Climate mitigation (reduced greenhouse gas emissions with increased efficiency)
Exacerbation of chronic health conditions due to wildfire, heat, and low air quality systems and human communities—with pronounced health impacts on communities of color.	• Initiate information campaigns around how smoke can exacerbate health issues. • Provide free public health screenings to help reduce incidence rates. • Promote/support universal healthcare. • Remediate dust at the mine. • Provide education and funding to teach people to mitigate health impacts.
Decreased ability to get outside, loss of social/recreational	• Use air quality flags to help people take advantage of good air days.

opportunities and associated economic impacts	• Develop an outdoor activity program with funding to enjoy days that are a low risk to health (e.g., family hiking days with healthy vendors on bike trail, summer hiking groups for kids and adults, ice skating in the winter). • Provide inside activities for kids and families on bad air days • Talk about healthy eating with parents at meetings to address concerns (e.g., too expensive). • Initiate PR campaigns with ideas for indoor social activities • Provide Indoor recreation centers with LEED accreditation that emphasizes air filtration. *Co-benefits:* Educational opportunities
Overburdening of health care and social service systems	• Find funding to cross-train providers who can provide mental health services (e.g., through programs such as the REACH Institute). • Rebuild the crisis response system (e.g., mobile crisis response, supply of crisis detention beds)**. • Restore funding for long-term case management. • Increase early intervention (including education) to mitigate long-term health problems and associated costs**. • Create a volunteer corps to support social services. • Partner with or expand on existing models such as peer support networks and Parent Partners.

Implementation Plans for Priority Strategies

The public health breakout group participants selected five priority adaptation strategies and developed implementation plans for each:

1. Adapt existing housing to be safe and energy-efficient during heat and smoke events.

   How to implement: Update codes and permitting; consider Commercial Property Assessed Capital Enhancement (C-PACE[11]), a funding mechanism through the state for energy efficiency, as well as funding through US Department of Agriculture's Rural Energy for America Program (REAP) and Rural Energy Pilot Program (REPP), the Low Income Energy Assistance Program (LIHEAP), Department of Energy, Northwestern Energy, and Department of Environmental Quality (the last four will soon apply to multi-family homes).

   Leads and partners:

   Leads: Action Inc. (funding) and BSB

   Partners: National Affordable Housing Network, National Center for Appropriate Technology (NCAT), Butte Affordable Housing, Northwestern Energy

[11] https://lastbestpace.com/

Resources and barriers: Existing resources include zoning (currently being updated); funding is needed, and homeowner buy-in represents a potential barrier—difficulty working with landowners is recognized as a barrier

Efficacy: High

Feasibility: High (But funding-dependent; new construction would be most difficult because funding is less available.)

2. Create pilot projects in specific neighborhoods.

How to implement: Potential projects include building on vacant land, community solar projects, community gardens. Organize within neighborhoods to get buy-in and involvement throughout the process because residents need to have ownership.

Leads and partners:

Leads: Project-dependent (ideally private sector, which has more funds)

Partners: Action Inc., BSB, National Affordable Housing Network (NAHN), NCAT, Butte Affordable Housing, Northwestern Energy

Resources and barriers: Could potentially use federal infrastructure funding as well as private investments and partnerships, including with communities; barriers include would need a lot of resources, but specifics would be project dependent.

Efficacy: High, on small scale, and would create change

Feasibility: Moderate; might be difficult, funding-dependent

3. Upgrade public buildings to serve as clean air and cooling shelters.

How to implement: Assess and then designate appropriate shelters, with messaging to inform residents of their location (possibilities include the civic center, YMCA, public libraries, Montana Technological University [MTU]); consider transportation needed to get people to shelter (e.g., bus/shuttle, cab vouchers).

Leads and partners:

Leads: Department of Emergency Services, BSB Health Department

Partners: St. James Hospital, Rocky Mountain Clinic, BSB, BSB school district, and others depending on buildings used

Resources and barriers: Existing shelter at Rescue Mission already available for at-risk populations and is trying to expand summer shelter hours for cooling; middle school just upgraded their HVAC system; funding for emergency services/hazard mitigation might be used for building upgrades. No barriers were identified.

Efficacy: High

Feasibility: High (This action would be low-hanging fruit.)

4. Re-build the crisis response system (e.g., mobile crisis response, supply of crisis detention beds)

   How to implement: Implement Crisis Now model (mobile unit); advocate to reopen detention unit; conduct trainings (e.g., de-escalation) for law enforcement, case managers, and all enforcement professions.

   Leads and partners:

   Leads: BSB mental health coordinator (new position)

   Partners: Community Counseling and Correction Services (CCCS), Shodair Hospital Pediatric Psychiatry, St. James Hospital, Southwestern MT Community Health Center, law enforcement

   Resources and barriers: CCCS has already expressed commitment to address lack of detention beds; a communications team with a planning grant is working on this. BSB has just hired a mental health coordinator; there is some funding already available for this work and more can be pursued; the greatest need/barrier is collaboration for redesign of facility.

