Improving Drought Resilience in Alberta Through a Simulation

FINAL REPORT AND RECOMMENDATIONS

ALBERTA WATER COUNCIL

February 2024

About the Alberta Water Council

Initially established in 2004 to serve an advisory function to government, the Alberta Water Council (AWC) evolved and incorporated as a not-for-profit society in 2007. The AWC is a collaborative partnership that consists of members from governments, industry, Indigenous groups, and non-government organizations. Its primary task continues to be to monitor and steward the implementation of Alberta's *Water for Life* strategy and to champion the achievement of the strategy's goals. It also advises the Alberta government, industry, governments, non-governmental organizations, and Albertans on matters pertaining to stewarding the outcomes of the *Water for Life* strategy and on effective water resources management policies, practices, and tools. The advice of the AWC generally has the consensus support of its members and is consistently considered when informing water resources management in Alberta.

Where there is consensus, the Council may advise on government policy and legislation. However, the Government of Alberta remains accountable for the implementation of the *Water for Life* strategy and continues to administer water and watershed management activities throughout the province.

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Contents

Tables and Figures

Acronyms

AGI	Alberta Agriculture and Irrigation
AWC	Alberta Water Council
CEP	Conservation, Efficiency, and Productivity
EPA	Alberta Environment and Protected Areas
GoA	Government of Alberta
IDT	Invitational Drought Tournament
IWCC	Intrabasin Water Coordinating Committee
MAA	*Master Agreement on Apportionment*
NGO	Non-Government Organization
OASIS	Operational Analysis and Simulation of Integrated Systems
SSRB	South Saskatchewan River Basin
SSROM	South Saskatchewan River Operational Model
ToR	Terms of Reference
WPAC	Watershed Planning and Advisory Council

Glossary

Call on priority or priority call	A priority call can occur when household users, licensees or traditional agricultural users are not able to receive their full allocation allotted under the *Water Act*. The receipt of a priority call from a licence holder may require the department to administer priority to a portion or all of a water management area, meaning licence holders with priority numbers more junior to the caller are cut off and can no longer divert water.[1]
Drought	A prolonged period of dry weather that depletes water resources, including: natural sources (rivers, streams, lakes, wetlands, groundwater), man-made storage (reservoirs and dugouts), and soil moisture.[2]
Green infrastructure	The strategic use of networks or natural lands, working landscapes, and other open spaces to conserve ecosystem values and functions and provide associated benefits to human populations.[3]
Water sharing agreements	A licensee or traditional agriculture user may, subject to the regulations for a period of time set out in an agreement, temporarily assign all or part of the water that the licensee or traditional agriculture user is entitled to divert under the licence or registration to another licensee or traditional agriculture user.[4] A key example of a water sharing agreement can be found in section 2.1.4 of Appendix D.
Water shortage	Water shortage refers to conditions when it is appropriate for EPA to be comprehensive and responsive in administering priorities for water licences and registrations to protect the aquatic environment and integrity of the water management system. A water shortage situation where there is insufficient water to meet all needs can result in a priority call.[5]

1 https://open.alberta.ca/publications/alberta-s-water-priority-system

2 https://www.alberta.ca/drought.aspx#jumplinks-0

3 https://www.wri.org/research/natural-infrastructure

4 https://open.alberta.ca/publications/w03

5 https://open.alberta.ca/publications/0778546195

Executive Summary and Recommendations

The Alberta Water Council (AWC) established the Improving Drought Resilience in Alberta Through a Simulation Project to use simulations to assist the Government of Alberta (GoA), municipalities, Indigenous communities, and other groups to understand and plan for drought preparation and response. The team completed a literature review which informed scoping, planning, and execution of the South Saskatchewan River Basin Drought Simulation Exercise. Participants provided feedback on the simulation exercise and key takeaways were synthesized. The following AWC recommendations were developed based on the outcomes and learnings of the drought simulation exercise.

Increase Collaboration

Recommendation 1:

For the GoA to complete and share their provincial Drought and Water Shortage Plan response plan with large water licence holders and key water users.

Recommendation 2:

For municipalities, irrigation districts, and other relevant groups to collaborate with Watershed Planning and Advisory Councils to use the AWC's Building Resiliency to Multi-Year Drought in Alberta Guide to create local drought response and management plans and test these plans through drought exercises. These local plans should include aspects of and be in alignment with the GoA's drought response plan. Drought exercises used to test these plans can range in complexity depending on available resources.

Recommendation 3:

For an additional simulation exercise to be carried out in the Bow River sub-basin.

Recommendation 4:

For the AWC to convene a multi-stakeholder group to create a package for other groups to plan their own drought exercises. The package would include the lessons learned from this exercise (section 3.1), information on the types of drought exercises, their resource needs, and how they can support drought planning.

Further Information Base

Recommendation 5:

For the GoA, partner organizations, and potential groundwater users to identify and address information and knowledge gaps pertaining to the availability and feasibility of groundwater serving as an alternate source of water during a drought emergency situation.

Recommendation 6:

For the GoA to continue to investigate the feasibility of adding or enlarging infrastructure (i.e., relating to water storage and conveyance) in addition to non-structural solutions (including green infrastructure and other nature-based solutions) to complement policy and administrative processes.

Recommendation 7:

For the sectors who developed water conservation, efficiency, and productivity (CEP) plans and their members to consider voluntarily reviewing their CEP plans through the lens of drought management within each sector, as applicable, considering climate change effects and population and economic growth.

Develop Guidance Tools

Recommendation 8:

For the GoA to lead a multi-stakeholder approach in developing guidance for water sharing agreements, such as a toolkit which could include templates, guidance documents, legal considerations, examples, and other facilitation and negotiation support for interested groups of water users.

Recommendation 9:

For the GoA to:

- Provide an overview of the process and key considerations for an inter-basin transfer water licence, which requires a special act of the legislature.
- Outline the potential considerations or circumstances that could inform the GoA if a recommendation to declare an emergency related to water may be necessary.
- Review whether the terms of reference of the Intrabasin Water Coordinating Committee are still relevant.

1. Introduction

Drought is a natural, recurrent phenomenon in Alberta that has environmental, economic, and social impacts. Recent studies show we can expect more frequent and extended droughts as well as higher heat extremes which may impact drought responses. Several initiatives are underway in the province to improve drought preparedness, including:

- The Alberta Environment and Protected Areas' (EPA) Drought and Water Shortage Plan which will outline management and communication actions in times of drought.
- The Alberta Water Council's (AWC) Building Resiliency to Multi-Year Drought in Alberta Guide to assist Watershed Planning and Advisory Councils (WPACs) as they engage municipalities to better prepare for, mitigate the effects of, respond to, and recover from multi-year droughts.
- The Miistakis Institute is a research institute, conservation charity, and social enterprise non-government organization (NGO). They are working with a pilot community to develop a process for drought mitigation planning.

A drought evolves slowly, and its beginning and end tend to be unclear. Managing a drought involves complex monitoring, decision making, and communication before, during, and after its occurrence to mitigate the impacts proactively and respond effectively. Droughts are often difficult to anticipate and strategize for when not in a time of drought. Simulation exercises provide an opportunity to work through one or multiple scenarios that closely mimic real-life acute and/or chronic drought events and can be a powerful tool to test management structures and communication strategies.

1.1 Definitions of Drought

Drought may be caused by several mechanisms, and its duration can vary, ranging from weeks to decades. Drought events may have unique impacts on the economy, people, and the environment depending on the location and timing of its occurrence. Consequently, drought can be defined in several ways. Listed below are four types of drought which may occur independently or simultaneously.[6]

- **Meteorological:** a result of less precipitation than normal over a prolonged period in a specific region. As this type of drought refers to water shortage and not impacts which typically appear later, this is usually the first type of drought to occur.
- **Agricultural:** occurs when there is not enough soil moisture to meet the needs of crops and pastures during the growing season. It usually follows a meteorological drought.
- **Hydrological:** occurs when surface water or groundwater levels fall to below-average levels because of a lack of precipitation. It usually occurs more slowly than a meteorological or agricultural drought.
- **Socio-economic:** occurs when the prolonged absence of water in a region begins to impact people and the economy.

6 https://www.awchome.ca/_projectdocs/?file=70a1c08fe4e869f0

1.2 Alberta Environment and Protected Areas' Drought and Water Shortage Plan

Alberta Environment and Protected Areas is the lead organization for the Government of Alberta's (GoA) response to drought and water shortage events and works closely with Alberta Agriculture and Irrigation (AGI) (the lead on agriculture drought situations), the Alberta Energy Regulator, and key stakeholders to manage the impacts of these events. In accordance with the Alberta Emergency Plan, EPA is actively working toward updating its Drought Response Plan to produce an EPA Drought and Water Shortage Plan that incorporates best practice and describes the roles, responsibilities, and actions taken by EPA to prevent and mitigate, prepare for, respond to, and recover from drought and water shortage events. The plan describes the emergency management procedures used by the department for coordinating activities to meet Alberta's water and aquatic ecosystems needs preceding, during, and following drought and water shortage, to the maximum extent possible. The plan also covers, in lesser detail, the roles and responsibilities of key stakeholders and other Alberta ministries during drought and water shortage conditions. The intent of simulating drought through an exercise is to inform EPA's Drought and Water Shortage Plan and the response plans of other water managers.

1.3 Building Resiliency to Multi-Year Drought

The Building Resiliency to Multi-Year Drought project was brought to the AWC by WPACs to facilitate the delivery of customizable information to support municipalities and communities across the province in building resiliency to multi-year drought.[7]

In 2018, the AWC approved terms of reference for a project team to assist WPACs as they engage municipalities and communities within their watershed to better plan for, mitigate, respond to, and recover from multi-year droughts. Representatives from governments, NGOs, and industry participated on the team. The project's objectives were to:

1. Highlight the importance of multi-year drought management in Alberta by documenting lessons learned from previous droughts and expected changes due to climate change.
2. Compile existing drought management information and resources in Alberta and case studies from selected jurisdictions.
3. Increase awareness of federal, provincial, and municipal water management roles, responsibilities, and regulations relevant to drought.
4. Provide guidance on management objectives, potential risk and impacts, triggers, and suggested actions for small urban and rural municipalities before, during, and after a drought.
5. Produce a guide and workshop materials to help WPACs engage small urban and rural municipalities.

The Building Resiliency to Multi-Year Drought Guide and companion report were released in 2020 and the Improving Drought Resilience in Alberta Through a Simulation project continues to build on this work.

7 https://www.awchome.ca/projects/building-resiliency-multi-year-drought-6/

1.4 About this Project

In June 2019, the GoA brought forward a statement of opportunity to build on the work being conducted by the AWC, GoA, and the Miistakis Institute to develop a simulation that will allow communities to test proposed drought management structures, communications channels, tools, and resources in a workshop environment. Further discussions by a working group resulted in draft terms of reference (ToR) for a project team to carry out.[8] In February 2020, the ToR (Appendix A) were accepted, and a project team was struck.

The purpose of this work is to use appropriately scoped and scaled simulation(s) to assist the GoA, municipalities, Indigenous communities, and other groups (e.g., WPACs, irrigation districts) to understand and plan for drought preparation and response, including mitigation, monitoring, decision making, and communication before, during, and after a drought. The objectives of this project were to:

- Compile existing information on drought management resources, roles and responsibilities, regulations, metrics, thresholds, indicators, and responses in Alberta and other jurisdictions.
- Identify necessary models and decision support tools and review simulation methodology options.
- Develop the scope for a science-based drought scenario or scenarios that meet the needs of the stakeholders involved.
- Complete and integrate background and simulation exercise materials.
- Execute the drought simulation(s) with relevant stakeholders.
- Compile the simulation results, lessons learned, and any recommendations in a final report and disseminate to relevant stakeholders.

1.5 Purpose of this Document

This report provides information on why and how this project was undertaken. Specifically, it highlights how a drought simulation exercise in the South Saskatchewan River Basin of Alberta was developed and executed. The appendices contain supplementary materials that informed the project team during development of the exercise and recommendations made to the AWC. Lastly, the report includes key learnings from the drought simulation exercise and recommendations for applying and continuing this work.

8 Available online: https://www.awchome.ca/uploads/source/21_Improving_Drought_Resilience_in_Alberta_Through_a_Simulation_ToR_Amended_June_2023_v1_1.pdf

2. Methodology

The project team learned about different drought simulation types and the work required for planning an effective exercise. A consultant was engaged to conduct a literature review, develop and facilitate a simulation exercise, and compile and synthesize key information and takeaways of the simulation exercise. A pilot exercise was completed in April 2022, followed by the actual simulation exercise in June 2022.

The project approach involved the following key tasks:

1. Develop a work plan that includes key tasks, deliverables, and timelines.
2. Compile summaries and studies of historical examples of drought and its impacts in Alberta and other provincial jurisdictions, lessons learned, and expected changes due to climate change through a literature review.
3. Document drought-related information and resources relevant to Alberta (including, but not limited to decision-making processes, drought management agreements, roles and responsibilities, regulations, communication processes, existing tools, and programs).
4. Identify gaps in drought management and make a recommendation on standardization of drought indicators, thresholds, and responses to test during the drought simulation.
5. Identify necessary models and decision support tools, review simulation methodology options, and determine any modification needed to these models and tools.
6. Examine drought simulation case studies from Alberta and other jurisdictions.
7. Develop drought simulation scope, including identifying the following:
    a. level of complexity
    b. simulation methodology based on task group recommendations
    c. standardized metrics, indicators, regional thresholds, and responses
    d. simulation boundaries and considerations
    e. balance of environmental, social, and economic impacts
    f. geographic scope and level of regional detail required
    g. communication needs and managing expectations
    h. timeline scoping for drought scenario and climate projections
    i. key stakeholders and their roles in the simulation
8. Develop a simulation participant package, including objectives, ground rules, background, methodology, boundaries, and any other relevant information.
9. Test the simulation with a focus group and sector engagement and revise the materials as necessary based on feedback.
10. Execute drought simulation(s) with stakeholders and interested Indigenous participants.
11. Document simulation outcomes in a post-exercise assessment and distribute to stakeholders and interested Indigenous participants.
12. Provide regular updates to the AWC board during the project and a final project team report with supporting simulation materials.

2.1 Resources Used to Inform the Project Team

2.1.1 Presentations

Several presentations enhanced the project team's knowledge and understanding of drought management processes and the process of executing an effective drought simulation exercise (Table 1, Appendix C). The project team reviewed information from the presentations to determine the content foundation for a literature review.

Table 1: Presentations delivered to the project team

Presenter(s)	Affiliation	Presentation Topic(s)
Deborah Bathke, Tonya Bernadt*	National Drought Mitigation Center (University of Nebraska-Lincoln) (NDMC)	■ Types of drought exercises ■ Drought exercise planning process
Ana Potzkai, John Collins	EPA	■ EPA's draft Drought Response Plan
Harvey Hill*	Agriculture and Agri-Food Canada	■ Drought tournament events ■ 2011 Invitational Drought Tournament
Heather Zarski, Ryna Brideau-Thombs	EPCOR Utilities Inc.	■ EPCOR Water Shortage Plan
Brian Hills	EPA	■ South Saskatchewan River Basin Water Shortage Management Plan

The NDMC presented four types of drought exercises to the project team and presented case studies which highlighted different situations in which the exercises would be applicable:

- Workshops:
  - informal discussion to demonstrate tools and techniques and exchange ideas
  - designed to build a specific product or draft a component of a drought plan
- Table Top Exercises:
  - informal discussion in which key personnel work through simulated scenarios
  - used to test, validate, and practice existing agency plans, policies, and procedures
- Games:
  - simulation involving two or more teams, in a competitive environment, using rules, data, and procedures
  - can be designed to depict actual or hypothetical situations
  - used to identify proactive solutions for drought management
- Functional Exercises:
  - practice run of communication and management activities
  - designed to depict conditions and operations during an actual drought
  - used to validate plans, policies, agreements, and procedures; clarify roles and responsibilities; and identify resource gaps

The project team wanted the simulation exercise to satisfy certain conditions, namely, that it should:

- Be realistic and based on real data.
- Be based on existing watersheds in the province.
- Facilitate the testing of existing drought plans to identify gaps and overlaps.
- Be interactive and engaging.

Based on these conditions and the presented information, the project team decided to pursue a functional simulation exercise with a game-style environment.

* Presentations by these presenters can be found in Appendix C.

2.1.2 Literature review

WaterSMART Solutions Ltd. (WaterSMART) was selected to conduct a literature review as the first step toward development of the simulation exercise (Appendix D).[9] The review was meant to build on the project team's understanding of drought and drought simulations, fill gaps in knowledge, and to provide perspective on similar projects in other jurisdictions. The literature review was comprised of three tasks:

1. a drought management review to understand the regulatory framework, historical drought response, and drought management approach within Alberta and external jurisdictions of interest
2. a review of drought simulation exercises conducted in other jurisdictions to identify and assess exercise types, goals, and outcomes
3. a review of models, interactive decision support tools, and simulation methodologies that can be used to potentially support the AWC simulation exercise

In addition to drought management approaches in Alberta, approaches were also reviewed in Saskatchewan, California, and South Carolina. The jurisdictions reviewed were chosen by the project team because of their similarities to (e.g., use of a permitting system giving priority to specific users during periods of water shortage) and differences from (e.g., ways of overcoming regulatory challenges) Alberta. The review also included case studies of drought simulation exercises which took place in Alberta, Saskatchewan, South Carolina, Colorado, and Chesapeake Bay. Eleven simulation tools were reviewed, ranging from game-style educational tools to highly complex and regionally-customized realistic drought planning tools. The WaterSMART literature review can be found on the AWC website.

2.2 Simulation Exercise Scoping, Planning, and Model Selection

The project team followed the approach recommended in the Drought Simulation Literature Review to select an appropriate simulation type by:

1. identifying and prioritizing desired outcomes that will support an effective drought response in Alberta
2. selecting an appropriate exercise best suited to achieving desired outcomes
3. selecting an appropriate tool that supports the selected exercise type

Through this process, the project team eliminated less appropriate tools and developed a Request for Proposals to develop and conduct the drought simulation exercise using either the Invitational Drought Tournament (IDT) or Operational Analysis and Simulation of Integrated Systems (OASIS) tools. This refinement of the selection ensured that the exercise would meet project needs such as:

- having participant role clarity
- enhancing understanding and working through the various stages of drought
- portability to other areas of the province for subsequent simulations
- ability to accommodate for local guidelines and actions
- flexibility in delivery method
- use of real-world data
- consideration of multi-year drought

9 Available online: https://www.awchome.ca/uploads/source/FINAL_Simulation_Literature_Review_2021_03_12.pdf

The scope targeted an audience that would include all levels of government, environmental groups, industry, water licence holders, and other organizations or people involved in water management or drought response. The simulation intent was identified in the scope to:

- Inform EPA's draft Drought and Water Shortage Plan through a vulnerability and risk assessment using either the IDT or OASIS.
- Test existing regional drought response guidelines and identify gaps and areas for improvement.
- Be based in the South Saskatchewan River Basin (SSRB), with a focus on the Red Deer River and Oldman River watersheds.
- Carry out one simulation due to the level of complexity involved and desired use of real-world data.

After a review of submitted proposals, the project team retained WaterSMART to develop, run, and evaluate the drought simulation exercise.

The simulation tool chosen for the exercise was the South Saskatchewan River Operational Model (SSROM), which is a hydrological model built on the OASIS platform. The model's focus on the SSRB reduced any costs associated with modifying the model. Other rationale for tool choice included the following:

- Users are enabled to identify, examine, and assess scenarios interactively for adapting to changes in water supply and demand.
- The model was designed as a support tool for collaborative processes and mutual learning among potentially competing water users.
- The model effectively simulates water-facility operations as it is flexible, transparent, and data-driven.
- Mass balance is preserved—water enters the model through inflows and exits only through demands, evaporation, or an end point.
- Water is allocated through a modifiable weighting system.
- The model considers multi-year droughts.
- WaterSMART had extensive experience and expertise with the model.

The scenario run in the SSROM contained several assumptions which impacted how water shortage was reflected across the three sub-basins during the exercise:

- Inflow data from 1977 and 2001, important drought years in Alberta, were used.
- TransAlta reservoirs used the 2021 Modified Operations Agreement which allows the provincial government to modify operations at TransAlta facilities.[10]
- Growth scenarios were not included.
- Current basin operations were modelled.

Focus on the SSRB was based on the following factors:

- **History:** Southern Alberta has the most history with and continually faces the main challenges of drought. There have been substantial amounts of data collected and work completed relating to drought in this geographic area.
- **Risk:** areas with high risk of future drought include the Red Deer River and Oldman River sub-basins, both of which are part of the SSRB.

10 https://www.alberta.ca/bow-river-basin-transalta-operations

2.3 Overview of the Drought Simulation Exercise

The pilot run and actual exercise occurred in April and June of 2022, respectively, with the exercise consisting of 40 participants and observers from 18 organizations representative of various sectors and groups involved in drought response within the SSRB. Named the South Saskatchewan River Basin Drought Simulation Exercise (the exercise), the main objectives of the exercise were to:

- Assess current drought vulnerabilities within the watershed.
- Identify gaps in current drought mitigation actions, legislation, and policy.
- Identify procedures and mitigations to address current gaps in procedure or policy within the SSRB.
- Identify lines of communication between stakeholders.

Prior to the exercise, participants were sent a participant package which included: basin status information for the previous year, background information on how the model worked, and instructions on how to interpret the performance measures. This information along with a more in-depth description of the exercise process can be found in Appendix E.

Briefly, the scenario ran for two years rather than the intended three to ensure that all five drought stages would be met. There were seven decision points throughout the year (Figure 1). At each decision point, new information was provided, and participants needed to decide the most appropriate course of action. Actions that reduced water demand were implemented in the model such as changes to municipal, irrigation, industrial, and temporary demands. At the end of the simulation year, the participants were shown the impact of their actions on the performance measures used in the model: reservoir storage, environmental flow, shortage as a percentage of demand, and apportionment. Some considerations (e.g., snowpack and groundwater status) were not modelled and in these cases, descriptions were provided instead. Similarly, some mitigations (e.g., changing reservoir operations, adding new infrastructure) could not be modelled and participants were instead encouraged to talk through them to avoid potentially causing problems with the model.

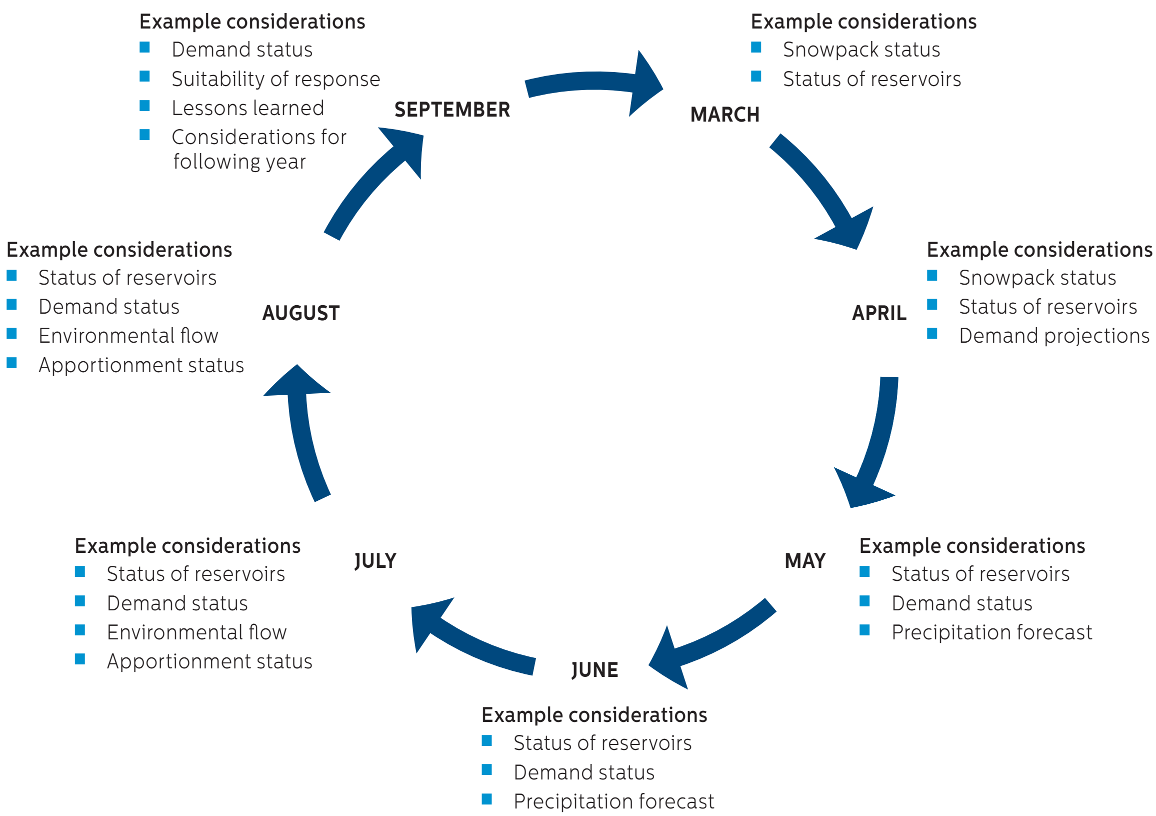

Figure 1. Diagram illustrating the seven decision points throughout the simulation drought years and corresponding considerations for decision making (adapted from WaterSMART).

3. Key Learnings

From the outcomes of the exercise and participant feedback, key learnings on planning and running a drought simulation exercise were synthesized to inform the development of the EPA's Drought and Water Shortage Plan. These findings were first compiled by WaterSMART and the project team in a post-exercise final report (Appendix F),[11] the content of which is referenced throughout sections three and four of this report.

3.1 Hosting a Simulation Exercise

In-person Exercise Format

While the exercise was held in person, there was an opportunity for participants and observers to join online. However, the exercise was more demanding than initially realized and required a significant level of engagement from the participants. As a result, some of those who joined online eventually dropped off. Additionally, developing an effective, participatory hybrid format is challenging and requires a great amount of planning, audiovisual support, and emphasis on online participants; this exercise was not designed with that in mind. It was recognized that the benefits of a drought simulation exercise are more likely to be realized when it is held in person instead of hybrid or exclusively online formats.

Pilot Run

Prior to the exercise, a drought simulation pilot run was completed in the same venue that the exercise would be held in. This was helpful in fine-tuning the simulation as it allowed participants to provide feedback about items such as the venue, presentation materials, exercise processes, and the model. However, the simulation was held at a different location due to pandemic-related delays and schedule conflicts. Overall, participants felt that the pilot run was successful at meeting the project goals, helped identify vulnerabilities and risks in the SSRB, provided opportunity for meaningful discussion, identified lines of communication both within and between sub-basins, and that it was an appropriate length.

Exercise Set-up

The exercise set-up was realistic as participants were able to react to updates in real time. While participants received a participant package prior to the simulation exercise (Appendix E), they were not provided many details in advance and were given updates throughout the exercise to react to. The lack of foreknowledge of the prepared scenario combined with supplying forecasts was both realistic and effective in keeping the groups engaged. The scenario not often playing out exactly as the forecasts predicted was very realistic and made the decision-making process dynamic and more reflective of actual processes.

Use of a Realistic Model

Subsequent exercises with other sub-basins and local water management areas should consider using realistic models if resources permit. The use of a realistic model (i.e., the SSROM) enhanced the effectiveness of the exercise and gained buy-in from the participants as the exercise was not based on a hypothetical model. The model used allowed participants to explore the connectivity of the sub-basins and see the impacts of their mitigation actions. As a result, the exercise showed the limits of the reservoir infrastructure conceptually and realistically.

11 Available online: https://www.awchome.ca/uploads/source/Drought_Simulation_Exercise_Memo_Final_Report.pdf

Exercise Dynamics

The dynamics of the exercise were a major contributing factor to its success. While the inherent format of a game-style drought simulation tends toward collaboration, the types of participants involved in the exercise also determined its successful outcome. Engaging the right people in the right way can allow them to understand and appreciate each other's situations. This can lead to increased willingness to support other sub-basins in a real-life drought situation and reach solutions that achieve consensus, or inclusivity at least.

Scope Limitations

By the end of the exercise, the sub-basins reached Stage 5 drought. By extension, it was assumed that participants experienced all four drought types (i.e., meteorological, agricultural, hydrological, and socio-economic). However, the exercise did not necessarily cover all aspects of drought management in the province. For example, the performance measures used were highly relevant to the irrigation sector while other industry sectors were not as heavily considered (e.g., oil and gas, dryland farming). Other sectors would benefit from running drought exercises that consider their own contexts within drought management in Alberta. For example, Alberta Agriculture and Irrigation have their own classifications of drought based on management responses and magnitudes of impact.[12] While this project adequately addressed main stem in-stream shortage with impacts to municipal and irrigation supplies, additional work is required to specifically address the impact that lack of growing precipitation has on different pasture situations during drought (e.g., dryland crops, forages, native and tame grasslands, livestock) and its subsequent response and management.

The performance measures used in the exercise were relatively successful in highlighting the impacts of meteorological and hydrological drought. However, the model faced limitations in effectively conveying the socio-economic impacts of drought which is an area that could be better represented in future drought exercises. While these impacts may not necessarily have to be modelled, as seen with the groundwater and snowpack statuses in this exercise, there is still merit in providing this information in drought scenarios.

The water quality aspect of water shortage was not part of the simulated drought exercise. However, water quality should be a topic of focus in future exercises as it is likely that hazards and associated risks arise due to poor water quality because of drought. Planning for future exercises could explore the degree that drought would affect river, lake, and reservoir levels; flows and hydraulic retention time with subsequent effects on key water quality parameters for aquatic life; irrigation use; and livestock. Drought can lead to water shortages which can hinder the ability to dilute all point and non-point sources, whether natural or human-caused. Future exercises could also explore how this causes water quality concerns for downstream users.

3.2 Drought Planning

Local Communication

The importance of local communication was apparent throughout the exercise. The drought response process within Alberta is structured to encourage bottom-up management during early stages of drought. This approach makes sense as local water managers and stakeholders have knowledge and understanding that should be accessed in any water shortage response plan. Specifically, water managers within a sub-basin can coordinate to identify the best approach and advise the government. This approach can lead to better outcomes as it incorporates local context and collaboration between relevant water users. It is also important to note the value of this local knowledge in early identification of issues and build this into forecasting tools. Frequent communication between water managers and water users at a local scale, even in the early stages of drought, could help water users rationalize mandatory actions and encourage voluntary reduction of water demand when necessary. Local communication between junior and senior licence holders is especially relevant. For example, some municipalities have relatively junior water licences[13] and are at risk of experiencing a call on priority. As a result, pressures may increase for large senior water licence holders to engage in water sharing agreements as an interim measure.

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12 https://open.alberta.ca/publications/alberta-s-agriculture-drought-and-excess-moisture-risk-management-plan

13 http://waterlicences.alberta.ca/

Water Sharing Agreements

Water sharing agreements were an important mitigation tool throughout the exercise, especially within the Oldman River sub-basin. Developing these agreements requires involved and coordinated communication which is reflected in the following learnings:

- Within a sub-basin, there is the possibility that individual licence holders in smaller watersheds would need to create their own localized sharing agreements.
- It is imperative for users in vulnerable watersheds to be proactive in discussing potential water sharing agreements before there is a need to implement them.
- Communication between water licensees takes up a significant portion of implementing water sharing agreements. Proactively identifying users who should be involved in the development of these agreements and being aware of the timeline required to draft and implement agreements could result in quicker response times during drought.

Despite the use of water sharing agreements as a primary mitigation tool during the exercise, there was still uncertainty surrounding the processes of creating and implementing those agreements. For example, participants required guidance from those experienced in developing historical water sharing agreements. Hence, there is an opportunity to ensure that all water licence holders understand water sharing agreement processes.

Identified Vulnerabilities

The exercise was successful at identifying vulnerabilities within the SSRB during a severe drought. Though snowpack conditions were not modelled in the SSROM, the incorporation of snowpack (i.e., through a qualitative description) in the pilot and exercise highlighted water users' reliance on snowpack as a water source. However, it is important to note that snowpack is increasingly vulnerable to climate change which can have an impact on drought planning.[14] The use of groundwater as an alternative water source in regions where it is a realistic option during times of drought was often overlooked during the exercise, which is further explained in section 4.2. Finally, the nature of the simulation exercise favoured reactive decision making. More long-term thinking and proactive measures are generally required, an idea that was highlighted in the Building Resiliency to Multi-Year Drought project.

Individual and Organizational Roles and Responsibilities

The exercise was only somewhat successful at highlighting the roles and responsibilities of individuals during a drought which is an extension of the uncertainty surrounding individual and organizational roles and responsibilities in real-life drought management. For example, during the exercise WPACs had decision-making roles. In reality, WPACs play a role in collaboration, coordination, and communication rather than being directly involved in decision making. Additionally, the role of the Intrabasin Water Coordinating Committee (IWCC) and its potential to manage communications during a drought was not well understood by participants. Finally, there was ambiguity surrounding the scope and role of government and the expectations of water users and water managers. The expectations, roles, and responsibilities of government, water managers, and licence holders should be well-defined and clearly communicated ahead of a drought.

14 https://www.nature.com/articles/s41598-022-16743-w

Need for Good Data and Accurate Forecasting

Accurate weather and water forecasting is needed to support real-time decision making. The exercise showed that staged drought response processes work well when supported by reliable data, knowledgeable water managers, and, ideally, reliable drought forecasting. At multiple decision points throughout the exercise participants highlighted the importance of and need for frequent and regular monitoring of water sources (i.e., surface water, groundwater, and snowpack) for the purposes of obtaining quality data. During the exercise, surface water, snowpack monitoring, and groundwater information were provided, but groundwater was often overlooked by participants. The lack of focus on groundwater as an alternative water source appeared to be driven by the lack of reliable groundwater data and the participants' lack of understanding data that was available. This highlights the need for regular and better monitoring of groundwater (and all water sources in general) as well as education for water managers so that they are better able to understand and synthesize available data. Having effective monitoring and education programs in place can result in good, applicable data that can be used in models, support accurate forecasting, and aid real-time decision making.

Meeting Apportionment Obligations

While the sub-basins of the SSRB manage water supply and demand separately, all are jointly responsible for meeting the *Master Agreement on Apportionment* (MAA) which defines when and how water is shared across the prairie provinces.[15] The exercise highlighted that better and more proactive coordination and collaboration are needed to help meet apportionment. The participants in the role of water managers had a lack of in-depth and nuanced understanding of apportionment; while all sub-basin groups recognized the need for meeting apportionment, few choices were available for operating to meet it. In practice, the Prairie Provinces Water Board produces a quarterly report about conformance to the MAA and a monthly report can be requested when there is concern that the agreement may not be met. As the IWCC is "the main source of advice to [Alberta Environment and Protected Areas (EPA)] concerning actions that should be taken to ensure the *Master Agreement on Apportionment*... is met",[16] there is an opportunity for improving education and communication surrounding apportionment as well as the much-needed incorporation of frequent, whole basin conversations across provinces. While the Bow River sub-basin pre-emptively stored water to help meet apportionment during the exercise, guidance on precautionary measures like holding water would be valuable to provide. Further, communication between neighbouring sub-basins is imperative in optimizing actions required to meet apportionment. The following are questions that should be considered when planning:

- How do we recognize when Alberta's share is not enough for all the expressed needs in the watersheds?
- When and how could sub-basins assist other sub-basins in fulfilling their apportionment obligations?
- What happens if all three sub-basins within the SSRB experience similar drought severity in the same period?

Drought Stages

While the participants found the drought stages useful for defining and communicating the severity of the drought, there was still a lack of understanding about what the drought stages mean. The following uncertainties were brought up:

- Must all descriptive points be met to declare a drought stage?
- What type of legislative authority and responsibility is present at each drought stage?
- Which tools are available at each stage?
- What forms of mitigating actions can be implemented?

15 https://www.ppwb.ca/about-us/what-we-do/1969-master-agreement-on-apportionment

16 Available online: https://open.alberta.ca/dataset/9b9126f8-7cef-4036-8f77-2e0a33d38cb4/resource/81cb8aea-f2a0-4f11-a00f-50d7f6b969d1/download/intrabasinwatercommittee-reference-2008.pdf

It was noted that the stages could be further defined and contextualized so they are less open to interpretation. Having a guidance and interpretation document developed to supplement the list of the five drought stages would be one way to mitigate this gap. The document would be developed to:

- target water managers to provide considerations and improve understanding
- be sent to all water licence holders when Stage 1 drought is declared
- include historical and jurisdictional case studies and narrative descriptions of the drought
- stages and subsequent mitigation actions

Dam and Reservoir Operations

In Alberta, dams and reservoirs are currently operated to fulfill multiple purposes, including, but not limited to:

- hydroelectricity generation
- supplying the water demands of municipalities, industries, and agriculture
- providing flows downstream to maintain water quality and ensure fish survival, enhance recreational opportunities, and sustain riparian vegetation
- offering flexibility in meeting transboundary apportionment agreements

Dam and reservoir licences have limits in place to protect aquatic ecosystems such as in-stream objectives, water conservation objectives, and fish rule curves. The exercise highlighted constraints that operators could face during a drought and the lack of government policy/legislation/direction on whether required operations of dams and reservoirs can be changed to prioritize other outcomes through rebalancing of existing operating rules. The exercise allowed participants to recognize that there may need to be discretion when it comes to reprioritizing limits depending on objective intents. The need for constant communication between operators and downstream users was also highlighted as reservoir operators rely heavily on supply and demand forecasts.

3.3 Information Gaps

As there was no groundwater expert present at the drought simulation exercise, there was uncertainty about how supplied groundwater information should be applied to the exercise scenarios. The project team has identified the following areas as knowledge gaps which could potentially be the focus of future work:

- identifying areas that rely heavily on groundwater and providing information on which users rely on groundwater
- developing proposals (with increased budget) for increased real-time groundwater monitoring and mapping and increase reporting frequency where groundwater has been identified as a source
- investigating the feasibility of groundwater to fill source water supply gaps during drought (i.e., how does availability and quality of groundwater compare to geographic locations of source water licences?)
- developing materials on effective groundwater data interpretation including groundwater subject matter experts and major groundwater users or groundwater user representatives in drought management planning discussions and drought simulation exercises where groundwater use is high or could increase

4. Recommendations

Based on learnings from this project, nine recommendations were developed to further improve drought resilience in Alberta and inform the GoA's development of the Drought and Water Shortage Plan.

4.1 Increase Collaboration

Enhance Drought Management

Currently, some key water managers and decision makers regularly meet to discuss drought response. This semi-formal process encourages a more localized approach to drought response. This exercise validated EPA's use of more localized water management areas to identify water supply status. It also showed that drought can be very localized, and plans need to be in place to manage at the local scale. However, there was uncertainty regarding what action(s) would be taken at each drought stage and which tools are available for sub-basins to help themselves and other basins alleviate drought. Having a formal plan with guidance for effectively and efficiently mobilizing a response during a drought would be valuable (e.g., Ontario Low Water Response).[17] Sub-basins within a greater basin respond to drought differently and may choose different approaches within the provincial legal framework based on local context and needs of each basin. During the exercise, municipalities, irrigation districts, and water managers who had their own drought and water shortage plans in place were able to take appropriate action at the right time.

Recommendation 1:

For the GoA to complete and share their provincial Drought and Water Shortage Plan response plan with large water licence holders and key water users.

Rationale:

- Distribution of the Drought and Water Shortage Plan will act as a basis for further local drought response and management plans.
- Specific communication is required between sub-basins and the provincial government. Government actions that may be implemented at each drought stage, clear expectations of water users, a comprehensive set of best practices, and a well-maintained contact list will allow key water managers to convene quickly during water shortages.

Recommendation 2:

For municipalities, irrigation districts, and other relevant groups to collaborate with WPACs to use the AWC's Building Resiliency to Multi-Year Drought in Alberta Guide to create local drought response and management plans and test these plans through drought exercises. These local plans should include aspects of and be in alignment with the GoA's drought response plan. Drought exercises used to test these plans can range in complexity depending on available resources.