   Efficacy: High

   Feasibility: High

5. Increase early intervention (including education) to mitigate long-term health problems and associated costs

   How to implement: Advocate at the state level for Medicaid/Medicare expansion; expand on existing efforts in clinics/workplace programs; evaluate when updating Community Health Needs Assessment; increase collaboration between BSB Health Department and others working on this; and bring hospitals and clinics to the table

   Leads and partners:

   Leads: Health Department, St. James Hospital

   Partners: Hospitals and clinics, Intermountain Health, Action Inc., BSB school district, Butte 4-C's

   Resources and barriers: BSB Health Department has grants for education. No barriers were articulated for this solution.

   Efficacy: High

   Feasibility: High

Water Resources

The water resources group focused on a goal of ensuring the sustainable function of the Basin Creek Watershed to provide affordable, high-quality drinking water to all residents, while also maintaining associated ecosystems. The time frame considered for this assessment was 20 to 50 years.

VULNERABILITY ASSESSMENT

Summary of observed and/or anticipated effects of pre-existing conditions and climate stressors

Pre-existing Conditions

Mining, including the contamination of groundwater and both the state of and perceptions of water quality; built and natural infrastructure for headwater storage and for users; and **water rights and utilitarian versus conservation approaches to water use** were identified by group participants as the primary pre-existing conditions that have the most significant impacts on water resources.

Mining and its consequent impacts on groundwater and water quality interferes with water resources by contributing to the loss of use of aquifers; functioning as a source of contamination; creating manipulations of the water system; being a competitor for use of water resources; and impacting biodiversity in aquatic systems.

The condition of built and natural infrastructure challenges water resources due to infrastructure aging, the complex system of its ownership, and the expense of maintaining and replacing it. Private ownership can be a barrier to modification or adaptation, and there is an expanding need for additional infrastructure. Infrastructure also has impacts on the function of natural hydrologic systems.

Water rights and utilitarian versus conservation approaches to water use sets up the potential for conflicts and barriers to effective water resource management. These include issues of primary rights and seniority rights, stakeholder pressures, and overallocation of resources—the community has only one primary water source that is not overallocated. As a result, litigation rather than collaboration drives management (though Big Hole Watershed was noted as an exception to this). As all drinking water is surface water, and surface water rights are important and can be limiting.

Climate Stressors

Wildfire, drought, and **increasing temperatures** were identified by participants as the primary climate stressors that impact water resources.

Wildfire is likely to have impacts on water quality and water chemistry; reduce soil health and capacity for infiltration; reduce stream bank stability; increase sedimentation in streams; increase water treatment costs or compromising water drinkability if suspended solids overwhelm treatment methods; and increase total daily maximum load (TMDL) violations.

Drought is likely to decrease in-stream flow, which would cause increasing pressure and damage on remaining water resources; increase nutrient problems; increase concentrations of pollution in water and mobilization of pollutants; and compromise infrastructure at intake, transportation, and diversions (dams needed to hold more water for longer as the dry season increases in length).

Increasing temperatures are likely to contribute to increased rates of snow and glacial melt; changes in both aquatic and terrestrial vegetation; increasing evaporation rates and consequences for water storage and transportation; declines in biodiversity and at-risk species; and increased use of and stress on water systems by both people and ecological systems.

Combined Impacts of Pre-existing Conditions and Climate Stressors

Climate change is likely to exacerbate the impacts of or be exacerbated by all three pre-existing conditions. Breakout group participants identified the following challenges:

Increasing wildfire risk and length of season is likely to intersect with pre-existing conditions to exacerbate impacts in several ways, including the following:

- Wildfire and associated heat can mobilize mining contaminants and increase exposure risk.
- History of logging and mining may predispose the landscape due to impacts on soil, vegetation health to be more vulnerable to wildfire.
- Chemicals in/on the landscape, as well as their application to suppress fires (all of which can affect water quality) may be mobilized by extreme weather or wildfire.
- Past wildfire and other land use damages impacting water quality and erosion

- Loss of vegetation from wildfire can impact the ability of the soils to provide filtration capacity.
- Increased wildfire risk can threaten built infrastructure both in terms of the systems themselves and threatening their power sources.
- Wildfire impacts that lead to loss of water resources result in increased pressure and cost on other systems that are potentially already overallocated.