Rationale:

- Water managers within a sub-basin possess local knowledge and can incorporate local context when identifying best approaches and advising the provincial government which can lead to better outcomes.
- Local drought response plans can provide guidance on communicating the environmental, social, and economic implications of drought to communities by taking local context into account, which have the potential to decrease costs associated with drought impacts.
- Documenting best practices through local water shortage response plans will also help maintain and transfer knowledge relating to different roles.
- Testing plans through exercises can highlight effective strategies and areas of improvement.

17 https://www.lioapplications.lrc.gov.on.ca/webapps/swmc/low-water-response/

- More localized exercises can allow all appropriate parties to be present which can lead to more detailed discussion on individual roles and responsibilities.
- Considering economic implications and operational impact in drought response and management plans allows these plans to be more robust.

Test Plans Through Drought Exercises

There are opportunities to implement additional collaborative stakeholder drought-modelling exercises throughout the province. For example, as the Bow River sub-basin did not experience as intense a drought as the other two sub-basins during the exercise, the City of Calgary is considering running a simulation to further stress the Bow River sub-basin. The SSROM Phase 3: Assessment of Strategic Projects to Support Economic Development was convened by stakeholders in December 2022. The year-long project involves development and inclusion of a hydrologic model into the SSROM. This added functionality will allow assessment of future climate changes on water management in the SSRB.

Recommendation 3:

For an additional simulation exercise to be carried out in the Bow River sub-basin.

Rationale:

- During the simulation, the Bow River sub-basin was not tested in the way the Red Deer and Oldman River sub-basins were. As the Bow River is the most populated and regulated river in Alberta,[18] the sub-basin would benefit from additional exercises that simulate more severe drought conditions.

While the exercise used a model to simulate a drought, it is recognized that the use of models is resource intensive. It is important to consider economic implications and operational impact in drought response and management plans. Subsequently, these should also be considered in any further drought exercises completed at a more local scale. However, the planning process for the simulation exercise highlighted a suite of useful tools and resources for creating realistic drought scenarios that are not strictly dependent on modelling or simulations.

Recommendation 4:

For the AWC to convene a multi-stakeholder group to create a package for other groups to plan their own drought exercises. The package would include the lessons learned from this exercise (section 3.1), information on the types of drought exercises, their resource needs, and how they can support drought planning.

Rationale:

- A drought exercise-planning package would provide guidance for other groups wishing to complete a drought exercise and complement the desired outcomes of the Building Resiliency to Multi-Year Drought project.

18 https://ecr.brbc.ab.ca/ (See: History of the Bow River Basin)

4.2 Further Information Base

Improve Groundwater Knowledge

During the exercise, groundwater was an area that was overlooked by participants. While participants recognized that decisions could be made in a drought based on groundwater status, it was noted that participants: 1) did not let groundwater status impact their decisions, and 2) felt that the available groundwater data was unreliable. A lack of focus on groundwater is likely due to a general lack of knowledge, monitoring, and data surrounding groundwater use and availability. For example, groundwater pumping rates may not be known, not all groundwater wells around the province are monitored, or the data are not reported as well as they could be. Addressing this gap in data relates to improving the system of monitoring, wells, data collection, and management. In addition, licence amendments are required to shift from one source of licensed water diversion to another.

Recommendation 5:

For the GoA, partner organizations, and potential groundwater users to identify and address information and knowledge gaps pertaining to the availability and feasibility of groundwater serving as an alternate source of water during a drought emergency situation.

Rationale:

- Groundwater may be a means to mitigate surface water drought management issues.
- Groundwater monitoring is relevant in areas that rely heavily on groundwater as their main source of water as its absence in a multi-year drought creates an emergency.
- Encouraging users to report data can lead to increased information regarding which users rely on groundwater.
- Increased knowledge on interpreting groundwater data can better inform water users and managers' decision-making processes.

Evaluate the Value of Infrastructure and Non-Structural Solutions

Limitations of existing storage and the ability to divert sufficient water are barriers to effective drought planning and response. One of the main risks to properly planning and mitigating for drought are the operation limitations surrounding reservoirs and the general lack of reservoirs in certain sub-basins (e.g., the Red Deer River sub-basin). Assignments and revising reservoir operations are not a substitute for planning improved water storage, especially storage reservoirs and the large conveyance infrastructure to fill them during prime diversion opportunities (e.g., during spring freshet). The associated costs of limited storage and conveyance, while often difficult to pin down, tend to get higher as drought progresses. Drought simulation exercises have the potential to lower these costs by highlighting areas or providing scenarios in which the benefits of additional infrastructure outweigh the costs of implementing them. However, infrastructure projects are long-term solutions and there is also a need to look at shorter-term, non-structural solutions, like retaining and restoring wetlands and riparian areas.

Recommendation 6:

For the GoA to continue to investigate the feasibility of adding or enlarging infrastructure (i.e., relating to water storage and conveyance) in addition to non-structural solutions, including green infrastructure, to complement policy and administrative processes.

Rationale:

- This recommendation aligns with the current and planned GoA-led investigations on feasibility. For example, the province is currently completing a feasibility study as part of Phase 2 in a project assessing options to mitigate the impacts of both flood and drought on the Bow River.[19]
- Continued investigations into the feasibility of adding or enlarging structural and non-structural solutions ensure that any associated environmental, economic, and social implications are known and available for consideration.
- It is important to determine the point at which the cost of additional infrastructure is warranted. This analysis should be integrated with a coordinated approach whereby an objective prioritization process is applied within each sub-basin to best determine where the greatest value will be realized.
- Natural or naturalized infrastructure like wetlands and riparian vegetation are natural assets that improve watershed resilience and mitigate both flooding and drought.

Increase Drought Resilience

The exercise highlighted the vulnerability of the Red Deer River sub-basin to multi-year droughts, but this can go beyond water shortages. During the exercise, catastrophic impacts such as loss of crops, risk to human health, and a high likelihood of extensive fish kills were observed in the second year of drought highlighting the entire SSRB's vulnerability to multi-year droughts.

Recommendation 7:

For the sectors who developed water conservation, efficiency, and productivity (CEP) plans and their members to consider voluntarily reviewing their CEP plans through the lens of drought management within each sector, as applicable, considering climate change effects and population and economic growth.

Rationale:

- CEP was a key action in the 2009 *Water for Life* action plan,[20] was reaffirmed in the 2014 report *Our Water, Our Future; A Plan for Action*,[21] and continues to be a main theme in AWC projects and recommendations.[22]
- CEP plans may be used to inform drought simulation exercises and subsequent drought management planning.
- Water restrictions were used by municipalities during the simulation to understand essential water use and reduce demand. During drought events, the municipal sector will need to continue to use water restrictions and other CEP tools to reduce demand. The use of water restrictions was realized in August 2023 when the City of Calgary enacted Stage 1 Outdoor water restrictions for the first time.[23, 24]

19 https://www.alberta.ca/bow-river-reservoir-options

20 https://open.alberta.ca/dataset/2a91e8c6-ea9a-44c4-a76d-cd35a9a296f7/resource/49531a5a-e16c-4250-a9a4-0028fa500854/download/2009-waterforlife-actionplan-nov2009.pdf

21 https://open.alberta.ca/dataset/d1d7962a-d926-4e89-866f-1f6cb71e4d1f/resource/721910e6-6cd4-423c-975c-130f806d67dd/download/zz-2014-our-water-our-future-plan-action-2014-11.pdf

22 https://www.awchome.ca/projects/water-conservation-efficiency-productivity-1/

23 https://globalnews.ca/news/9897314/calgary-outdoor-water-restrictions-drought/

24 https://newsroom.calgary.ca/city-of-calgary-lifts-outdoor-water-use-restrictions-encourages-calgarians-to-use- water-wisely/

4.3 Develop Guidance Tools

The exercise highlighted several gaps in understanding of tools outlined in the *Water Act*. Water sharing agreements were adopted in the exercise for senior licensees to share water with junior licensees who otherwise may have been cut off. While the agreements were key to the results of the exercise, participants were not clear on the process for entering into an agreement. Although participants identified that there are limited tools available for neighbouring basins to assist one another, inter-basin transfers are available via a special act of the legislature. There was uncertainty and limited understanding about how the GoA would prioritize water during severe droughts. There is little guidance to government to assign priority by use once an emergency has been declared under the *Water Act*. Finally, while the IWCC was recognized as a useful body during the exercise, participants were unclear on their role.

Create Guidance for Water Sharing Agreements

Recommendation 8:

For the GoA to lead a multi-stakeholder approach in developing guidance for water sharing agreements, such as a toolkit which could include templates, guidance documents, legal considerations, examples, and other facilitation and negotiation support for interested groups of water users.

Rationale:

- While there is a formal established approach for mass water licence user assignment, the exercise highlighted the need for guidance in developing both regulatory and non-regulatory agreements.[25]
- If water sharing agreements are part of drought response plans, all participants must be clear on the process for entering into an agreement.

Clarify Drought Planning and Management Tools

Recommendation 9:

For the GoA to:

- Provide an overview of the process and key considerations for an inter-basin transfer water licence, which requires a special act of the legislature.
- Outline the potential considerations or circumstances that could inform the GoA if a recommendation to declare an emergency related to water may be necessary.
- Review whether the terms of reference of the IWCC are still relevant.

Rationale:

- There is potential for basin-wide droughts to occur and currently, there is no guidance on inter-basin transfers.
- Having guidance in place for water prioritization during a severe drought can decrease uncertainty and response times.
- The IWCC is an active body that provides "advice on managing water during periods of water shortage in any or all of the sub-basins of the SSRB, and on how to best meet the requirements of the Master Agreement of Apportionment".[26] Confirming the IWCC's role may lead to increased understanding of the committee's role in managing communications during a drought.

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25 Note: Water sharing agreements can take the form of a non-regulatory, voluntary agreement to share water or a regulatory agreement to assign water under section 33 of the *Water Act*.

26 https://open.alberta.ca/publications/terms-of-reference-intrabasin-water-coordinating-committee-of-ssrb

5. Conclusion

Droughts are regular occurrences in Alberta and are likely to occur more frequently as the effects of climate change increase. Preparedness and adaptability are the keys to successfully responding and adapting to the risk of multi-year drought. However, droughts are often difficult to plan for and respond to when they are not occurring. Simulation exercises can closely mimic real-life drought events which allows groups to test strategies and plans used to prepare for, respond to, and mitigate drought. The South Saskatchewan River Basin Drought Simulation Exercise was successful at identifying risks and vulnerabilities within the basin during a severe drought, was a productive environment through which decision-making processes could be tested, and highlighted the importance of and need for communication and collaboration between water management areas within the basin. The AWC believes the recommendations in this report, when implemented, will improve drought resiliency in Alberta. The recommendations address further opportunities for running additional simulations across the province, which will enhance communication and understanding of processes available to water managers and users during a drought, and increase knowledge surrounding risks and information gaps identified in the exercise.

APPENDIX A
Terms of Reference

Improving Drought Resilience in Alberta Through a Simulation Project Team Terms of Reference

Final approval by the Alberta Water Council on: June 2023

Context:

Drought is a natural, recurrent phenomenon in Alberta that has environmental, economic, and social impacts. Recent studies have shown we can expect more frequent and extended droughts. Several initiatives are underway in the province to improve drought preparedness, including:

- The Government of Alberta's Drought and Water Shortage Plan will outline management and communication actions in times of drought.
- The Alberta Water Council (AWC) guide to assist Watershed Planning and Advisory Councils (WPACs) as they engage municipalities to better prepare for, mitigate the effects of, respond to, and recover from multi-year droughts.
- The Miistakis Institute is a research institute, conservation charity, and social enterprise non-government organization (NGO). They are working with a pilot community to develop a process for drought mitigation planning.

A drought evolves slowly, and its beginning and end tend to be unclear. Managing a drought involves complex monitoring, decision making, and communication before, during, and after its occurrence to mitigate the impacts proactively and respond effectively. Droughts are often difficult to anticipate and strategize for when not in a time of drought. Simulation exercises provide an opportunity to work through one or multiple scenarios that closely mimic real-life acute and/or chronic drought events and can be a powerful tool to test management structures and communication strategies.

Strategic Intent (Goal):

The purpose of this work is to use appropriately scoped and scaled simulation(s) to assist the Government of Alberta, municipalities, Indigenous communities, and other groups (e.g., WPACs, Alberta Irrigation Districts Association) to understand and plan for drought preparation and response, including mitigation, monitoring, decision making, and communication before, during, and after a drought.

Objectives:

1. Compile existing information on drought management resources, roles and responsibilities, regulations, metrics, thresholds, indicators, and responses in Alberta and other jurisdictions.
2. Identify necessary models and decision support tools and review simulation methodology options.
3. Develop the scope for a science-based drought scenario or scenarios that meet the needs of the stakeholders involved.
4. Integrate and complete background and simulation exercise materials.
5. Execute the drought simulation(s) with relevant stakeholders.
6. Compile the simulation results, lessons learned, and any project team recommendations in a final report and disseminate to relevant stakeholders.

Key Tasks:

1. Develop a work plan that includes key tasks, deliverables, and timelines.
2. Compile summaries and studies of historical examples of drought and its impacts in Alberta and other provincial jurisdictions, lessons learned, and expected changes due to climate change through a literature review.
3. Document drought-related information and resources relevant to Alberta (including, but not limited to decision-making processes, drought management agreements, roles and responsibilities, regulations, communication processes, existing tools and programs).
4. Identify gaps in drought management and make a recommendation on standardization of drought indicators, thresholds, and responses to test during the drought simulation.
5. Assemble a group of subject matter experts to:
    a. Define the types of models and tools available (e.g., hydrologic models, decision support tools).
    b. Review existing models and decision support tools used regionally, provincially, and federally, and in other jurisdictions.
    c. Identify appropriate existing or components of existing models for use in a drought simulation at the appropriate provincial, regional or watershed scale to be determined as an outcome of the literature review and given the costs and available resources.
    d. Determine any modifications needed to these models and decision support tools for use in the context of Alberta's historical and predicted droughts.
    e. Generate and evaluate (cost/benefit) a list of potential adaptation strategies which may be incorporated into the models or decision support tools.
    f. Provide the project team with different simulation methodology options based on their review of available models, decision support tools, and resource requirements.
6. Examine drought simulation case studies from Alberta and other jurisdictions.
7. Develop drought simulation scope, including identifying the following:
    a. level of complexity (e.g., live modelling vs. pre-modelled adaptation strategies)
    b. simulation methodology based on task group recommendations (e.g., cumulative impacts of strategies chosen, feedback on decisions, simulation type)
    c. standardized metrics, indicators, regional thresholds, and responses
    d. simulation boundaries and considerations (e.g., licensed priorities (FITFIR), inter-basin transfers, transboundary agreements)
    e. balance of environmental, social, and economic impacts
    f. geographic scope and level of regional detail required
    g. communication needs and managing expectations
    h. timeline scoping for drought scenario and climate projections.
    i. key stakeholders and their roles in the simulation
8. Develop a simulation handbook, including objectives, ground rules, background, methodology, boundaries, and any other relevant information.
9. Test the simulation with a focus group and sector engagement and revise the materials as necessary based on feedback.
10. Assemble a subgroup to develop event communications and simulation supporting materials.
11. Execute drought simulation(s) with stakeholders.
12. Document simulation outcomes in a post-exercise assessment and distribute to stakeholders.
13. Provide regular updates to the AWC board during the project and a final report and supporting simulation materials.

Timelines and Deliverables:

The project team will provide the following deliverables to the AWC:

- Share findings from the literature and jurisdictional review . . . . February 2021
- Share the simulation handbook . . . . April 2022
- Share post-simulation draft report and results from fall 2021 simulation. . . . November 2022
- Final report and supporting simulation materials . . . . October 2023

Membership:

Open to AWC members and other relevant groups identified by the project team. The project team will operate in a manner that is consistent with the rules, policies, and procedures adopted by the AWC, including the use of consensus to make decisions in a multi-stakeholder process.

Key sectors identified for participation include:

- Provincial government subject matter experts
- Federal government subject matter experts
- WPACs and Watershed Stewardship Groups
- Municipalities
- Regional boards
- Indigenous communities
- Alberta Irrigation Districts Association
- Food grower associations
- Food processors
- Individual growers/ag producers
- Insurance organizations (AFSC)
- Academic institutions
- Hydroelectricity generators
- Oil & gas sector
- The SSRB Intrabasin Water Coordinating Committee (IWCC)

Budget:

The working group estimates a budget of $210,000 as follows

Core Funding Costs (covered by the AWC)

Type	Amount
Stakeholder support	$50,000
Hosting	$5,000
Communications	$15,000

Project Funding Cost (provided by stakeholders)

Type	Amount
Literature review on drought tools and models	$50,000
Simulation hosting & materials	$15,000
Simulation development & facilitation	$75,000

APPENDIX B
Acknowledgements

Appendix B — Acknowledgements

The Alberta Water Council acknowledges the contributions of the following working group and project team members who volunteered their invaluable time and expertise on this project, along with their member organizations for supporting their participation.

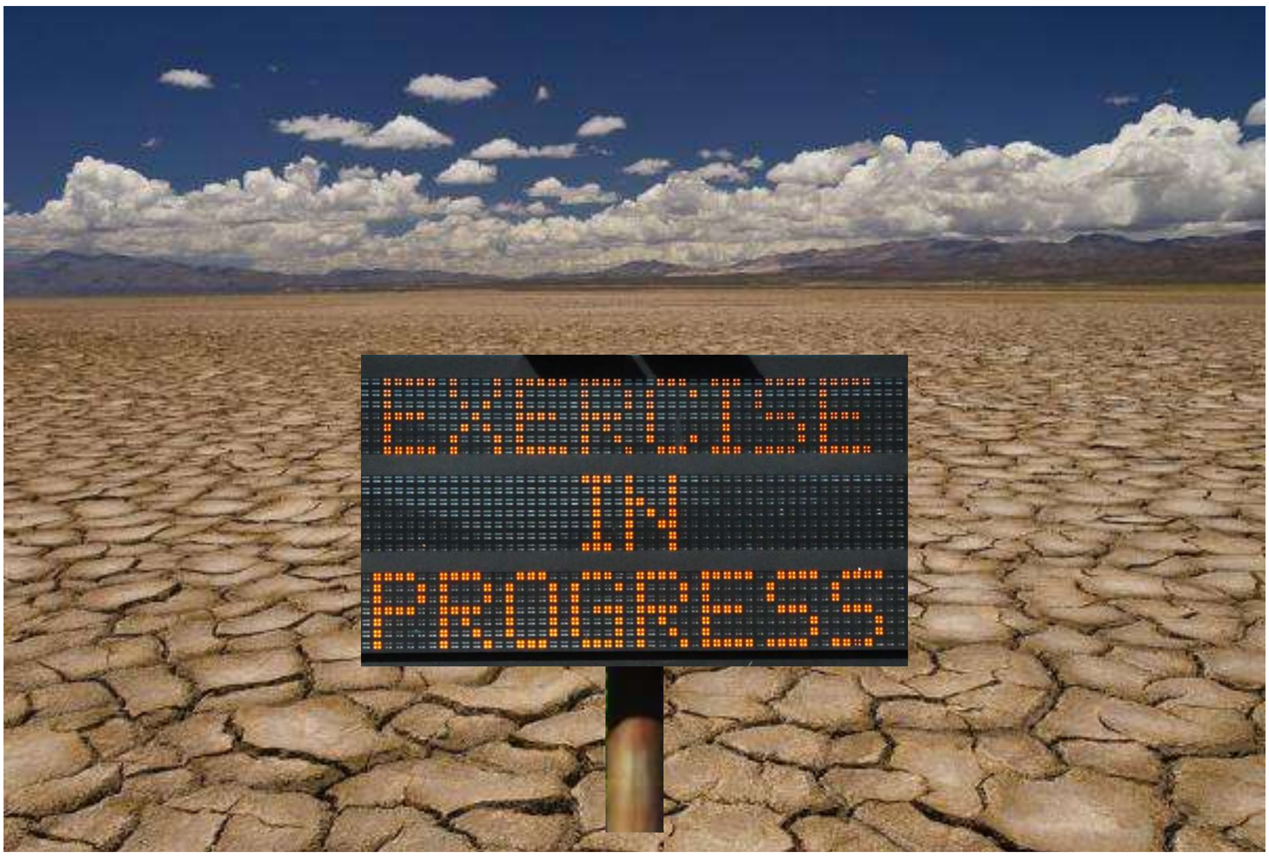
This project was a success with the financial support of Alberta Innovates' Water Innovation Program, and the expertise and support of WaterSMART Solutions and EPA. The AWC also greatly appreciates the contributions of those who participated in the drought simulation exercise.

Name	Organization
Ana Potzkai	Alberta Environment and Protected Areas
Brett Purdy	Alberta Innovates
Brian Brewin	Rural Municipalities of Alberta
Catriona White	City of Calgary
Christopher Gallagher	Alberta Irrigation Districts Association
Daryl McEwan	Alberta Environment and Protected Areas
Doug Kaupp	City of Lethbridge
Greg Paxman	City of Medicine Hat
Helge Nome	Red Deer River Watershed Alliance
Jason Schneider	Rural Municipalities of Alberta
Jennifer Nitschelm	Alberta Agriculture and Irrigation
John Michalopoulos	City of Medicine Hat
Keziah Lesko-Gosselin	South East Alberta Watershed Alliance
Kyle Swystun	Alberta Environment and Protected Areas
Lora Brenan	Alberta Municipalities
Morris Nesdole	Athabasca Watershed Council
Nicole Pysh	Alberta Environment and Protected Areas
Pamela Duncan	City of Calgary
Paul Taylor	Alberta Municipalities
Steve Meadows	Bow River Basin Council
Wendy Giamberardino	Alberta Environment and Protected Areas
Zahidul Islam	Alberta Environment and Protected Areas

Project Managers: Cara McInnis, Jacqueline Noga, Katie Duffett, Lauren Hall, Mariem Oloroso

APPENDIX C
Presentations

Summary of Drought Management Exercises



National Drought Mitigation Center

University of Nebraska Lincoln

NIDIS
National Integrated Drought Information System

Why should you conduct a drought exercise?

Proactive drought preparedness can be challenging

- Competing priorities for a limited resource
- Multiple levels of decision-making, each with unique perceptions
- Drought is a complex, variable phenomenon

What are the benefits of conducting a drought exercise?

- Simulate the disaster without the risk
- Increase readiness
- Educate, train, and inform participants

What types of drought exercises exist?


Workshops


Table Top Exercises


Games


Operations Simulations

Which one is right for your organization?

Desired outcomes

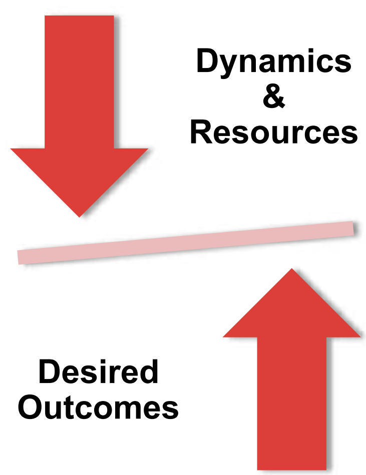
- Increase communication and stakeholder engagement?
- Educate and/or train staff?
- Inform the planning process?
- Develop a drought plan?
- Test an existing plan?
- Tackle tough issues, consider worst case scenarios, or brainstorm strategies for past or future conditions?
- Other?

Dynamics

- Contentious basin?
- Complexity of issues?
- Number of participants?
- Working relationship of participants?

Resources

- Budget?
- Personnel?
- Time allocation?



Workshops

- Informal discussion to demonstrate tools and techniques and exchange ideas
- Designed to build a specific product or draft a component of a drought plan

Managing Risk on the Ranch, Lincoln, NE 2009

Building Drought Early Warning Capability in Montana, 2015, Bozeman, MT

Pros & Cons

+

Allows for interaction with planning experts

Tailored to a specific audience or planning component

Follows a step-by-step procedure

Creates a framework for planning activities

Helps agency representatives get to know one another and become familiar with the capabilities of other agencies

Provides an engaging environment

Fosters innovative thinking and strategies

Requires a modest commitment of time, cost, and resources

−

Can require a significant time commitment for scenario development and event exercise

Can include a great deal of follow up work

Can be difficult to convey outcome expectations

Can be challenging to track outcomes

Table Top Exercises

- Informal discussion in which key personnel work through simulated scenarios
- Used to test, validate, and practice existing agency plans, policies, and procedures

Hualapai Nation Drought Plan Exercise, 2005, Peach Springs, AZ

Pros & Cons

+ (Pros)

Enables the inclusion of multiple sectors, stakeholders, and points of view with relatively fewer stakeholders than other exercises

Familiarizes participants with their actual roles & responsibilities

Identifies strengths and weakness of an existing plan

Builds trust and teamwork

Provides an engaging environment

Promotes communication

Requires a modest commitment of time and resources

– (Cons)

Provides only a superficial exercise of plans, procedures, and capabilities

Can create a great deal of follow up work as participants identify issues, challenges, and resource needs

Can be challenging to track outcomes

Games

- Simulation involving two or more teams, in a competitive environment, using rules, data, and procedures
- Can be designed to depict actual or hypothetical situations
- Used to identify proactive solutions for drought management

Colorado Drought Tournament, 2012
Denver, CO

Pros & Cons

Provides a fun and engaging environment

Promotes communication & cooperative learning

Fosters innovative thinking and strategies

Enables the inclusion of multiple sectors, stakeholders, and points of view

Constrains risk through budgets, drought scenarios, and institutional considerations

Limited interaction with planning experts

Can be costly

Can require a significant time commitment for scenario development and play

Can require a large number of participants to play the game

Can require hiring a consulting firm for scenario development

Can be difficult to score or judge

Can be challenging to track outcomes or link to the planning process

Operations Simulations

- Practice run of communication and management activities
- Designed to depict conditions and operations during an actual drought
- Used to validate plans, policies, agreements, and procedures; clarify roles and responsibilities; and identify resource gaps

Interstate Commission on the Potomac River Basin Drought Exercise, 2013, Washington Metropolitan Area

Pros & Cons

+	−
Most realistic exercise of plans, procedures, and capabilities Familiarizes participants with their actual roles & responsibilities Helps agency representatives get to know one another and become familiar with the capabilities of other agencies Identifies strengths and weakness of an existing plan Builds trust and teamwork Promotes communication	Requires a large commitment of time and resources Involves the use of complex models Can create a great deal of follow up work as participants identify issues, challenges, and resource needs Can be challenging to track outcomes

EXAMPLES

- The following pages provide examples of each of the four types of drought exercises.
- Please note that others exercises and activities have been conducted – with and without the NDMC's awareness and/or participation.
- There are NO right or wrong exercises. The selection depends on balancing your desired outcomes with system dynamics and resources.
- All exercise types are subject to customization. Some can be done in-house with assistance from NDMC, while other may require complex modeling and the hiring of engineering/ consulting firms.

Managing Risk on the Ranch, 2009 to present

EXAMPLE #1 WORKSHOP

Goals

- Develop a generic drought planning process for livestock and forage producers

Facilitators & Developers

- NDMC, USDA, UNL Extension, National Integrated Drought Information System

Participants

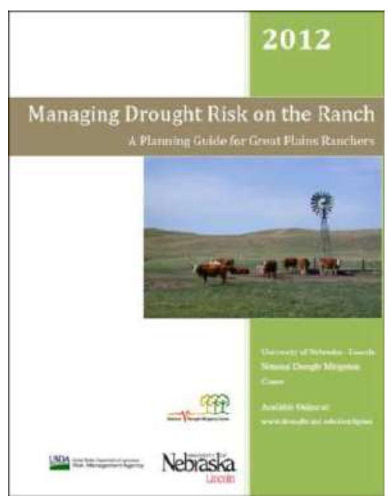
- About 20 ranchers and rangeland advisors

Characteristics

- Large group discussions, small group breakouts, World Café sessions, and sticky wall activities
- Needs assessment and consensus building

Outcomes

- Recommendations to include in drought inventory, monitoring, mitigation, and contingency plans
- Recommendations on the use of critical dates and useful decision support tools for livestock and forage producers
- Guidance document



For more information: see report at https://drought.unl.edu/ranchplan/ or contact Tonya Haigh (NDMC) at thaigh2@unl.edu

Building Drought Early Warning Capability in Montana, 2015

EXAMPLE #2 WORKSHOP

Goals

- Provide watershed stakeholders with drought monitoring and planning resources
- Equip watershed stakeholders with a framework for future drought planning and resiliency efforts

Facilitators & Developers

- NDMC, National Integrated Drought Information System, EPA, Montana DNRC, National Drought Resiliency Partnership

Participants

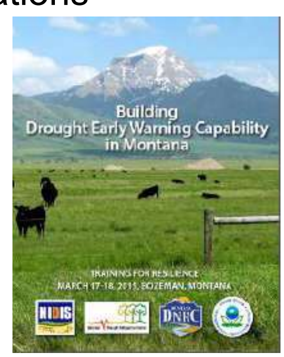
- Approximately 50 participants from state and federal agencies and non-profit organizations located with 8 watersheds in the Upper Missouri River Basin

Characteristics

- Large group discussions
- Breakouts by watershed teams to discuss impacts, vulnerabilities, and challenges
- Hands-on decision support tool demonstrations

Outcomes

- Information regarding local issues and challenges
- Course of action to reduce drought risk in their watershed



For more information: See report at http://www.drought.gov/drought/news/upper-missouri-river-basin-building-drought-early-warning-capability or contact Deborah Bathke (NDMC) at dbathke2@unl.edu

Hualapai Nation, 2005

EXAMPLE #3 TABLE TOP EXERCISE

Goals

- Test their drought plan
- Identify lessons learned for future drought management efforts

Participants

- Approximately 12 from tribal and federal agencies

Facilitators & Developers

- NDMC

Characteristics

- Roundtable discussion with tribal representatives on the development and implementation of the drought plan

Outcomes

- Educated new tribal representatives on their role and responsibilities before and during times of drought
- Yielded information on barriers that need to be addressed to fully implement the plan
- Provided suggestions to help the Hualapai Tribe improve their drought plan

For more information: https://hazards.colorado.edu/uploads/basicpage/qr183.pdf or contact Cody Knutson (NDMC) at cknutson1@unl.edu

North Carolina, 2008

EXAMPLE #4 TABLE TOP EXERCISE

Purpose

- Facilitate interagency dialogue on means to address the 2007-2008 drought

Participants

- Approximately 80 from multiple state agencies

Facilitators & Developers

- URS Corporation

Characteristics

- Three 45 minutes rounds
    - Events, Reaction, Response & Recovery
- Utilized a Drought Response Toolbox to help with decision-making during the exercise
- Included catastrophic drought, water main breaks, and vandals opening flood gates at a dam

Outcomes

- Identified strengths and weakness in the planning process
- Provided face-to-face interaction for those in the planning process
- Generated ideas for drills, exercise, and improvements

For more information: See report at
https://awwa.onlinelibrary.wiley.com/doi/10.1002/j.1551-8833.2008.tb09697.x

Colorado Drought Tournament, 2012

EXAMPLE #5 GAME

Goals

- Create a fun, engaging environment to educate participants on the multi-sector implications of drought
- Provide a forum to develop contacts and useful information for future drought planning efforts
- Encourage collaboration among stakeholders

Participants

- Approximately 40 participants from multiple sectors/agencies

Facilitators & Developers

- AMEC with guidance from Agriculture and Agri-Food Canada, NDMC, Colorado Water Conservation Board, and NIDIS

Characteristics

- Included five teams of 4-5 players, 5 referees, and fans
- Consisted of 4 rounds (1 mitigation and 3 response)
- Played over the course of an entire day
- Centered on a fictitious basin (to maintain neutrality)
- Involved complex modeling of the basin characteristics
- Used drought conditions based on historical data
- Included scoring based on identification of impacts and vulnerabilities and effectiveness of management actions
- Cost ~$70,000

Outcomes

- Provided face-to-face interaction for stakeholders and officials involved in the drought planning process

For more information: https://www.drought.gov/documents/summary-report-colorado-drought-tournament-0 or contact Courtney Black (NIDIS Program Office) at Courtney.Black@noaa.gov

Lower Platte South NRD Drought Tournament, 2015

EXAMPLE #6 GAME

Goals

- Understand how stakeholders across the NRD manage drought
- Identify potential gaps in planning and response
- Inform LPSNRD's Drought Emergency Response Plan

Participants

- Approximately 32 participants representing emergency management, water suppliers, communities, irrigation and domestic well owners, and other stakeholders

Facilitators & Developers

- HDR
- JEO with guidance from NDMC

Characteristics

- Included four teams of 5 - 6 players, 2 evaluators, and 4 recorders
- Consisted of 4 rounds focused on a drought scenario and 1 round focused on improving regional drought management
- Played over the course of one half day
- Based on historical data (droughts of 2012 and early 2000s)
- Centered on actual NRD characteristics
- Included scoring
- Cost ~$10,000

Outcomes

- Provided face-to-face interaction for stakeholders and officials involved in the drought planning process
- Identified weakness in current management activities

For more information: Contact Jeffrey Henson (JEO Consulting Group), (402) 435-3080

Iowa and Texas Multi-hazard Tournaments (under development)

EXAMPLE #7 GAME

Goals

- Will include drought, flooding and water quality issues

Participants

- Unknown

Facilitators & Developers

- Local teams with guidance from USACE and NDMC

Characteristics

- Centered on actual basin characteristics
- Involve complex modeling of the basin
- Include scoring
- Cost ~$100,000 +

Outcomes

- TBD

For more information: Contact Deborah Bathke (NDMC) at dbathke2@unl.edu

Extreme Event

EXAMPLE #8 GAME

Goals

- Give participants a taste of what it takes to build community resilience in the face of disaster as players work together to make decisions and solve problems during an engaging, fast-paced disaster simulation

Participants

- Flexible, using 12-48 participants

Facilitators & Developers

- May potentially be developed by NDMC, building off an existing game for students called Water Banking

Characteristics

- Involves role playing
- Includes scoring
- Exists only for hurricanes with a river flooding event anticipated in September 2015
- Materials are free online
- Need to be adapted for drought

Outcomes

- Team building
- Critical thinking regarding issues of resiliency, community, and investment of resources

For more information: See website at https://labx.org/games/extreme-event or contact Deborah Bathke (NDMC) at dbathke2@unl.edu to explore adapting for drought.

Interstate Commission on the Potomac River Basin, (annually since 1981)

EXAMPLE #9
OPERATIONS
SIMULATION

Goals

- Allow participants to practice and improve communication procedures among organizations
- Provide staff with an opportunity to practice using operational tools and making management decisions
- Explore the effects of different management strategies

Participants

- Staff, USACE, surrounding water suppliers and government officials

Facilitators & Developers

- Interstate Commission on the Potomac River Basin

Characteristics

- Focus and length varies each year
- Example: 2012
  - Took place over 1 week
  - Included a conference call of the regional Drought Coordination Technical Committee to discuss water use restrictions; use of a flow prediction tool to determine release need; communications regarding simulated withdrawals, discharges, and storage; etc.

Outcomes

- Identification of strengths and weaknesses
- Education
- Team building

For more information:
http://www.potomacriver.org/focus-areas/water-resources-and-drinking-water/cooperative-water-supply-operations-on-the-potomac/drought-monitoring-and-operations/drought-exercises/

For questions or more information please contact:

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The Drought Tournament

What is it?

Why Is It Useful?

How Could it Help the Alberta Water Council?

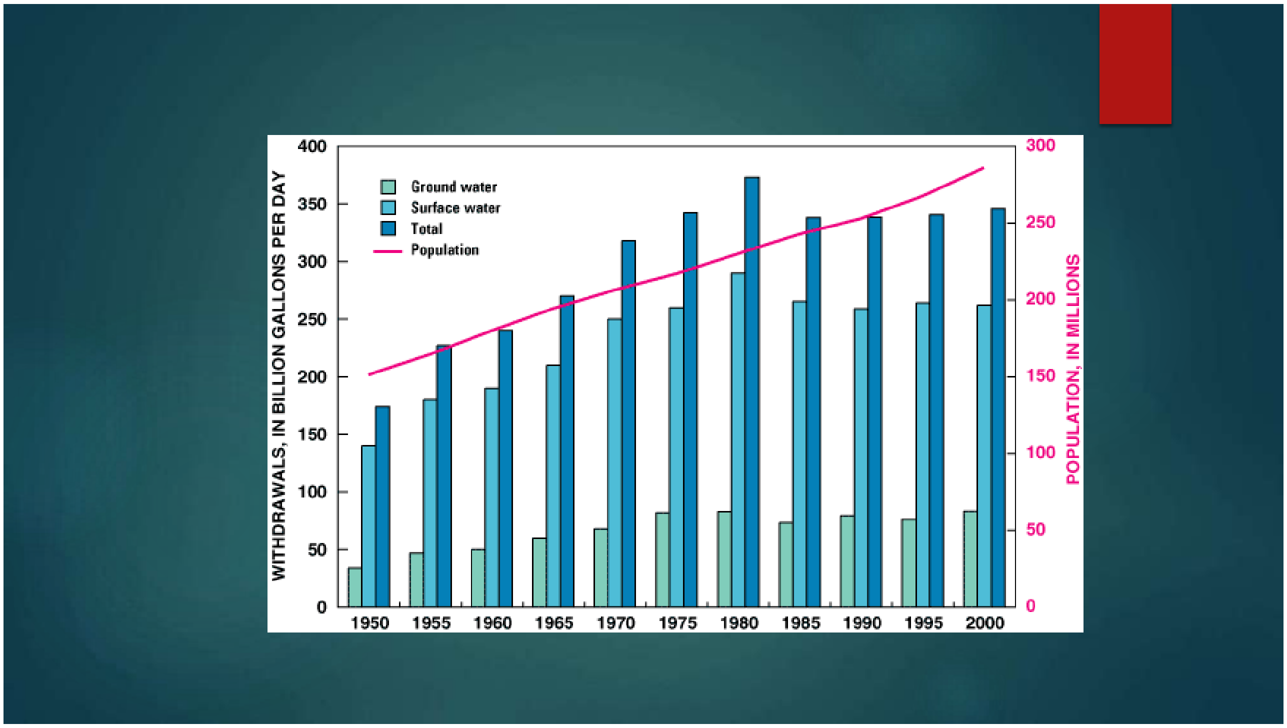
PRESENTATION TO THE

ALBERTA WATER COUNCIL

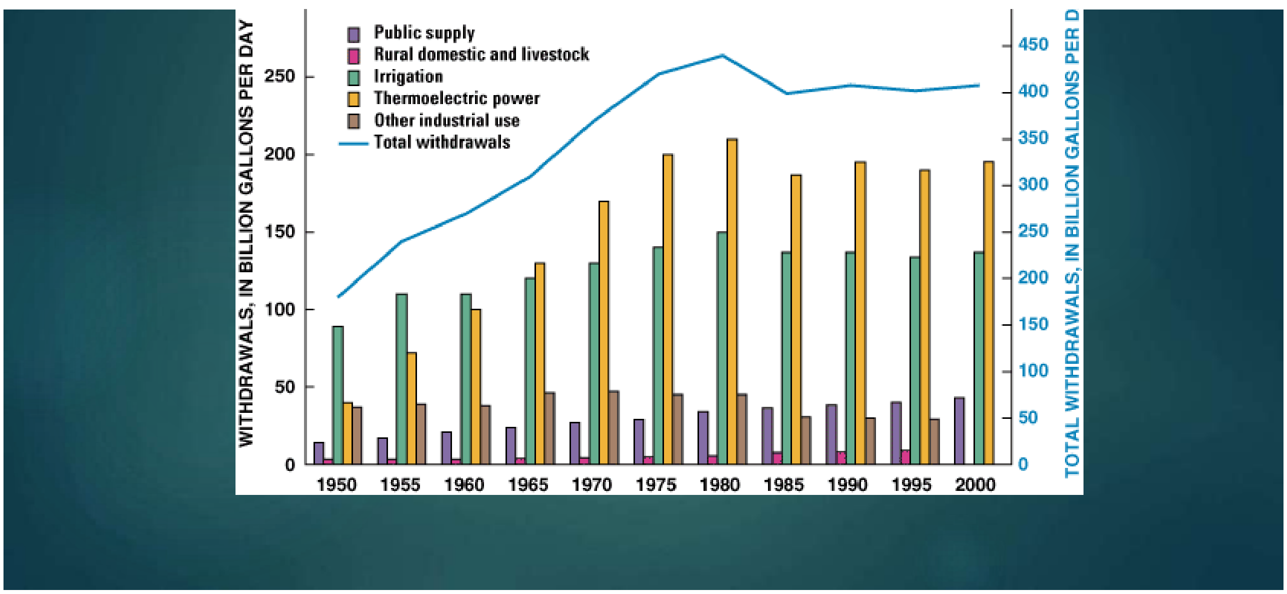
HARVEY HILL, PH.D.