Drought is likely to intersect with pre-existing conditions to exacerbate impacts in ways listed below:

- More dust resulting from drought may increase pressure on water resources because additional dust mitigation is needed at mine sites.
- Drought may exacerbate mining impacts on biodiversity and vegetation.
- Drought may interfere with and alter the growth of vegetation on capped sites and possibly threaten cap integrity.
- Drought may impact the ability to provide water that is contracted to mining operations.
- Drought may impact the community's ability to store and deliver water, including decreased late season water delivery from headwater dams.
- Maintenance and operating costs for water infrastructure can rise during periods of drought.
- Drought may lead private owners to request a state 310 permit[12] to alter diversions, and in-stream flow requirements may be violated.
- Drought may completely compromise Butte's access to water—as the community is at the top of the watershed, there is nowhere higher to go for water.
- Mental health and safety may be compromised by lack of access to water from drought.
- Litigation is increasingly likely under added pressure from drought on water resources.

[12] http://dnrc.mt.gov/divisions/cardd/conservation-districts/the-310-law

Extreme temperatures are likely to intersect with pre-existing conditions to exacerbate impacts in ways that include the following:

- Significant costs to maintain mining equipment and aging water system infrastructure may be exacerbated by additional costs brought on by extreme temperature.
- Extreme temperatures may also interfere with and alter the growth of vegetation on capped sites and possibly threaten cap integrity
- More chemicals may be needed to treat algal growth in water systems.
- More wear and tear is likely on infrastructure, including increased demand and consequent increased pumping and costs.
- Increased demand from end users, including agricultural users, will place additional stress on water resources.
- Water rights might limit or complicate the conversation about how to address increasing temperatures in water systems.

Overall vulnerability

Participants selected six impacts of greatest concern to the sustainable function of water resources in Butte-Silver Bow and assessed vulnerability for each of these impacts (Table 3), as described below.

An **impacted ability to provide water contracted to the mine and consequent economic impacts** was evaluated as having **moderate vulnerability** due to moderate risk and moderate adaptive capacity. **Increasing demand on infrastructure (increased pumping, increased wear and tear on infrastructure, increased use)** was evaluated at **moderate vulnerability** due to high risk and moderate adaptive capacity. **100% of Butte-Silver Bow water system vulnerable to fire (headwaters, transport, Silver Lake, quality, and quantity)** was ranked by breakout group participants as having **high vulnerability** due to extreme risk and moderate adaptive capacity. **Having an economy dependent on water** was viewed as having **moderate vulnerability** due to moderate risk and moderate adaptive capacity. **That Butte-Silver Bow is at the top of the watershed and therefore there is nowhere else to get water if resources are threatened by climate impacts** was viewed as being **high vulnerability** due to extreme risk and low adaptive capacity. **Increases in litigation on over-allocation of water resources** was ranked as having **high vulnerability,** viewed as being high to extreme risk, combined with a moderate adaptive capacity to respond to the impact.

Table 3. Vulnerability Assessment Ranking Results for Effects/Impacts of Greatest Concern for Water Resources

Effects/Impacts of Greatest Concern	Likelihood	Consequence	Risk	Adaptive Capacity	Vulnerability
Impacted ability to provide water contracted to mine (plus economic impact)	Unlikely	Major	Moderate	Moderate	Moderate
Increasing demand on infrastructure (increased pumping, increased wear and tear on infrastructure, increased use)	Likely	Major	High	Moderate	Moderate
100% of Butte-Silver Bow water system vulnerable to fire (headwaters, transport, Silver Lake, quality and quantity)	Almost Certain	Catastrophic	Extreme	Moderate	High
Economy dependent on water	Likely	Moderate	Moderate	Moderate	Moderate
Nowhere else to get water as Butte-Silver Bow is at the top of the watershed	Likely	Catastrophic	Extreme	Low	High
Litigation on over-allocated water resources	Almost Certain	Moderate to Major	High to Extreme	Moderate	High

PROPOSED ADAPTATION STRATEGIES AND IMPLEMENTATION PLANS

Adaptation strategies for effects of greatest concern

Breakout group participants identified several possible adaptation strategies for water resources. The following table summarizes adaptation strategies in response to effects of greatest concern that were explored by breakout group participants (Table 4). Time limitations meant that not every effect of concern and not all co-benefits and unintended consequences were identified by the breakout group.

Table 4. Identified Effects of Greatest Concern and Possible Adaptation Strategies for Water Resources. Starred adaptations were those carried forward to discuss for implementation.

Effects of Greatest Concern	Adaptation Strategies to Reduce Vulnerabilities
Impacts on the ability to provide water contracted to the mine (plus economic impact)	● Create a countywide growth plan with water allocations. ● Upgrade, repair, and maintain infrastructure. ● Increase public education regarding finiteness of resources and allocation.
Increasing demand on infrastructure (increased pumping, increased wear and tear on infrastructure, increased use)	● Increase water conservation (mechanisms can include education, outreach, drought tolerant plantings, rain barrels, water use timing technology/metering, leak repair, neighbor use information on utility bills, no flood irrigation)** ● Develop reach code for water efficiency (limit lawn square footage) ● County-wide growth plan with allocation for existing systems (including users of individual wells with poor water quality)** ● Impact fees ● Infrastructure replacement and expansion ● Gray water irrigation systems ● Storage (above and below ground reservoirs, beaver mimicry, recharge, off-stream storage/ponds, raising dams) (may adversely affect aquifer recharge) *Co-benefits:* Storage could (1) reduce litigation by having enough water for those with rights; (2) provide water for supporting restoration; and (3) design for ecosystem protection (also could allow for use of EIS compliance funds to support). *Potential challenges/unintended consequences:* Groundwater recharge Is not acknowledged by the state as a beneficial use; could increase the price of water (by sales from some primary users).
100% of Butte-Silver Bow water system vulnerable to fire (headwaters, transport, Silver Lake, quality, and quantity)	● Implement existing grant to timber deadfall. ● Reclassify Silver Lake (ongoing process). ● Install upstream filtration system (design to be fire-resistant, plus additional membranes and larger pipeline)** ● Free up potable water by re-sourcing irrigation and industrial water.

	• Support climate-informed forest management—support U.S. Forest Service (USFS) plans/staff, including efforts around wildlife habitat/migration that requires some deadfall clearing; reinstate Healthy Forest Initiative.** • Implement development limits due to fire risk—insurance requires defensible space and use. • Adopt fire safe programs. *Co-benefits:* All these actions are co-benefits because they can reduce or meet demand for water; air quality could be improved from decreased wildfires. *Potential challenges/unintended consequences:* New actions become harder with more rules in place.
Economy dependent on water; nowhere else to get water as Butte-Silver Bow at top of watershed (adaptation strategies discussed for these two impacts in tandem)	• Do not allow sales of water for out of basin use/transport.** • Create compacts between user basins • Reuse sewage effluent (not meeting nutrient standards).
Nowhere else to get water as Butte-Silver Bow is at the top of the watershed	• Create water leasing and reuse with proper timing (agricultural, recreation, industrial), split season leasing. • Find new water sources (cloud seeding, storage, raising dam levels). • Limit conversion of agricultural lands to residential development (which has greater water use) and buy water rights.

Implementation plans for priority strategies

Participants discussed five of their highest priority adaptation strategies for water resources.

1. Water conservation actions and outreach, including education, drought-tolerant plantings, rain barrels, water use timing technology/metering, leak repair, use information on utility bills, eliminating flood irrigation practices, and creating reach code for water efficiency (such as limiting lawn square footage).

   ***How to implement*:** Start now. Some state funding is available already (e.g., FireSafe program). Some of these ideas are relatively easy to implement (e.g., utility bill comparisons), and work with groups/stakeholders (e.g., agriculture, industry, residents). Conservation districts can provide resources on low water use landscaping.

Leads and partners:

Leads: County water utility

Partners: Conservation Districts, Fire Departments, U.S. Forest Service (USFS), and Clark Fork Watershed Education Program NCAT

Resources and barriers: State funding exists through programs including FireSafe, Superfund/Natural Resource Damages funding; Conservation District could write/acquire grants; Natural Resource Conservation Service (NRCS) programs could provide support through farm bill for some urban work. Barriers include public's unwillingness not to water lawns.

Efficacy: High

Feasibility: Moderate/High (Feasibility should increase with more outreach and engagement in solutions.)

2. County-wide growth plan with allocation for existing systems, including individual well users with poor water quality.

   How to implement: Comprehensive Plan update in 2020 with related Zoning Plan update is currently in progress; Could the comprehensive Plan be amended; alternatively, address this in 2030 Comprehensive Plan with Water Inventory and coalition building in run-up to the 2030 plan.

   Leads and partners:

   Leads: County government

   Partners: Watershed Restoration Coalition, MT Climate Office, U.S. Geological Survey, Bureau of Mines, local developers, residents/businesses coalition (to be determined), and Restore our Creek Coalition. MTU and University of Montana could work on "Basin Water Budget" with updated climate projections,

   Resources and barriers: BSB Planning and Zoning and urban revitalization area and Bureau of Mines are resources. Barriers include opposition from organizations and businesses affected.

   Efficacy: High

   Feasibility: Moderate (It was noted that "harder things have happened.")

3. Implement upstream filtration system (design to be fire-resistant, plus additional membranes and larger pipeline).

   How to implement: Start design and budgeting ASAP; pursue Department of Environmental Quality (DEQ) approval; create a blue-ribbon panel of partners.

Lead: County, with sub-contracting civil engineering firm

Partners: Butte Natural Resources Damage Council

Resources and barriers: Existing infrastructure money from the federal allocation. Major barrier is that this project is very expensive; it just needs money to happen.

Efficacy: High

Feasibility: Low/Moderate (Other community needs may currently be more pressing.)