SEPTEMBER 15TH, 2020

Lake Mead, October, 2004



Ground water
Surface water
Total
Population
WITHDRAWALS, IN BILLION GALLONS PER DAY
POPULATION, IN MILLIONS
0
50
100
150
200
250
300
350
400
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000



Public supply
Rural domestic and livestock
Irrigation
Thermoelectric power
Other industrial use
Total withdrawals
WITHDRAWALS, IN BILLION GALLONS PER DAY
TOTAL WITHDRAWALS, IN BILLION GALLONS PER D
0
50
100
150
200
250
300
350
400
450
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000

What is The Drought Tournament?

5

- *Is a game based decision framework that helps institutions and stakeholders:*
  - *Better understand, and*
  - *Consider ways to reduce their vulnerability to drought;*

The Drought Tournament can be applied to one, or multiple risks:

6

Where risk is defined as:

Risk = Vulnerability/Exposure x Hazard

and the following criteria exist:

- *There are competing interests;*
- *The risk(s) can't be easily removed due to constraints; and*
- *But there are ways to reduce or mitigate the risk.*

Invitational Drought Tournament (IDT)

7

- Depending on the level of complexity it can be a *Discussion or Discussion/Decision*-support tool to:
  - Help institutions increase drought preparedness under current and future conditions.
  - Identify gaps and vulnerabilities in drought preparedness
  - Provides a forum for multi-disciplinary stakeholders to discuss climate preparedness and adaptation.

Why Is It Useful?

8

- *It can help in a number of ways:*
  - ***Training;***
  - ***Policy Development;***
  - ***Testing of Drought Plans;***
  - ***Development and comparison risk management strategies and actions for decision-making.***

What Happens in A Tournament/Game to Help Reduce Drought Risk?

9

- *Diverse teams of stakeholders discuss and make drought risk management and adaptation decisions*
- *Compare their decisions with other teams to assess alternative approaches,*
- *Help participants understand their current resilience in terms of risk management and adaptation, and*
- *Factors to consider to increase their resilience.*

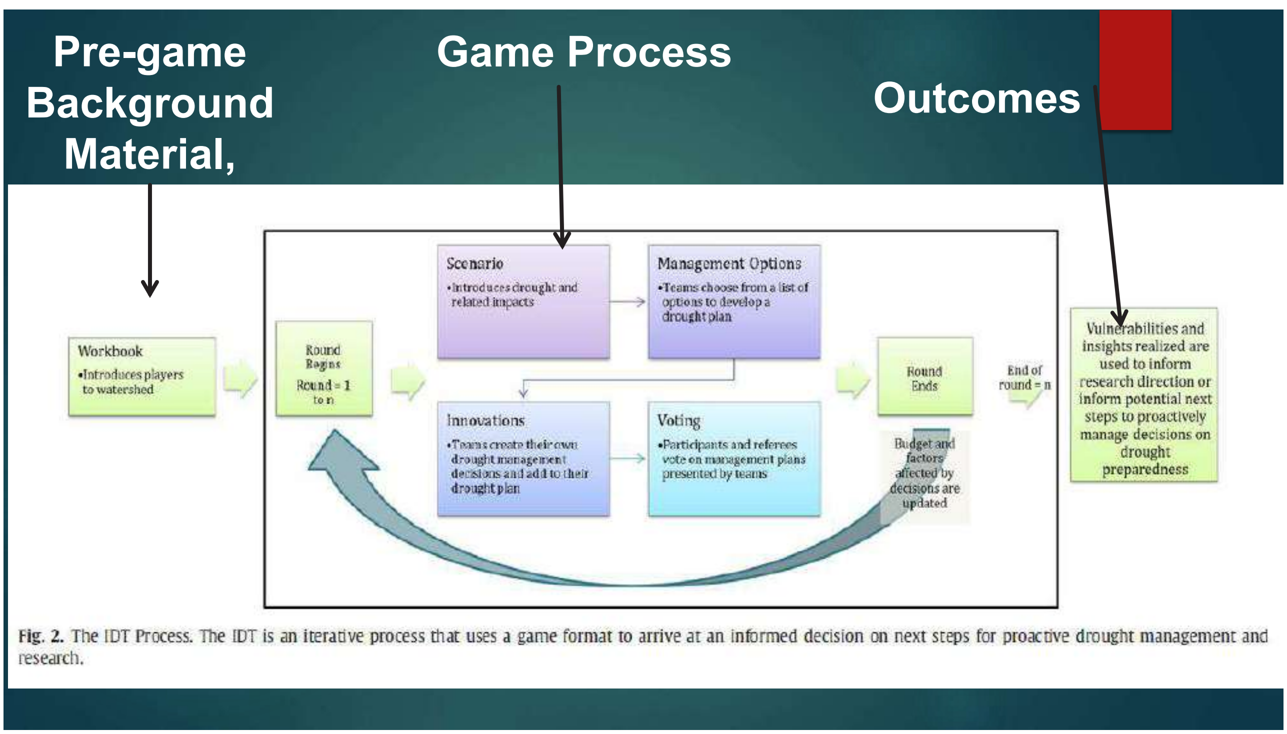


Fig. 2. The IDT Process. The IDT is an iterative process that uses a game format to arrive at an informed decision on next steps for proactive drought management and research.

Tournament Phases

Scoping Phase

- USACE District Champion Identification,
- Stakeholder Identification,
- Problem and Objectives definition
- Resource Identification

Technical Development and Logistics,

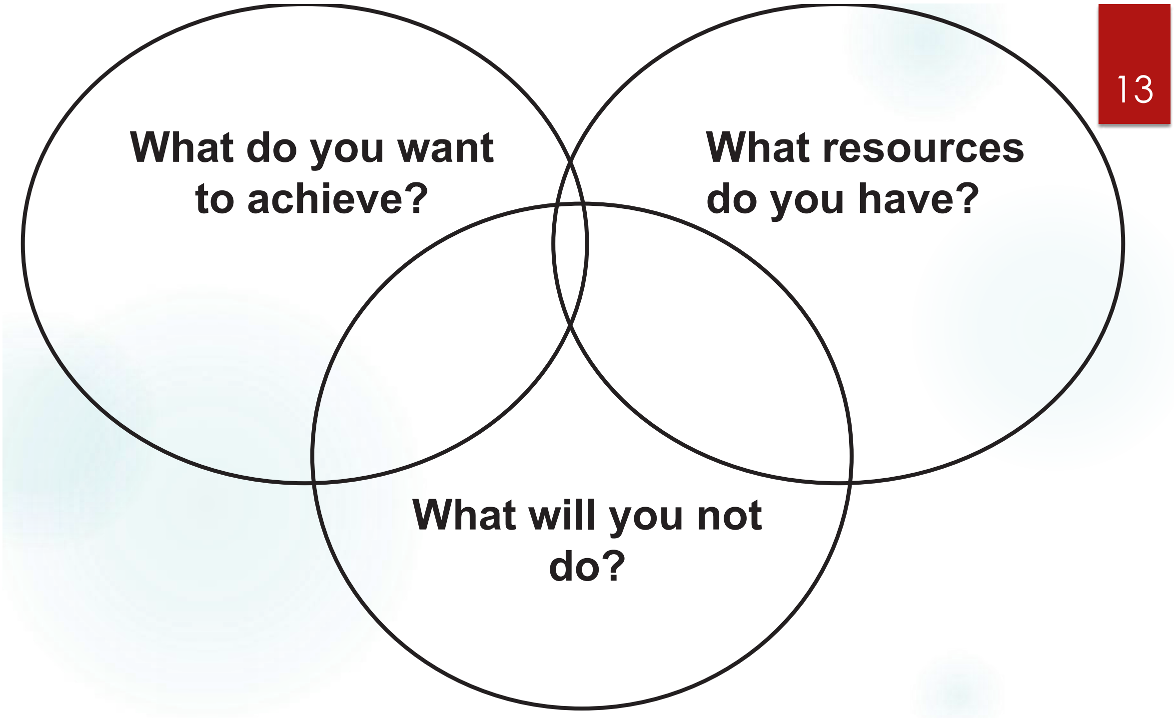
- Scenario development,
- Describe the impact of the hazard,
- Definition of the types of adaptation options,
- Identify the effects, tradeoffs and synergies of alternation adaptation choices by eliciting expert opinion or modeling,
- Develop the decision support tool,
- Create workbook
- Complete the logistics (Invitations, recruit referees, etc.)
- Design of agenda

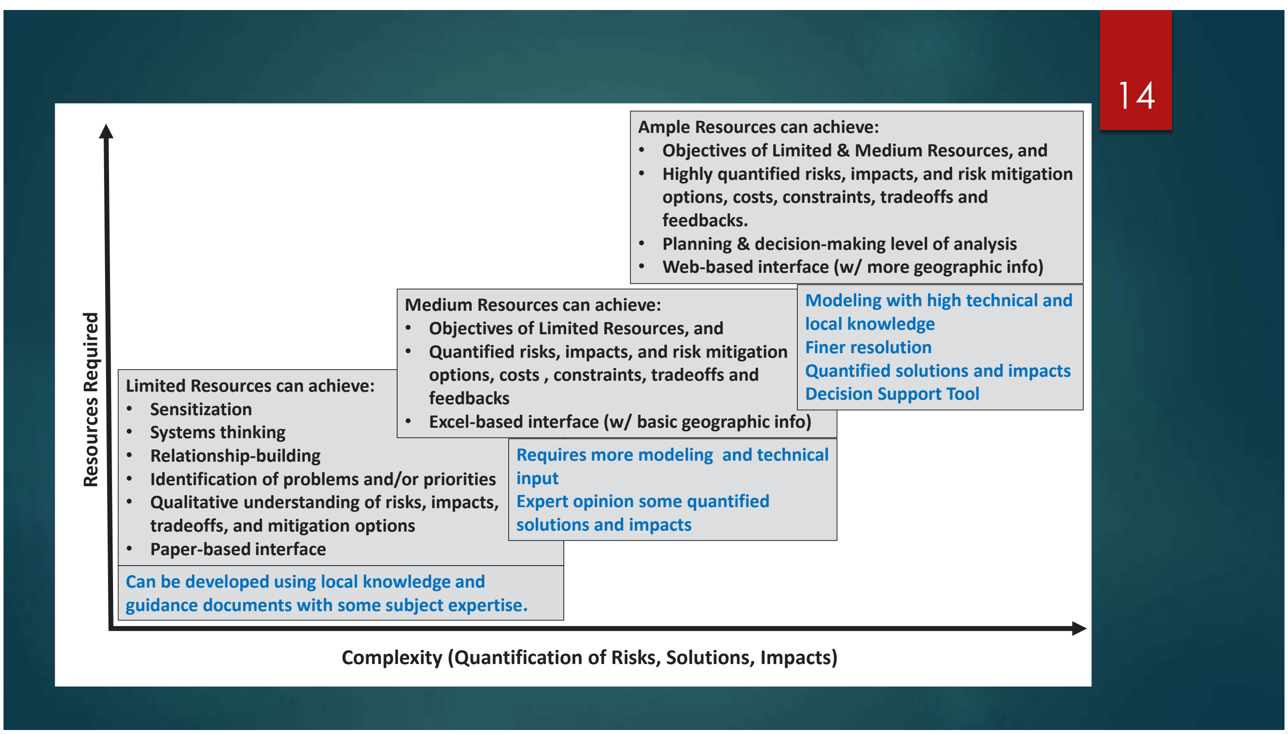
Testing and Implementation

- Dress rehearsal,
- Actual tournament,
- Post tournament evaluation

Documentation

- Post tournament reports,
- Articles


13
What do you want to achieve?
What resources do you have?
What will you not do?


14
Ample Resources can achieve:
• Objectives of Limited & Medium Resources, and
• Highly quantified risks, impacts, and risk mitigation options, costs, constraints, tradeoffs and feedbacks.
• Planning & decision-making level of analysis
• Web-based interface (w/ more geographic info)
Modeling with high technical and local knowledge
Finer resolution
Quantified solutions and impacts
Decision Support Tool
Medium Resources can achieve:
• Objectives of Limited Resources, and
• Quantified risks, impacts, and risk mitigation options, costs , constraints, tradeoffs and feedbacks
• Excel-based interface (w/ basic geographic info)
Requires more modeling and technical input
Expert opinion some quantified solutions and impacts
Limited Resources can achieve:
• Sensitization
• Systems thinking
• Relationship-building
• Identification of problems and/or priorities
• Qualitative understanding of risks, impacts, tradeoffs, and mitigation options
• Paper-based interface
Can be developed using local knowledge and guidance documents with some subject expertise.
Resources Required
Complexity (Quantification of Risks, Solutions, Impacts)

First Phase of The Invitational Drought Tournament

- Explored how the methodology could facilitate knowledge exchange and consensus building
- Multi-disciplinary teams worked through drought scenarios in a fictitious watershed to collaboratively develop drought management plans.
- Plans were scored by referees and team players.

Participants

- Prairie Provinces Water Board
- Regional District of North Okanagan
- Government of Alberta
- Manitoba Water Stewardship
- Canada West Foundation
- Meewasin Valley Authority
- Alberta Department of Agriculture
- Alberta Innovates
- BC Ministry of Natural Resource Operations
- University of Calgary
- Nature Conservancy Canada
- Saskatoon Environmental Association
- Natural Resources Canada
- Agriculture and Agri-Food Canada
- Red River College
- Canadian Association of Petroleum Producers
- Canadian Cattlemen's Association
- Bow River Irrigation District
- Saskatchewan Irrigation Projects Association
- Cenovus - Canadian Association of Petroleum Producers
- AECOM
- Red River Basin Commission
- Soil Conservation Council of Canada
- Canadian Water Resources Association
- Drought Research Initiative
- Environment Canada
- City of Calgary
- University of Regina
- National Drought Mitigation Centre, USA
- R Halliday and Associates
- Hursh Consulting and Communications

16

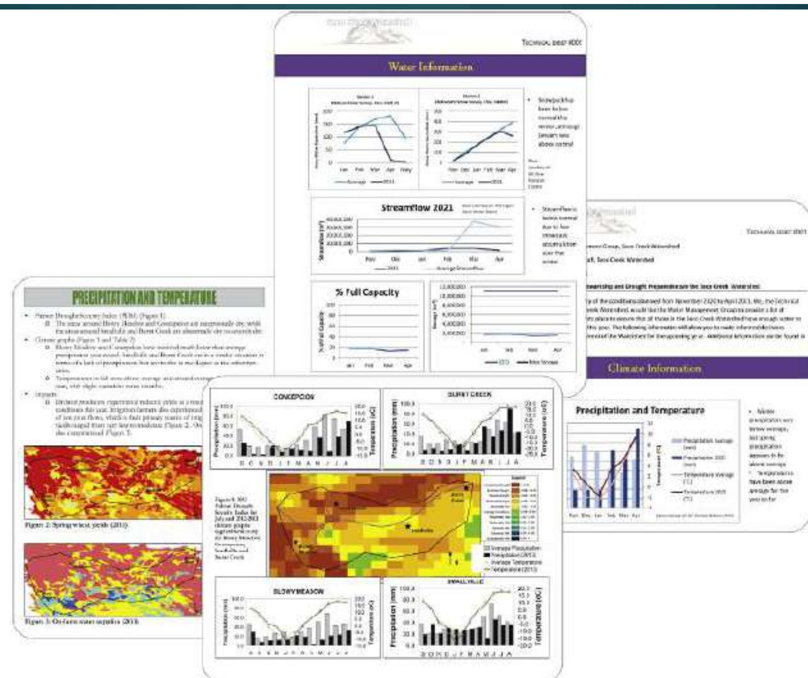


Fig. 4. Sample scenarios from two Invitational Drought Tournaments watersheds (the Oxbow basin [bottom] and Seco Creek [top]).

Lessons Learned

1. Combining representatives from different sectors enhanced understanding of the issues related to drought management.
2. Diverse social, physical, policy and general stakeholders could collaborate on drought issues.
3. The level of information provided allowed for learning about drought risk management qualitatively,

Phase 2: Increased Complexity

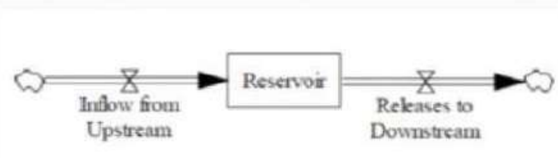
19

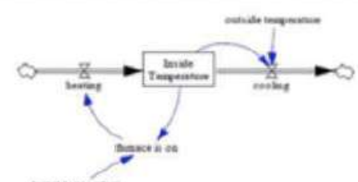
- Explored how the methodology could help stakeholders reduce drought risk with more detailed scenarios and decision options,
- First attempt to integrate a decision support tool (Dr. Evan Davies and his student, Dr. Kai Wang (https://www.youtube.com/watch?v=JJUvkFGzRc4)

The IDT model – Version 1

20

- Dynamic simulation model
  - Show effectiveness of each policy in reducing drought risk
- Methodology: System Dynamics (SD)
  - Uses nonlinear feedbacks, stocks and flows, and delays to describe the real-world structure.





- Developed and runs in Vensim (Ventana Systems)

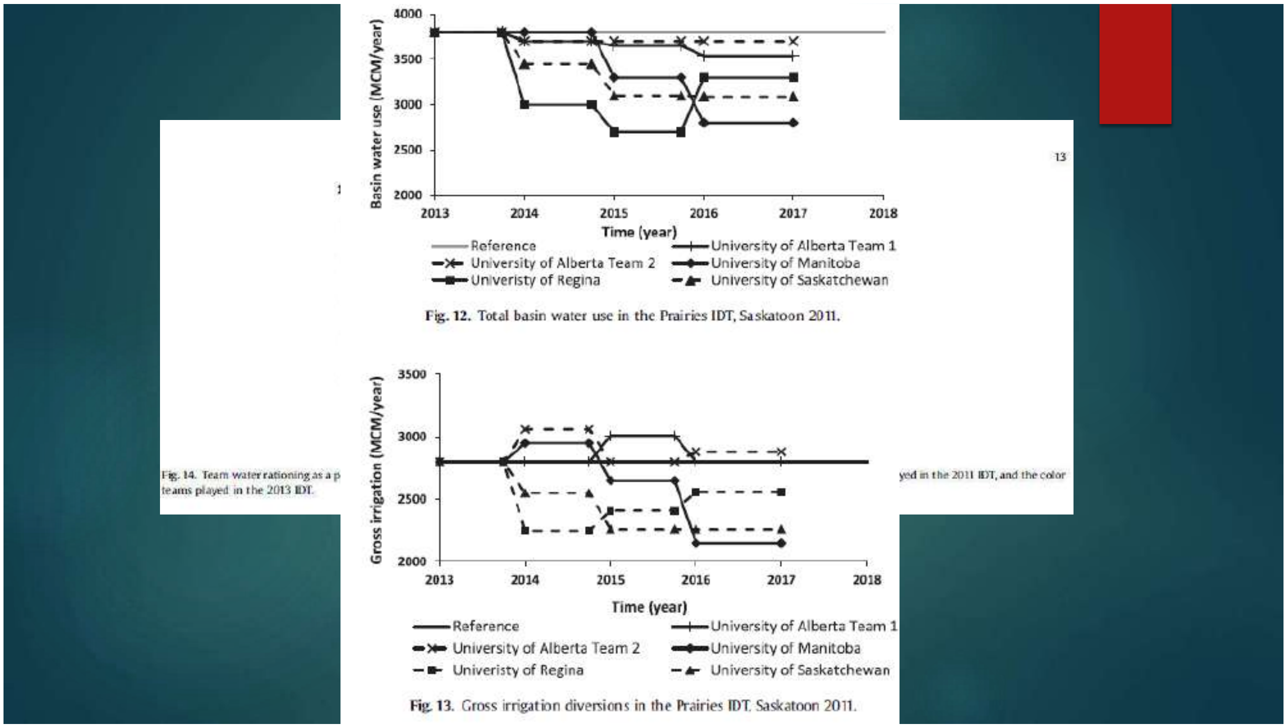


Fig. 12. Total basin water use in the Prairies IDT, Saskatoon 2011.

Fig. 13. Gross irrigation diversions in the Prairies IDT, Saskatoon 2011.

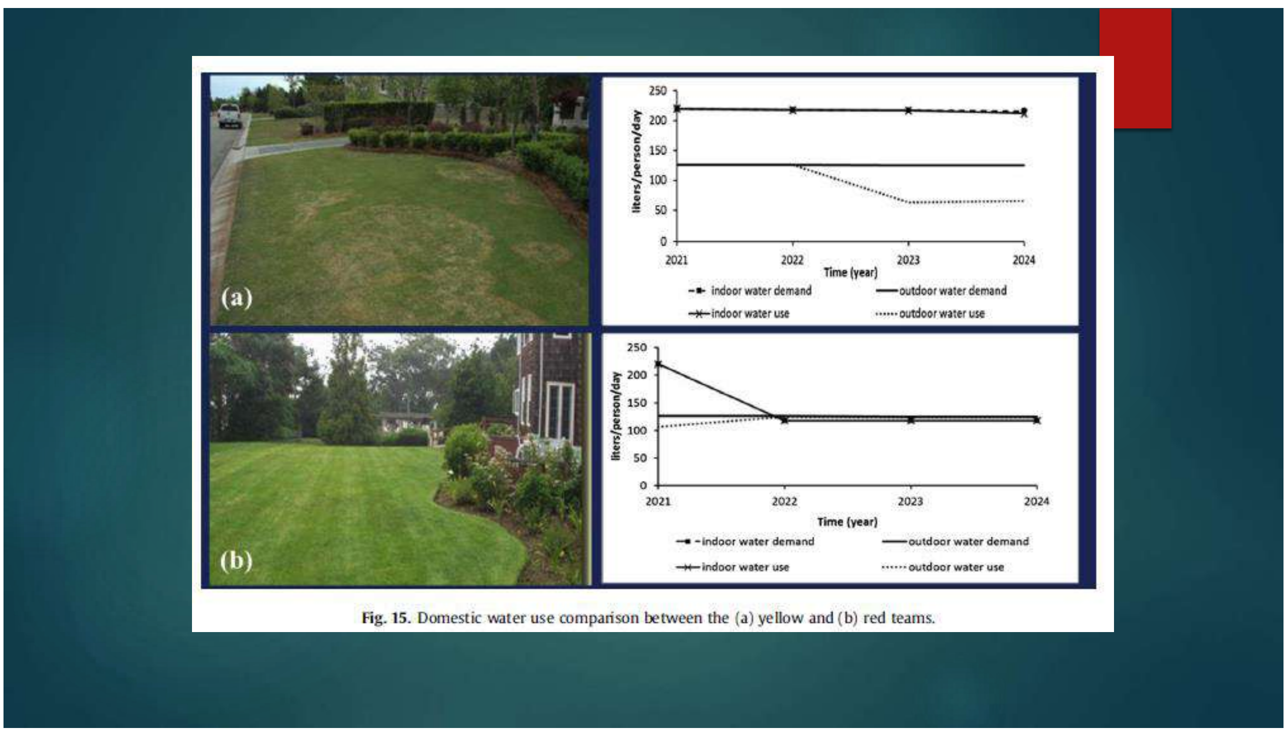


Fig. 15. Domestic water use comparison between the (a) yellow and (b) red teams.

Lessons Learned From Phase 2

23

- Four phases to a tournament,
- Dynamic Systems models appear to hold promise,
- Credible scoring metrics & decision options take time and thought,
- Geographic Information system useful as are charts & tables.
- Visual aids possibly (photographs & video).
- Background information is useful but there is a tradeoff between developing and relevance.
- Careful agenda planning necessary for productive team interaction,
- Strong support team, pre-event testing, & facilitation required

Summary Report:
Colorado Drought Tournament
September 18, 2012

November 2012

Sponsors:

Colorado Water Conservation Board

National Integrated Drought Information System

Contributors:

National Drought Mitigation Center

Agriculture and Agri-Food Canada Science and Technology Branch

Tournament Designers:
AMEC Environment and Infrastructure
1002 Walnut St Suite 200
Boulder, CO 80032
303-443-7839

https://www.drought.gov/documents/summary-report-colorado-drought-tournament-0

Summary Report:
Oklahoma Water Supply Reliability and Management Challenge
September 17, 2014

October 14, 2014

http://www.owrb.ok.gov/drought/docs/OKDroughtChallengeReportOct2014.pdf

Sponsors:

Bureau of Reclamation

Oklahoma Water Resources Bo

A Medium Level of Complexity

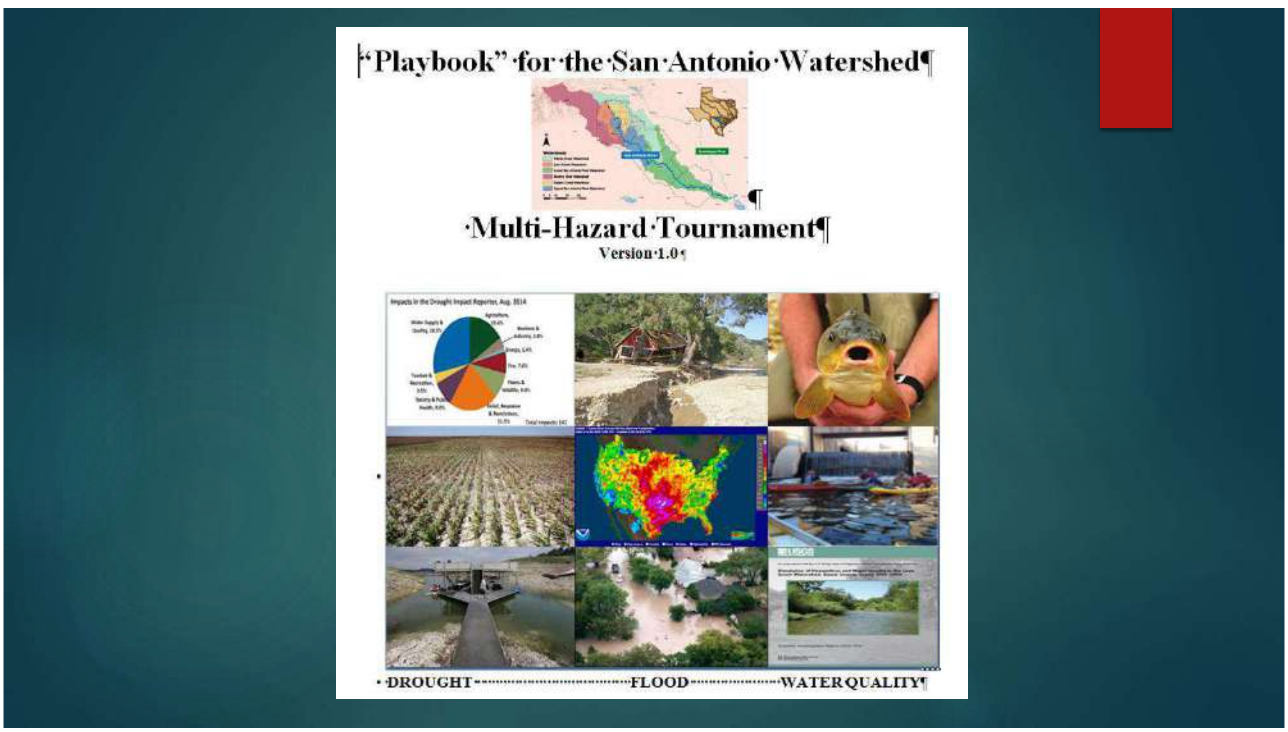
26

- **Can help decision-makers better understand options and actual tradeoffs,**
- **Better understand the impact of decisions made in one year on the next year's water supply and other factors.**
- **This level of investment will not have the quantitative rigor of the most complex events but does not cost as much in time and money.**

Phase 3, Multi-Hazard, Greater Realism, More complex Modeling, Greater Integration

27

- While at the US Army Corps of Engineers' institute for Water Resources my colleagues and I developed a multi-hazard tournament version,
- Because of the nature of the work done by the Corps the work focused on real world problems.



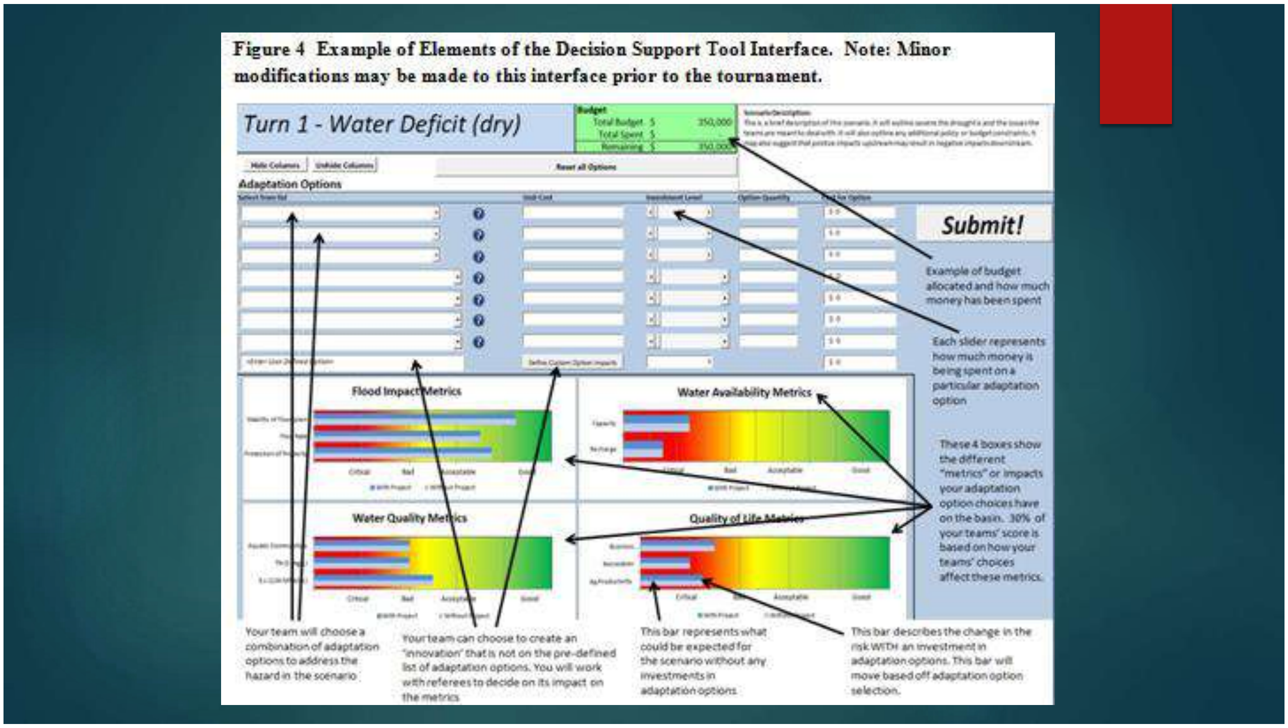
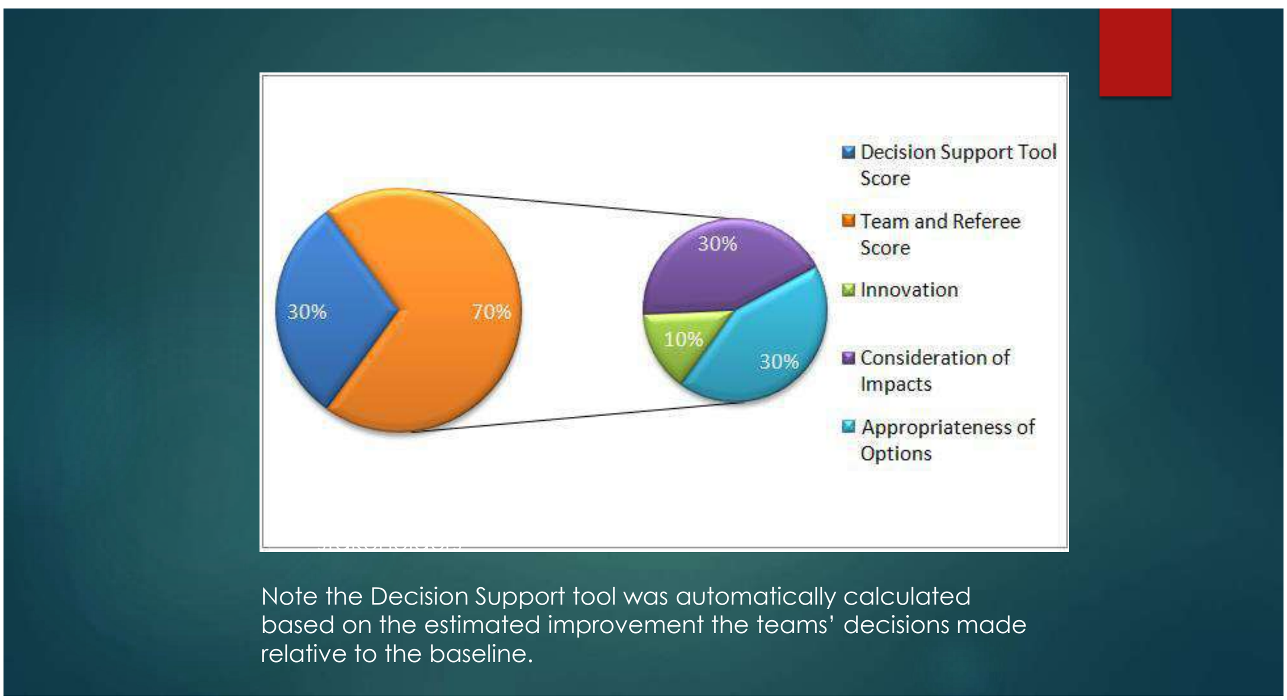


Figure 4 Example of Elements of the Decision Support Tool Interface. Note: Minor modifications may be made to this interface prior to the tournament.
Turn 1 - Water Deficit (dry)
Budget
Total Budget $ 350,000
Total Spent $
Remaining $ 350,000
Reset all Options
Adaptation Options
Submit!
Example of budget allocated and how much money has been spent
Each slider represents how much money is being spent on a particular adaptation option
Flood Impact Metrics
Water Availability Metrics
Water Quality Metrics
Quality of Life Metrics
Critical
Bad
Acceptable
Good
These 4 boxes show the different "metrics" or impacts your adaptation option choices have on the basin. 30% of your teams' score is based on how your teams' choices affect these metrics.
Your team will choose a combination of adaptation options to address the hazard in the scenario
Your team can choose to create an "innovation" that is not on the pre-defined list of adaptation options. You will work with referees to decide on its impact on the metrics
This bar represents what could be expected for the scenario without any investments in adaptation options
This bar describes the change in the risk WITH an investment in adaptation options. This bar will move based off adaptation option selection.


Decision Support Tool Score
Team and Referee Score
Innovation
Consideration of Impacts
Appropriateness of Options
30%
70%
30%
10%
30%
Note the Decision Support tool was automatically calculated based on the estimated improvement the teams' decisions made relative to the baseline.

Outcomes of complex events included:

31

- Participant's learned how to use the San Antonio River Authorities' drought/excess water master plans.
- Cedar Rapids, Iowa compared land subsidies to water treatment equipment costs under drought and flood scenarios.
- The City of Hampton, Virginia decided to move a neighborhood out of a flood plain.

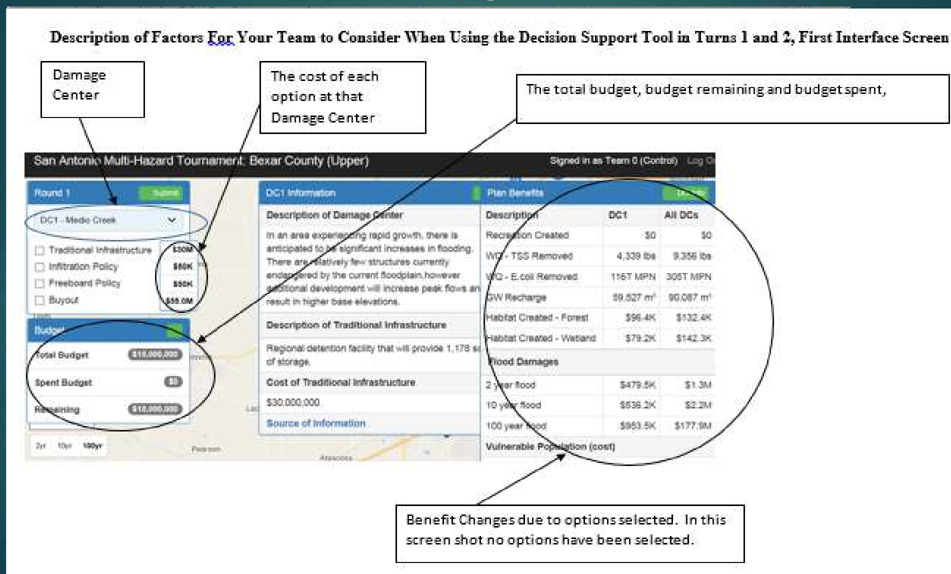
The Most Complex Tournaments

32

- Consider real world problems,
- Are more rigorously modelled,
- Support more quantifiably rigorous decisions.

Most Complex Provides The Most Information For Decision-Making

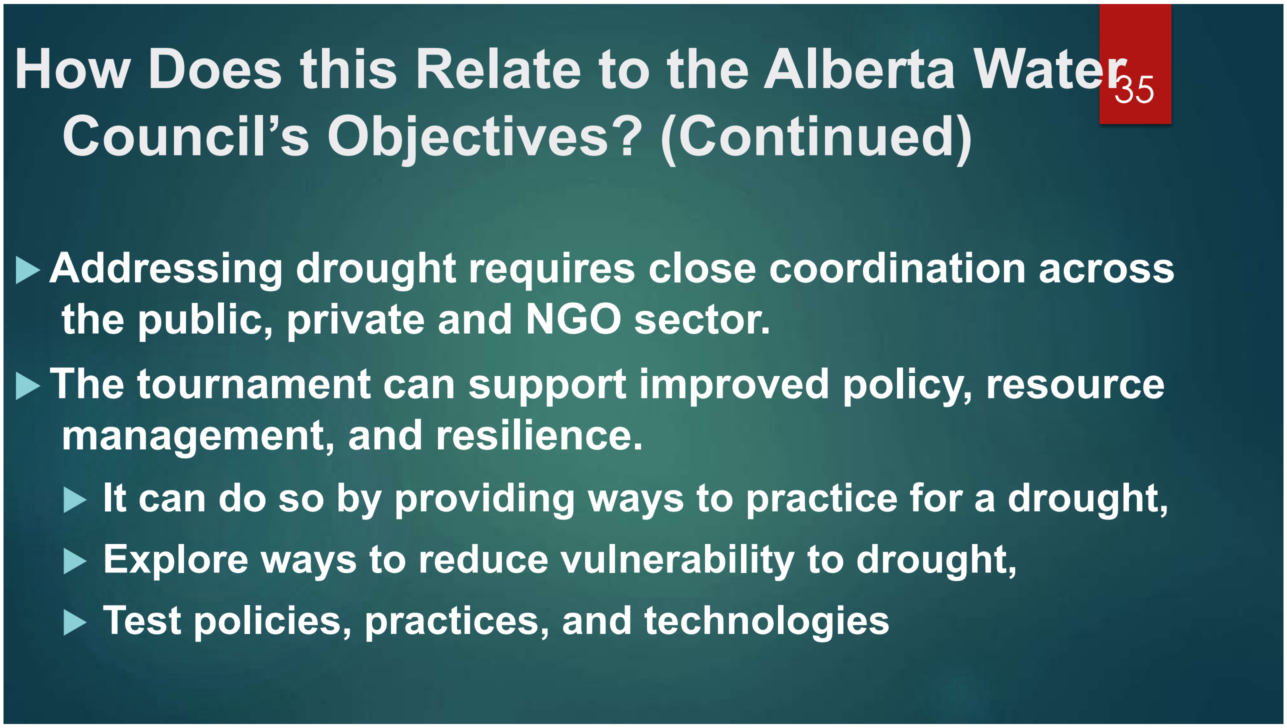
33



How Does this Relate to the Alberta Water Council's Objectives?