4. Climate-informed forest management—support USFS plans/staff, including efforts around wildlife habitat and migration, which requires some deadfall clearing; reinstate Healthy Forest Initiative.

   How to implement: Some of this is already underway (Beaverhead National Forest project started in May). Expand to other watersheds in other USFS and Bureau of Land Management (BLM) units.

   Lead: USFS/BLM with County Public Works

   Partners: BSB, adjacent counties (e.g., Silver Lake is in another county), Congressional delegation; state lands; MT Fish, Wildlife & Parks

   Resources and barriers: USFS and university programs in forest management already exist; the County supports this effort. Barriers include the need for multiple National Forest ranger districts to support this work. The public might not have a favorable opinion of this type of forest management, as there are groups that litigate against the USFS. Preparing an environmental impact statement to support this type of work is a very slow process.

   Efficacy: High

   Feasibility: High

5. No sales of water for out-of-basin use/transport

   How to implement: A possible model exists from Missoula barring out-of-basin use; implement through BSB government/community initiative; should be undertaken within next 4 years.

   Lead: City/County government

   Partners: Water rights groups, legal resources for the protected status designation of Silver Bow Creek designation, Montana Department of Natural Resources and Conservation (determines water rights), and Clark Fork Coalition

***Resources and barriers*:** If a law prohibiting out-of-basin use were passed, it could end up in litigation, but during that time water may remain in situ. County-wide growth plan is needed to justify demand. Barriers include Montana Resources owning rights to water they want to sell, and opposition by those who could profit via jobs or money.

***Efficacy*:** Moderate

***Feasibility*:** Low (Partners may be hard to organize.)

Contaminated Sites Protection and Redevelopment

This focus area considered dual goals of the sustainable revegetation and maintenance of contaminated sites in the face of climate change impacts, and climate-informed redevelopment and reuse of contaminated properties in Butte-Silver Bow. A planning timeframe of 10 to 30 years and adaptation action lifetime of 100 or more years were considered for this assessment due to the unique management context for this focus topic.

VULNERABILITY ASSESSMENT

Summary of observed and/or anticipated effects of climate stressors and pre-existing conditions

Pre-existing Conditions

Remedial action management contexts with long-term requirements and potential inflexibility, the extent of contaminated soil and air-born dust, and **novel ecosystems with low native biodiversity and invasive species threats** were identified by group participants as the primary pre-existing conditions stressors that have the most significant impacts on contaminated sites.

Inflexibility in management contexts and varying perceptions of risk associated with existing remedial actions is likely to impact contaminated sites by contributing to slow regulatory response and increasing uncertainty in criteria, creating challenges to public buy-in to remediation actions, and contributing to challenges due to private land ownership.

Contaminated air and soil drives contamination of soils as well as surface water and groundwater, increases recontamination and cross-contamination, decreases the availability of good soil for caps and infill, and contributes to shifting regulatory criteria for cleanup and containment.

Low native biodiversity combined with local novel ecosystems with anthropogenic stressors reduces the selection of plant species and ecological alternatives available for cap stabilization and remediation and limits revegetation options where priorities differ for private and public land use.

Climate Stressors

Extreme weather, including heat, drought, and rain-on-snow; seasonal shifts in precipitation and associated declines in snowpack and soil moisture; and **wildfire** were identified by participants as the primary climate stressors that impact contaminated sites.

Extreme weather is likely to have impacts on contaminated sites, including erosion caused by flooding, greater contaminant transport, and decreases in remedial capacity and resilience; reductions in containment cap stabilizing vegetation due to drought; proliferation of invasive plants, many of which are not appropriate for cap plantings; and temperature stresses on aquatic organisms.

Seasonal precipitation shifts are likely to affect contaminated sites by changing germination, seeding, fertilization, and weed control timing for cap stabilization and decreasing water availability for fire management.

Wildfire is likely to cause losses in cap vegetation and complicate cap management, increase cultural and historic landmark losses, and increase contaminants in smoke.

Combined Impacts of Pre-existing Conditions and Climate Stressors

Climate change is likely to exacerbate the impacts of or be exacerbated by all three pre-existing conditions. Breakout group participants identified the following challenges:

- Regulatory inflexibility and variation in risk perceptions are likely to make it more difficult to respond and plan for extremes in weather and challenge the prioritization of budgets and resources. These factors can also slow planning and response times, which can further increase wildfire risk, and lead to deferral of maintenance, which can increase vulnerability to climate stressors.
- Pathways of exposure from contaminated soils are likely to increase when extreme weather increases soil erosion and runoff and when wildfire leads to contaminant mobilization.
- Low native biodiversity, local novel ecosystems, and proliferating invasive species can be exacerbated by extreme weather patterns and ecological resets, including erosion that can favor invasives. Wildfire can also exacerbate invasive species issues because some invasive species fare better in fire-disrupted areas,

and erosion following wildfire can also create conditions that facilitate invasive species.

Overall vulnerability

Impacts of wildfire and extreme weather on re-exposure and increasing and new contaminate exposure pathway risks were ranked by breakout group participants as impacts to which the community has **moderate to high vulnerability** due to high to extreme risk and moderate to high adaptive capacity. **Impacts of wildfire and extreme weather on existing remedial actions, monitoring and maintenance** was identified as an impact to which the community has **moderate to high vulnerability** due to high risk) and low to high adaptive capacity (low if changing management policies is difficult and slow; high if actions can occur within existing management policies). Table 5 summarizes this vulnerability assessment.

Table 5. Vulnerability Assessment Ranking Results for Effects/Impacts of Greatest Concern for Contaminated Sites

Effects/Impacts of Greatest Concern	Likelihood	Consequence	Risk	Adaptive Capacity	Vulnerability
Impacts of wildfire and extreme weather on re-exposure and increasing and new contaminant exposure pathway risks	Likely Almost Certain in Floodplains	Major to Catastrophic	High to Extreme	Moderate to High	Moderate to High
Impacts of wildfire and extreme weather on existing remedial actions, monitoring, and maintenance	Almost Certain	Moderate	High	Low (if changing management policies is difficult and slow) to High (if actions are within existing management policies)	Moderate to High

PROPOSED ADAPTATION STRATEGIES

Adaptation strategies for effects of greatest concern

Breakout group participants identified several possible adaptation strategies for contaminated sites. Table 6 summarizes adaptation strategies in response to effects of greatest concern that were explored by the group participants.

Table 6. Identified Effects of Greatest Concern and Possible Adaptation Strategies for Contaminated Sites. Starred adaptations were those carried forward to discuss for implementation.

Effects of Greatest Concern	Adaptation Strategies to Reduce Vulnerabilities
Impacts of wildfire and extreme weather on re-exposure and increasing and new contaminant exposure pathway risks	● Implement local, neighborhood safety and response planning. ● Conduct outreach and education, which depend on forming and strengthening relationships with community.** ● Foster public and private health care collaboration. ● Implement zoning changes (e.g., curbs and gutters, mini grants to mitigate property owner costs).** ● Increase adoption of needed action on private lands. ● Improve stormwater management. ● Apply engineered water controls, slope aspect, storm water storage (contaminated sites). ● Use citizen science to monitor site containment integrity and invasive plants. *Co-benefits:* Can be part of larger outreach and education effort (increase understanding and support from community); water conservation. *Potential challenges/unintended consequences:* People's perception of their rights or what they are "due"; community values conflicts.
Impacts of wildfire and extreme weather on existing remedial actions, monitoring, and maintenance	• Operation, maintenance, and monitoring plans** o Update and expand to anticipate future impacts. o Create contingencies and decision matrices to speed responses. o Explore thresholds for responses, such as starting over, updating existing, or stay with existing. o Increase frequency and capacity for inspecting and monitoring integrity of containment systems. ● Update fire response planning for Superfund sites o Regulate fireworks to decrease incidental fire risk. *Co-benefits:* Improve aesthetics and recreation opportunities, benefits could be added by solar fields on contaminated lands (possible as part of significant site management challenges), prevention and planning saves money, promote water reuse and savings, and historical and cultural asset preservation *Potential challenges/unintended consequences:* Community mistrust (historic and can improve), and opportunity loss with inaction

Implementation plans for priority strategies

Breakout group participants discussed three of their highest priority adaptation strategies for contaminated sites. The group also wanted to highlight for their solutions that success is dependent on social tolerance and consideration of components including the aesthetics and the economic opportunities associated with these solutions.

1. Update and expand operation, maintenance, and monitoring plans to be more responsive to climate change

   How to implement: Work with existing plan-making and review teams and processes. Start as soon as possible.

   Leads and partners:

   Leads: Atlantic Richfield, BSB

   Partners: Public stakeholders, MTU, U.S. Environmental Protection Agency (EPA), Montana DEQ, Clark Fork Watershed Education Program, BSB Citizens Technical Environmental Committee (BSB CTEC)

   Resources and barriers: Existing operations, maintenance, and monitoring plans, policies, working groups and capacity already exist; Resilient Butte project; will need research, monitoring, and funding, though some exists. Barriers include public buy-in and support, and a slow-to-move bureaucracy.

   Efficacy: High

   Feasibility: High

2. Local education, outreach, and safety planning partnerships

   How to implement: Organized, coordinated communications to public; should be an important component of Resilient Butte project; increase outreach using existing traditional media and information outlets; increase digital presence and available information; decrease and address misinformation; highlight climate change.

   Leads and partners:

   Leads: NCAT

   Partners: EPA, BSB CTEC, MTU, Community discussion groups

   Resources and barriers: Existing resources include the Resilient Butte website, the BSB newsletter, and public transportation signs; new resources to include on-site demonstration tours. Barriers include gaining the attention of people who have limited time.