34

- You face increasing competition for water,
- Drought exacerbates that reality,
- Alberta has already experienced droughts that have been some of the worst in the last 800 years.


How Does this Relate to the Alberta Water Council's Objectives? (Continued)
35
Addressing drought requires close coordination across the public, private and NGO sector.
The tournament can support improved policy, resource management, and resilience.
It can do so by providing ways to practice for a drought,
Explore ways to reduce vulnerability to drought,
Test policies, practices, and technologies


36
Questions?
Observations?

APPENDIX D

Drought Simulation Literature Review

waterSMART
Water Management Solutions

Alberta Water Council

Drought Simulation Literature Review

Submitted by:
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kim.sturgess@watersmartsolutions.ca

Submitted to:
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Project Manager
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Submitted on:
March 12, 2021

Classification: Protected A

Executive Summary

The Alberta Water Council (AWC) launched a project to improve community resiliency and stakeholder understanding of multi-year drought in Alberta. One aspect of this project is the development of a drought simulation exercise to assist stakeholders understanding and planning for drought preparation and response in Alberta. The AWC engaged WaterSMART Solutions Ltd. (WaterSMART) to conduct a literature review as the first step towards development of the simulation exercise. The literature review is comprised of three tasks:

1. A drought management review to understand the regulatory framework, historical drought response and drought management approach within Alberta and external jurisdictions of interest.
2. A review of drought simulation exercises conducted in other jurisdictions to identify and assess exercise types, goals and outcomes.
3. A review of interactive decision support tools that can be used to potentially support the AWC simulation exercise.

In addition to Alberta drought management, approaches were reviewed in Saskatchewan, California and South Carolina. All four jurisdictions use some form of permitting system which gives priority to specific users during water shortage periods. However, in the United States jurisdictions, the permits were found to be less prescriptive and were not necessarily required for smaller water users. By contrast, the regulatory system in Alberta is highly structured and the licencing framework in place provides some degree of drought management. To overcome regulatory challenges, California and South Carolina engage stakeholders in the development of highly detailed drought plans. There is an opportunity for Alberta to benefit from stakeholder engagement in the development of local and provincial drought plans as they create buy-in from all groups and stakeholders through understanding their roles and responsibilities.

Five drought simulation exercises were reviewed that took place in Alberta, South Carolina, Saskatchewan, Colorado and Chesapeake Bay. Some exercises like the Saskatchewan Invitational Drought Tournament used competitive games to engage participants while others such as the South Carolina Tabletop exercise used fixed paper-based scenarios. Common outcomes across all exercises included increased awareness of drought risks and stakeholder roles in drought response.

Eleven tools were reviewed, ranging from game-style educational tools to highly complex drought planning tools. It is recommended that when choosing a supporting tool, the AWC first clearly define the desired outcomes of the simulation exercises and focus on tools which will best support the selected exercise style. When considering tools for the AWC Drought Simulation exercise, it is recommended that a stepwise process is implemented in which the desired exercise outcomes are identified, that the exercise type and style is selected based upon the desired outcomes and finally, that the tool is selected by considering how it can support the desired outcomes and how it fits within the boundary conditions of the project. This approach is more likely to lead to beneficial outcomes of the AWC Drought Simulation exercise that will effectively support improvements to drought resiliency and response in Alberta.

Contents

1.0 Introduction

Drought management sits at the complicated interface of policy, society, technology, and the physical world. The management of drought involves complex monitoring, collaboration across diverse entities, communal decision making and coordinated communication.

It is difficult to prepare for the complexity of the required management efforts and collaboration needed before a drought takes place. Drought is a natural phenomenon that can have very serious negative impacts. However droughts occur over a long period of time, making it easy for planning to be postponed. One way to overcome this barrier is to engage the diverse actors and decision makers in drought management in thinking about and planning for drought through simulation exercises.

Drought simulation exercises can also support adaptive planning because successive droughts are rarely the same in terms of length, regionality, severity, and impacts. Being able to test multiple drought scenarios through a simulation is advantageous.

The Alberta Water Council (AWC) launched a project to improve community resiliency and stakeholder understanding of multi-year drought in Alberta. The effort is multi-pronged and includes developing and conducting a drought simulation exercise to improve drought resiliency.

This report compiles the results of a literature review and analysis that was conducted to support the drought resilience work of the AWC. The report is split into two separate sections, each with a different focus. This first section provides the results from examining drought management systems in the jurisdictions of interest. The second area (Section 4) examines relevant tools and case study examples of drought simulation exercises.

1.1 Project background and approach

The intent of this literature review is to compile information that will support the AWC Drought Simulation Project Team's decisions by defining the key outcomes, the geographic scope, and the ideal tools for the simulation exercise. The AWC Drought Simulation Project Team will decide to move forward in developing and executing an appropriate drought simulation exercise following the conclusion of this literature review.

The literature review was completed by WaterSMART using the following process:

1. Confirmed the expectations and requirements, including selection of jurisdictions of interest and preferred characteristics for the tools and case studies. A shortlist of tools and case studies was identified and provided to the AWC Project Team.
2. Completed the research and review.
3. Submitted three tables with compiled literature review results. The tables detail drought planning and management in three jurisdictions of interest, five relevant case studies, and eleven tools that

could potentially be used for drought simulation.

4. Presented the results to the AWC through a workshop style meeting.
5. Compiled the final report (this document) and submitted it to the AWC Project Team.

1.2 Definitions

For this analysis and through this report, the following words and definitions are used.

Drought: Natural occurrences resulting from a lack of precipitation over a prolonged period of time, as well as depletion of natural water sources, human-made storage, and soil moisture. Includes agricultural, hydrological, meteorological, and socio-economic droughts.

Drought Exercise: An exercise undertaken individually or as part of a group to educate, validate, or drive a decision-making process for some aspect of drought management.

Game: A tool that encourages users to meet a goal or objective by manipulating certain elements or components of a simulation. Games typically involve cooperation and/or competition, as well as a challenge, rules and scoring.

General public: Refers to people with no technical background in watershed management and who are not members of a broader group or organization connected to watershed management or operations.

Scenario: A plausible story that describes an event or situation. In this case, a drought scenario provides the description, details and context of a plausible drought.

Simulation: An imitation of a system, event, or process.

Stakeholder: A person who is a member of a broader group or organization connected to drought management, water management operations, or who makes decisions that affect other water users in the event of a drought.

Tool: A virtual or paper-based instrument or device that can be used to support a drought exercise.

1.3 Assumptions

This literature review focuses on tools, case studies, and governance models for drought management. Although there are numerous 'how to' documents for planning and running drought simulation exercises, these have not been specifically reviewed for this work. The AWC has already reviewed many of the most relevant 'how to' documents and provided them to WaterSMART; where appropriate, WaterSMART has referenced those documents in this report.

It is assumed that this report will support the AWC Drought Simulation Project Team's decisions. The report does not provide a recommendation regarding which simulation tool to use or how to conduct a drought simulation exercise.

The WaterSMART research team understands that a game-style simulation exercise is of most interest to the AWC Project Team. Therefore, the case study literature and tools selected for review are games or adaptable to game-style exercises. In addition, it is understood that the AWC Project Team expects drought exercise participants to include both stakeholders and the general public. Therefore, the tools selected for review represent a range of technicality and complexity.

Jurisdictions of interest were selected and confirmed by the AWC Project Team to be Alberta, Saskatchewan, South Carolina, and California. These informed, but did not limit, the selection of case studies and tools for review.

2.0 Drought Management Review

The purpose of this section is to compile information from each jurisdiction on drought management regulations and regulatory systems, existing resources and plans, identified roles and responsibilities, and metrics and indicators. Where available, information on historical drought response is reviewed and included. The jurisdictions of interest for this study are Alberta, Saskatchewan, South Carolina, and California.

2.1 Drought management - Alberta

2.1.1 Drought planning and existing resources

Alberta Agriculture and Forestry (AAF) created a drought management framework titled "*Alberta's Agriculture Drought and Excess Moisture Risk Management Plan*" (ADEMRMP). The document was first published in 2001, superseded in 2010, and then published once again in 2016. This document provides a framework for a coordinated, proactive approach to reduce the short and long-term effects of drought and excess moisture on Alberta farmers and ranchers. It is also a guide for government agencies in assisting producers to more effectively reduce the impacts before, during, and after an adverse event, and will help the agriculture industry be more prepared. The framework is broken down into three sections: preparedness, monitoring, and reporting and response.

Key metrics used in AAF's framework to monitor drought include:

- Soil moisture monitoring program
- Precipitation monitoring
- Snowfall accumulations
- Temperature and humidity monitoring
- Release rates from reservoirs and stream flows
- Wildfire risk
- Grasshopper levels
- Duration of drought (relative to historical conditions)

Additionally, Alberta Environment and Parks (AEP) created a response procedures manual in 2009 for managing water shortage conditions in the South Saskatchewan River Basin (SSRB) (Alberta Environment, 2009). The procedure details AEP's responsibilities with respect to the *Water Act* and is set out in four stages. Each stage is dependent on the severity of the water shortage.

AEP defines water shortage as a period of time when it is appropriate for the department to be comprehensive and responsible in administering priorities for water licences and registrations to protect the aquatic environment and integrity of the water management system.

In the SSRB, four response stages are noted depending on severity:

- **Stage 1** – Normal operations: monitoring for water shortage potential in water management areas and preparing for water shortages.
- **Stage 2** – Priority call assessment and administration of priority.
- **Stage 3** – Large scale water shortage with risk to the majority of household users / licensees / traditional agricultural users across multiple water management areas of the SSRB or the entire SSRB.
- **Stage 4** – Due to unforeseen circumstances that could not be mitigated, the Lieutenant Governor in council may consider a declaration of an emergency under the *Water Act*.

Note: AEP has developed a more recent version of this document that includes procedures for the Milk River Basin; however it is not yet available for public release.

2.1.2 Regulatory system specific to drought management

The *Water Act (1999)*, and associated regulations made under it, is the overarching legislation governing water in Alberta. The *Water Act* supports and promotes the conservation and management of water through the use and allocation of water in Alberta (*Water Act,* 1999). It requires the establishment of a water management framework and sets out requirements for the preparation of water management plans (*Water Act*, 2000). The *Water Act* is also the primary legislative mechanism for managing water withdrawals during a drought. The *Water Act* also addresses the following:

- A licence holder's right to divert water and the priority of water rights among users.
- The types of legislative instruments available for diversion and use of water and the associated processes for decision-making. This includes statutory rights to divert water without a licence for household use and traditional agriculture use.
- The range of enforcement measures available to ensure the goals of the *Water Act* are met (*Water Act*, 2000).

AEP delivers the *Water Act* mandate, manages provincially-owned reservoirs, and regulates impacts to water quality under the *Environmental Protection and Enhancement Act* (EPEA) for all water matters not associated with oil, gas, coal, and pipelines. For these energy related matters, the *Water Act* and EPEA mandate is delivered by the Alberta Energy Regulator (AER) under the *Responsible Energy Development Act* (REDA).

Under section 30 of the *Water Act*, water allocations (water licences) have a priority number based on when the application was originally submitted. This system of priority is the basis for management of water under water shortage situations. Priority numbers indicate seniority, and in times of water shortage, the most senior licence has the right to withdraw their full allocation, provided all conditions on the licences are met, including stream flow. Under this system, the more junior the licence (i.e., licences that were applied for more recently), the greater the risk of not receiving all or part of the allocated water in low flow years. However, during emergency situations, the GoA has the power to suspend a water licence and reassign the water for other uses, with compensation.

There is no legislated priority for specific water uses. However, in 2011, the 13 irrigation districts in Alberta, all licence holders that include senior licences, approved a declaration committing that in times of water shortage, the water needs of humans and livestock would be met. This is a commitment by those with senior licences and with the greatest allocated water volume (in the southern half of the province) to ensure essential human and livestock water needs are met, even if they are junior licences, in times of water shortage.

The Province of Alberta has a strong regulatory framework for water management that includes dynamic management and operations aimed at adapting to constantly changing water availability. The tools made available by the *Water Act* include assignments, temporary transfers, and transfers, as well as normal operating agreements made during the weekly meetings of large water-volume licence holders during irrigation season. There are priorities and adjustments to priorities that have been made within this framework at a basin-wide scale.

Section 33 of the *Water Act,* "Agreements to assign water", includes the formal process for sharing water which can be undertaken as a way to manage impacts from a water shortage or drought. It allows water sharing between higher and lower priority licensees, and the formal agreement and oversight by the AEP supports water users abiding by the terms of their agreements.

Another significant piece of water-related legislation is the *Approved Water Management Plan for the South Saskatchewan River Basin (2006)*, which is designed to guide water management decisions and protect both the aquatic environment and water allocation licensees. The *Approved Water Management Plan for the SSRB* was approved by Lieutenant Governor in Council in 2006. It makes various recommendations, including to close the Bow, Oldman, and South Saskatchewan River sub-basins to new applications for water licences and to designate Water Conservation Objectives (WCOs) on the mainstem rivers and their tributaries. *The Bow, Oldman and South Saskatchewan River Water Allocation Order* was subsequently issued in 2007 as a regulation under the *Water Act.* The order formally implements the recommendation of the *Approved Water Management Plan for the South Saskatchewan River Basin* to close specific sub-basins. Since the *Order* was issued, all unallocated surface water in the Bow, Oldman, and South Saskatchewan River sub-basins has been reserved; however, the Director may allocate reserved water for limited and specific licences for each basin. Please see the *Order* for details on these specific uses.

The *Oldman River Basin Water Allocation Order (2010)* is a regulation issued under Section 35 of the *Water Act* that reserves 11,000 acre-feet per year to the projects within the area meeting criteria in the *Order*, and can be issued by the Director for agricultural, municipal, commercial, industrial, recreational or rural water supply uses. This *Order* governs water allocation in the basin and does not directly contribute to drought management or response.

Apportionment for downstream provinces

Commitments for cooperation on the management of transboundary waters are recorded in three documents: the Mackenzie River Basin Transboundary Waters Master Agreement for the north, the 1969 *Master Agreement on Apportionment (MAA)* for east-central, and the Boundary Waters Treaty 1909 to the south. *The MAA* outlines how waters are to be shared between the three Prairie Provinces (Alberta, Saskatchewan and Manitoba) and includes water quality objectives at the borders. All water management decisions that are made within each province's jurisdiction should be done in the context of variability in the annual water supply from year to year, and the monitoring data on *MAA* commitments throughout a particular year, which is particularly relevant in drought years.

Under the *MAA*, Alberta is entitled to a minimum of 2,590,000,000 m^3 annually even if this is more than 50% of the annual natural flow, but cannot do this if it reduces the flow to less than 1,500 cubic-feet per second (42.5 m^3/s) in the South Saskatchewan River downstream of the confluence with the Red Deer River, near the Alberta-Saskatchewan border. If 1500 cubic-feet per second cannot be maintained then 50% of the annual flow must be passed downstream.

Water Conservation Objectives (WCOs) and Instream Objectives (IOs)

WCOs and IOs are the instruments used in Alberta that ensure there is a minimum amount of water to support basic ecosystem needs. WCOs are established under the *Water Act* as a regulatory tool for balancing human, environmental and ecosystem needs for water flows. WCOs can be implemented in several different ways, including by specifying the volume of release from a public reservoir or by specifying when a water allocation licence holder can divert water. Water allocations may be held for WCOs in licences with priority either by the government applying for a licence to protect instream flows, or by transfer from existing licences.

Water allocation licences include conditions that determine minimum flows that must be present before water can be diverted in order to protect the aquatic environment. WCOs guide government officials on decisions about when water can be allocated and the amount of water needed for flow restoration.

WCOs do not guarantee that the designated WCO volume of water remains in the water course, as some licensees are not subject to a WCO condition and may withdraw water when a WCO threshold is surpassed (GoA, n.d.).

In the absence of an established WCO, IOs are flows that are included in the conditions of some water licences. Licences are not permitted to withdraw water when river flows fall below the specified IO. In areas where WCOs are identified they are not backdated to apply to licences that existed when the WCO was established, and the IOs that may have conditioned licences before that time remain in force. AEP provincial infrastructure licences have IO conditions but are often operated to meet WCO objectives when sufficient water is available.

IOs were historically set on a river reach by reach basis. Since the first minimum flows were developed and applied to licences in the mid-1970s, gradually evolving to IOs in the 1990s, there have been many updated versions used, resulting in an uneven application of restrictions to licences issued since that time. In the period 1891 to 1967 licences were limited by time periods, such as different permitted diversion rates at flood, high and low flows.

2.1.3 Roles and responsibilities relating to drought management

There are diverse entities that have both direct and indirect roles and responsibilities in drought management and resilience. Both water supply management and demand management are important roles in drought management, and they must be coordinated. Additionally, the roles and responsibilities should cover a wide range of methods for drought management, including providing accurate and current information to all water users regarding water availability and forecasting drought, creating public awareness and offering recommendations and guidelines for responsible water use, and legislated authority to reduce water use where necessary.

Supply Management

In Alberta, most direct roles are played by provincial government departments, municipal governments, and entities that manage water control structures. Monitoring of available surface water and groundwater and forecasting of water supply is the responsibility of AEP through the River Forecast Centre and the Groundwater Observation Well Network. Surface water data is sourced primarily through the Water Survey of Canada system. AEP and the AER have programs that are responsible for notifying water licensees of approaching water shortage and below-minimum flow conditions in source water bodies, as well as monitoring to ensure water licensees are abiding by the conditions of their licences, and that water use is reported where required. As well, several water reservoirs and water control structures are managed by AEP as part of delivering water licence allocations and regulating flow in the several rivers.

AAF has several direct roles in drought management, including providing the online Alberta Climate Information Services (GoA, 2020) and issuing monthly Farm Gate Allocation Forecasts for irrigators from the Southern Tributaries of the Oldman River. AAF is also responsible for facilitating the Drought and Excessive Moisture Advisory Group and for publishing and updating the *Agriculture Drought and Excessive Moisture Risk Management Plan* (AAF, 2016).

Irrigation districts have responsibilities to their irrigators as well as to the other water needs in the province and, due to the volume and seniority of their water licence allocations, they play key roles in water sharing agreements (as seen in the 2001 drought, see section 2.1.4) under section 33 of the *Water Act*. Irrigation districts own and operate many water storage and management structures in the province, and some irrigation districts deliver water to certain municipalities through their water conveyance infrastructure. These both translate into roles and responsibilities during a drought.

Certain corporations also play various roles. For example, TransAlta managing its hydropower facilities on the Bow River plays a direct role in flood and drought management.

Demand Management

There are also direct roles and responsibilities held by the municipal governments, particularly in municipal demand management through bylaws and in communications to the public.

Watershed Planning and Advisory Councils, watershed stewardship groups, community organizations, and other stakeholder collaboration and planning entities also play important roles in drought management and mitigation, although their roles are more often indirect. They contribute particularly to awareness-raising, building community resilience before a drought, and initiatives to mitigate drought impacts. Drought planning and guidance manuals are also created by these types of organizations; for example, the Miistakis Institute published a Municipal Flood and Drought Action Planner in 2018 (Miistakis Institute, 2018).

Corporate initiatives to increase water use efficiency in connection to public image during a drought is an aspect of drought mitigation that is indirectly related to demand management. Aside from any legislated requirements for water efficiency or water licence restrictions, some corporations take on responsibility for their water stewardship and water use. A corporation that voluntarily implements a series of water saving and water reuse measures that reduces their overall water demand by 30% may be promoting this achievement explicitly during a water shortage as part of improving their public image. This leading by example is effective at reducing overall water demand.

Drought Impact Mitigation

The economic and social impacts caused by drought are another area of roles and responsibilities related to drought. There are many government responsibilities in these areas, including through crown corporations like the Agriculture Finance Services Corporation (AFSC) to provide financial incentives for producers to build on-farm drought resilience as well as loans, and supports including insurance and income stabilization.

Research and experience in many countries has found that preparation is one of the best ways to reduce losses and negative impacts from drought (Bathke et al., 2019). Because building community resilience and adaptive capacity is a cross-sectoral effort, no one entity is solely responsible for drought planning and preparation. Initiatives and projects by groups like the AWC and the Miistakis Institute, which support building drought resilience and understanding across a wide range of stakeholder and community groups, are very important for building a body of support resources. Implementing a drought risk management plan can be a very valuable tool, and planning documents, manuals, and stakeholder engagement efforts of many kinds can be key to developing a sound drought risk management plan (Bathke et al., 2019).

Further detail on roles and responsibilities can be found in Module 3 of the document "*Building Resiliency to Multi-Year Drought in Alberta*" (AWC, 2021).

2.1.4 Historical drought response (2001 drought in southern Alberta)

The period from 2000 through 2002 is widely considered the most recent, significant multiyear drought experienced in Alberta (AWC, 2021). This is referred to as the 2001 drought. The greatest water supply shortage was seen in the Oldman River Basin, but a variety of drought effects were experienced in many other parts of the province and in Saskatchewan.

Snowfall over the winter between 1999 and 2000 was below normal. Following that, recorded precipitation from April to November 2000 was below normal in much of the province and ranged between 36% to 56% of the normal precipitation in the headwaters areas of the Oldman River (Alberta Environment, 2000). The snowpack conditions in the spring of 2001 were also below normal across the entire province except the Red Deer River headwaters, and the volumes forecast for the Oldman River were 59% of average (Alberta Environment, 2001). These conditions caused Alberta Environment (at the time) to forecast that there would be insufficient water in the system to supply all water licences and still meet in-stream flow needs on the Southern Tributaries of the Oldman River (Albert Environment, 2002). In addition, the summers during this time were hot and dry, leading to higher-than-normal water demand. By the end of the 2000 irrigation operation season, storage reservoirs in the Southern Tributaries were drawn down to historically low levels (Alberta Environment, 2001).

The St. Mary River, Taber and Raymond irrigation districts share a common irrigation canal ("main canal"), operations on the main canal were managed via regular meetings of the Main Canal Advisory Committee which comprised of water managers from the irrigation districts. In November 2000, the existing Main Canal Advisory Committee invited other large water users to join their regular meetings and called themselves the Expanded Main Canal Advisory Committee (EMCAC) to prepare for the possibility of drought conditions in 2001. The EMCAC included eight irrigation districts as wells as some private irrigator associations.

At a meeting on April 19, 2001, the Regional Water Manager who was the decision-maker from Alberta Environment presented a comprehensive list of all water licences (excluding stockwater licences with storage) in the St. Mary, Belly, and Waterton basins by priority. This list included 388 licences. Based on the water forecast, 336 junior licensees were at risk of having their licences suspended for the year. The alternative discussed during the meeting was to create a water sharing agreement, as provided for under section 33 of the *Water Act*. Any licences whose priority was junior to 1950 would be suspended until water availability improved if water sharing measures were not agreed to. The scale of the needed water sharing agreement was in the order of a total demand of approximately 1.1 million acre feet (1.3 billion cubic metres), and a supply of approximately 600 thousand acre feet (740 million cubic metres) representing a regional population of about 200,000.

A water sharing agreement was drafted by the EMCAC and submitted to Alberta Environment on May 9th, 2001. The agreement included an offer to all licensees in the basin including mainstems, tributaries to mainstems, and private licenses supplied through the works of the respective districts to join the agreement. Letters were sent to licensees in the Southern Tributaries basins containing information on the sharing agreement as well as the water supply forecast, the priority system and the potential consequences of not joining the water sharing agreement based on the available forecast data. Due to data systems at the time, it was hard to easily access the address of all licence holders and some letters were returned due to wrong addresses.

Some private water sharing agreements were made between water users who chose not to participate in the basin-wide agreement. Private agreements were permitted among licensees providing they did not conflict with the overall water sharing agreement.

A deadline of June 27, 2001 was set for water users in the Southern Tributaries to sign up to the sharing agreement, after which those who had not signed were subject to administration of priorities. Enforcement of priorities was conducted through the issuing of Water Management Orders which defined a licence cut-off date. Water users with licences junior to the date specified that were not part of a water sharing agreement were subject to the restrictions outlined in the Water Management Order. The Regional Water Manager reviewed the merit of each order. By July 21, 2001, 63 Water Management Orders had been signed.

Weekly inspections were done to ensure licence holders were following the rules of the private water sharing agreements, Water Management Orders and the water sharing agreement. The water sharing agreement allowed junior licensees to continue diversion, provided irrigators reduced use to 10 inches of water over their project area and other users (municipal, industrial, commercial) reduced their usage to 60 percent of their licenced water allocation. Additional initiatives by Alberta Agriculture supported stockwatering projects, and water pumping and equipment rentals, which facilitated reduced agricultural water withdrawals and improved efficiencies.

In general, the water sharing agreement was considered to have worked effectively. Despite some challenges experienced with the administration of a sharing agreement on such a wide scale, this implementation of water sharing under section 33 of the *Water Act* as a drought management tool was effective and successful. Generally, feedback from users was positive and most participants abided by the spirit of the agreement.

The Alberta government identified the following key lessons from the 2001 drought in southern Alberta:

- Data monitoring tools and ease of access to data has changed the way droughts can be managed.
- Initial information for a water sharing agreement should be sent out sooner (possibly mid-April).
- Agreement should be finalized prior to the irrigation season.
- All licensees should be required to record the dates and times of diversions during a sharing agreement.
- The installation of water meters on all licenced water diversions should be encouraged.

See Appendix A – Drought Management Literature Review Summary Table for further details and discussion of impacts in other parts of the province from the 2001 drought.

Relevant literature:

Alberta Agriculture and Forestry. (2016). *Alberta's Agriculture Drought and Excess Moisture Risk Management Plan*. https://open.alberta.ca/dataset/19be574e-8a12-41f3-9880-403f93747655/resource/9c4ba961-016c-42f2-ac51-f49d41de8b01/download/2016-albertas-agriculture-drought-excess-moisture-risk-management-plan-2016-06-16.pdf

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Miistakis Institute. (2018). Municipal Flood and Drought Action Planner, access from https://www.rockies.ca/miradm/uploads/1c6f89bf3c419806ff8791b2e11b5128f2b6717c.pdf

Water Act (2000), (AB)(Can.) https://open.alberta.ca/publications/w03

2.2 Drought management – California

Water rights in California are governed by the California State Water Resources Control Board. Three types of water rights exist in the state: riparian, prescriptive, and appropriative. Permits are issued for prescriptive and appropriative rights issued after 1914, and permit priority for water rights is based on seniority of right. Appropriative water rights issued pre-1914 and riparian rights do not require a permit (California State Water Resources Control Board, 2020).

Water rights permits are granted to individuals to develop a project, which is assessed by the State Water Resources Control board to determine the user's eligibility for a license. A permit is only issued once the board assesses the environmental risk, whether the project is in the public interest and if there are any conflicting appropriative rights.

In California, drought management policy is determined by the *California Drought Contingency Plan* (*The Plan*), developed by the California Department of Water Resources (California Department of Water Resources, 2010). *The Plan* is a drought plan developed to assist state governance in preparation, response, and recovery from drought. Within *The Plan,* a framework for agency coordination to respond to and manage drought is detailed, including the development of an Interagency Drought Task Force that provides direction for implementing drought management between agencies. Within *The Plan*, roles and responsibilities regarding drought response are outlined for various local, regional, state, tribal, and federal agencies. The Interagency Drought Task Force plays a key role in coordinating drought response from all levels of government within the state and works to provide policy recommendations for drought response and recovery. Though more of a government response framework, *The Plan* documents some metrics used to monitor and forecast drought: water supply data (snowpack, precipitation, runoff, reservoir storage), hydrologic data collection (snow reporting gauges, precipitation and river stage sensors), and water year precipitation.

Water storage and delivery system entities such as the California State Water Project or the California Central Valley Project are permitted to develop their own drought contingency plans (California Department of Water Resources, 2015, 2016). These contingency plans are developed for the California State Water Resources Control Board by a variety of agencies within the federal and state government including the U.S. Bureau of Reclamation, California Department of Water Resources, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and California Department of Fish and Wildlife. These drought contingency plans are developed to provide an alternative framework for water operations within the state based on modeled hydrological scenarios for that year. The plan may also propose possible requests for changes to legislation for operational standards for water based on potential hydrologic scenarios. Metrics used in such plans can include water quality (salinity), hydrology (precipitation to date, runoff, reservoir storage, snowpack) and biology (local fish and wildlife populations). Development of a state contingency plan is required by law under Division 6 of the *California Water Code*. Urban water providers are required by law to create contingency plans under the *California Water Code* Section 10632. Other water users such as irrigation districts are not required to create contingency plans but may choose to implement them to manage drought effectively (California State Legislature, 2019).

See Appendix A – Drought Management Literature Review Summary Table for further details.

Relevant links and sources:

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California Department of Water Resources. (2016). *Central Valley Project and State Water Project 2016 Drought Contingency Plan For Water Project Operations* (State of California, Natural Resources Agency, California Department of Water Resources). Retrieved from https://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/tucp/docs/febnov_2016plan.pdf

California State Legislature. (2019). *Water Code Division 6: Conservation, Development and Utilization of State Water Resources*. California Legislature Information. https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=WAT§ionNum=10632#:%7E:text=10632.,each%20of%20the%20following%20elements%3A&text=The%20annual%20supply%20and%20demand,of%20the%20urban%20water%20supplier.

California State Water Resources Control Board. (2020, August 20). Water Rights. Retrieved January 20, 2021, from https://www.waterboards.ca.gov/waterrights/board_info/faqs.html#toc178761097

2.3 Drought management – South Carolina

Surface water withdrawals in South Carolina are issued under the *South Carolina Surface Water Withdrawal, Permitting, Use and Reporting Act (SC Withdrawal Act)* administered by the South Carolina Department of Health and Environmental Control (SCDHEC). The *SC Withdrawal Act* requires users withdrawing more than three million gallons per month (11,356 m^3 per month) to obtain a permit from the SCDHEC. Permitted users can withdraw up to their monthly volumetric limit and must abide by any conditions placed upon their permit (South Carolina Legislature, 2010). There is no priority system that governs permitted users, however, permits specify minimum instream flow limits that will trigger below which the user will have to introduce specified reductions in water withdrawal (South Carolina Legislature, 2010).

Users withdrawing less than three million gallons per month are not required to obtain a permit but must register their use with the SCDHEC. This process requires the user to notify the SCDHEC of their intended water use, withdrawal rate, and monthly withdrawal volume. Registered users are not placed under any conditions that may restrict their withdrawals. There is no priority system for registered users so it is possible that small users may not have enough water to meet their demands during low flow periods.

Groundwater withdrawals are regulated under the *Groundwater Use and Reporting Act* under which those withdrawing more than three million gallons per month must apply for a permit. Similar to surface water withdrawals, smaller water users are not required to obtain a permit for groundwater withdrawals (South Carolina Legislature, 2000).

The *South Carolina Drought Response Act (SC Drought Response Act)* was implemented to outline the responsibilities of the South Carolina Department of Natural Resources (SCDNR) and other bodies to prepare for and in the event of drought. Drought forecasting is the responsibility of the SCDNR, and the severity and type of drought governs the response under the *SC Drought Response Act.* Figure 1 shows the responsibilities denoted by the *SC Drought Response Act* during successive phases of drought.

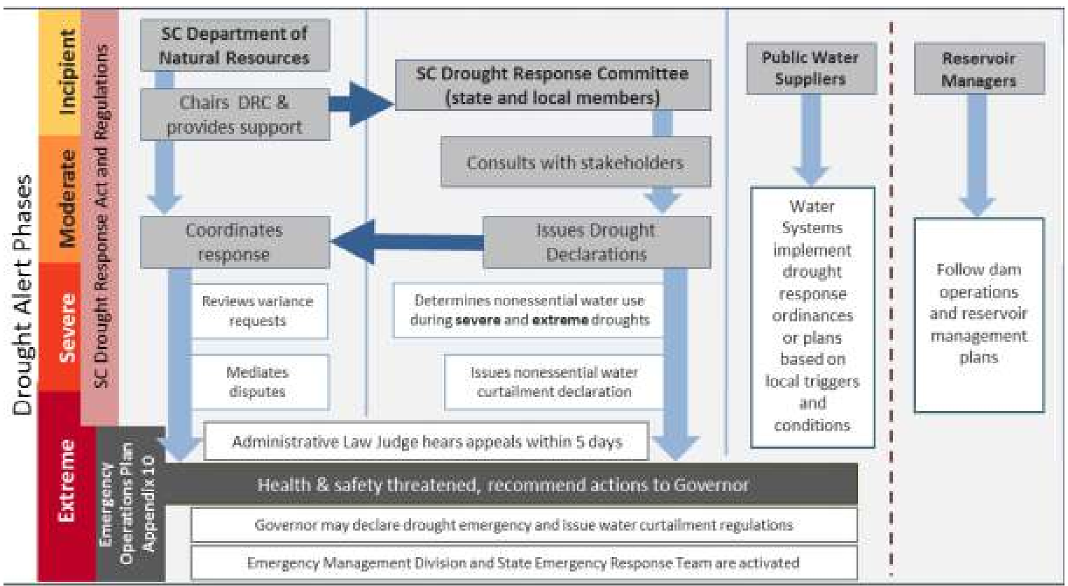

Figure 1 Components of South Carolina's drought response process (CISA, 2019)

The *SC Drought Response Act* mandates the SCDNR to establish localized drought response committees which are responsible for the creation and implementation of localized drought response plans. Under the *SC Drought Response Act*, the drought response committees must contain members representing the following interests:

- Counties, municipalities and public service districts
- Private water suppliers
- Agriculture
- Domestic water users
- Regional councils

- Commissions of public works
- Power generation facilities
- Special purpose districts
- Soil and Water Conservation Districts

The drought response plans created by the localized committees detail responsibilities and procedures at the local level including reservoir operations, municipal restrictions, and agricultural withdrawal limitations during each phase of drought. South Carolina uses the U.S. Drought Monitor to define each stage of drought. In total there are five stages of drought severity:

- **D0 Abnormally dry** – Irrigation may begin early, row crop growth is stunted and the risk of brush fires increase.
- **D1 Moderate drought** – Tree pests increase, water levels are low and water use is higher than normal.
- **D2 Severe drought** – Number and intensity of fires increases, fisheries are impacted, and recreational boating is impacted by water levels.
- **D3 Extreme drought** – Soil moisture is low, small aquatic species are stressed, and winter crops are slow to germinate.
- **D4 Exceptional drought** – Trees are stressed, daily life is compromised, and wells are contaminated or running dry.

Engaging stakeholders in the development of drought response plans and within local committees ensures that all water users buy into the response plan. Engagement also helps prevent non-permitted water users being cutoff during drought through negotiations and compromise from permitted water users. In recent years, the SCDNR has sought to test and optimize the drought response plans through stakeholder engagement exercises such as the South Carolina Tabletop exercise held in 2017 and 2019. See section 4.1.2 for further discussion of this simulation exercise.

See Appendix A – Drought Management Literature Review Summary Table for further information on South Carolina's drought management system.

Relevant links and sources:

South Carolina Legislature. (2010). *South Carolina Surface Water Withdrawal, Permitting Use, and Reporting Act*. South Carolina Code of Laws Unannotated. https://www.scstatehouse.gov/code/t49c004.php

South Carolina Legislature. (2000). *Groundwater Use and Reporting Act*. South Carolina Code of Laws Unannotated. https://www.scstatehouse.gov/code/t49c005.php

Santee Cooper. (2020, July 29). *5 LEADING INDUSTRIES IN SC*. https://www.santeecooper.com/news/2020/072920-Leading-Industries-in-SC.aspx

CISA. (2019, July). *South Carolina Drought Tabletop Exercise*. Carolinas Integrated Sciences and Assessments. http://www.scdrought.com/pdf/2019_SC-DroughtTTX_FinalReport.pdf

National Drought Mitigation Center. (n.d.). *United States Drought Monitor > Current Map > State Drought Monitor*. United States Drought Monitor. Retrieved November 27, 2020, from https://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?SC#:%7E:text=D1%20(Moderate%20Drought),D4%20(Exceptional%20Drought)

2.4 Drought management – Saskatchewan

Historical drought management in Saskatchewan was largely handled by the Prairie Farm Rehabilitation Administration (PFRA). This administration was established in 1935 after a long series of droughts in Alberta and Saskatchewan necessitated management action that would aid farmers in restoring their landscapes.

Although multiple periods of drought were experienced throughout the prairie provinces in the early 20th century, Saskatchewan farmers suffered severe drought between 1928-1939. This period of extreme agricultural hardship in the province spurred the establishment of the PFRA by the federal government and headquartered in Saskatchewan. The PFRA was designed to rehabilitate once-productive farmland that had desertified, and particularly addressed issues such as soil erosion and water shortages.

Marchildon et al. (2008) detail the conditions of the southern regions of both provinces most prone to drought (the Dry Belt, and later the Palliser Triangle), drought exposure in these areas, agricultural drought, and institutional adaptation through establishment of bodies such as the Special Areas Board in Alberta. Marchildon et al. (2008) utilize the drought index as a metric of drought measurement, which is a "climate moisture index that expresses the moisture deficit in terms of mean crop year precipitation minus potential evapotranspiration (P-PET)."

See Appendix A – Drought Management Literature Review Summary Table for further information.

In modern-day Saskatchewan, the *Water Security Agency Act* (Government of Saskatchewan, 2005) is the primary piece of legislation concerning the management of water rights within the province. The Water Security Agency (WSA), a crown corporation, is responsible for the majority of the provincial government's water management tasks (Saskatchewan Water Security Agency, n.d.). Responsibilities include issuing water licenses for both surface water and groundwater, owning and operating dams and works, monitoring water quality and quantity, and managing transboundary water issues. The WSA also leads the implementation of the *25 Year Saskatchewan Water Security Plan*, developed in 2012, which includes discussion of water shortage. The *25 Year Saskatchewan Water Security Plan* was developed to provide the province with a vision, principles, and action items to meet water security goals (Saskatchewan Water Security Agency, 2012).

The water license system in Saskatchewan is based on the principal of priority of purpose although this is not formalized through the legislation. The WSA develops and directs water sharing strategies based on prevailing conditions, which includes the authority to manage water licensees' withdrawals. Irrigation is generally lowest priority while municipal and domestic use is generally given highest priority. The Ministry of Agriculture has become the de-facto drought planning and response entity as historically water shortages have most severely impacted the agricultural sector.

In the past, drought management in Saskatchewan was largely reactive rather than proactive and most mitigation was aimed towards protecting agricultural losses. In 2012, the province of Saskatchewan began developing the *25 Year Saskatchewan Water Security Plan* (Saskatchewan Water Security Agency, 2012) to proactively manage water security throughout the province. Within this plan, drought is identified as a potential risk and identifies areas requiring improvements such as water allocation systems, climate change adaptation, dam operations, ecosystem health and biodiversity protection, and drought response. Goals set within this plan to adapt to and / or mitigate drought include ensuring dams safely meet water supply and management needs, ensuring measures are in place to effectively respond to flood and drought, and ensuring adequate data, information, and knowledge are available to support decision making.