Efficacy: Medium

Feasibility: High

3. Update and take advantage of and leverage zoning changes and requirements.

   How to implement: Update zoning; increase incentives and micro grants; undo contradictory grandfathered issues; leverage "form-based zoning" approach

   Lead: BSB

   Partners: Consultant, stakeholders, public survey input

   Resources and barriers: Zoning is currently undergoing significant update process, which is funded and well supported; primary barrier is the limited capacity and staff time to do all that is needed.

   Efficacy: High

   Feasibility: High

Conclusions

This workshop and the resulting report aimed to improve the understanding of how Public Health, Water Resources, and Contaminated Sites Protection and Redevelopment are vulnerable to changing climate conditions in the Butte-Silver Bow community. This report summarizes possible adaptation strategies that were identified and discussed by the breakout groups as well as adaptation implementation plans designed to minimize vulnerabilities and/or increase resilience of the focus areas.

Similarities were found across focus areas in terms of pre-existing conditions and climate stressors, and the combined impacts of these effects emerged across focus areas, including the following:

- *Pre-existing conditions*: Environmental contamination, and regulatory and policy frameworks that could help or hinder adaptation, were discussed across the focus areas.
- *Climate stressors*: Extreme weather, increasing temperatures and drought, and wildfire risk were the most selected climate stressors.

Combined impacts of pre-existing conditions and climate stressors listed above were also identified across breakout groups as impacts of greatest concern, including the following:

- Existing environmental contamination is being mobilized and the public is being increasingly exposed to contamination due to climate stressors, including wildfire and extreme weather.
- There are recognized challenges of working within complex, entrenched, or bureaucratic frameworks that are being further challenged by novel or exacerbated impacts associated with climate change.
- There are significant increases in costs to maintain public health and resource delivery integrity, including costs of water and air filtration, cooling resources, and soil cap integrity, resulting from climate change impacts.

The similarities in impacts of greatest concern also resulted in overlapping and intersecting adaptation strategies, such as:

- Private-public partnerships to bring more resources to bear to a wide variety of adaptation solutions, including air and water quality improvement, cooling options, mental health treatment, and water resource allocation

- Public education and outreach to increase public awareness and support for adaptation efforts
- Leveraging existing resources to support adaptation (e.g., existing cooling shelters and buildings with modern HVAC systems; technical expertise of academic and nonprofit organizations to support efforts such as reducing contaminant exposures; evaluating water allocation systems under climate change)
- Updating codes and zoning to better address risks including wildfire, poor building performance, and contaminant exposure

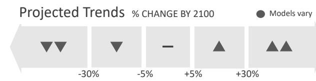
This report can be used as a reference for decision-makers in Butte-Silver Bow as they plan for and commit resources to create a more sustainable and resilient community. The adaptation strategies that participants have identified during this workshop can advance resiliency and may present opportunities to leverage resources across multiple focus areas. Because climate adaptation is an iterative process and new research and modeling on projected climate changes and impacts is regularly released, it is important to revisit and/or revise the vulnerability assessments and adaptation strategies on a regular basis (e.g., every 5 to 10 years), as well as when additional topics of concern become priorities.

Appendix A. Workshop Participants and Breakout Group Assignments

Participant Name	Affiliation	Breakout Group
Cathy White	Retired, pediatrician	Public Health
David Paige Gilkey	Montana Technological University	Water Resources
Dori Skrukrud	Butte-Silver Bow Community Development	Contaminated Sites
Elisabeth Osborn	Butte-Silver Bow Planning Dept	Contaminated Sites
Gautham Hari	Montana Technological l University	Water Resources
Ivy Fredrickson	Ocean Conservancy Inc. and Butte-Silver Bow Board of Health	Public Health
J.P. Gallagher	Butte-Silver Bow Executive	Public Health
Jackie Thompson	Butte-Silver Bow Environmental Health	Public Health
Jesse Sims	Pioneer Technical Services	Water Resources
John Moodry	Mile High Conservation District	Water Resources
John McKee	Headframe Spirits Manufacturing	Water Resources
Jon Sesso	Consultant	Public Health
Josh Bryson	Atlantic Richfield Company	Contaminated Sites
Julia Crane	Butte-Silver Bow Department of Reclamation	Contaminated Sites
Karen Byrnes	Butte-Silver Bow Community Development	Public Health
Kristen Rosa	Butte-Silver Bow Economic Development	Contaminated Sites
Logan Brauer	University of Montana	Water Resources
Margie Seccomb	Action Inc.	Public Health
Paul Babb	NorthWestern Energy	Public Health
Ravyn Goodwin	Montana Technological University	Contaminated Sites
Robert Pal	Montana Technological University	Contaminated Sites
Rylie Yaeger	National Center for Appropriate Technology	Water Resources
Shanna Adams	HDR Engineering Inc.	Contaminated Sites