Drought management is also an area that is addressed within Saskatchewan's *Climate Resilience Measurement Framework* (Saskatchewan Ministry of Environment, 2018). This framework provides structure and clarity on provincial climate change resilience initiatives. The framework defines a pathway to climate resilience comprising of several focus areas including Natural Systems, Physical Infrastructure, Human Well-Being and Community Preparedness. Drought mitigation is identified as a priority under the Natural Systems and Human Well-Being focus areas and as a key outcome of Saskatchewan's agricultural water management framework. Resilience to drought and improved drought response are identified as key outcomes of these two focus areas.

3.0 Metrics, Indicators and Thresholds for Assessing Drought Management

In the table below, drought indicators and metrics for Alberta, Saskatchewan, California, and South Carolina were identified by reviewing the regulatory framework, drought plans, and relevant reports. The purpose of this review is to understand which metrics are used in each jurisdiction and how these metrics inform drought resiliency and drought planning. Indicators of drought impact such as economic implications of droughts were not reviewed as part of this project (AWC, 2021).

Table 1 summarizes the metrics, thresholds and indicators identified in each jurisdiction, a more detailed version of the table is included in Appendix A. It was found in most jurisdictions, drought response is not governed by individual indicators, but all indicators will be assessed holistically by decision makers to understand the severity of water shortage. When considering individual water users, most jurisdictions that have a licencing or permitting system identify certain thresholds, such as instream flow, below which water withdrawals are reduced or restricted. These thresholds are typically determined by the regulatory body and identified on each permit or licence.

Table 1 Metrics, thresholds and indicators for drought monitoring and response identified in Alberta, Saskatchewan, California, and South Carolina.

Jurisdiction	Documentation containing metrics, indicators, or thresholds	Metrics, indicators, and thresholds
Alberta	Alberta's Agriculture Drought and Excess Moisture Risk Management Plan (ADEMRMP)	• Soil moisture monitoring program • Precipitation monitoring • Snowfall accumulations • Temperature and humidity monitoring • Release rates from reservoirs and streamflow • Wildfire risk • Grasshopper levels • Duration of drought (relative to historical conditions) • Groundwater levels
	City of Calgary Climate Resilience Strategy	• Reduction of per-capita water use

Jurisdiction	Documentation containing metrics, indicators, or thresholds	Metrics, indicators, and thresholds
Saskatchewan	Synthesis Report: Agricultural Adaptation to Drought (ADA) in Canada: The Case of 2001 to 2002	• Standard Precipitation Index (SPI) • Palmer Drought Severity Index (PDSI) • Drought Index - A climate moisture index that expresses the moisture deficit in terms of mean crop year precipitation minus potential evapotranspiration (P-PET)
California	California Drought Contingency Plan	• Water supply data (snowpack, precipitation, runoff, reservoir storage) • Hydrologic data collection (snow reporting gauges, precipitation and river stage sensors) • Water year precipitation
	Central Valley Project and State Water Project 2015 and 2016 Drought Contingency Plan	• Water quality (salinity) • Hydrology (precipitation to date, runoff, reservoir storage, snowpack) • Biology (local fish and wildlife populations)
South Carolina	South Carolina Drought Response Plan	• Soil moisture • Stream flow • Well levels • Precipitation
	South Carolina Drought and Water Shortage Tabletop Exercise Summary Report	• Palmer Drought Severity Index • Crop Moisture Index • Standardized Precipitation Index • Keetch-Byram Drought Index • U.S. Drought Monitor • Average daily streamflow • Groundwater static level in an aquifer

All jurisdictions seek to monitor water availability by measuring streamflow and precipitation at multiple locations. California and Alberta both use snowpack as an indicator of the potential for drought to occur.

Both Saskatchewan and South Carolina make use of the Palmer Drought Severity Index (PDSI) which was developed in the 1960s to estimate relative drought conditions using precipitation and temperature. The PDSI is best suited to measuring hydrological drought (Alley, 1984), so Saskatchewan and South Carolina have each used supplementary methods for assessing crop health. Saskatchewan assesses crop health using the Drought Index, while South Carolina has opted for the Crop Moisture Index.

All jurisdictions use continuous monitoring at multiple locations to capture data so they can understand where droughts may occur. Data collected within a jurisdiction is monitored and analyzed by state or provincial regulators and used to implement restrictions and controls. In U.S. jurisdictions, drought is usually declared by the state based on the indicators, and state and local drought response plans are implemented based on drought severity.

In Alberta, drought indicators are monitored by AEP and water users are obligated to abide by the conditions of their licences which include no withdrawal when the source water body is below a certain threshold. AEP also monitors drought indicators that are used to predict imminent water shortages and monitors ongoing local, regional and multi-basin water shortages. In the event of regional and multi-basin droughts, AEP will implement drought response procedures in basins that have these procedures established. As part of the drought assessment, AEP determines whether implementation of priority-based water restrictions is necessary. In Saskatchewan, the WSA has a similar mandate and can also cut off users as a last resort; however, there are not currently any basin scale drought response procedures in place to be implemented in the event of regional droughts.

In the U.S., data is also collected by federal entities such as the National Drought Mitigation Center (NDMC) and National Oceanic and Atmospheric Administration (NOAA). This data is collated into a tool called the U.S. Drought Monitor which is made available to all states as well as the public (NDMC, n.d.). South Carolina uses this map to supplement their own data and to understand when to implement their drought response plans.

Relevant literature and links:

Alberta Agriculture and Forestry. (2016). *Alberta's Agriculture Drought and Excess Moisture Risk Management Plan*. https://open.alberta.ca/dataset/19be574e-8a12-41f3-9880-403f93747655/resource/9c4ba961-016c-42f2-ac51-f49d41de8b01/download/2016-albertas-agriculture-drought-excess-moisture-risk-management-plan-2016-06-16.pdf

Alberta Water Council. (2021). Building Resiliency to Multi-Year Drought in Alberta.

Alley, William. (1984). The Palmer Drought Severity Index: Limitations and Assumptions. Journal of Climate and Applied Meteorology. 23. 1100-1109. 10.1175/1520-0450(1984)023<1100:TPDSIL>2.0.CO;2.

California Department of Water Resources. (2015). *Central Valley Project and State Water*

Project Drought Contingency Plan (State of California, Natural Resources Agency, California Department of Water Resources). Retrieved from https://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/2015_drought_contingency_plan.pdf

California Department of Water Resources. (2016). *Central Valley Project and State Water Project 2016 Drought Contingency Plan For Water Project Operations* (State of California, Natural Resources Agency, California Department of Water Resources). Retrieved from https://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/tucp/docs/febnov_2016plan.pdf

City of Calgary. (2019). *Climate Resiliency Strategy 2019 Update*. https://www.calgary.ca/content/dam/www/uep/esm/documents/esm-documents/climate-strategy-report-2019.pdf

CISA. (2019, July). *South Carolina Drought Tabletop Exercise*. Carolinas Integrated Sciences and Assessments. http://www.scdrought.com/pdf/2019_SC-DroughtTTX_FinalReport.pdf

National Drought Mitigation Center. (n.d.-b). *What is the U.S. Drought Monitor?* United States Drought Monitor. Retrieved November 27, 2020, from https://droughtmonitor.unl.edu/About/WhatistheUSDM.aspx

Natural Resources Agency, State of California, & California Department of Water Resources. (2010). *California Drought Contingency Plan*. California Department of Water Resources. https://drought.unl.edu/archive/plans/Drought/state/CA_2010.pdf

Saskatchewan Research Council. (2007). *Agricultural Adaptation to Drought in Canada: The case of 2001 to 2002*. https://cariboo-agricultural-research.ca/documents/CARA_lib_Wheaton_et_al_2007_Agricultural_Adaptation_to_Drought_ADA_in_Canada_The_Case_of_2001_to_2002.pdf

4.0 Simulation Tools and Case Studies

This section of the literature review summarizes the reviews of drought simulation exercise methods and supporting tools. All of the case studies reviewed use some form of exercise to explore or improve drought management. To the extent possible, case studies were selected from the jurisdictions of interest identified in section 2.0.

There are many more tools available than could be reviewed in the scope of this project. The tools selected for review are games or adaptable to game-style exercises and are capable of simulating drought. The tools were also selected to represent a variety of technicality and complexity, and to align with one of the case studies where possible. The shortlist of tools and case studies were provided to AWC before the review work was conducted.

4.1 Case studies

Each of the case studies below includes a description, objectives, outcomes, key lessons learned, budget, and the simulation tool used (if any). For further information, including the organization that conducted the exercise, see Appendix B – Simulation Case Study Research Summary Table.

4.1.1 Bow River Live Simulation

This case study is relevant to the Alberta Water Council Drought Simulation project because the study used a simulation tool, involved stakeholders gathering and making decisions together, focused on a watershed in Alberta, and focused on water management during a drought year.

Key considerations for AWC:

- Technical capabilities of the tool and good data were essential to the success of the exercise.
- Participants were expert stakeholders and familiar with the simulation tool.
- Outcomes were concrete and implementable with direct drought management implications.
- The tool and the exercise were specific to a single basin.

The information about the Bow River Live Simulation comes from the "*Bow River Live Simulation Summary Report,"* prepared by Alberta WaterSMART and Alberta Innovates – Energy and Environment Solutions, or from proposal documentation and personal communications from the project team members.

Description

In 2011, a group of key stakeholders and people who make decisions about the Bow River operations came together to run a simulation of collaborative drought management decisions for the Bow River watershed. This group were the same people who worked together to develop and refine the *Bow River Operational Model (BROM)* in a prior project. The Bow River Live Simulation built directly off the work done to initially develop the *BROM* tool which was part of the Bow River Project (BRP). The BRP resulted in a series of recommendations for integrated Bow River management operating rules and a specific 'preferred scenario'. The *"Bow River Live Simulation Study"* was intended to compare the current operations of the river system, the preferred scenario developed through the BRP, and the live operation from the simulation exercise.

This simulation exercise took place over one half-day workshop in which the management decisions (operations) for the Bow River were made week by week, progressing through the simulated spring and summer months. In order to make management decisions, participants were provided the current conditions for each week (including decisions from previous weeks), the forecasted inflows, and various other data produced from the *BROM*. Running the whole final sequence of decisions on the BROM took approximately 10 minutes. The simulation included the perspective of the public perception and media coverage of decisions.

The participants were all key stakeholders and decision-makers in their professional lives, with very strong familiarity with the river system and with the *BROM* tool. The weather and river flow data used was from the year 1941, which was one of the five worst drought years on record in Alberta. Participants did not know in advance that this was the source of the data used for the simulation.

Objectives

1. Revisit and validate the *BROM* and the preferred scenario recommendations.
2. Test and improve the proposed integrated river management operating rules.
3. Identify and address the consequences of the proposed integrated river management operating rules.

Outcomes

Model Outcomes

In comparing the performance measures, the live simulation outperformed the current management approach to the river (that is, the current operations) and in most cases, also outperformed the preferred scenario developed in the BRP. Performance measures used included Bow River flow below Bassano Dam, water shortages in the system, Kananaskis River flow below Pocaterra hydroelectric plant, Kananaskis River Flow, and water bank storage.

The simulation study identified possible recommendations for integrated river management operations. It also identified several needed improvements or adjustments to the BROM tool.

Participant Outcomes

Participants concluded that the *BROM* is a realistic and valuable tool for understanding the Bow River system and for exploring potential opportunities to manage the system for broader benefits for various water users.

Key lessons learned

The simulation study confirmed that the Bow River system can and should be managed differently to achieve many economic, environmental, and social goals throughout the Bow basin.

Given the participants represented subject matter experts and key stakeholders, their conclusion that the *BROM* is a is a realistic and valuable tool speaks strongly for it being useful for actual governance and drought management decision making.

The simulation confirmed the value and effectiveness of various key recommended operational changes from the BRP.

Budget

The budget for planning, coordination with attendees, running the event, and drafting the summary report was $87,250. The total does not include development of the tool or data compilation.

Simulation tool/exercise used

Bow River Operational Model (BROM) - built using *OASIS* (*Options Analysis in Irrigation Systems*) (see section 4.2.11).

Relevant literature and links:

> Alberta WaterSMART and Alberta Innovates – Energy and Environment Solutions. (2011). *Bow River Live Simulation Summary Report*.

4.1.2 South Carolina Drought and Water Supply Shortage Tabletop Exercise

This case study is relevant to the Alberta Water Council Drought Simulation project because it is a good example of stakeholder-based engagement with drought response plans to identify gaps and pathways for improving drought resiliency. South Carolina was selected as one of the jurisdictions of interest for comparison with Alberta.

Key considerations for AWC:

- Paper-based scenarios were developed specifically for this event.
- Existing drought response plans provided the response options.
- Participants were from entities that have decision-making roles in a drought event.
- It functioned as a ‘dry run’ for actual drought event management.
- Multiple real river basins were used, and outcomes applied to the whole state.

All the information about the South Carolina Drought and Water Supply Shortage Tabletop Exercise came from the “*South Carolina Drought and Water Shortage Tabletop Exercise Summary Report”*, or from personal communication with Tom Walker, Research coordinator at Clemson University.

Description

This tabletop exercise engaged drought response stakeholders at local, state, and federal levels to practice responding to drought by simulating a moderate, severe, and extreme drought scenario. Scenarios were paper-based, and each group worked through their drought response plans to identify gaps in response and legislative challenges.

Objectives

- Test the South Carolina drought monitoring and response processes.
- Identify gaps in existing processes and prioritize follow-up actions.
- Increase awareness of participant roles and responsibilities for drought response planning within their agencies and organizations.

Outcomes

Model Outcomes
N/A

Participant Outcomes
Engaging stakeholders in a "dry run" drought scenario identified gaps in the legislative process and helped identify additional key people who needed to be involved in drought response (e.g., media representatives for dispersal of information).

Key lessons learned

Although legislative gaps were not resolved as a result of the simulation, stakeholders became aware of the challenges, know who to contact, and have introduced their own best practices for drought response.

Engaging stakeholders from all basins allowed information sharing and networking, which improves drought response.

Budget

The budget for planning the scenarios and running the event was under $10,000. The budget did not include catering, venue, or any tool costs (as no tool was used).

Simulation tool/exercise used

The tabletop exercise consisted of four paper-based scenarios:

- Incipient drought – based on U.S. Drought Monitor rating of D0.
- Moderate drought – based on U.S. Drought Monitor rating of D1.
- Severe drought – based on U.S. Drought Monitor rating of D2.
- Extreme drought – based on U.S. Drought Monitor rating of D3.

Each scenario was located in real world basins within South Carolina. Groups were tasked with developing and / or using existing drought response plans for each specific area.

During the 2019 exercise, Mentimeter was used to engage participants and encourage discussion. Mentimeter is an interactive presentation software that uses live polls, word clouds and Q&As to allow participant engagement and real time feedback.

Relevant literature and links:

Altman, E. and Lackstrom, K. (2018). *South Carolina Drought and Water Shortage Tabletop Exercise Summary Report*. Accessed from https://www.cisa.sc.edu/PDFs/2017%20SC%20Drought%20Tabletop%20Exercise/SC%20Drought-Water%20Shortage%20Tabletop%20Report%20FINAL%204-18.pdf

4.1.3 Saskatoon Invitation Drought Tournament (IDT)

This case study is relevant to the Alberta Water Council Drought Simulation project because it specifically focused on drought adaptation and management, used a tool that can be adapted to other jurisdictions, and used either a specific watershed or a fictional one. Participants were from a variety of backgrounds where technical expertise was not necessary. This exercise was conducted with participants from throughout the South Saskatchewan River Basin, including both Alberta and Saskatchewan stakeholders.

Key considerations for AWC:

- The scenario was adapted from an existing framework.
- This framework could be adapted for a specific basin or outcomes, or it could be adopted directly.
- A computer model was a support tool for participants to understand the consequences of drought management actions.
- Game qualities included competition, cooperation, strategies, rules, players, and referees.

The information contained in this section about the IDT is directly from "*The Invitational Drought Tournament: What is it and why is it a useful tool for drought preparedness and adaptation?*" by Harvey Hill et al., (2014), "*A water resources simulation gaming model for the Invitational Drought Tournament*" by Wang and Davies (2015), and personal communication with Harvey Hill.

Description

The IDT combined a workshop with features of a game, including competition, cooperation, strategies, rules, players, and referees. The IDT game was developed by Agriculture and Agri-Food Canada in 2010 to support discussions between stakeholders from different specialties on different proactive drought management policies. The IDT is a day-long workshop in which multidisciplinary teams compete against each other to develop the best drought management plan. Constraints on team options were in the form of an annual budget (for each round), the physical realities of the drought as presented in the scenario, and the technical expertise of the game referees.

Participants were provided with a workbook in advance of the tournament which included background information on the simulation and on the watershed. The IDT can be run based on a real or fictitious watershed. There are two fictional watersheds already developed.

The game consists of three or four rounds, each representing one year. Each team must decide which drought management or adaptation options to choose from, within the annual budget they have. A system dynamics-based simulation gaming model called the IDT Model was developed to support the IDT game. It was designed to quantify and communicate the effects of IDT teams' drought management decisions both in the short-term and over several years of drought conditions. The IDT event held in Saskatoon in 2013 included use of the *IDT Model*.

Objectives

Since 2011, multiple IDT events have been held in Canada and the US with objectives that include:

1. Improving participants' understanding of drought management.
2. Sharing experiences in dealing with drought.
3. Improving collaborative decision-making and consensus-building approaches.

Outcomes

Participant Outcomes

The IDT supports interactive learning and creativity in drought management. Participants found the IDT engaging and effective at bringing together stakeholders with different perspectives to engage in meaningful dialogue to achieve consensus decisions around drought preparedness.

The *IDT Model* clearly illustrated the effects of team policy choices, based on different policy combinations and their cumulative effects on both physical and socio-economic variables, with results that sometimes surprised participants and contributed to learning about both drought and drought management.

Model Outcomes

The use of the *IDT Model* enabled the Saskatchewan IDT event to be more technical and to have information feedback mechanisms so that participants understood the impacts of the decisions, and the consequences carried forward through each round.

Key lessons learned

The IDT framework was tested and improved over a series of years and events with different participants. The *IDT Model* was developed and added later to address some of the responses from participants to have better mechanisms for in-game learning.

For government institutions, the *IDT Model* framework could be used experimentally to explore policy combinations and motivate creative thinking about drought management. In this capacity, the model could aid regional and local levels of government in developing and accessing plans, soliciting public support for drought management, and contributing to proactive drought management efforts.

Budget

Unknown as it varies significantly based on the IDT event.

Simulation tool/exercise used

The Invitational Drought Tournament framework and the *IDT Model* (see section 4.2.2).

Relevant literature and links:

Hill, H., Hadarits, M., Rieger, R., Strickert, G., Davies, E., and Strobbe, K. (2014). *The Invitational Drought Tournament: What is it and why is it a useful tool for drought preparedness and adaptation?* Weather and Climate Extremes, 3, pp 107-116.

Wang, K. and Davies, E. (2015). *A water resources simulation gaming model for the Invitational Drought Tournament*. Journal of Environmental Management, 160 pp 167-183.

4.1.4 Colorado Drought Tournament

This case study is relevant to the Alberta Water Council Drought Simulation project because it used a gaming forum to specifically engage stakeholders and communities on drought preparedness for the whole state of Colorado.

Key considerations for AWC:

- The scenario was adapted from an existing framework for predetermined objectives and the regional context.
- Drought management for the whole state was tested in this event.
- Participants were selected from across the state and had real-world roles in drought mitigation and management.

The information about the Colorado Drought Tournament is taken from "*Summary Report: Colorado Drought Tournament"* (2012) prepared by AMEC Environment and Infrastructure, or from personal communication with Courtney Black.

Description

A drought tournament was held on September 18, 2012 in Denver, Colorado, as a precursor to the two-day State Drought Conference. The tournament was adapted from the Canadian Integrated Drought Tournament (IDT) framework to the context for the State of Colorado by AMEC specifically for this event.

The drought tournament was designed over the prior summer through a series of meetings and included a simulation day when it was tested before the actual tournament. The simulation day provided valuable points for game refinement, definition of referee roles, round timing, and familiarity for the facilitators and referees.

Approximately forty people were involved in playing and running the tournament. The game was based on a fictional basin developed to characteristically represent watersheds in Colorado. Each of the teams developed a drought response plan and competed against each other for the best one. Teams were constrained by an annual budget, the river administration rules that are legislated in Colorado, and a list of specific drought mitigation or response options. The final scoring combined individual, team and referee perspectives.

Objectives

- Educate participants on multidisciplinary and multi-sector implications of drought.
- Encourage collaboration among stakeholders with various backgrounds.
- Introduce the concept of a game as a way to engage stakeholders and develop relationships.
- Provide a forum to develop contacts and information useful for future local, regional, and statewide drought planning purposes.
- Create an environment that was engaging, competitive, fun, and worthwhile to attend for education and networking.

Outcomes

Model Outcomes

N/A

Participant Outcomes

In the response survey following the tournament, 88% of participants strongly or moderately agreed that it was effective in achieving the objectives of educating participants, encouraging collaboration, and was an effective tool for a fun environment for engaging stakeholders. 65% of participants agreed strongly or moderately that it was an effective tool to collect information for planning purposes.

The tournament was effective at engaging participants in the game, provided an excellent forum for discussion and critical thinking about drought, facilitated connections between stakeholders from sectors that normally would not interact, and created an effective collaboration environment.

Key lessons learned

Specific learnings provided by participants identified that there was an overwhelming amount of information and too much to read during the session time, specifically in the short time for each round. Various suggestions for how to improve this are noted in the "*Summary Report: Colorado Drought Tournament.*" There was interest from participants in having economic impacts, agriculture, and water storage level information provided at greater detail, and in having a way to track trade-offs.

Overall, the "*Summary Report: Colorado Drought Tournament*" concludes that a drought tournament framework must be customized to the predetermined objectives for that session and to the local region context. Technical components were important for developing the drought tournament framework; however, the selection of stakeholders to invite and the formation of teams was critical to the success of the tournament. The Colorado Drought Tournament was successful at engaging stakeholders in a competitive and fun environment by fostering multidisciplinary collaboration on drought issues and solutions. It is suggested that this exercise could be used for a variety of real-life planning efforts (e.g., for water supply and management or for drought management planning), and it could be a tool to build trust among stakeholders throughout the State.

Budget

Unknown, sponsored by the Colorado Water Conservation Board (CWCB) and the National Integrated Drought Information System (NIDIS).

Simulation tool/exercise used

The paper-based exercise was built on the IDT framework (see section 4.2.2). There was very detailed planning, but no modelling tool was used during the simulation exercise.

Relevant literature and links:

AMEC Environment and Infrastructure. (2012). *Summary Report: Colorado Drought Tournament*, prepared for Colorado Water Conservation Board and National Integrated Drought Information System. Accessed from https://cpaess.ucar.edu/sites/default/files/meetings/2016/documents/2012DroughtTournament.pdf

4.1.5 Basin-Wide Framework for Drought Forecasting and Planning in the Chesapeake Bay Region

This case study is relevant to the Alberta Water Council Drought Simulation project because it was specifically aimed at practical application of drought planning and management, and it included stakeholders modelling in workshop settings. This project used the tool in a series of localized water supply utility 'case studies' throughout the Chesapeake Bay Region.

Key considerations for AWC:

- The technical capabilities of the tool and good data are essential to the success of the exercise.
- The objectives required a significant amount of communication before and after the in-person events.
- The tool and the exercise were specific to a single basin.

All the information about the Basin-Wide Framework for Drought Forecasting and Planning in the Chesapeake Bay Region is directly from "*Sectoral Applications Research Program (SARP) Final Report: Developing A Basin-Wide Framework for Drought Forecasting and Planning in the Chesapeake Bay Region",* on the Hazen and Sawyer website (Hazen Sawyer, 2021).

Description

National Oceanic Atmospheric Administration (NOAA) and Susquehanna River Basin Commission (SRBC), along with several partner organizations, ran this project with the primary goals of developing a *Drought Planning Tool (DPT)* for the Susquehanna River Basin to inform stakeholder planning and drought coordination activities and to evaluate the tool for use in drought planning and operations.

The *Drought Planning Tool* consists of a system simulation model (*OASIS*); time series of climatological/meteorological drought indices and forecasts; model code for water supply drought operations; and a post-processing dashboard for the evaluation of tradeoffs among cost, water supply reliability, and other performance metrics of interest for alternative drought scenarios.

This project used the *DPT* in a series of localized water supply utility 'case studies.' For each case study, two sets of *DPT* simulations were carried out: (1) one set to compare responses of drought indices and reforecasts to dry periods and severe droughts within the historical simulation period under baseline (current) water supply operations; and (2) one set to compare alternative operating strategies specific to each case study, triggered by a subset of drought indices and reforecasts.

This project included extensive outreach efforts, including project-specific and basin-wide stakeholder workshops, numerous conference presentations, and a planned nationwide webinar to be facilitated by Water Research Foundation.

Two sets of workshops were conducted for the project case studies, one set with staff from the City of Baltimore's Department of Public Works and a second set with case study participants from the Lower Susquehanna River Basin. Initial project workshops were conducted in the first half of the project during design of the case study analyses. These workshops focused on introducing the project and the Drought Planning Tool; discussing drought indices and forecasts; reviewing baseline operating policies; and soliciting input from utility staff on potential alternatives to evaluate. These workshops were followed by informal phone calls with utility staff to discuss follow up questions. A second set of workshops was held near the end of the project to review case study results and to solicit input on any additional refinements or alternatives to evaluate.

In addition to the case study workshops, the project team conducted outreach via several local and regional stakeholder groups including: the Baltimore Metropolitan Council's Reservoir Watershed Management Program; the Lower Susquehanna River Source Water Protection Partnership; the Maryland Water Monitoring Council; the Conowingo Pond Management Workgroup; and the Pennsylvania Section of the American Water Works Association. This outreach focused on briefing regional stakeholders on NOAA drought products and development of the *DPT*. Finally, project members gave presentations on this project at several national conferences.

Objectives

Project objectives included:

1. Developing a quantitative *Drought Planning Tool* for the Susquehanna River Basin based on the OASIS system simulation model and other tools.

2. Evaluating the use of the *Tool* to support water utility drought planning and operations.
3. Developing a set of methodologies for near-and medium-term predictions of drought likelihood.
4. Identifying key climate, other climate and other drought index parameters of importance in the Chesapeake Bay Region.
5. Developing practical guidance for NOAA drought products and a framework for implementation.

Outcomes

Model Outcomes

Various outcomes were found for each case study. This project work resulted in several concrete and technical outcomes, including specific operational changes for reservoirs, agreed-upon demand cutbacks, and how forecasting changes or supports decisions.

For Baltimore DPW (one case study), this project has already enabled changes to the allocation management for the Susquehanna River and has supported negotiations between the City and the Susquehanna River Basin Commission.

Participant Outcomes

The outreach and communication activities met the objectives by:

- Raising awareness of the *DPT* within the basin stakeholder community.
- Raising awareness of the NOAA early warning drought and forecast products within the Chesapeake Bay region.
- Soliciting peer review and guidance on *DPT* applications from the broader research and water resources communities.

Key lessons learned

This project was initiated to address a critical need for water resources planning in the Chesapeake Bay Region, and more specifically in the Susquehanna River Basin. Much of the drought planning in the region is done in silos with various divisions based on state and local requirements, industry, and individual objectives. The *DPT* works successfully to address these shortcomings because the platform provides a quantitative, simulation-based tool to evaluate alternative drought policies across multiple scales. It allows alternative planning or operations scenarios for individual entities that are then simulated in the overall basin, which allows recognition of the bigger impacts, and facilitates coordination of decision-making across the basin.

Inclusion of these products in the *DPT* enables evaluation of alternative drought mitigation policies triggered by index and forecast-informed measures of weather and basin conditions. The inclusion of existing drought indices and forecasts in the tool helps stakeholders emphasize proactive and “no regrets” policies for which performance can be predicted in a quantitative manner through DPT simulations.

Budget

Unknown. Funded by NOAA, matching funds noted to include $52,000 USD (in-kind labour) by the SRBC. There is no information on what the total budget was or the total matching amount.

Simulation tool/exercise used

This project included the development of *a Drought Planning Tool based* on the *OASIS* system simulation model (see section 4.2.11). The streamflow and precipitation are in daily timestep and allows for a climate change scenario to be represented in the data. The geographic scale is a basin/watershed, but crosses state boundaries.

Relevant literature and links:

National Oceanic Atmospheric Administration. (2017). Sectoral Applications Research Program (SARP) Final Report: Developing A Basin-Wide Framework for Drought Forecasting and Planning in the Chesapeake Bay Region. Accessed from https://www.srbc.net/our-work/programs/planning-operations/docs/drought-forecasting-planning-chesapeake.pdf

Hazen and Sawyer. (2021) Basin-Wide Framework for Drought Forecasting and Planning in the Chesapeake Bay Region, under "All Projects." Accessed from https://www.hazenandsawyer.com/work/projects/basin-wide-framework-for-drought-forecasting-and-planning-in-the-chesapeake/%20%20%20 https://www.srbc.net/our-work/programs/planning-operations/docs/drought-forecasting-planning-chesapeake.pdf

4.2 Simulation tools

The eleven tools described through this section are games or can be adapted to a game-style exercise. For a table breakdown of the tools for easy comparison, see Appendix C – Tools Summary Table.

4.2.1 Bow River Sim

Bow River Sim is a single-player desktop game developed by AEP and BGC Engineering. It has a user-friendly interface and fun visual elements that allow players to navigate the Bow River Basin (Figure 2) based on the *Water Resources Management Model (WRMM),* developed by AEP. The *WRMM* is a computer program that simulates water uses, priorities, and flows with a water allocation model using naturalized streamflow data from the South Saskatchewan River Basin from 1928-2009. It is a valuable decision-support tool due to its ability to allocate water resources according to the Alberta *Water Act* and has been used for numerous water studies at a local, regional, inter-provincial, and international scale. *Bow River Sim* runs on a simplified *WRMM* model with only 50 key water management components, allowing it to run quickly and provide players with more instant results. Through three different modes (tutorial, *WRMM*, and challenge), players are engaged in the water management planning process to improve their understanding of parameter constraints and influences on the Bow River basin. In the challenge mode, players aim to distribute water to stakeholders so that they all receive 100% of the requested amount.

Adjustable parameters include reservoir capacity, maximum reservoir levels for wet and dry seasons, City of Calgary water demand, return flows from different irrigation districts, inflows from the three tributaries (Bow, Elbow, and Highwood Rivers), percentage and volume of minimum flow apportionment, and priority of water licences. Data needed to run the tool are already built into it.

The game is not currently available for public distribution, however the AWC can likely gain access by contacting AEP or the current owner. Multiple participants can play *Bow River Sim* on separate computers simultaneously, allowing it to be used in a workshop setting. It has been tested at two workshops in Alberta, one in Calgary and one in Edmonton. Workshops were four hours in length to allow participants to explore the three different modes. The minimum number of participants is one, and the maximum is conceivably only limited by the number of computers available. The game could be played by individuals at home with discussion held by video-conference, allowing an exercise to align with COVID-19 health guidelines.

Figure 2 Screenshot from the *Bow River Sim* game.

Relevant literature and links:

Bow River Sim – A Serious Game for Water Management in the Bow River Basin. (2018, May 3). [Video]. YouTube. https://www.youtube.com/watch?v=pSEhUNqSFVo

Akhtar, M., C. Chevrotière, S. Tanzeeba, T. Tang, & P. Grover. 2020. A serious gaming tool: Bow River Sim for communicating integrated water resources management. Journal of Hydroinformatics. 22 (3): 491–509.

4.2.2 Invitational Drought Tournament

The *Invitational Drought Tournament* (*IDT*) is a multiplayer, in-person game developed by Agriculture and Agri-Food Canada where teams of players work competitively to develop solutions to a drought scenario (Figure 3). Teams must manage water resources with competing budgetary, cultural, regulatory, and institutional constraints. Teams are provided with background information regarding the watershed and work through three to four rounds with site-specific scenario drought data to develop a management plan that is environmentally, economically, and socially sustainable. The *IDT* framework was originally developed for two semi-fictitious basins, one based on a prairie watershed and the other on a sub-watershed in the Okanagan, British Columbia. The *IDT* framework can be adapted to create different iterations of the game based on different river basins. The amount of data required will depend on the detail and complexity of the basin setting and the drought scenario. Using one of the scenarios that was previously developed for a fictional basin may require less new data.

To provide players with more instantaneous feedback, the *IDT Model* was developed to accompany the *IDT*. The model simulates short-term and long-term effects that various policy combinations have on land use and water balances within the basin. The game is designed to be run through a one-day workshop and should be coordinated with technical personnel. Cost of the workshop is unknown and likely to be highly variable. The *IDT* was originally tested in Calgary, Alberta, in 2011 with 46 participants, and has also been tested since, with and without the *IDT Model*, in Saskatoon, Saskatchewan (2012; 49 participants), Kelowna, British Columbia (2012; 53 participants), Colorado (2012; 40 participants), and Lincoln, Nebraska (2015; 32 participants).

The *IDT* framework can be used to create a single game scenario that can be run at multiple events across the province. It can also be used to develop one technical and one non-technical version of the same scenario, aimed for different objectives and participants. A tournament game held based on the *IDT* framework is best suited to 12 to 60 participants per event. It would not be possible to host a tournament entirely virtually; however previous examples have had some attendees participate virtually.

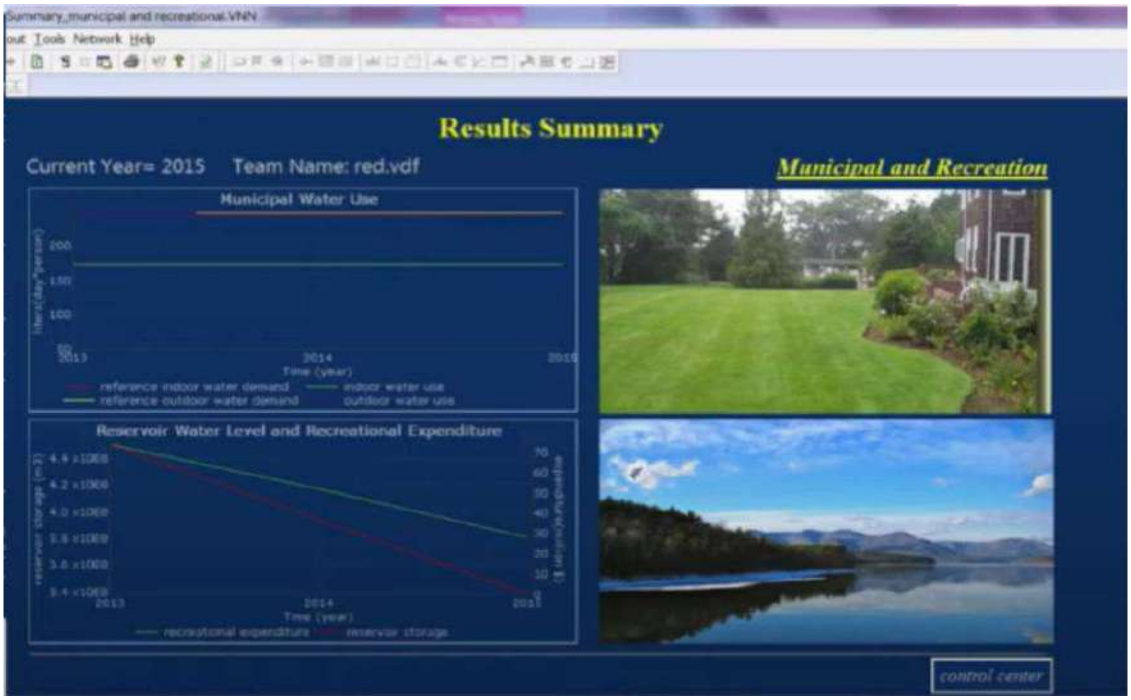

Figure 3 Screenshot from the Invitational Drought Tournament accompanying IDT Model.

Relevant literature and links:

Hill, Harvey, M. Hadarits, R. Rieger, G. Strickert, E. Davies, & K. Strobbe. 2014. The Invitational Drought Tournament: What is it and why is it a useful tool for drought preparedness and adaptation? Weather and Climate Extremes. 3: 107 – 116.

Wang, K. & E. Davies. 2015. A water resources simulation gaming model for the Invitational Drought Tournament. Journal of environmental management. 160: 167 – 183.

Drought Policy Modelling: The Invitational Drought Tournament Model. (2013, July 11). [Video]. YouTube. https://www.youtube.com/watch?v=JJUvkFGzRc4

Okanagan Basin Water Board ,2012. Okanagan Invitational Drought Tournament. https://www.obwb.ca/workshops/okanagan-invitational-drought-tournament/

4.2.3 Aqua Republica

Aqua Republica is an online, single-player game created by DHI and the UNEP-DHI Centre for Water and Environment. *Aqua Republica* takes place in a fictitious world created with real-world data where players compete to manage limited water resources and a growing demand (Figure 4). Players must manage population increases, social pressures and competing water demands, as well as environmental and economic impacts in response to decisions made. Players learn water management best practices, integrated water resources management, and ecosystem-based approaches. The developer, DHI, can customize the game to different geographical locations, water data, scenarios, and learning objectives.

The original version should be available for free, although at the time of writing the website was no longer operational. The game was developed based on MIKE BASIN software, a map-based tool that supports water resource decision making processes. The game has been played in numerous countries and was part of the Eco Challenge where students compete to have the highest score in creating a prosperous basin. There is no evidence that the game has been played in Alberta in a formal workshop setting.

The game is designed for a single player on a single computer, however multiple participants can group around a table to discuss and play the game on a single computer. Multiple tables of participants could also play in a workshop setting. The game could be played by individuals at home, with discussion held by video-conference, allowing an exercise to align with COVID-19 health guidelines. The minimum number of participants is one, and the maximum is conceivably only limited by the space and number of computers available.

Aqua Republica is designed to facilitate players' understanding of how integrated and complex decision-making is with social, economic, environmental and political factors at play. The pre-built versions do not require any data inputs. A version with Alberta context and more specific types of drought-scenario objectives could be developed with the support of the developers, which would require the provision of significant amounts of data.

Figure 4 Screenshot from the Aqua Republica game.

Relevant literature and links:

CWR, 2013, Aqua Republica: Water Strategems. China Water Risk. https://www.chinawaterrisk.org/opinions/aqua-republica-water-strategems/

DHI, 2013,. Our Aqua Republica uses serious gaming to improve water resource management. https://www.dhigroup.com/global/news/imported/2013/10/4/ouraquarepublicausesseriousgamingtoimprovewaterresourcemanagement

DHI., 2013a,. Aqua Republica [Slides]. Australian Water Association. http://www.awa.asn.au/documents/WA_Conference_June2016/02_PBhautoo_Innovative_teaching_of_sustainable_water_management.pdf

Games4Sustainability., 2018,. Aqua Republica. https://games4sustainability.org/gamepedia/aqua-republica/

4.2.4 Ready for Drought?

"Ready for Drought?" is an in-person role-playing game based on the game *Extreme Event.* Players work collaboratively to solve community problems during a drought in order to build community resilience. Players learn to assess and respond to droughts by prioritizing resources and building coalitions. *Ready for Drought?* was created by the National Drought Mitigation Center and can be played in as little as 90 minutes and accommodates 12-24 players. The game can be downloaded for free and includes instructions (Figure 5).

The game takes place in the Missouri River basin and parameters of the game cannot be changed easily to another basin. The game is based on the drought planning decision-support model *THIRA (Threat and Hazard Identification and Risk Assessment)*. It has been tested at University of Nebraska-Lincoln and drought-related meetings, including the Natural Resource District drought planning meeting, the Federal Emergency Management Agency (FEMA) Region 8 drought workshop, and the North Central Agricultural and Natural Resources Academy. It is not believed that the game has been played in Alberta in a formal workshop setting.

If this style of in-person, role-playing game is appealing to the AWC, it may be possible to create a very similar version of the game based on a real or fictitious watershed of Alberta.

"Ready for Drought?" is a pre-build game and does not require any data inputs. It is designed to be played around a table in person and does not seem to be adaptable to video-conference to align with COVID-19 health guidelines.