Shawn Fredrickson	Butte-Silver Bow Council of Commissioners	Contaminated Sites
Shelly Cleverly	City-County of Butte-Silver Bow	Water Resources
Stacie Peterson	National Center for Appropriate Technology	Public Health
Steve Thompson	National Center for Appropriate Technology	Contaminated Sites
Victorian Smart	National Center for Appropriate Technology	Contaminated Sites

Appendix B. Climate Changes and Impacts Table for Butte-Silver Bow



CLIMATE CHANGES	METRIC	TREND	OBSERVED/PROJECTED CHANGES
Air temperature	Minimum temperature AVG DAILY MIN TEMP (°F)	▲	28.1°F (+4.3°F) by 2050 and 34.2°F (+10.4°F) by 2100[1] COMPARED TO HISTORICAL AVERAGE OF 23.8°F FROM 1961–1990
	Maximum temperature AVG DAILY MAX TEMP (°F)	▲	54.7°F (+4.8°F) by 2050 and 60.9°F (+11.0°F) by 2100[1] COMPARED TO HISTORICAL AVERAGE OF 49.9°F FROM 1961–1990
Extreme heat	Days over 90°F # OF DAYS WITH MAX TEMPS >90°F	▲▲	9.0 days (+1,025%) by 2050 and 39.2 days (+4,800%) by 2100[1] COMPARED TO HISTORICAL AVERAGE OF 0.8 DAYS PER YEAR FROM 1961–1990
Precipitation	Annual precipitation AVG INCHES PER YEAR	▲	19.2 in (+3.8%) by 2050 and 20.0 in (+8.2%) by 2100[1] COMPARED TO HISTORICAL AVERAGE OF 18.5 INCHES PER YEAR FROM 1961–1990
	Seasonality	▲▼	Significant increase in winter (+21%) and spring (+22%) precipitation, with slight decreases in summer (-7%) and fall (-5%) by 2100[2]
Snow	Snowpack APRIL 1 SNOW-WATER EQUIVALENT	▼▼	~20% decline in April snowpack from 1935 to 2015 (greater at low elevations)[3] 50% or greater decline in April snowpack by 2100[3]
	Snowmelt timing		Earlier spring snowmelt due to warmer temperatures, increasing spring peak flows and reducing late-summer streamflows[3]
Extreme precipitation	Frequency # OF DAYS WITH 1" RAIN IN 24 HOURS	▲	0.9 days (+12.5%) by 2050 and 1.4 days (+75%) by 2100[1] COMPARED TO HISTORICAL AVERAGE OF 0.8 DAYS PER YEAR FROM 1961–1990
	Amount 20-YEAR RETURN PERIOD TOTAL	▲	+16% increase in precipitation amount during 20-year events projected by 2100[4]
Drought	Frequency & severity	▲▲	Likely increases in the frequency and severity of both seasonal and persistent (i.e., multi-year) droughts, largely due to rising temperatures[3,5]
Wildfire	Fire activity	▲▲	Significant increases in the length of the fire season, the frequency of large wildfires,[6] and annual area burned[7] in the Northern Rockies

[1] U.S. Climate Resilience Toolkit Climate Explorer (https://crt-climate-explorer.nemac.org), county-scale projections generated using the high-emissions (RCP 8.5) scenario for the average of 2041–2049 and 2091–2099 time periods compared to historical conditions (average of 1961–1990).
[2] J.R. Alder, J. R. and S. W. Hostetler, 2013. USGS National Climate Change Viewer. US Geological Survey (https://doi.org/10.5066/F7W9575T), county-scale projections generated using the high-emissions (RCP 8.5) scenario for the mid-century (average of 2025–2049) and late-century (average of 2075–2099) time periods compared to recent conditions (average of 1981–2010).
[3] C. Whitlock, W. F. Cross, B. Maxwell, N. Silverman, A. A. Wade, "2017 Montana Climate Assessment" (Montana State University and University of Montana, Montana Institute on Ecosystems, Bozeman and Missoula, MT, 2017), , doi:10.15788/m2ww8w 88/m2ww8w.
[4] D. R. Easterling et al., in Climate Science Special Report: Fourth National Climate Assessment, Volume I, D. J. Wuebbles et al., Eds. (U.S. Global Change Research Program, Washington, DC, 2017; https://science2017.globalchange.gov/chapter/7/), pp. 207–230.
[5] B. I. Cook, J. E. Smerdon, R. Seager, S. Coats, Clim Dyn. 43, 2607–2627 (2014).
[6] A. L. Westerling, Phil. Trans. R. Soc. B. 371, 20150178 (2016).
[7] S. A. Parks, J. T. Abatzoglou, Geophysical Research Letters, 47, e2020GL089858 (2020).