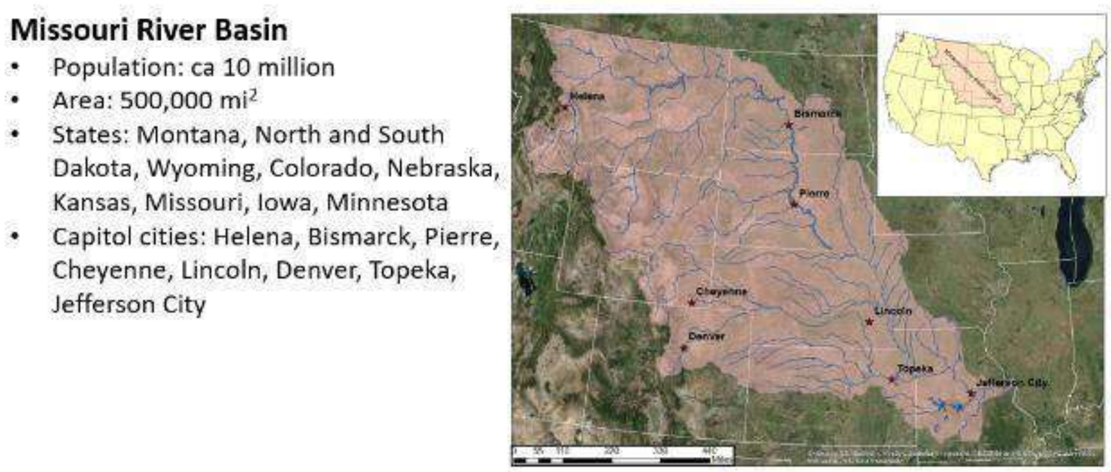

Figure 5 Screenshot of some of the materials provided with the Ready for Drought? download.

Relevant literature and links:

Podebradska, M., M. Noel, D. Bathke, T. Haigh, & M. Hayes. 2020. Ready for Drought? A Community Resilience Role-Playing Game. Water. 12. 2490. 10.3390/w12092490.

NDMC, n.d., Ready for Drought? A community resilience role-playing game. National Drought Mitigation Center. https://drought.unl.edu/Education/DroughtGame.aspx#:%7E:text=About%20the%20Game,drought%20%2D%20building%20a%20community%20resilience.

4.2.5 Water Wars

Water Wars is a 3D desktop, multiplayer role-playing strategy game developed by Intel that takes place in New Mexico along the Rio Grande (Figure 6). Players manage land parcels in several different roles, including farmers, developers, and policymakers, and must manage their water allocations accordingly. As players are presented with different water scenarios with unique problems, players must make hard decisions and negotiate with each other for water resources. Existing policies that are based on real-world policy scenarios detail how water resources are allocated and governed and can be altered by the policy maker during the game. *Water Wars* provides an opportunity for players to think critically and to negotiate policy under various water scenarios; however, the game does not appear to be available currently. There is no evidence that the game has been played in Alberta in a formal workshop setting.

There is limited information regarding the access to, or availability of this game, but the AWC may be able to gain access by contacting the developer or current owner. The game is pre-built, does not require data, and parameters cannot be changed. It is not clear what the minimum number of players required is, or if this game can be played in a way that aligns with COVID-19 health guidelines.

Figure 6 Screenshot from the Water Wars game, taken from Hirsch (2010).

Relevant literature and links:

Hirsch, T., 2010. Water wars: designing a civic game about water scarcity. In: Proceedings of the 8th ACM Conference on Designing Interactive Systems. ACM, Aarhus, Denmark, pp. 340-343.

United Nations. (n.d.). Water Wars. UN Framework on Climate Change. https://www4.unfccc.int/sites/NWPStaging/Pages/item.aspx?ListItemId=24053&ListUrl=/sites/NWPStaging/Lists/MainDB

4.2.6 Catchment Detox

Catchment Detox is an online single-person game where the player manages a fictitious watershed while simultaneously trying to create a strong economy (Figure 7). The game was developed by the Australian Broadcasting Corporation and is available online for free to help educate players about the challenges of balancing catchment-scale environmental issues, economic impacts, and population growth. Players are given 100 turns and are scored based on their ability to balance development with environmental demands. The game is based on a model developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Division of Land and Water and e-water Co-operative Research Centre and parameters cannot easily be changed by players. It is not believed that the game has been played in Alberta in a formal workshop setting.

The game is designed for a single player on a single computer; however multiple participants can group around a table to discuss and play the game on a single computer, and multiple tables of participants could play in a workshop setting. The game could also be played by individuals at home with discussion held by video-conference, allowing an exercise to align with COVID-19 health guidelines. The minimum number of participants is one, and the maximum is conceivably only limited by the space and number of computers available.

Catchment Detox is a pre-build game and does not require any data inputs. The parameters of the game cannot be changed.

Figure 7 Screenshot from the Catchment Detox game.

Relevant literature and links:

Alhadeff, E., 2010, Online Water Conservation Serious Game. Serious Game Market. https://www.seriousgamemarket.com/2010/02/online-water-conservation-serious-game.html
Australian Broadcasting Corporation, 2008, ABC Catchment Detox - FAQs. ABC Science. https://www.abc.net.au/science/catchmentdetox/files/faq.htm#faq

4.2.7 WAT-a-GAME

WAT-a-GAME is a multiplayer, in-person game where players manage land plots in a watershed and must make decisions on how to utilize their land and water resources. The game consists of spatial structures such as river segments, land plots, pipes, aquifers, and cards, all of which can be printed or drawn, or purchased in the "all-in-one" kit for €50. There are several versions of the game currently available. The *"Self-WAG"* version of the game (short for *Self-WAT-a-GAM*E; Figure 8) has been designed to be flexible in nature and allow the game to be adapted to suit local situations. The game is designed to run for approximately a half day, and courses and instructions are available online to help set up and run the game. The game has been used in a number of countries but there is no indication that the game has been played in Alberta in a formal workshop setting.

This is a pre-build game and does not require any data inputs. Depending on which version is being played, the minimum number of players is one and the maximum number is 150. It is designed to be played around a table in person and does not seem to be adaptable to video-conference to align with COVID-19 health guidelines.

Figure 8 Photo of some of the spatial structures that can be purchased in the "All-in-one" kit version of WAT-a-GAME.

Relevant literature and links:

Ferrand, N. S. Farolfi, G. Abrami, D. Du Toit. WAT-A-GAME: sharing water and policies in your own basin. 40th Annual Conference, Int. Simulation and Gaming Association, Jun 2009, Singapour, France. 17 p. ffhal-01355501

WAT-A-GAME, n.d., WATaGAME. https://sites.google.com/site/waghistory/

4.2.8 Run the River

Run the River is a single player game created by Unity and the Australian Government (Murray-Darling Basin Authority) for use on a desktop or smartphone and is free to download. Players allocate river water to different water uses in a basin, such as agriculture, ecosystem health, or human use, and try to keep the connection between the river and the ocean (Figure 9). At each level of the game, the difficulty increases with challenges in the form of natural disasters, seasonal changes, and increased water demand. The game was developed based on historic and modelled data from the Murray–Darling Basin from 1905 to 2006. The game parameters are not adjustable, and it is unknown if the game has been played in Alberta in a formal workshop setting, though it is unlikely given that it is a simplified game and is more ideal as an educational tool for a younger audience.

This game is pre-built, no data input is required, and parameters cannot be changed. The game is designed for a single player, but likely could be conducted in a workshop discussion setting. It could be played by individuals at home with discussion held by video-conference, allowing an exercise to align with COVID-19 health guidelines.

Figure 9 Screenshot from the *Run the River* game.

Relevant literature and links:

Games4Sustainability., 2018b, Run the River. https://games4sustainability.org/gamepedia/run-the-river/

Murray-Darling Basin Authority, 2018, Teacher supplement: Run the river. https://www.mdba.gov.au/education/apps/run-the-river/teacher-guide

4.2.9 CAULDRON (Climate Attribution Under Loss & Damage: Risking, Observing, Negotiating)

CAULDRON is an in-person game developed by the Environmental Change Institute, University of Oxford, AfClix (the Africa Climate Exchange), and the University of Reading in partnership with the Red Cross Climate Centre. The purpose of *CAULDRON* is to create discussion around extreme weather events and how they may impact policy development. Players begin as farmers that need to make decisions and roll dice to determine their success in response to various climate challenges, then become climate scientists, and finally policy makers that need to negotiate a climate change treaty for their region. Designed to be played in 90 minutes and accommodate between 24 – 80 players, the game is free though parts need to be constructed in advance. Three variations are currently available with online facilitation guides. It is not believed that the game has been played in Alberta in a formal workshop setting.

This is a pre-build game, does not require any data inputs, and game parameters cannot be changed. It is designed to be played around a table in person and does not seem to be adaptable to video-conference to align with COVID-19 health guidelines.

Figure 10 Screenshot of some of the materials available online to support the CAULDRON game.

Relevant literature and links:

Walker Institute, n.d., The CAULDRON Game is a free, Climate Change game. http://www.walker.ac.uk/research/projects/the-cauldron-game

University of Reading, AfClix, EQUIP, ECI, University of Oxford, & Red Cross/ Red Crescent Climate Centre, n.d., The CAULDRON Game Climate Attribution Under Loss & Damage: Risking, Observing, Negotiating [Slides]. Walker Institute. http://www.walker.ac.uk/media/1093/2-cauldronslides_version1.pdf

University of Reading, 2015, The CAULDRON Game Climate Attribution Under Loss & Damage: Risking, Observing, Negotiating. Walker Institute. http://www.walker.ac.uk/media/1092/1-cauldronrules-main-document.pdf

4.2.10 SeGWADE (*Serious Game for WDS Analysis, Design & Evaluation*)

SeGWADE is an online, web-based game developed by the University of Exeter, Centre for Water Systems. It is driven by a hydraulic simulation engine based on EPANET, a water-distribution system modelling software, and was developed to help players learn to optimize water distribution systems. The goal of the game is to change the diameter of pipes along a water distribution system to find the most cost-effective configuration that meets pressure requirements. Multiple versions are available for free, custom versions can be created by changing input files, and the game can be set up as single- or multi-player. There is no evidence that the game has been played in Alberta in a formal workshop setting.

The game is designed for a single player on a single computer; however multiple participants can group around a table to discuss and play the game on a single computer, and multiple tables of participants could play in a workshop setting. The game could be played by individuals at home, with discussion held by video-conference, allowing an exercise to align with COVID-19 health guidelines. The minimum number of participants is one, and the maximum is conceivably only limited by the space and number of computers available.

SeGWADE is designed to facilitate a player's understanding of water distribution systems. The pre-built versions do not require any data inputs. Custom versions require data.

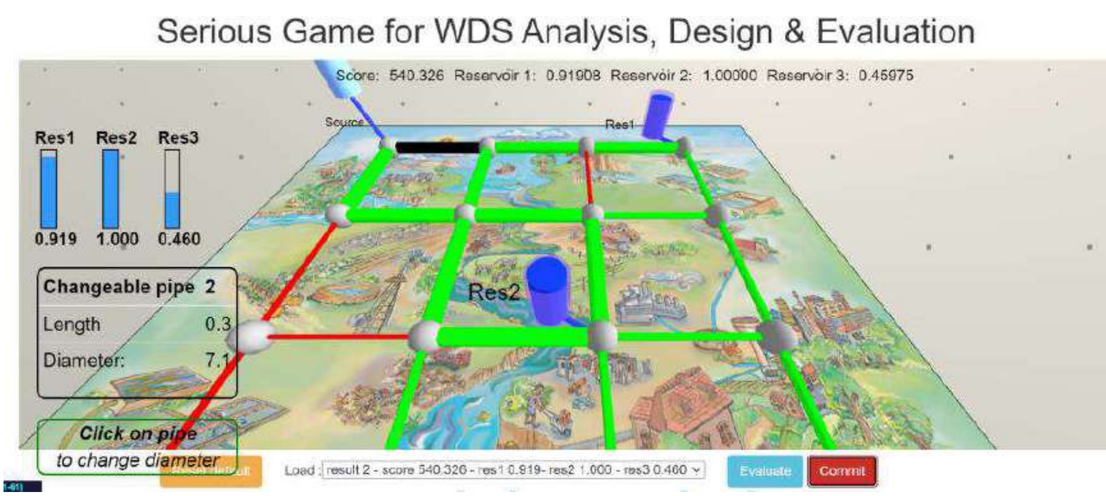

Figure 11 Screenshot from the SeGWADE game.

Relevant literature and links:

Khoury, M., M. Morley, & D. Savic. 2016. Serious Game Approach to Water Distribution System Design and Rehabilitation Problems. Procedia Engineering 186: 76 – 83.

University of Exeter, n.d., Serious Game for WDS Analysis, Design & Evaluation. Water Serious Games. http://waterseriousgames.org/

4.2.11 *OASIS (Options Analysis in Irrigation Systems)*

The *OASIS (Options Analysis in Irrigation Systems)* model was developed by Hydrologics Inc. in 2009. It is an arc and node type model which simulates the flow of water through a multi-user watershed. *OASIS* allows the user to define water management systems in a watershed by setting up an arc-node system and by defining a set of operating goals, constraints, and performance measures. User defined inflows can be entered into the model as well.

OASIS typically functions at hourly to monthly time steps and can be applied to variably sized basins from small and simple to large and complex. Generally, the model runs quickly (in a matter of minutes) and is designed to be very flexible. Multiple scenarios can be created which allow for simulation of different operating rules and implementation of alternative management scenarios.

Past examples of *OASIS'* real world application extends to its use in the Bow River Project, the South Saskatchewan Adaptation Project, and the Athabasca River Basin Initiative. *OASIS* has also been applied to investigate how climate change will affect water storage in the New York City Water Supply System. Although *OASIS* has been deemed a good example of a computer-aided negotiation tool, it is not necessarily set up as a game and therefore may not be as intuitive or engaging to use. The tool can be used by an individual or to support large groups in a workshop style.

The *OASIS* tool is a versatile building block and can be used to create a simulation of one or multiple watersheds with whatever level of detail is appropriate to gain the desired objectives from an exercise. Potentially one of the models already developed for an Alberta watershed could be simplified and adapted for the AWC's purposes. A collaborative or competitive game-style drought exercise could be designed with a simple *OASIS* model as the supporting tool.

This tool requires data inputs including flow data. It may be possible to design an exercise that participants could attend via video-conference. This would allow some networking and cross-sectoral collaboration, which is currently being done for more specific watershed projects; however, this exercise is more compelling when in person networking and cross-sectoral collaboration is possible.

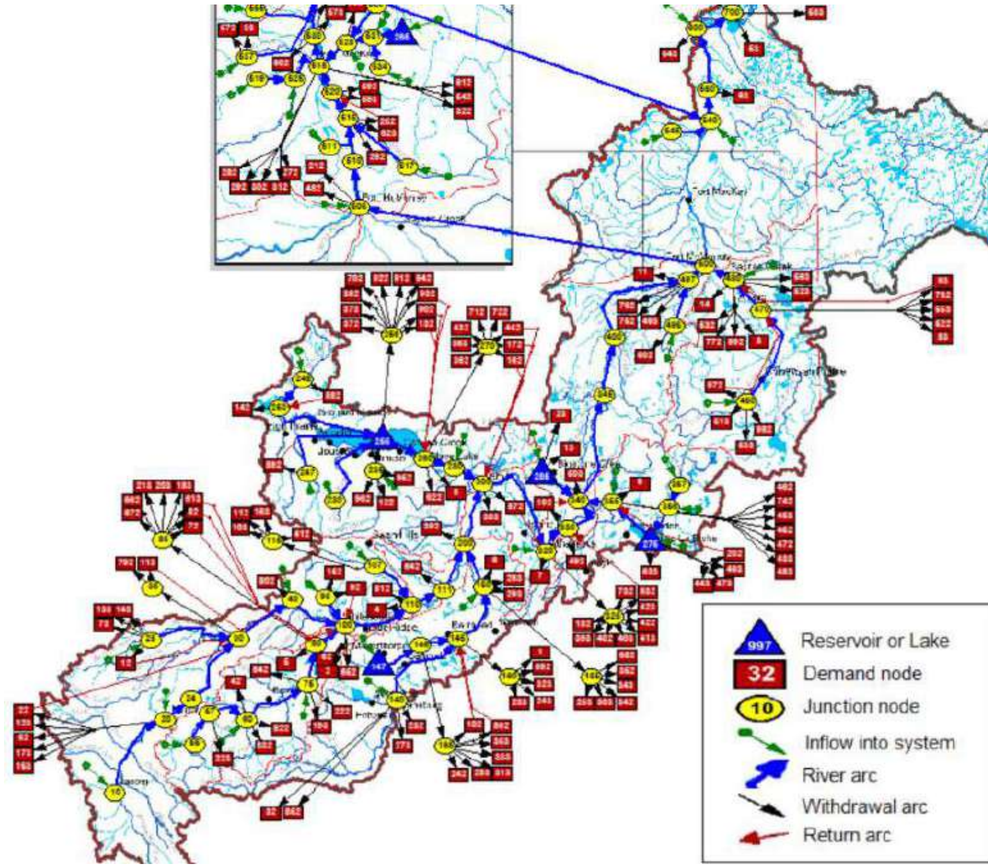

Figure 12 Screenshot of the graphical user interface for a version of the OASIS model

Relevant literature and links:

Kelly, M. 2012. The Bow River Project: An Exercise in Water Management, Resource Protection, and Collaborative Decision Making. http://www.hydrologics.net/documents/TheBowRiverProject.pdf

University of Lethbridge. 2014. The History of OASIS use in Alberta. http://www.uleth.ca/research-services/node/432/#history

WaterSMART. 2014. South Saskatchewan River Basin Adaptation to Climate Variability Project. Phase III: Oldman and South Saskatchewan (OSSK) River Basins Summary Report. 113 pp.

WaterSMART Solutions Ltd. 2018. A Roadmap for Sustainable Water Management in the Athabasca River Basin. Produced by WaterSMART Solutions Ltd. for Alberta Innovates, Calgary, Alberta, Canada. 247 pages. http://www.albertawatersmart.com/

Matonse, A.H., Pierson, D.C., Frei, A., Zion, M.S., Schneiderman, E.M., Anandhi, A., Mukundan, R., and Pradhanang, S.M. 2011. Effects of changes in snow pattern and the timing of runoff on NYC water supply system. *Hydrol. Process*. 25, 3278–3288. DOI: 10.1002/hyp.8121

Rivera, M.W. and Sheer, D. 2013. Computer Aided Negotiation and River Basin Management in the Delaware. Chapter 7 p 66 in Water Resources Systems Analysis through Case Studies; Data and Models for Decision Making. Prepared by Task Committee on Environmental and Water Resources Systems Education. Edited by David W. Watkins Jr., Ph.D. Sponsored by Environmental and Water Resources Institute American Society of Civil Engineers.

5.0 Summary and Observations

5.1 Drought management review

The regulatory framework and approach to drought management was reviewed in four jurisdictions. The review noted that Alberta and Saskatchewan have a more prescriptive regulatory framework than in the two U.S. jurisdictions reviewed. Both provinces use a priority-based system allowing government some control over total water withdrawals during low flow periods. This type of regulatory framework, with certain conditions on water licences, can support sharing water between users during a shortage. This approach can also be supplemented by voluntary agreements between water users such as those seen in Alberta on the Southern Tributaries during the 2001 drought.

Historically, in both Alberta and Saskatchewan, drought planning and response has been the basis for decisions about infrastructure and the design of regulatory systems for water management, as both provinces are drought prone. However, neither Alberta nor Saskatchewan has implemented a formal, provincial drought response plan. Alberta has implemented water shortage procedures and water management plans in basins impacted by severe historical droughts. In both provinces, the agriculture sectors have been most seriously impacted by droughts. As a result, in Saskatchewan historical drought response has focused on mitigating the impact of drought to agriculture through various methods including the development of irrigation infrastructure.

In both South Carolina and California, the regulatory framework is less prescriptive than Alberta or Saskatchewan. In these states, certain high volume water users or industries do not require permits to access surface or groundwater resources, meaning, historically, there was no regulatory instrument to reduce water consumption during periods of water shortage. During droughts, this type of regulatory framework has the potential to result in water conflicts that must be resolved through the courts. In addition, regulators cannot apply conditions to the withdrawals of smaller water users which has the potential to lead to excessive withdrawals and result in environmental damage. To mitigate conflict and the potential for excessive withdrawals, both states require stakeholders to be actively involved in the development and implementation of drought response plans. This collaborative approach allows discussion and compromise between stakeholders so that water can be shared in times of drought. The resulting drought plans are localized and highly detailed, and prescribe communication and reporting pathways as well as operational responsibilities at different stages of drought.

The review of historical drought simulation exercises showed that a simulation exercise can be an effective way to increase drought awareness and preparation when a drought is currently not being experienced. Keeping drought awareness front of mind in non-drought times may be beneficial to drought mitigation and response.

Relevant literature:

Government of Saskatchewan. (2005). *The Water Security Agency Act*. Regina, Saskatchewan.

Marchildon, G. P., Kulshreshtha, S., Wheaton, E., & Sauchyn, D. (2008). Drought and institutional adaptation in the Great Plains of Alberta and Saskatchewan, 1914–1939. *Natural Hazards, 45*, 391-411. doi:10.1007/s11069-007-9175-5

Saskatchewan Ministry of Environment. (2018). *Saskatchewan's Climate Resilience Measurement Framework* (Government of Saskatchewan, Saskatchewan Ministry of Environment). Regina, Saskatchewan.

Saskatchewan Water Security Agency. (2012). *25 Year Saskatchewan Water Security Plan* (Government of Saskatchewan, Saskatchewan Water Security Agency). Moose Jaw, Saskatchewan: Saskatchewan Water Security Agency.

Saskatchewan Water Security Agency. (n.d.). Retrieved January 25, 2021, from https://www.wsask.ca/About-WSA/About/

5.2 Case study and simulation tool review

The most successful simulation exercises had focused agendas that aimed to achieve only one or two specific outcomes from the exercise. Centering the objectives this way encouraged participants to ask specific questions pertinent to the exercise goals and for participants and organizers to manipulate the exercise tools effectively to answer those questions. This approach encourages discussion amongst participants and may result in other secondary beneficial outcomes. A good example of this was reported with the South Carolina Tabletop Exercise where the primary outcome was for stakeholders to understand how to implement their drought response plan, but participants reported secondary outcomes including an improved knowledge of other stakeholder roles and responsibilities in the context of drought response.

Simulation exercises using game-style tools such as *AquaRepublica* are well suited to collaborative learning and education. Game-style tools are often very visual with user friendly interfaces that allow the user to change certain parameters to achieve simple objectives. These game-style tools are frequently tailored to cater to participants who have limited technical knowledge of watershed operations and drought management and are useful for increasing awareness and understanding amongst non-technical people. Game-style tools are often simplified so only certain parameters can be changed by the user. This approach has the advantage that scenarios can be run quickly using a web-based interface or even on portable devices; however, scenarios are less realistic as they do not pull from an extensive background dataset.

More complex tools such as the *IDT* and *OASIS* are highly adaptable for use in different workshop types. They are also well suited to use in workshop style exercises that require realistic basin operations to be understood by participants, for example when testing basin operations during a drought or during development of basin drought plans. In exercises where there is a requirement for realistic simulations, there may be many parameters within the tool that can be changed, and a large background dataset may be required to simulate realistic basin operations. Simulations of multiple basins or at the provincial scale may require greater computer processing power meaning it may not be possible to run live scenarios during a workshop. In this case, the simulation developer would need to run the scenarios ahead of the exercise and graphical scenario outputs would form part of the workshop discussion.

The themes that are identified in the AWC report "*Building Resiliency to Multi-Year Drought in Alberta*" align with what could be determined to be the objectives for the simulation exercise. For example, Theme I – Public Education and Theme J – Collaboration, align very well with most game-type exercises. Theme B – Planning for Drought, Theme C – Supply Management, and Theme D – Demand Management may be partially addressed through a simulation exercise; however, they likely cannot be achieved with the same game-style tools as Themes I or J.

'Education' or 'raising awareness' are common objectives for drought simulation exercises. These are easily achievable objectives; however, for the outcomes of the simulation exercise to be measurable and valuable, it is important to specify the type of education or awareness desired and who the audience is that is learning. The tools themselves may all be deemed educational in one way or another, but they vary widely in what is being learned by the players.

The educational tools assessed in this project point to two very different types of educational tools. The first type are 'general drought understanding' educational tools. These tools help players or participants gain a general appreciation for the complexity of drought and water management, and they may understand some aspects of who makes decisions or what factors must be considered in drought management. The 'general drought understanding' tools can support understanding, but generally not action or direct engagement in drought management systems. The second group of tools might be called 'Alberta-specific drought understanding' tools. These tools support the player or participant learning specific parts of the water management system in Alberta and understanding concrete roles, actions and options for drought mitigation. These types of educational tools may support a wide range of engagement and practical action. One major difference between these two types of tools is cost; a 'general drought understanding' tool can be adopted from another developer, but a tool or game that is for 'Alberta-specific drought understanding' will require adjustments to the game at minimum. The tool may need to be essentially redeveloped to facilitate the type of education desired, and if additional outcomes from the overall simulation exercise are desired, this will need to be included in the tool re-design.

6.0 Recommendations

6.1 General approach to exercise development

The simulation tool that will be used to engage participants will be the foundation of the AWC simulation exercise. Selection of an appropriate tool should support the desired outcomes from the exercise and provide a valuable step towards the strategic intent of improving drought response within Alberta.

Figure 13 outlines the recommended approach to selecting an appropriate tool to support the AWC simulation exercise.

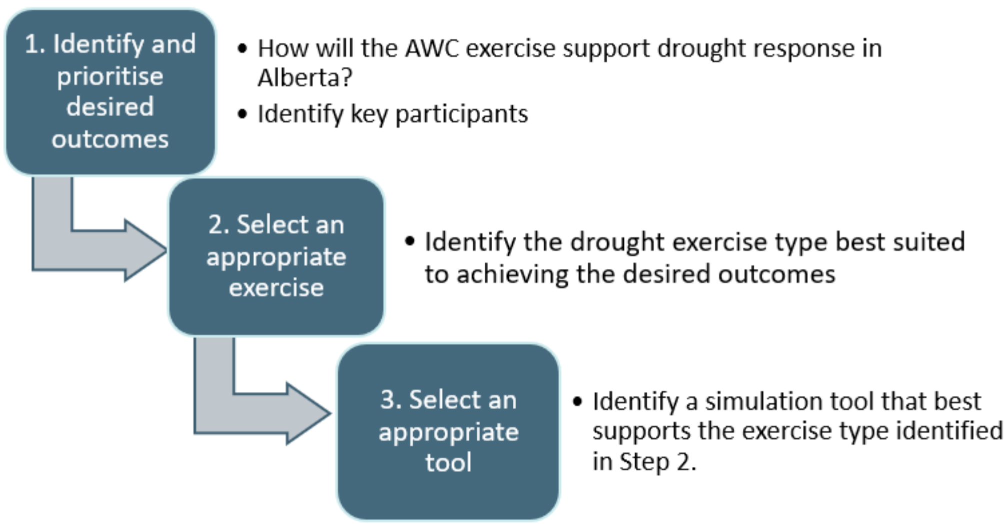

Figure 13 Recommended approach for selecting an appropriate simulation tool to support the AWC Simulation Exercise

The first step in the tool selection approach is identifying the desired outcomes from the AWC project. In the workshop held with the AWC Simulation Project Team on January 15th, 2021, the AWC Project Team identified that the broad desired outcome was to support the development of the provincial drought response plan currently being developed by the AEP. In addition, the following potential outcomes were highlighted as being of interest to the project team:

- Identifying strengths and weaknesses (costs and benefits) of various strategies for solving problems.
- Increasing awareness (e.g., informing, education) around water resources management and

drought management procedures.
- Building relationships, partnerships, collaboration, and coordination.
- Engaging stakeholders in planning and decision-making.
- Improving cross-sectoral communication and collaboration.
- Generating innovative mitigation and response strategies.

It is recommended that the project team select up to two of these outcomes as high priority, primary desired outcomes for the AWC Simulation Exercise. Selection of only two primary desired outcomes will allow for the optimal design of the simulation exercise and the creation of game scenarios that will focus discussion and make it much easier to achieve the outcomes as well as measure the success of the exercise. Selection of two high priority, primary outcomes is not to restrict the number of beneficial outcomes from the exercise, but to keep focused. Additional and overlapping secondary outcomes may also be achieved from the exercise. These secondary outcomes can also be considered as part of the selection process but are assigned a lower priority.

After selecting the primary desired outcomes, it is recommended that AWC consider which groups of participants should attend the exercise to best support the desired outcomes. While planning the simulation exercise, it is important to consider who the participants will be and their level of technical knowledge to ensure there is adequate time for participants to effectively engage and to avoid overloading them with information. For exercises based on the *IDT* framework (case studies in 4.1.3 and 4.1.4), the selection of participants and game team makeup were important elements of designing the exercise and achieving the desired outcomes.

It is understood that the AWC Simulation Exercise will engage stakeholders who have some technical watershed background; however, if a more technical outcome is desired there may be a need to provide an informational package or session to participants who may have limited technical knowledge.

Identifying the primary outcomes and considering participants will allow the AWC Project Team to identify the main focus or theme of the simulation exercise outlined in Step 2 of Figure . Once the main focus of the exercise is well understood, a tool can be selected that is suited to supporting the focus of the exercise as well as achieving the primary desired outcomes identified in Step 1 of the process.

Table 2 shows some examples of different exercise types and the requirements that supporting tools must have to achieve the desired goals.

Table 2 Examples of exercise types and desirable tool attributes.

Main exercise focus	Exercise description	Potential tool attributes
Broad educational	Non-technical participants would be educated about the general risks of droughts and some of the types of considerations required in managing drought risk.	• Visual interface • Minimal parameters • Do not overload the user with information • Does not need to be basin-specific
Specific educational	Participants may have a basic understanding of drought risk and the focus would be to educate participants on a specific aspect of drought management e.g., the regulatory framework governing drought management, drought plans or roles and responsibilities in a drought.	• Visual interface • Reflects basin operations to the extent necessary to achieve the educational goal
Vulnerability and risk assessment	A technical exercise in which stakeholders and water managers with a depth of knowledge of drought management assess current mitigation processes and identify gaps in plans, policy and legislation that could be addressed to improve drought resilience.	• Realistic representation of basin operations • Realistic present and future climate scenarios • Does not necessarily require a simple user interface
Drought plan testing	A technical exercise in which participants test a specific plan or procedure and identify any improvements that could be made. Participants would likely represent a broad spectrum of water stakeholders with interest in the outcomes	• Capable of realistic scenarios • Easily manipulated to create many scenarios

6.2 Exercise tool selection

It is recommended that when reviewing the tools and identifying which contains the greatest number of desired attributes, the attributes of each are considered individually in the context of how each can support the exercise as well as compared to one another.

6.2.1 Individual assessment of tools

Many tools, including most game-style tools, have been developed for specific purposes; however, many can be adapted to support simulation exercises. Comparison of the features of each tool in the context of the main focus of the exercise and the primary desired outcomes will help narrow the list of tools and identify which groups of tools are most suitable. Table 3 shows some examples of tools that could be grouped with certain exercise types based on how their attributes match the desired attributes identified in Table 2.

Table 3 Example of matching tools to suitable exercises.

Main exercise focus	Exercise description	Example tools with attributes suitable to supporting project goals
Broad educational	Non-technical participants would be educated about the general risks of droughts and some of the types of considerations required in managing drought risk.	• *CAULDRON* • *Catchment Detox* • *Run the River*
Specific educational	Participants may have a basic understanding of drought risk and the focus would be to educate participants on a specific aspect of drought management e.g., the regulatory framework governing drought management, drought plans or roles and responsibilities in a drought.	• *Bow SIM* • *Aqua Republica*
Vulnerability and risk assessment	A technical exercise in which stakeholders and water managers with a depth of knowledge of drought management assess current mitigation processes and identify gaps in plans, policy and legislation that could be addressed to improve drought resilience.	• *OASIS* • *BowSIM* • *IDT*
Drought plan testing	A technical exercise in which participants test a specific plan or procedure and identify any improvements that could be made. Participants would likely represent a broad spectrum of water stakeholders with interest in the outcomes.	• *OASIS* • *IDT* • Paper based *(WATaGAME)*

6.2.2 Comparison of tools

When assessing the suitability of tools, it is important to consider how tools compare to one another, not only in the context of their suitability to achieve the desired outcomes, but also in how well they fit within the boundary conditions of the AWC Simulation Exercise project as a whole. Boundary conditions include considerations such as project timeline, project budget and the spatial area the project will cover.

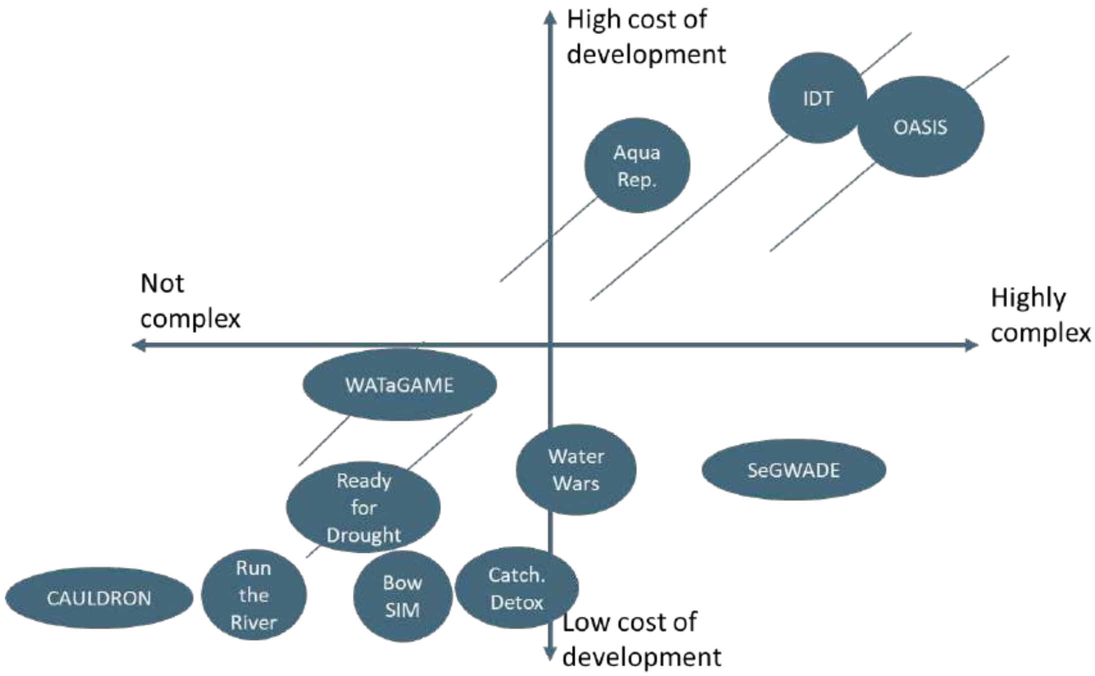

Figure 14 Simulation tools comparison of scenario development cost vs. complexity of the scenario

Figure 14 shows an approximate comparison of the potential cost of certain tools compared to the potential complexity of the scenarios run by the tool. For some tools, a range of costs is associated as they are capable of scenarios varying in complexity and cost of development. This is represented in Figure by the blue lines associated with each bubble. Game-style tools often have fixed scenarios that may be adaptable but cannot be changed. If scenarios are fixed, then the development costs associated with creating an exercise are lower; however, it should be noted that if the AWC were to request the developer adapt the game-style tools to be more specific to Alberta, development costs could increase.

Another comparison that could be made is assessing the tool's intended audience compared to the original goal of development. Tools are always best suited to the audience they were originally developed to address; understanding the intended audience can help match tools to relevant exercise types. Figure 15 shows the intended audience of the tools reviewed in section 4.2 compared to the outcomes that are realistically achievable with the tool. Tools in the bottom left quadrant tend to be more suited for education and understanding as they use simplified scenarios with user-friendly interfaces. Tools in the top right quadrant are suited to decision making and driving policy and tend to be suited to those who already have a technical understanding of drought and watersheds.

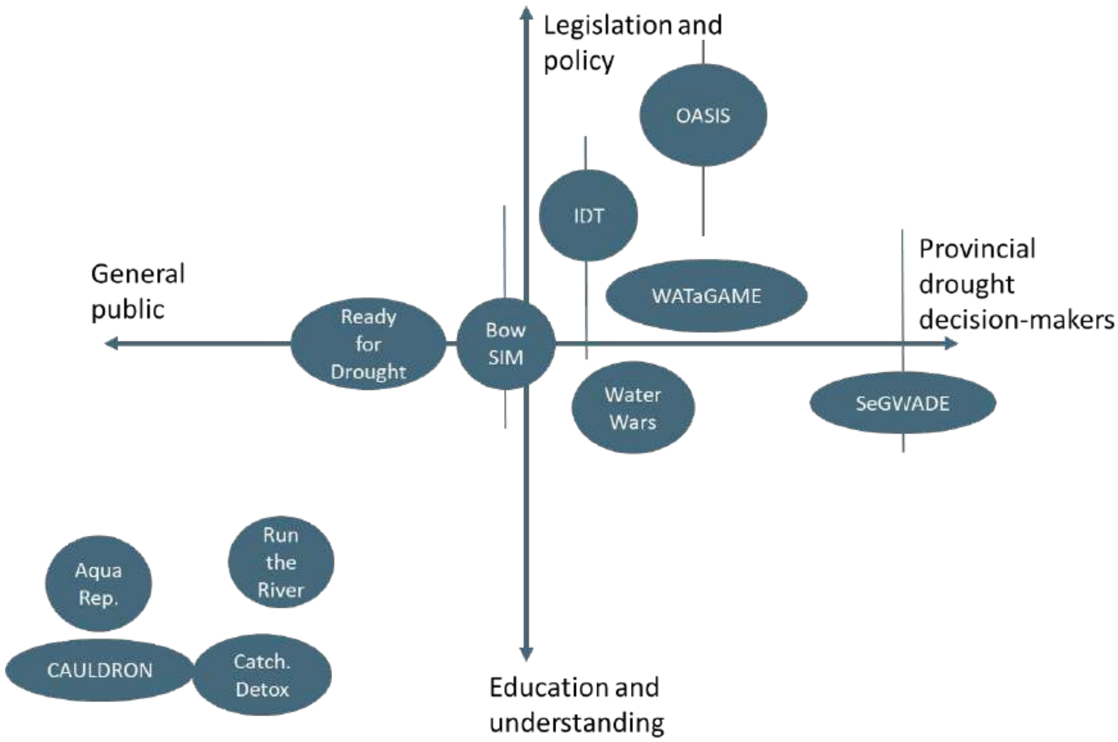

Figure 15 Comparison between the intended audience of tools vs. realistically achievable outcomes from tool scenarios

6.3 Additional considerations

It is recommended the AWC Project Team consider external factors in their exercise and tool selection that could impact the implementation or attendance of the exercise, such as the restrictions currently in place due to the COVID-19 pandemic. The restrictions have resulted in many people working from home which can limit or prevent attendance at in-person events and workshops. Whether the event will be held in-person or virtually is a key consideration as most tools are more suited to in-person workshops. If the event were to be held virtually, the following should be considered:

- Whether the tool requires participants to have software to run it.
- How exercise breakouts groups could be managed.
- If scenarios need to be run beforehand and if the meeting would consist of discussion of scenario outputs.
- The size of the participating group; it may be helpful to limit numbers during a virtual event to avoid technical difficulties or a lack of discussion.

7.0 Conclusions

All four jurisdictions reviewed make use of some form of permitting system to manage water use; however, the intricacies of each regulatory framework differ greatly, meaning there are only limited similarities between jurisdictions. It was noted that Alberta has a structured regulatory framework that allows regulators to control water use diversions during times of water shortage. There are opportunities to further develop provincial and local drought response plans. Actively engaging stakeholders in the development of those plans is likely to lead to positive outcomes in stakeholder understanding and buy-in to the regulatory processes around drought response.

Based on our review of case studies, engaging stakeholders through development of a drought simulation exercise resulted in positive outcomes in all case studies reviewed. Each case study had different objectives but increased participant awareness of roles, responsibilities and understanding of drought impacts was common across the exercises.

There are a number of tools currently available that could be used or be adapted for use in a drought simulation exercise based in Alberta. The suitability of each tool should be determined based on the objectives of the exercise and desired outcomes. It was noted that in general, game-style tools are less complex and require less background data to run but are likely to be more suited to exercises with purely educational objectives.

When considering tools for the AWC Drought Simulation exercise, it is recommended that a stepwise process is implemented in which the desired exercise outcomes are identified, the exercise type and style is selected based upon the desired outcomes and finally, the tool is selected by considering how it can support the desired outcomes and how it fits within the boundary conditions of the project. This approach is more likely to lead to beneficial outcomes of the AWC Drought Simulation exercise that will effectively support improvements to drought resiliency and response in Alberta.

Appendices

Appendix A – Drought Management Literature Review Summary Table

Please refer to the attached document: *AppendicesCombined_2021_03_08*

Appendix B – Simulation Case Study Research Summary Table

Please refer to the attached document: *AppendicesCombined_2021_03_08*

Appendix C – Tools Summary Table

Please refer to the attached document: *AppendicesCombined_2021_03_08*

APPENDIX E
Pre-Exercise Materials

SSRB Drought Simulation Exercise: documentation

May 24, 2022

Classification: Protected A

Table of Contents

Classification: Protected A

1. Overall project and drought simulation exercise background

In early 2020, the Alberta Water Council (AWC) identified improving drought resilience as priority work and a project team was established to lead a multi-year project called 'Improving Drought Resilience in Alberta through a Simulation.' A literature review was completed in 2021 and based on the results, the project team decided on the style, scope and goals for the drought simulation exercise. The AWC engaged WaterSMART Solutions Inc. (WaterSMART) to work with the project team to design, organize and run the simulation exercise.

The objective of the overall project is to "*Assess current drought mitigation processes and identify gaps in plans, policy, and legislation that can inform the development of the AEP Drought Response Plan".* Using an appropriately scoped and scaled simulation of a drought will provide the Government of Alberta, municipalities, Watershed Planning and Advisory Councils (WPACs), irrigation districts, and industry the opportunity to understand and plan for drought preparation and response, including mitigation, monitoring, decision-making, and communication before, during, and after a drought. The simulation allows participants to test options for responding to drought, build communication relationships, and assess risks and vulnerabilities to drought in order to be better prepared for a real drought situation.

The drought exercise will engage organizations within the SSRB and inform the development of the AEP provincial drought response plan, facilitate a coordinated effort in terms of drought management and mitigation in Alberta, and develop an effective decision-making process for addressing impacts of drought.

The drought simulation is designed to be realistic enough for the outcomes of the simulation to be practical and inform the draft provincial drought response planning which is not yet publicly available, and provide an appropriate level of technical detail to be understandable for stakeholders who are not specialists.

1.1 Drought Simulation Exercise Objectives

The SSRB Drought Simulation Exercise will use model supported discussions to inform the draft drought response plan by achieving the following objectives:

1. Assess current drought vulnerabilities within the watershed
2. Identify gaps in current drought mitigation actions, legislation, and policy
3. Identify procedures and mitigations to address current gaps in procedure or policy within the SSRB
4. Identify lines of communication between stakeholders

Note that the exercise does not seek to optimize drought response, change existing legislation or update the existing SSRB Water Shortage Response plan. By identifying risks, vulnerabilities and lines of communication participants will inform the development of future response plans.

1.2 How the simulation exercise will be run

The exercise uses a plausible simulated water shortage in the SSRB using the South Saskatchewan River Operational Model (SSROM) as a tool to support discussion. Different conditions will be simulated across the Red Deer, Bow, Oldman and South Saskatchewan River sub-basins to encourage discussion between sub-basins surrounding meeting common goals across the SSRB.

The exercise begins in March 2035 following the hydrological conditions described in Section 4. Although 2035 is nominally a future year, the exercise reflects current basin infrastructure and operations without any growth or development projections.

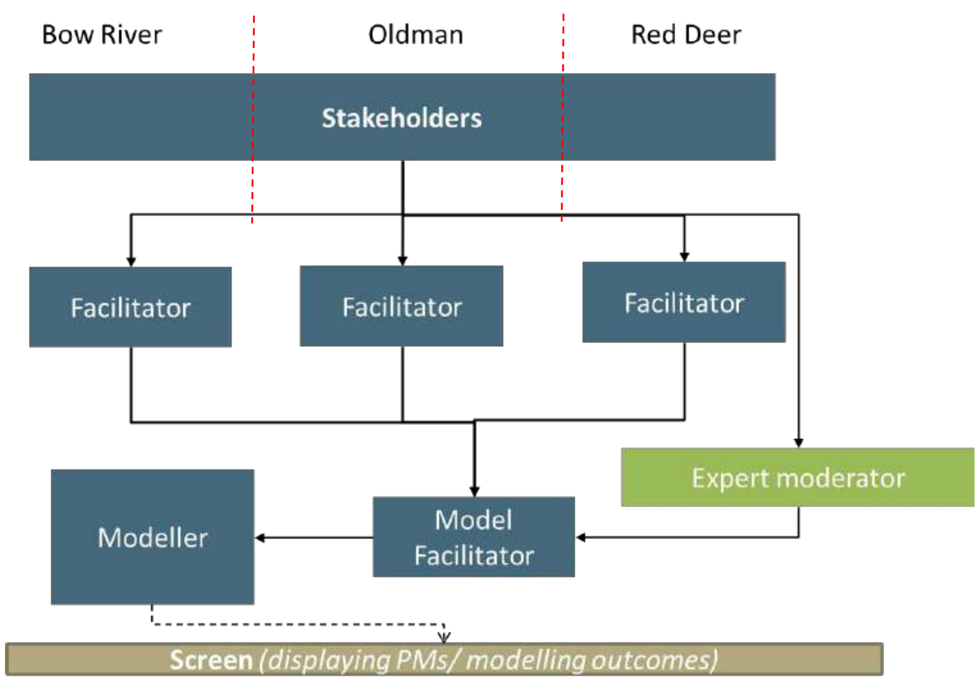

Figure 1 Schematic of room layout for the exercise

Figure 1 shows a schematic of the anticipated venue layout. Participants will sit in one of three groups representing the three major sub-basins in the SSRB (Red Deer, Bow and Oldman). Each table will be assigned a facilitator who will note key discussion points on a whiteboard.

Each table assumes the role of a Watershed Advisory and Planning Council (WPAC) in consultation with stakeholders who bring their own expertise. Each table will discuss conditions within the sub-basin and determine what advice will be provided to Government. At each decision point participants will hold a short discussion and use their knowledge as water managers to assess the basin health of their assigned sub-basin to:

- Determine what stage of the drought plan the sub-basin is experiencing
- Identify and implement a plan to mitigate water shortages in the sub-basin

The expert moderator assumes the role of the chair of the Intrabasin Water Coordinating Committee (IWCC) and will listen to the advice from each sub-basin and report decisions and actions to the other sub-basins. The expert moderator will also report the ministerial decision based on the advice provided to the whole group.

To support the decision making process participants will have a number of sources of qualitative and quantitative information to draw upon including:

- Drought response stage definitions and thresholds as described in Section 3
- Water supply outlook forecasts
- Snowpack status (where applicable)
- Groundwater status (where applicable) – *groundwater can be an indication of soil moisture on dryland or prior to the start of the irrigation season on irrigated land*
- SSROM Performance Measures
- Precipitation reports and forecasting information

Once decisions and actions have been reported to the chair of the IWCC they will be recorded and any changes to demand can be reflected in the model live. Live modelling changes could include:

- Changes to municipal demands
- Changes to irrigation demands
- Changes to industrial demands
- Changes to temporary demands

Due to exercise time constraints some model changes cannot be implemented live but will be recorded by note takers. These include:

- Changing reservoir operations
- Adding new infrastructure (e.g. reservoirs)

2. Simulation tool – South Saskatchewan River Operational Model (SSROM)

2.1 Overview of the SSROM

The South Saskatchewan Operational Model (SSROM) is a hydrological model. It is a comprehensive, mass balance model of the South Saskatchewan River system developed to enable users to identify, examine and assess scenarios interactively for adapting to changes in water supply and demand. It was originally designed as a decision support tool for collaborative processes and mutual learning among potentially competing water users to inform and optimize water management decisions.

SSROM is built on the OASIS (Operational Analysis and Simulation of Integrated Systems) platform, which is flexible, transparent, and data-driven, which effectively simulates water-facility operations. OASIS preserves mass balance, where water enters the model through inflows and exits only through demands, evaporation, or an end point. Water is also allocated, in the general sense, to each use (e.g., minimum flows, demands, reservoir storage, licensed allocations) through a modifiable weighting system; that is, higher-weighted uses access water first. Obviously, no model can operate with the same real time adjustments as would a human operator, and the model uses estimates for water travel times.

The SSROM is the culmination of twelve years of modelling effort by WaterSMART, supported by a variety of funders and partners including Alberta Innovates (AI) and the Climate Change and Emissions Management Corporation (CCEMC). It was developed through a collaborative Working Group process, incorporating knowledge and understanding from many experts and multiple model runs to reach an agreed-upon external model and representation of the basins. The foundation of the SSROM was created by connecting three sub-basin models, each of which were developed with considerable input from the Working Groups involved in each project.

Since its development, the SSROM and/or the sub-basin models have been extensively vetted and used as a planning support tool in a number of projects. The SSROM was developed with a level of detail relevant to basin-wide planning objectives.

2.2 Exercise Assumptions

The scenario run in the SSROM for this exercise contains a number of assumptions which impact how water shortage is reflected across the three sub-basins. These assumptions include:

- **The scenario uses recent historical climate conditions** – The exercise scenario uses consecutive historical drought years as a basis, no climate forecast modelling has been used to create the exercise scenario. This is because the intent is to model current climate conditions in the exercise and not speculate on the changes in timing and frequency of flow in the future.
- **TransAlta reservoirs use the 2021 agreement** – TransAlta reservoirs are operating in accordance

with the current agreement with the Government of Alberta. This means Ghost reservoir is drawn down during the period of May 16 to July 7 annually for flood protection. There is also an additional 40,000 dam^3 of water available from Kananaskis reservoir for water shortage periods.

- **Growth scenarios are not included** – The licence demands modelled are reflective of recent basin demands and do not include municipal or irrigation district growth estimates. Although the exercise is nominally set in the year 2035 the scenario could occur any year.
- **Current basin operations are modelled** – It is assumed that the basin will continue to be operated as it is currently and no additional infrastructure has been constructed.

It should also be noted that the model does not reflect individual water licences. Licences are grouped together in the model into nodes. Nodes are categorized into municipal, industrial, irrigation, environmental and junior licences. Priority within the model is assigned based on node category and broadly reflects the existing priority system.

2.3 Performance measures

Performance measures (PMs) are key assessment criteria that are important to exercise participants and are used to indicate the state of water availability in the basin at a given time. PMs are used to look at the relative difference and the direction and magnitude of changes in a parameter of interest which can be compared between model runs.

Due to the size of the basin and nature of the exercise three broad PMs have been created to describe the health of the basin at a high level. The high-level PMs described in Table 1 provide a broad overview of basin health and can be used as a screening tool for the exercise.

The PMs in Table 1 may not reflect all parameters that are of interest to participants. Participants are encouraged to ask questions regarding parameters important to them, this could include WCO violations, specific reservoir levels or fish rule curve violations. The modeller will be able to call up additional PMs as requested.

Table 1 High level Performance Measures used in this exercise

Performance Measure	Description	Locations
Composite sub-basin storage	Aggregates the storage from key reservoirs across each sub-basin and provides a high-level indicator of the water that is available to meet demand.	Red Deer • Available storage in Gleniffer Reservoir Bow • Available storage in Travers, McGregor, Newell Reservoirs Oldman • Available storage in Waterton, St. Mary, Oldman Reservoirs

Performance Measure	Description	Locations
Environmental flow	River flow at key locations in the basin	• Bindloss • Carseland • Lethbridge
Shortage as a percentage of demand	Percentage of demand not being met due to insufficient water supply	Red Deer sub-basin Bow sub-basin Oldman sub-basin

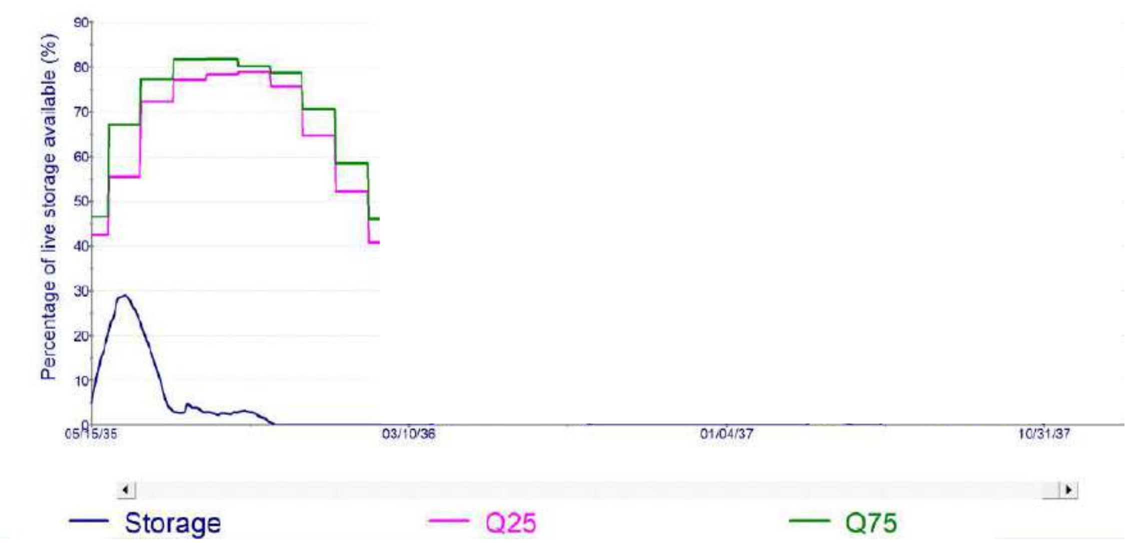

Figure 2 Example of a composite basin storage Performance Measure

Figure 2 shows an example of the composite sub-basin storage PM. The blue line shows the volume of water available as a percentage of the total capacity of the selected reservoirs on a given date. Upper (green line) and lower (pink line) monthly storage quartiles are also shown on the composite storage graph, when the storage line is between the upper and lower quartile lines this indicates the volume of water stored in the reservoir is at the expected level for the time of year. The example in Figure 2 shows reservoir storage is consistently below the lower quartile line (Q25) indicating reservoir levels are much below historical normal levels for the time of year.

The composite storage PM considers live storage. Live storage is defined as the volume of water that the reservoir can provide to meet demand.

Figure 3 shows an example environmental flow PM. In this case Red Deer River flow is shown at Bindloss. The red line indicates the statistical lower quartile of flows based on historical data, 75% of the time flow is above this line. If river flow is below this level, it indicates a low flow condition in the river.

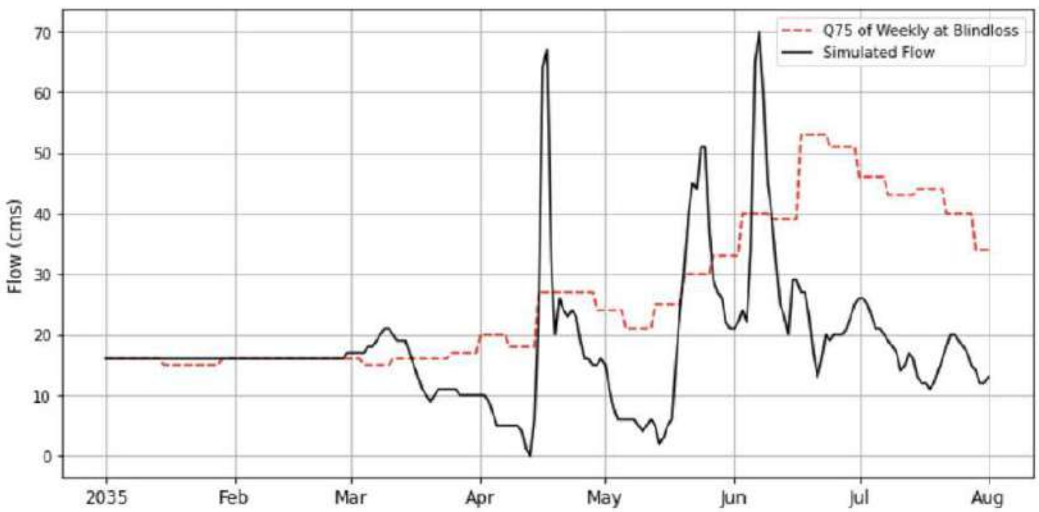

Figure 3 Example of Environmental flow Performance Measure

Figure 4 shows shortages as a percentage of total demand. In this exercise a shortage is defined as any time a municipal, commercial, First Nation, or irrigation licence in the model demands water but does not receive the full volume needed to meet the demand. This PM expresses the shortage as a percentage of the total water demand at a given time in the sub-basin.

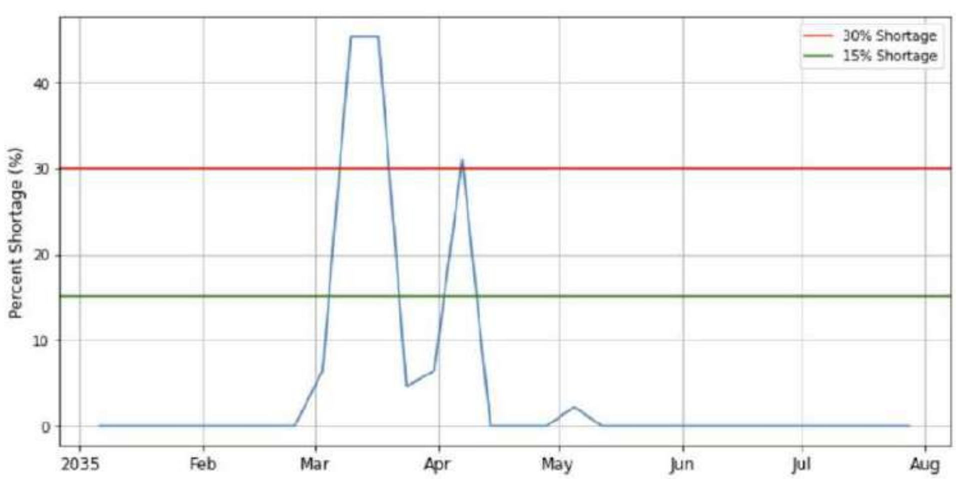

Figure 4 Example of a shortage as a percentage of demand Performance Measure

3. Drought Response Plan

During this exercise a comprehensive drought response plan is not available to water managers. A partial drought response plan describes five drought stages and the conditions at which a new drought stage can be declared. Participants must use the drought stage descriptors below to determine when a drought stage has been reached and whether additional action is required.

Stage 1

- River flows and reservoir water levels trending and generally persisting at levels at or below the lower statistical quartiles.
- Water availability trend is a concern, reservoir operations trend towards not filling; monitoring increases for drought potential in water management areas, participants identify resources needed to prepare for drought.

Stage 2

- Flows and water levels consistently below the lower statistical quartiles and trending and generally persisting at the lower statistical deciles.

Stage 3

- Participants are concerned an apportionment agreement may not be met.
- An individual licensee may with to enforce their licence priority to continue receiving water. The receipt of a priority call may require participants to enforce priority within their sub-basin.

Stage 4

- Large scale drought with risk to the majority of household users/licensees/traditional agricultural users across multiple areas of a basin, an entire basin and/or more than one basin in the province.
- A significant number of licensees/traditional agricultural users/household users in the water management areas are impacted and are unable to divert water; and/or
- Drought persists or is projected to persist.

Stage 5

- Elevated risk to human health and safety due to insufficient water supply;
- Elevated risk to human health and safety due to water quality degradation as a result of insufficient flow to dilute effluent releases to a water body; and/or
- Elevated stress on the health of the aquatic environment to a point where fish mortality occurs.

4. Basin hydrological conditions

The following information is intended to provide background and context to the hydrological conditions in the SSRB for the period leading up to the exercise itself. Note that groundwater levels, soil moisture and snowpack runoff have not been modelled in SSROM; however, qualitative descriptors of these parameters are provided. During the exercise similar descriptions will be provided at each decision point to support participant determination of basin health.

Red Deer River basin

In 2034 a relatively wet June and July period led to high reservoir levels in Gleniffer Lake, high groundwater levels and good soil moisture conditions. The August to October period saw much below average precipitation in the basin resulting in drawdown of shallow aquifers; however, thanks to precipitation early in the season this did not result in water shortage.

The November 2034 – February 2035 period saw much below average precipitation. As of March 1, 2035 snowpack in the headwaters of the Red Deer is 40 – 60% of average.

The resulting low flows in the river required significant reservoir drawdown to maintain environmental flows. Figure 5 shows reservoir levels in Gleniffer Reservoir as of March 1, 2035.

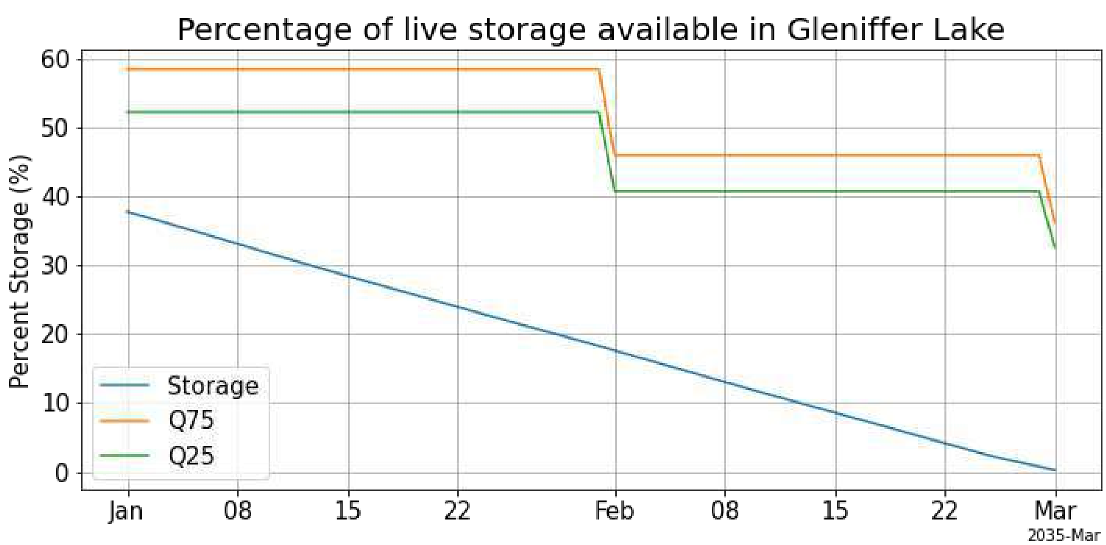

Figure 5 Storage in Gleniffer Reservoir between January and March 2035

Bow River basin

The spring of 2034 was relatively wet resulting in high groundwater levels across in the Bow River basin and a hot dry summer resulted in significant drawdown of groundwater and irrigation reservoirs and low soil moisture heading into fall.

Normal fall precipitation across the region allowed reservoir and groundwater levels to recover. However, snowfall in the December 2034 to February 2035 period has been below normal and the snowpack as of March 1, 2035 is 60-70% of average in the headwaters of the Bow River.

Figure 6 shows combined reservoir storage available in McGregor, Travers and Lake Newell for the period leading up to March 1, 2035.

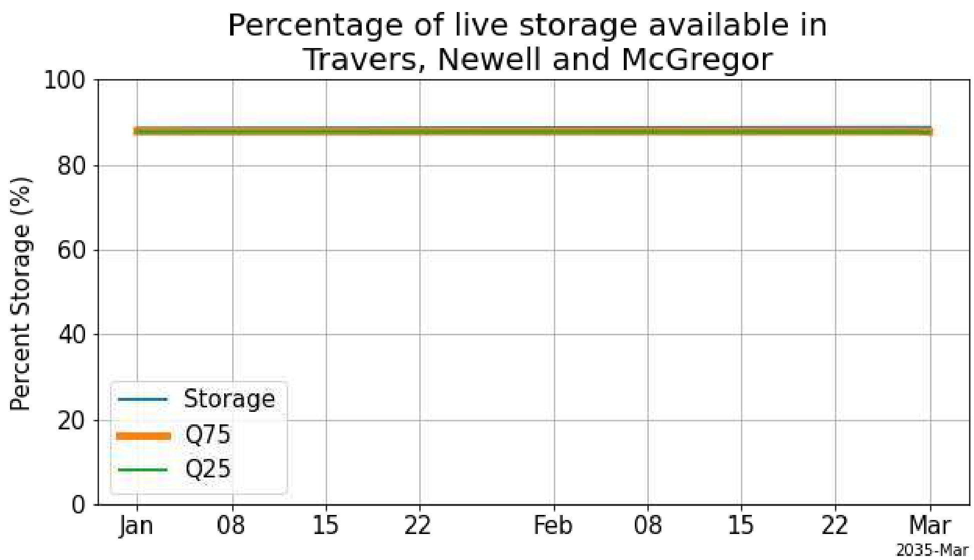

Figure 6 Composite storage in Travers, Newell and McGregor reservoirs between January and March 2035

<u>Oldman River basin</u>

In the Oldman River basin a well above average snowpack and normal spring precipitation levels in early 2034 resulted in a good water supply in the early irrigation season. Below average precipitation and hot conditions in the July – September period of 2034 led to significant drawdown of basin reservoirs and shallow aquifers. High temperatures led to low soil moisture content at the end of the irrigation season.

Normal fall precipitation across the region allowed reservoir and groundwater levels to recover. Much below average precipitation was recorded in the December 2034 – February 2035 period and the snowpack in the headwaters of the Oldman River is 40-55% of average as of March 1, 2035.

Figure 7 shows combined available storage in the St. Mary, Waterton and Oldman reservoirs for the period leading up to March 1, 2035.

Figure 7 Storage in St Mary reservoir between January and March 2035

5. Additional information

5.1 Alberta Water Council

The Alberta Water Council (AWC) is a collaborative partnership that provides leadership, expertise, and sector knowledge and perspectives to help governments, Indigenous peoples, industry, and non-governmental organizations to advance the outcomes of Water for Life.

The AWC is one of three partnerships established under the Water for Life strategy: the others are Watershed Planning and Advisory Councils and Watershed Stewardship Groups.

The AWC regularly reviews the implementation progress of the Water for Life strategy and champions the achievement of the strategy's goals. The AWC may advise on government policy and legislation in some instances. However, the Government of Alberta (GoA) remains accountable for implementing Water for Life and continues to administer water and watershed management activities throughout the province.

5.2 Project background

Drought management sits at the complicated interface of policy, society, technology, and the physical world. The management of drought involves complex monitoring, collaboration across diverse entities, communal decision making and coordinated communication.

It is difficult to prepare for the complexity of the required management efforts and collaboration needed before a drought takes place. Drought is a natural phenomenon that can have very serious negative impacts. However, droughts occur over a long period of time, making it easy for planning to be postponed. One way to overcome this barrier is to engage the diverse actors and decision makers in drought management in thinking about and planning for drought through simulation exercises.

Drought simulation exercises can also support adaptive planning because successive droughts are rarely the same in terms of length, regionality, severity, and impacts. Being able to test multiple drought scenarios through a simulation is advantageous.

The Alberta Water Council (AWC) launched a project to improve community resiliency and stakeholder understanding of multi-year drought in Alberta. The effort is multi-pronged and includes developing and conducting a drought simulation exercise to improve drought resiliency.

Drought simulation exercises from multiple jurisdictions were reviewed to understand how different approaches could be leveraged to understand vulnerabilities within the basin as well as inform the creation and implementation of drought response plans.

Drought simulation exercises commonly simulate a single watershed and discussion is focussed on the issues facing that watershed. The SSRB has three major sub-basins and while individual basin management is important the sub-basins share common goals such as meeting cross border flow targets. This exercise encourages participants to be more aware of actions and decisions beyond their own watershed boundaries and that communication between sub-basins is important to cooperatively manage water shortage effectively.

6. Relevant Acronyms

AWC – Alberta Water Council
FRC – Fish Rule Curve
GoA – Government of Alberta
IFN – Instream Flow Needs
IWCC – Intrabasin Water Coordinating Committee
PM – Performance Measure
SSRB – South Saskatchewan River Basin
SSROM – South Saskatchewan Operational Model
WCO – Water Conservation Objective
WPAC – Water Planning and Advisory Council

APPENDIX F
Drought Simulation Exercise Final Report

Alberta Water Council

Memorandum of Results
Drought Simulation Exercise
Final Report

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Submitted on:
August 05, 2022

In May 2021 WaterSMART Solutions Ltd. (WaterSMART) was engaged as a consultant to the Alberta Water Council (AWC) project team to plan and execute a drought simulation exercise focused on drought in the South Saskatchewan River Basin (SSRB). This exercise was subsequently titled the SSRB Drought Simulation Exercise. The AWC project team and WaterSMART worked closely together to plan and design the exercise.

This memorandum style document compiles the key information gathered and synthesizes the key takeaways from the SSRB Drought Simulation Exercise. This document is intended to be a reference for the AWC project team in preparing their final report.

Drought Simulation Exercise summary description

The SSRB Drought Simulation Exercise event was held on June 10th, 2022 as a full-day, collaborative planning exercise that used a computer model to support exploring sub-basin group responses to a drought scenario. A diverse group of experts and stakeholders took part, and they worked in sub-basin groups for the Red Deer, Bow and Oldman River basins within the scenario of drought for the overall SSRB. The computer model (i.e., SSROM) was used as a tool to support understanding and conversation around drought management decisions. The key learnings from the exercise came from the conversations and the perspectives shared by participants, not from the model results. A list of participating organizations is included in Appendix A.

The key learnings described in this document come from individual sub-basin tables, from the plenary discussions, and from overall learnings from the whole exercise. This document is organized into subsections that align directly with what the AWC project team identified as the objectives and desired outcomes for the exercise.

SSRB Drought Simulation Exercise objectives and desired outcomes

Alberta Environment and Parks (AEP) has documented water shortage procedures for the SSRB for internal government use. The purpose of the water shortage procedures is to guide provincial government response to water shortage through identification of drought severity and mitigation actions undertaken at the provincial government level. The SSRB Drought Simulation Exercise sought to use the AEP guidance as a basis to test the drought response process amongst water managers and stakeholders within the SSRB. The SSRB Drought Simulation Exercise had four objectives:

- Assess current drought vulnerabilities within the watershed,
- Identify gaps in current drought mitigation actions, legislation, and policy,
- Identify procedures and mitigations to address current gaps in procedure or policy within the SSRB,
- Identify lines of communication between stakeholders.

Each of these objectives sought to support the broader goal of assessing current drought mitigation processes and identifying gaps in plans, policy, and legislation. The information gathered from the exercise will be used to inform the development of the AEP Provincial Drought and Water Shortage Plan.

The SSRB Drought Simulation Exercise did not seek to change legislated water management under the *Water Act* or alter the existing AEP Provincial Drought and Water Shortage Plan. Instead, it sought to test the existing procedures with stakeholders to identify risks and vulnerabilities in drought response.

Progress of the drought stages through the exercise

For the purpose of the exercise, participants needed to understand what role they were playing in the system of drought management. Participants assumed the role of a Watershed Planning and Advisory Council (WPAC) in each sub-basin, enabling them to bring their actual experience and diverse perspectives to the table for managing a drought at an appropriate scale for decision-making (i.e., by sub-basin). As the exercise progressed the drought severity changed, and each sub-basin progressed through five drought stages (see Appendix B for descriptions of the drought stages). The "chair" of the Intrabasin Water Coordinating Committee (IWCC) relayed the ultimate decision made by the AEP Minister regarding the drought stage for each sub-basin based on the advice of the participants. The IWCC is an actual group established by the Approved Water Management Plan for the SSRB (2006). The IWCC is made up of representatives of each of the WPACs in the SSRB. Its primary responsibilities include providing guidance to AEP, preparing and maintaining an apportionment operations plan for meeting the requirements of the Master Agreement on Apportionment, and communicating to the public. The roles of the IWCC committee chair and the Minister were played by WaterSMART staff. The Minister balanced the advice with the needs of all concerned basins and a perception of the needs of the broader economy, historical advice, and operational limits, which occasionally led to decisions that were contrary to advice provided by the IWCC. Table 1 summarizes in the points in the exercise when there was a change in drought stage and when the change was advised by the sub-basin WPAC.

Table 1 Summary of exercise progression through drought stages

Month	Red Deer River Basin	Bow River Basin	Oldman River Basin/South Saskatchewan River Basin
March 2035	Stage 2 *(based on WPAC advice)*	No stage level	No stage level
April 2035	Stage 2	No stage level	Stage 1 *(based on WPAC advice)*
May 2035	Stage 2	No stage level	Stage 1
June 2035	Stage 2	Stage 1 *(WPAC advised no stage level – overruled by Minister)*	Stage 1 *(WPAC advised Stage 2 – overruled by Minister)*

Month	Red Deer River Basin	Bow River Basin	Oldman River Basin/South Saskatchewan River Basin
July 2035	Stage 2, on the verge of Stage 3	Stage 1	Stage 3 *(based on WPAC advice)*
August 2035	Stage 3 *(based on WPAC advice)*	Stage 1 *(WPAC now agree with this stage)*	Stage 3
September 2035	Stage 3	Stage 1	Stage 3
March 2036	Stage 4 *(declared basin wide by the Minister)*	Stage 4 *(declared basin wide by the Minister)*	Stage 4 *(based on WPAC advice)*
April 2036	Stage 5 *(based on WPAC advice)*	Stage 5 *(declared basin wide by the Minister)*	Stage 5 *(based on WPAC advice)*
May 2036	Stage 5	Stage 5	Stage 5
June 2036	Stage 5	Stage 5	Stage 5
July 2036	Stage 5	Stage 5	Stage 5
August 2036	Stage 5	Stage 5	Stage 5

Key Observations

Several key observations were identified across the sub-basins as the exercise progressed. The drought scenario impacted each sub-basin differently and water shortages were observed at different times. Overall, the Bow sub-basin was less severely impacted by the drought, while the Oldman and Red Deer sub-basins experienced severe water shortages.

Sub-basin observations

The sub-groups of the Red Deer, Bow, and Oldman River sub-basins each experienced the drought differently in the scenario, and there were different individuals and expertise represented at each table. Below are the overarching observations that were noted from each sub-group.

Red Deer River sub-basin

The Red Deer sub-basin experienced a severe water shortage and was forced to implement extreme measures by restricting water use. Managing the drought proved extremely challenging due to the limited storage available in the sub-basin, which only has the Gleniffer Reservoir (Dickson Dam). The Gleniffer Reservoir is a fraction of the storage capacity of either of the other sub-basins. Below are some key observations the participants identified in the Red Deer sub-basin.

A key observation in the Red Deer sub-basin was that there are not many tools available to mitigate a drought because the volume of storage is minimal. Gleniffer Reservoir is the only significant storage in the basin and is operated to maintain the Water Conservation Objective (WCO) of 16 m^3/s outflow. In the exercise, the model attempted to maintain the WCO target when possible, which meant the reservoir was drawn down over winter and little water was available when needed in the spring/summer months. In the real world, the reservoir would likely be operated differently during a drought with preference given to storing water to meet demand rather than maintaining the 16 m^3/s outflow throughout the winter months. This approach, which was not simulated, would have violated the WCO but may have reduced the impact of the drought in the summer months. This exercise highlighted that it would not be possible to meet both the full water supply demands and the WCO in a severe drought, which may have environmental implications.

Because the Red Deer River WCO was violated during the exercise, the participants noted that those water licences which are subject to the WCO would not have been able to withdraw any water, regardless of their priority. They noted that this would need to be considered in a drought and relating to the Gleniffer Reservoir operations.

An action the participants felt was necessary to take was to implement restrictions which cut water use to 40% of expected use. However, because the Red Deer sub-basin does not have a large volume of licenced water allocations, even this significant reduction in licenced water use did not result in a significant river flow increase. This suggests that other forms of drought mitigation will be needed in the Red Deer sub-basin, which ideally would create bigger improvements with less severe economic and social impacts than restricting water use to 40%.

Participants noted that it would be valuable to expand storage or change the operations of the Dickson Dam/Gleniffer Reservoir to effectively mitigate a drought in the Red Deer River sub-basin. The change in operation during a severe drought situation could acknowledge that, as seen in this exercise, meeting environmental targets (the WCO) at one time in the year can prevent meeting targets at other times and smaller flow releases throughout the year may be preferable. The change in operation may also be necessary to allow prioritisation of water supply for essential human use.

Early in the exercise, participants in the Red Deer sub-basin had an opportunity to hold back water but did not because they were conscious of apportionment obligations. It was noted that better communication with neighbouring sub-basins could have resulted in better drought response as they could have relied on the Bow River sub-basin providing a larger contribution to apportionment. The role of the IWCC and its potential to manage communications during a drought was not well understood by participants. There has not been a great deal of need for this communication in recent years thanks to good water supply. In the event of water shortage, communication from the IWCC members becomes crucial and there is a need for water users to understand their role in a drought.

The exercise also highlighted the vulnerability of the Red Deer sub-basin to multi-year droughts. In a multi-year drought, it is possible that there will not be enough flow in the river to fill the reservoir. If Gleniffer Reservoir cannot fill, then the Red Deer sub-basin can experience severe water shortage very quickly.

During the exercise, participants in the Red Deer River group expressed uncertainty around what methods and options were available to them, and if water uses would just be determined by a licence priority call and government decision. The group noted various points where they would expect the government to support drought management and water use priority decisions.

In the Red Deer sub-basin groundwater information was overlooked during the exercise which indicated that this is not a key consideration for most participants. There may be an opportunity to educate water managers on the significance of shallow groundwater and identify pathways to use groundwater to mitigate water shortages where possible.

The participants in the Red Deer sub-basin discussed at length the options and challenges associated with cutting off Temporary Diversion Licences (TDLs). In the Red Deer sub-basin TDLs are often used for livestock watering and there was concern that blanket cut-off would put livestock at risk.

Bow River sub-basin

The Bow River sub-basin was less severely impacted by the drought in this scenario, which provided an opportunity to explore the possible tensions arising between portions of the SSRB experiencing greater and lesser supply at the same time and to prompt discussion on the application of blanket restrictions across the basin. Although river levels were below normal, there was enough flow in the river to meet minimum flow requirements and maintain close to normal reservoir levels. This resulted in some discussion by the participants around the opportunities to assist neighbouring sub-basins.

Participants identified that limited tools are available to Bow sub-basin participants to alleviate drought in neighbouring basins. Participants in the Red Deer requested a transfer of water from the Bow using irrigation return flow infrastructure; however, this was not deemed practical because the drought conditions would encourage efficiencies in the districts resulting in very low return flows. Eventually, the Bow sub-basin participants elected to use the upstream TransAlta reservoirs to store water in the system as a pre-emptive measure to help meet apportionment when it was clear other sub-basins would be placed in a position of extreme difficulty trying to meet their share. This also included modifying the agreement on Ghost reservoir to begin filling before the agreed July 7th date as defined by the 2021 agreement between TransAlta and the Government of Alberta. The goal was to keep water as far upstream as possible to provide maximum benefit to river health if it was needed.

Participants in the Bow sub-basin were focused on the status of surface water, and shallow groundwater information was overlooked as a potential water source until late in the exercise. At that point investment in real time groundwater monitoring and mapping was identified as an action that would help drought preparedness.

Communication to the general public and licence holders was challenging because the Bow sub-basin had water available, but a severe drought had been declared across the SSRB. The participants elected to focus communications on voluntary reductions to help their basin neighbours, stressing there was no need to panic for water users in the Bow sub-basin. This balanced approach to communication was implemented to prevent licence holders storing water in anticipation of drought and leading to greater water use. The City of Calgary offered their expertise in managing restrictions efficiently to other municipalities which suggests that information sharing could lead to more knowledgeable water managers across the SSRB.

Participants primarily used reservoir status to gauge general water availability in the basin; however, it was recognised that this metric is less useful for certain water users, such as Western Irrigation District, who are reliant on flow in the river for their water. This caused the group to shift to reviewing the reservoir status alongside the river flow.

Oldman River sub-basin

The participants for the Oldman River sub-basin table were diverse and included people who are current key water management decision-makers and people with experience managing drought. Since water users and water managers in the Oldman River sub-basin are familiar with water-scarce situations, this expertise resulted in less uncertainty, with concrete actions for drought management being more easily identified.

The Oldman River sub-basin was able to manage a single year drought fairly comfortably, with the reservoirs and reservoir levels that they were given at the beginning of the scenario. Participants noted that the second year of drought is when the severe impacts are felt; this was observed in the exercise. The system of onstream and off-stream reservoirs provides the Oldman River sub-basin with more water management options and resilience for one year of drought. The participants relied heavily on the reservoir level information from the model for the decision-making in the exercise.

The participants were attentive to the reservoir levels in the Oldman Reservoir in particular because of the instream flow needs downstream, the need to meet apportionment, and for downstream municipal demand including the City of Medicine Hat. Participants highlighted there would be severe consequences to instream flow needs and all downstream users if the Oldman Reservoir was empty.

Water licence assignments, also called water sharing agreements, were a key part of the drought management in the Oldman River sub-basin. The group recognized that establishing the agreements would be a time-consuming process and would have to start in the winter prior to the demand season. They also recognized that smaller watersheds within the Oldman River sub-basin would likely need their own localized sharing agreements.

Irrigation District representatives articulated the decisions that would be made for reducing water use and limiting the economic impacts through preparedness, which centred around determining the farm-gate allocation based on the stored water and snowpack. The timing for communicating the farm-gate allocation decisions must be early in the season because producers will order their seed based on the amount of irrigation water available to them.

Municipality representatives at the table discussed the demand reduction measures that would be taken by municipal water users. They identified up to a 30 percent reduction (which would amount to the municipal demand being 70% of normal) to conserve water and help manage the drought.

The participants highlighted the importance of frequent meetings of key water user groups (e.g., irrigation districts, municipalities, hydropower generation companies, etc.) and management decision-makers during a drought, similar to the exercise format of frequent collaborative decision-points. The planning meetings would be more frequent than each month, and at stage 5 drought, the decision-making would be on a day-to-day basis. The group also noted that reaching certain points during the drought would prompt specific communication to the provincial government or the other sub-basins. For example, projecting the Oldman Reservoir could empty would be one of those key communication points because of the basin not being able to meet apportionment, among other serious impacts. The group suggested that it would be helpful to have a list of contact information for key people for drought management in the sub-basin, including decision-makers and people who manage water use. The list would be updated regularly to remain current and would be designed to shorten the time required to coordinate and sign water licence assignments.

At Stage 5 drought the participants prioritized municipal needs and livestock water, noting that irrigation districts deliver water to livestock operations so shutting down irrigation districts completely would not be advisable. They discussed an opportunity for Stage 5 emergency management involving communication with AEP to change the operation of the Oldman Dam. The operational change would purposefully not meet instream flow needs (IFNs) over winter with the aim of holding water back to be released for municipal uses in early spring before the snow melts.

Does the overall drought management process in Alberta work?

In the SSRB Drought Simulation Exercise, the drought management process was likely applied slightly differently than it would be in the real world. However, the results can still inform whether the process works effectively. The exercise showed that a staged drought response process works well as long as it is supported by reliable data, knowledgeable water managers and, ideally, reliable drought forecasting. The exercise highlighted the need for proactive drought management through the development of local, regional, and provincial drought response best practices and accepted procedures. The exercise highlighted that drought planning is not just the responsibility of provincial government; municipalities, irrigation districts, and water managers who had their own plans in place were able to take appropriate action at the right time.

Local management of water shortages

The exercise highlighted that the three sub-basins of the SSRB respond to drought differently and may choose different approaches within the provincial legal framework based on the local context and needs of each basin. The drought response process within Alberta is structured to encourage bottom-up management during early stages of drought. Specifically, water managers within a sub-basin are able to coordinate to identify the best approach and advise the government. This approach can lead to better outcomes as it incorporates local context and collaboration between water users.

Use of water assignments

During later stages of drought, there is still opportunity for water users to balance their own sub-basin needs through the use of assignments, as opposed to the priority system which could result in cutting off some users. This system, enabling voluntary water licence assignments with government support, was key to the results seen in the exercise. When it is deemed necessary, the drought management process allows government to actively manage drought through water management actions in the AEP Provincial Drought and Water Shortage Plan. This approach encourages those closest to water use to play a more active role in managing water shortage. However, the exercise demonstrated that there was some ambiguity surrounding the scope and role of government and the expectations of water users and water managers.

Organizational roles and responsibilities and communication

Participants noted that in reality, WPACs do not play the role that they did in the SSRB Drought Simulation Exercise. WPACs do not recommend what actions should be taken but may act as one of the many inputs to the decision making process. In the real world, there are small groups of key water users and decision makers who do meet regularly and take on the role mirrored in the exercise.

The exercise included robust communication between many major water users and government. However, participants felt operational decisions made by government could be communicated more broadly as these decisions can impact their own actions.

Feedback on drought stages

The drought stage descriptors used in the SSRB Drought Simulation Exercise are appended to this report in Appendix B. These stages were adapted from the defined stages detailed in the AEP Provincial Drought and Water Shortage Plan. It is understood that the drought stage descriptors are used internally by AEP as a reference and framework for drought response. Exercise participants found that the drought stages were useful for defining and communicating the severity of the drought. Exercise participants felt that the drought stage thresholds could be defined more clearly so that they are less open to interpretation. It was unclear if all descriptive points must be met to declare a drought stage.

Exercise participants expressed that it was unclear what action would be taken at each drought stage. It may be beneficial for the AEP to provide guidance to water users so they better understand the government actions that may be implemented during a drought. As an example, guidance could be provided outlining when statutory actions such as priority calls might be taken and when community decisions such as voluntary conservation and water assignments might be implemented. This guidance may also help water users develop or refine their own procedures. A guidance document could also define expectations of water users and clarify when government would impose actions, especially during severe Stage 4 or Stage 5 drought when government may impose control over water uses. During the exercise, participants felt this boundary between self-governance by water users and government control was not always clear.

Oldman sub-basin participants noted that according to the definition of Stage 1 as it is currently written, the Oldman likely qualifies as Stage 1 drought almost every year in early spring. The Oldman water managers monitor snow pillows closely to understand the drought potential in that year, especially in the spring. The definition of frequency of monitoring and how it differs from normal monitoring frequency could be better defined in future drought response plans.

Participants in the Red Deer River sub-basin suggested that Stage 3 may need to be reworded because there is too much focus on apportionment and not enough focus on the available water for meeting user needs. They suggested that the river flow was violating the WCO because there was no remaining stored water to supplement natural flows, and that this could potentially indicate being at Stage 3. The impact on the environment from violating the WCO was not known but monitoring for impacts of these violations was discussed.

Participants in the Red Deer River sub-basin did not understand which stage of drought relates to the legislative authority for the government to alter the water licence priority system, and which stage relates to a declaration of a state of emergency. Participants noted the need for the government to intervene to enforce reductions in licence diversions and ensure water for essential human uses, which was experienced when the Red Deer River sub-basin was declared to be in stage 4 drought. This points to a need for clarification of legislative authority and responsibility at each drought stage.

Drought vulnerabilities

Loss of crops, risk to human health and a high likelihood of extensive fish kills were some of the catastrophic impacts were observed in the second year of drought during this exercise highlighting the vulnerability of the SSRB to multi-year droughts. The simulated drought was very severe, but it is conceivable that a drought period could be less severe but extend beyond a two-year period, which would also result in catastrophic conditions. It is also conceivable that all three sub-basins within the SSRB experience similar drought severity in the same time period, in which case there would be challenges meeting apportionment. In addition, low reservoir levels as a consequence of a multi-year drought threaten the water supply for large municipalities such as Medicine Hat, Calgary, Red Deer, and Lethbridge.

The Red Deer River sub-basin was identified as vulnerable to even a single year of severe drought because of the sub-basin's limited storage. The participants at the Red Deer River table attempted to mitigate the drought through implementing usage restrictions, but they found that the Gleniffer Reservoir operations to meet the WCO through the winter used up any water they managed to store during the summer and early fall. This identified a vulnerability to municipal and livestock water users downstream of the reservoir as the natural river flow (flow-through the empty Gleniffer Reservoir) during summer of a drought year was not sufficient to meet their needs.

Some rural municipalities and livestock producers are supplied water from irrigation districts, which may make them more vulnerable if irrigation district water use is restricted. This adds complexity to restricting irrigation water diversions and may potentially result in restrictions to supply where it is not intended. AEP may consider addressing water supply for these users directly in localized plans.

The SSRB Drought Simulation Exercise used a high-level approach and defined drought severity by sub-basin. In reality, there may be smaller watersheds within a sub-basin that are more vulnerable to drought; participants noted Willow Creek and Little Bow as two such watersheds. To manage this, AEP uses more localized Water Management Areas (WMAs) to identify water supply status. This exercise validated that approach and showed that drought can be very localized, and plans need to be in place to manage at the local scale. Water users in more vulnerable watersheds such as Little Bow and Willow Creek should be proactive to discuss and outline potential water sharing agreements before there is a need to implement them.

Exercise participants in the Oldman River sub-basin identified the agriculture industry as particularly vulnerable in drought. The irrigation districts try to provide producers information early for buying seed and planting crops that align with the available water that year. Irrigators often have access to stored water, which provides some resilience against drought. Dryland farming is always vulnerable to drought as these farmers rely only on precipitation.

The Oldman River sub-basin group relied on water licence assignments for sharing water within the context of the priority system. For assignments to work, water licence holders must willingly participate and understand the benefits of such an agreement. Low participation in the water licence assignment requires more AEP resources to manage licence priorities as well as a water licence assignment.

It is time consuming to set up agreements, and water licence holders must feel confident that no one is able to cheat without consequence. There is a vulnerability in the current drought management system in that there is no formal established approach for mass water licence user assignments and there is a reliance on undocumented historical knowledge of previous agreements. There may also be a lack of trust in the role of government to enable these assignments to be agreed upon in the event of a drought. Exercise participants noted that senior water licence holders may not be willing to join water sharing agreements, so a means of making the case to them could be a key measure toward effectively mitigating impacts of drought.

Gaps in current drought mitigation actions, legislation, and policy

Participants in the Oldman River sub-basin quickly assumed water-sharing agreements would be the primary mitigation action against shorting water users; however, there is a gap in understanding the specific mechanisms for how water assignments would work and if every user can functionally take part. The concept of ‘sharing the pain’ was agreed to be the preferred approach, although participants did not seem to know exactly how to move forward in thinking through what that would look like. Participants needed guidance from those who had experience in developing historical water sharing agreements. The participants noted that some users may not physically be able to access water due to their location within the river system. For example, there are ranchers who are upstream of irrigation districts; there is no physical way an irrigation district can convey water to their land, these water users may still wish to be a part of the agreements to prevent their licences from being cut off in favour of supplying water downstream.

During severe droughts when reservoir levels are low there is little guidance for water managers and operators to determine appropriate reservoir operations. There is a balance between storing what little water is available and meeting demands. During the exercise participants had to determine when water should be released to meet demands and when it should be stored as a precautionary measure which prompted significant debate during severe water shortage conditions. A decision making matrix could help water managers assess and mitigate risk in these scenarios.

It is possible that the conditions observed during the exercise in which a drought stricken sub-basin is next to a sub-basin with ample water could occur in the real world. Participants in the Bow sub-basin did not identify an effective method to directly aid their neighbouring sub-basins within the current regulatory structure. Although intra-basin transfers are not limited by the *Water Act*, during the exercise participants were concerned that using this mechanism for transfer would set a precedent. The concern was that their own sub-basin may be seen as a 'water bank' that could be drawn upon by others during water stressed times and would remove the incentive for their own efficiencies. Discussion of water transfers between basins drew concern regarding how the sub-basin losing water would be compensated if an emergency transfer were imposed. Compensation would likely be a topic of contention in the event of a transfer application.

Operations of the Oldman Reservoir contributes significantly to Alberta's apportionment obligation to Saskatchewan. During severe drought, the reservoir may have limited capacity to provide meaningful contribution to apportionment or may undergo temporary operational changes to meet demands. There appears to be a gap in the ability to meet apportionment if the Oldman Reservoir cannot provide any meaningful contribution to river flow.

The Oldman River sub-basin discussed the possibility of releasing lower-than-required flow volumes from the Oldman Reservoir through winter to mitigate the impacts of drought to users and to the river in the spring/summer, especially before the snowpack melts. There is currently a gap in government policy around when the required operation of the dam can be changed to mitigate extreme drought situations. An official government guidance document might be drafted to define the circumstances under which the reservoir operation can be changed. Essentially, at what point is the original purpose of the required releases superseded by the need to store an unknown amount of water to meet future demand. The Red Deer River sub-basin identified a similar challenge with the operations of Gleniffer Reservoir which releases during the winter months to meet the WCO, causing un-mitigatable challenges during the summer season when demand is highest. The pressure of an ongoing drought highlights the need for these discussions ahead of drought but it is recognized this may be a difficult topic to find time to address when there isn't an imminent need to address a water shortage.

The Red Deer River sub-basin had several discussions around licence priority decisions by the government, and how water use might be prioritized during severe water shortages. Participants suggested that water conservation measures would likely occur in the form of a water sharing agreement but during very severe drought there may be a need for government to assign water based on the use. Participants suggested municipal use be highest priority followed by livestock but there was not time to consider the implications of these to their full extent. Some large commercial entities use municipal water for their operations while their competitors may not as they are outside municipal boundaries. Prioritizing municipal water may result in a competition issue if a commercial entity is allowed water while their competitor is cut off. Existing policy and guidance documents provide little guidance to decision-makers how to prioritize water during severe droughts. Some general guidance on potential issues to be aware of such as those highlighted here provide helpful insight for decision makers during a drought.

Procedures and mitigations suggested by participants to address current gaps

A gap identified through the exercise is general understanding of what the drought stages (see Appendix B) mean, what are the tools available at each stage, and what forms of mitigation actions can be implemented. A way to mitigate this gap and improve understanding would be to have a guidance and interpretation document developed to supplement the list of the five drought stages. The document would be designed for a public audience and the government could send it to all water license holders when Stage 1 drought is declared. It was suggested that this document include historical case studies and narrative descriptions of the drought stages and subsequent mitigation actions. The language should not be prescriptive or instructional for decision-makers; the target audience is water managers to provide considerations and improve understanding.

The exercise identified a gap related to groundwater data; participants recognized that decisions could be made in a drought based on groundwater status. In various instances during the exercise, participants noted that the groundwater status was concerning, but that this did not impact their decisions. Participants also identified where the available groundwater data appeared to be unreliable. Addressing the gap in data relates to improving the system of monitoring wells, data collection and management. A possible means of addressing the gap in understanding is related to education. There is an opportunity for the provincial government to provide information on which water users rely on shallow groundwater and suggestions for how to address the risk of drought for them, as well as how interpreting shallow groundwater status may indicate context of a drought.

A common point of interest from participants was the quantity and quality of data (e.g., water use data) and increasing user-friendly modelling capacity. The Red Deer River sub-basin table discussed wanting more forecasting information and more monitoring data to support their decision-making.

In the winter of the first drought year, the Oldman River group noted that they had concerns about being able to meet apportionment from the Oldman River in the following year due to the level of the Oldman Reservoir. This early flag about a concern, and notifying the relevant authorities and other basins, could be considered when meeting apportionment expectations.

Participants at the Oldman River group noted that they would be interested in having access to the model that was supporting the exercise as a tool for real-world decisions.

Lines of communication

The exercise highlighted the importance of communication between sub-basins, especially regarding apportionment. It was recognized that communication between and within AEP occurs from the monitoring stages of drought. During the exercise, communication between sub-basins allowed participants in the drought stressed Red Deer and Oldman sub-basins to note that they would not be able to meet their expected apportionment contribution and the Bow River sub-basin agreed to make up the difference. The Bow River sub-basin took the initiative, even before the communication, to store water in upstream reservoirs to help meet apportionment in the second year of drought.

The Red Deer River sub-basin discussed the need to communicate with the other two sub-basins to ask for their assistance in any form possible, particularly in terms of water management operations. The Red

Deer sub-basin requested the Bow River sub-basin transfer water to the Red Deer River to help meet the WCO and user demands. Although this request was unsuccessful, the communication between basins was acknowledged as important.

As previously noted, implementing water sharing agreements/water licence assignments requires significant effort, and communication with water licensees is a significant portion of that. Time to act during a drought situation may be limited and expediting the identification of water users who should be involved with drafting water sharing agreements could help reduce the impacts of drought. Exercise participants suggested maintaining a list of key contacts who could be quickly called upon to provide input to the decision-making process.

The participants in the SSRB Drought Simulation Exercise represented key water managers, water users, government, and NGOs within the SSRB. The exercise provided an opportunity for broad communication in the context of drought. Participants expressed that involving WPACs in drought planning was a beneficial exercise, since it provided input into government plans but also provided an educational opportunity for water managers to learn of plans and procedures that are outside of their normal scope of work. A semi-regular planning or training exercise could support water managers in making connections, identifying best practices, and raising awareness.

Participants also identified an opportunity for more frequent communication between water managers and water users at a local scale, even in the early stages of drought. Frequent communication could help water users rationalize mandatory actions and encourage voluntary reduction of water demand when necessary.

Although not included as material in the simulation exercise, the Oldman River sub-basin participants identified that yield and demand forecasts, which are produced currently by Alberta Agriculture, Forestry, and Rural Economic Development (AAFRED), are important for decision-makers early in a drought. These reports are a key form of communication as they arm everyone with the same information about available water in the current year.

The Red Deer River group discussed declaring a state of emergency as a means of communicating the urgency of the drought, and to support and justify the extreme reduction in water usage being enforced. In this context an emergency would enable the government to override licence priorities to restrict water use. The emergency status would also allow access to more funding to implement emergency measures. This is particularly relevant because the municipal uses are among the largest water licence holders in the Red Deer sub-basin. This conversation points to the recognized need for communicating to the public and to water users in general the level of drought, in order to garner support and buy-in for the hardships that would come from extreme reduction in water use.

Unexpected results from the exercise

There is an opportunity and a challenge in that the three sub-basins manage water supply and demand separately but are essentially jointly responsible for meeting apportionment. The format of the exercise and the participants themselves tended toward collaboration. This may or may not be the case in managing a real-life drought situation; however, it is encouraging to note that there was some clear willingness to support other sub-basins.

The apportionment obligation of Alberta to Saskatchewan is a central theme in water management, and a key concern during a drought, but operating to meet apportionment is difficult. The need for meeting apportionment obligations was discussed in all the sub-basin groups, but there were very few choices for actions that related to operating to meet it, except for precautionary measures in upstream storage by the Bow River group. The exercise highlighted that apportionment is generally approached in a manner akin to 'let's see how we do at the end of the year' and operating to meet apportionment is not precise. The exercise also highlighted that an in-depth and nuanced understanding of apportionment is not widespread among water managers.

In this exercise two sub-basins experienced a severe drought, while the third one experienced only minor drought. This situation posed a different form of challenge for the Bow River sub-basin compared with the other two, as the challenge was more around managing human behavior and messaging than about water supply and demand. An unexpected result from the exercise, arising from this situation, was that the drought Stage 1 and later drought Stage 5 were imposed on the Bow River sub-basin by the Minister even though they did not feel their situation warranted that decision.

One unexpected result from the exercise was the need for careful planning around reducing demand from various municipal water uses. The participants identified that some water uses serviced by municipal treatment plants are more essential than others, and that there would be value in differentiating and prioritizing these different demands for reducing water use. However, the complexity of prioritizing between uses in a municipality is challenging. The discussions identified socio-economic and industry investment implications; for example, if locating an industrial processing facility in an urban centre provides more reliable water in a drought than being located in rural areas near the source of primary production, this could impact where development occurs. These conversations in the SSRB Drought Simulation Exercise pointed to the need for municipalities to have established response plans that include the mechanism and the approach for managing and reducing water demand within the municipality during a drought. When developing these plans, municipalities must be aware of the larger developmental and economic consequences associated with water use restrictions. For example, municipalities may consider indoor water rationing during severe water shortage. The impacts of reducing indoor water consumption for residential and commercial entities needs to be fully understood when developing a drought response plan.

Exercise success at meeting desired outcomes

The SSRB Drought Simulation Exercise was successful at meeting the objectives of the exercise. The exercise successfully identified risks and vulnerabilities within the SSRB during a severe drought and highlighted the need for proactive water shortage response plans to be in place ahead of a drought. The drought scenario was able to test decision-making through all five drought stages. The exercise also highlighted the need for collaboration and communication between water management areas, especially between sub-basins.

The discussions throughout the exercise clearly demonstrated the procedures and actions that could be used to address a severe drought; this also indirectly identified a variety of gaps, as well as potential procedures or mitigation options to address the gaps.

The exercise was designed to test the drought response process in Alberta, rather than optimizing water management operation in a drought, and this was successful. The exercise facilitation, the duration (one day), the length of the simulated drought (two years), and the large number of participants from various sectors all aligned to guide lively discussion and thoughtful reflection toward the overall response process.

Participants were placed in a high-pressure scenario in which they made decisions about two years of drought in a single day. Normally there would be more time to communicate, discuss ideas and consider options which would likely result in better outcomes.

Participant feedback

At the end of the exercise all participants were invited to complete a feedback form ranking various aspects of the exercise on a scale from one to five. A full summary of participant feedback is available in Appendix C. Based on this feedback, participants found that the exercise realistically represented a potential drought in the SSRB and provided an appropriate scenario for planning and decision-making. Participants felt relevant interests were represented in the exercise, which provided opportunity for participants to identify lines of communication between water managers.

In general, exercise participants agreed that the simulated drought scenario represented a realistic potential drought in Alberta (average score 4.38 out of 5). Some felt the Bow River sub-basin could have been challenged more by simulating a drought of similar severity to the Red Deer and Oldman sub-basins; however, it was recognized that a less severe drought in one sub-basin led to valuable conversations surrounding apportionment and intra-basin water transfers.

The average scores from participants indicate that the exercise was very successful at providing an opportunity for meaningful discussion (score 4.76), that the number of participants was appropriate for meaningful discussion (score 4.57), and that the facilitators provided meaningful guidance (score 4.81).

Participants only somewhat agreed that the exercise highlighted the roles and responsibilities of individuals with an average score of 3.57 (see Appendix C). Participants also noted that not all individuals with drought responsibilities were present in the room for the exercise. Although not a primary goal of this exercise, there may be an opportunity to focus on individual roles and responsibilities in a future workshop or exercise on a more local scale.

Identified benefits beyond the primary objectives of the exercise

Several benefits were achieved beyond the primary objectives of the exercise. Participants expressed that the exercise provided a valuable learning opportunity, particularly noting how they learned from other participants at their table. Some improved their understanding of how drought is managed in Alberta. Although simplified, the exercise included the realistic procedure of the IWCC advising the Minister, who makes drought management decisions for the whole SSRB, and participants noted this provided valuable understanding. Several participants left the exercise with a better understanding of apportionment requirements because of the explanation of apportionment provided in the introductory portion of the exercise event.

The exercise was an opportunity for participants to build relationships with one another and connect with those in neighbouring basins. Participants learned through the plenary discussions of the experience of the drought for other sub-basin groups and the actions chosen in response. The Minister's summary and decision at the end of discussions each month helped build an understanding of drought management across the SSRB. These discussions led to a better overall understanding of drought management.

The participants were able to gain an understanding of the risks and opportunities for their sub-basin in a severe drought, and considerations that are relevant to their real-life roles in water use and water management decision-making.

Modelling with the South Saskatchewan River Operational Model (SSROM) allowed participants to explore the connectivity of the sub-basins and see the impacts of their mitigating actions.

Future Opportunities/considerations

Considerations for the Provincial Drought Response Strategy

The SSRB Drought Simulation Exercise highlighted the importance of developing effective water shortage response plans at local, regional, and provincial scales. Having an effective plan allows faster and more integrated response to a drought.

Drought preparedness

The exercise highlighted the importance of continuous monitoring of surface water, groundwater, and snow pillows. As water shortage conditions become apparent, it should be possible to increase the monitoring frequency, and the preference is for real time data to be available from these sources.

The drought management system encourages water managers to proactively respond to drought and implement their own drought plans so impacts can be mitigated without prescriptive action from government. Although this process works well, there is some ambiguity on the scope and timing of government response. As such, water users may not be aware of what conditions may prompt government intervention, which can result in confusion, especially for water managers with less experience managing drought. It is recommended that the role of government and the expectations of licence holders are well defined and clearly communicated ahead of a drought.

Currently some key water managers and decision makers regularly meet to discuss drought response. This semi-formal process encourages a more localized approach to drought response. A list of key contacts and water managers should be kept and regularly updated by the government and shared among the listed contacts. Maintaining an up-to-date contact list will allow key water managers to convene quickly in the event of water shortage. It would also be prudent to advise large licence holders and key water users to maintain their own local contact list as part of their water shortage management plans.

There is a risk that knowledge of drought response could be lost when experienced water managers leave their roles. Documenting best practices through local water shortage response plans will help mitigate this risk, and regular meetings on drought response for water managers and decision makers should be encouraged. Meetings could be in the form of lectures, workshops, or further simulation activities. Communication between water managers provides valuable learning opportunities for knowledge transfer, sharing best practices and networking with other decision makers.

A consideration for AEP would be to prepare a document that defines the criteria for changing the operation of major reservoirs (particularly the Oldman and Gleniffer) in the event of a drought. There may also be guidance needed for the legislative process to approve temporary changes, and possibly examples for calculating what the new reservoir operations could be for the specific purpose of managing extreme water shortage.

Drought response

The Red Deer sub-basin had limited tools with which to mitigate the impacts of severe drought since there is not much water storage available. In areas of the province where there is little water storage there is limited time to react to a significant change in water availability. These areas should focus on creating well defined drought plans with a focus on approaches to demand management, monitoring, and accurate forecasting. Rapid communication and implementation of drought response actions will be key to limiting the severity of drought impacts in areas with no significant water storage. In areas with limited storage water licence assignments may be even more important as there may be a need to implement these even during a less severe drought. It is important that decision makers and water users understand how to implement assignments and the level of effort involved. This process could also be integrated into drought response plans.

The SSRB Drought Simulation Exercise used drought thresholds adapted from the AEP Provincial Drought and Water Shortage Plan, which are used internally by the Government of Alberta to help define drought. Exercise participants identified an opportunity for some contextual descriptors of drought to be provided to water users as part of communication plans. For example, an indicator of the severity of the water shortage conditions could be provided through comparison to historical droughts and examples of response actions that were used in those past circumstances. This communication could be designed for the general public or for key water users.

Exercise participants found there were few tools available to assist neighbouring sub-basins. Guidance could be provided to those who are proximate to water management areas experiencing drought but who are not themselves experiencing drought. This guidance could include precautionary actions such as encouraging voluntary water reductions, or more active steps such as holding water to meet apportionment.

Restricting water use by cutting off temporary licences is a mitigation that is often undertaken to protect the health of the watershed, and TDLS are generally issued with the applicant understanding that they can be cut-off with no notice in the event of water shortage. TDLs are often used for industrial purposes so there is the perception that the only impacts would be economic. In fact, TDLs are often used for livestock watering and a cut-off could put livestock at risk. Future plans might consider reviewing TDLs more holistically and reviewing their specific purposes before cutting them off.

Addressing gaps in legislation and policy

Water sharing agreements were adopted in the exercise to prevent water users being cut off; however, participants were not clear on the process for entering into an agreement. If water sharing agreements are considered as part of a drought response plan, then guidance should be provided to outline the process for creating water sharing agreements. Consideration should be given to the timeline required for drafting and implementing such an agreement, as it may be necessary to begin the process in anticipation of the potential need for an agreement rather than waiting until the crisis has arrived.

The Oldman Reservoir is operated to meet apportionment. The regulatory system allows for reservoirs such as the Oldman to be operated to another objective with the consent of the Director. During severe drought this could be a barrier preventing quick response to deteriorating water supply conditions. One potential consideration is to trigger a review of reservoir operations when a certain threshold is reached. This may allow a quicker response and potentially mitigate some of the impacts of drought.

Inter-basin transfers are transfers between basins such as transferring water from outside the SSRB to alleviate an SSRB wide drought. These transfers require a special act of the Legislature. Intra-basin transfers allow the transfer of water between sub-basins within a connected watershed e.g. a transfer between the Bow and the Red Deer sub-basins. This type of transfer is permitted under the *Water Act*.

Water shortages can be localized, and it is possible that a water management area (WMA) could experience severe drought while the neighbouring WMAs experience close to normal conditions. In extreme cases inter-basin transfers may be considered via a special act of the Legislature; however, initiating such a transfer is a slow process. An intra-basin transfer may be a better and more legally feasible alternative, although geographic distance or infrastructure can still be prohibitive. Consideration could be given to defining when an intra-basin or an inter-basin transfer could be considered in extreme cases such as drought, and the possible process to follow.

In a very severe drought, the Government of Alberta has the authority to override the priority system and assign water through emergency measures. This government may identify the highest priority uses and determine how much water is available to assign to each use. Existing drought plans, policy and guidance documents provide very little guidance to government to assign priority by use in these extreme cases. How water could be assigned should be considered in some detail ahead of a drought and built into a drought plan or guidance document.

Future opportunities

Exercise participants expressed interest in having access to software that could be used to model severe drought in local watersheds. Broad access to modelling software that helps visualize and assess the effectiveness of their response would allow water users to run their own drought scenarios and assist with development of their own drought response plans. The South Saskatchewan River Operational Model (SSROM) has recently been updated and will be publicly accessible via the University of Lethbridge. Open access to the SSROM could provide this opportunity.

There is an opportunity to implement additional collaborative stakeholder drought modelling exercises within the SSRB and elsewhere in the province. Other simulation exercises could have similar goals to gauge vulnerabilities in the drought response process, or alternative goals such as optimization of reservoir operations. A similar exercise to the SSRB Drought Simulation Exercise could focus on the Bow River sub-basin and test existing drought response plans and help operators optimize their response. There is also an existing OASIS model for the Athabasca River Basin which could be leveraged to investigate the impact of changes in water supply to an area that historically has had little issue with water supply.

Localized drought response plans and procedures could be tested by undertaking local exercises focusing on a single Water Management Area or a single watershed. A localized exercise could allow all appropriate parties to be present and facilitate a more detailed discussion on individual roles and responsibilities.

Appendix A Participating organizations

Below is a list of organizations that were represented as part of the SSRB Drought Simulation Exercise held on June 10, 2022.

- Eastern Irrigation District
- St. Mary River Irrigation District
- Alberta Irrigation Districts Association
- Special Areas
- Bow River Basin Council
- Red Deer River Watershed Alliance
- City of Calgary
- City of Red Deer
- City of Lethbridge
- Alberta Wilderness Association
- Southern Alberta Group for the Environment
- Alberta Environment and Parks
- Alberta Energy Regulator
- Ministry of Agriculture, Forestry and Rural Development
- Alberta Emergency Management Agency
- TransAlta
- Alberta Beef Producers
- Blood Tribe Agricultural Project

Appendix B Definitions for the five Drought Stages used in the SSRB Drought Simulation Exercise

Drought Stage Thresholds

During this exercise a comprehensive drought response plan is not available to water managers. A partial drought response plan describes five drought stages and the conditions at which a new drought stage can be declared. Participants must use the drought stage descriptors below to determine when a drought stage has been reached and whether additional action is required.

Stage 1

- River flows and reservoir water levels trending and generally persisting at levels at or below the lower statistical quartiles.
- Water availability trend is a concern, reservoir operations trend towards not filling; monitoring increases for drought potential in water management areas, participants identify resources needed to prepare for drought.

Stage 2

- Flows and water levels consistently below the lower statistical quartiles and trending and generally persisting at the lower statistical deciles.

Stage 3

- Participants are concerned an apportionment agreement may not be met.
- An individual licensee may wish to enforce their licence priority to continue receiving water. The receipt of a priority call may require participants to enforce priority within their sub-basin.

Stage 4

- Large scale drought with risk to the majority of household users/licensees/traditional agricultural users across multiple areas of a basin, an entire basin and/or more than one basin in the province.
- A significant number of licensees/traditional agricultural users/household users in the water management areas are impacted and are unable to divert water; and/or
- Drought persists or is projected to persist.

Stage 5

- Elevated risk to human health and safety due to insufficient water supply;
- Elevated risk to human health and safety due to water quality degradation as a result of insufficient flow to dilute effluent releases to a water body; and/or
- Elevated stress on the health of the aquatic environment to a point where fish mortality occurs.

Appendix C Participant response survey results

After the exercise was completed, participants were invited to complete a ten-question survey. The responses are compiled in the table below.

Participants were given a sheet with ten statements and asked to assess their level of agreement with each statement using the following scale. Each response was assigned a weighting between 1 and 5 with 1 indicating strong disagreement and 5 indicating strong agreement.

- Strongly disagree = 1
- Somewhat disagree = 2
- Neutral = 3
- Somewhat agree = 4
- Strongly agree = 5

Responses were received from 21 participants with some also providing additional comments. Table 2 shows the collated responses from the exercise. An average score was taken for each participant to provide an indication of overall exercise satisfaction. All

The following additional comments were also received from participants:

- *Would have been more valuable to have a more significant event on the Bow, not enough to have a single monitoring point*
- *The facilitators and modellers at the RDR table were awesome!*
- *Great job WaterSMART Team! This was worth taking a day out of our schedules. It highlighted risks and opportunities.*

Table 2 Summary of participant feedback responses

Question	Respondent number																					Average
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
The exercise helped identify relevant lines of communication during a drought.	3	4	4	5	5	4	4	2	5	4	3	5	5	3	5	5	5	5	2	4	4	4.10
The Exercise provided an appropriate scenario and context for planning and decision making.	4	4	4	5	5	3	4	2	4	5	4	4	4	5	4	5	5	5	3	5	5	4.24
The scenario realistically represented a potential drought in Alberta.	4	3	3	5	5	4	5	2	5	5	4	4	5	5	5	5	5	4	4	5	5	4.38
The exercise identified potential vulnerabilities and risks in the SSRB during a drought.	4	4	5	5	5	4	4	4	5	5	4	3	5	5	4	5	4	4	5	5	4	4.43
The exercise highlighted the roles and responsibilities of individuals.	3	3	5	5	4	2	3	3	4	4	3	4	4	3	4	5	4	3	1	4	4	3.57
The exercise provided an opportunity for meaningful discussion.	5	5	5	5	5	5	4	4	5	5	4	5	5	4	5	5	5	5	4	5	5	4.76
The relevant stakeholders and interests were represented at the exercise.	4	4	5	4	5	2	4	5	5	5	5	5	5		5	5	5	5	2	5	4	4.45
The number of exercise participants was appropriate to allow meaningful discussion.	3	5	5	4	5	4	4	5	5	4	4	5	5	4	5	5	5	5	4	5	5	4.57
The length of the exercise was appropriate.	4	5	5	5	4	5	4	4	5	5	4	4	5	4	5	5	5	4	4	5	5	4.57
The facilitators provided meaningful guidance to the participants.	5	5	5	5	5	5	5	4	5	5	5	4	5	4	5	5	5	5	5	5	4	4.81

Key	1 = completely disagree	2 = somewhat disagree	3 = Neutral	4 = Somewhat agree	5 = completely agree	Did not respond

APPENDIX G
Communications Plan

Improving Drought Resilience in Alberta Through a Simulation

PROJECT TEAM

Communications Plan
February 2024

Background

Drought is a natural, recurrent phenomenon in Alberta that has environmental, economic, and social impacts. Recent studies have shown we can expect more frequent and extended droughts. Several initiatives are underway in the province to improve drought preparedness, including:

- The Government of Alberta's Drought and Water Shortage Plan will outline management and communication actions in times of drought.
- The Alberta Water Council (AWC) guide to assist Watershed Planning and Advisory Councils (WPACs) as they engage municipalities to better prepare for, mitigate the effects of, respond to, and recover from multi-year droughts.
- The Miistakis Institute is a research institute, conservation charity, and social enterprise non-government organizations (NGO). They are working with a pilot community to develop a process for drought mitigation planning.

The Building Resiliency to Multi-Year Drought Project (2018–2021) was established to assist WPACs as they engage municipalities and communities within their watershed to better plan for, mitigate, respond to, and recover from multi-year droughts. There was a large focus on drought preparedness and drought simulations were introduced as a best practice example for drought response planning. The project Improving Drought Resilience in Alberta Through a Simulation was informed by recommendations from the Multi-Year Drought Project.

Work on this project began in October 2019, with the goal of using an appropriately scoped and scaled drought simulation to assist the Government of Alberta, municipalities, Indigenous communities, and other groups (e.g., WPACs, irrigation districts) to understand and plan for drought preparation and response, including mitigation, monitoring, decision making, and communication before, during, and after a drought.

Goals

The release of the Improving Drought Resilience in Alberta Through a Simulation Project Team Final Report is intended to achieve the following goals:

- Share the work of the project team.
- Inform and enhance the effectiveness and accuracy of the drought planning process and drought management in general.
- Raise awareness of both this work and the work of the *Building Resiliency to Multi-Year Drought* project
- Assist relevant stakeholders in drought planning and management highlight the importance of learning from others and sharing knowledge.
- Raise the profile of the AWC.

Audiences

The audiences for these documents are:

- Government of Alberta (Environment and Protected Areas, Agriculture and Irrigation)
- Alberta Innovates
- AWC members and their networks
- participants of the drought simulation exercise
- small urban and rural communities, including towns, villages, and municipalities
- WPACs
- Drought and Excess Moisture Advisory Group
- other jurisdictions interested in completing drought simulation exercises:
  - Saskatchewan's Water Security Agency
  - Prairie Provinces Water Board
  - Canadian Water Resources Association
  - Intrabasin Water Coordinating Committee (IWCC)

Proposed Approach

To achieve the above goals and communicate with target audiences, the project team will use the following tools and methods:

1. Factsheet
    a. Short, readable, and to the point
    b For members and other organizations to post on social media
    c. Can include topics like risks associated with each watershed/sub-basin as highlighted in the WaterSMART report
2. Template slides
    a. For member use in presentations for conferences, seminars, and other meetings
3. Webinar(s)
    a. Can collaborate with other water organizations that regularly hold webinars (e.g., Canadian Water Resources Association, Water Canada)
4. Effective use of the AWC website and social media
    a. Post the factsheet and all other project documentation
    b. Share the factsheet and other relevant articles and information brought forward by sectors on AWC's social media platforms
5. Effective use of existing partnerships
    a. Use partner networks and social media to share the factsheet and final report where appropriate
        i. WPAC newsletters
        ii. Share materials directly with the IWCC

AWC staff will provide Alberta Environment and Protected Areas' communications staff with release materials and timelines in advance of the release to ensure their response can be coordinated. Copies of the documents will be sent to team members, AWC Directors and Alternates, and others. The spokespersons for the release will be the AWC's Executive Director and the team's co-chairs. A press release, backgrounder, and newsletter article will be developed by project managers, in consultation with the team's co-chairs, for distribution to AWC Directors. Project managers will also prepare a website update and cover letters for the documents' mail-out.

Budget

The communications plan and any related project documentation will be made available electronically. Hard copies of project documentation will be provided upon request to AWC. The number of requests is expected to be low, with minimal budget implications (likely under $5,000 for printing hard copies). Core AWC operating budget is available to complete this work.

We have $5,000 allocated in the project budget for communications.


ALBERTA WATER COUNCIL