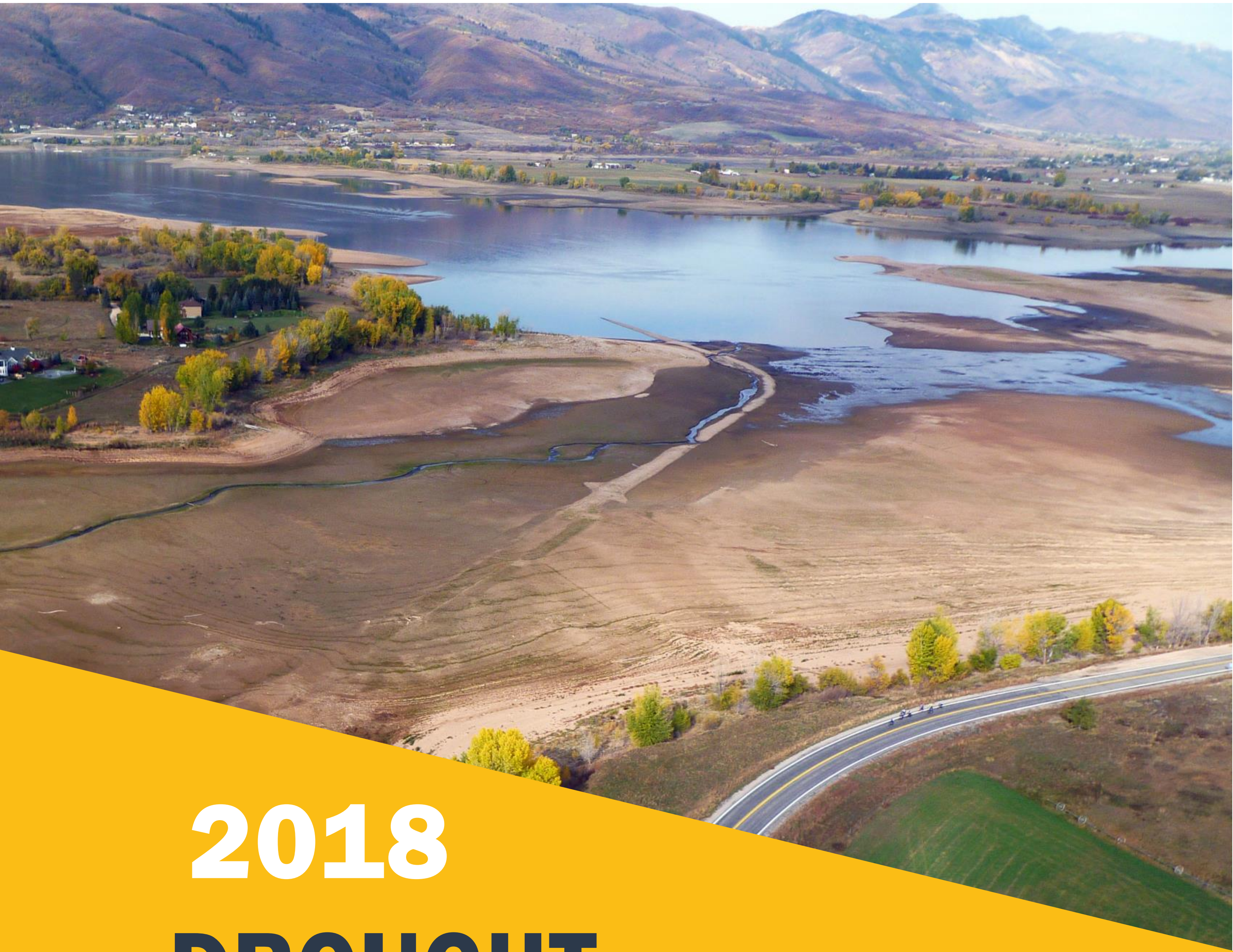

2018

DROUGHT CONTINGENCY PLAN

Weber Basin Water Conservancy District

2837 East Highway 193, Layton, UT 84040

J-U-B ENGINEERS, INC.

THE LANGDON GROUP

GATEWAY MAPPING INC.

OTHER J-U-B COMPANIES

J-U-B ENGINEERS, Inc.
466 North 900 West
Kaysville, UT 84037

WESTERN WATER ASSESSMENT
A NOAA RISA TEAM

UTAH DNR
WATER RESOURCES

UTAH STATE UNIVERSITY 1888

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LIST OF ACRONYMS AND TERMS

ASR: Aquifer Storage and Recovery

BOR: Bureau of Reclamation

CBRFC: Colorado Basin River Forecast Center

DCP: Drought Contingency Plan

Dendrochronology: The science or technique of dating events, environmental change, and archaeological artifacts by using the characteristic patterns of annual growth rings in timber and tree trunks

DWRe: State of Utah, Division of Water Resources which is part of the State Division of Natural Resources (DNR)

GSL: The Great Salt Lake

Mitigation Measures**:** Measures taken prior to a drought to help lessen the impacts of drought within Weber Basin.

NOAA: National Oceanic and Atmospheric Administration

NRCS: Natural Resources Conservation Service

Paleohydrology: The study of the evidence of the movement of water and sediment in stream channels before the time of hydrologic recorders, direct measurements, or historical observation.

Response Action: A planned action taken after a drought level trigger event occurs. The purpose of a response action is to manage the resulting impact of an adverse event.

Short Term Transfer Areement: Written agreement between WBWCD and an owner of water rights or shares that allows WBWCD to compensate the owner for temporary use of the water associated with those rights during periods of drought.

Total Basin Active Storage: Total usable storage within the Weber River Basin including storage owned by WBWCD and others.

Upstream Active Storage: The same as the Total Basin Active Storage, excluding the water that is stored in the Willard Bay reservoir.

USGS: United States Geological Survey

USU: Utah State University consultant team that assisted in the creation of the plan.

WBWCD: Weber Basin Water Conservancy District

WBWCD Storage: Storage in the Weber River Basin that is owned by Weber Basin Water Conservancy District

1 INTRODUCTION

1.1 Weber Basin Project Background

The United States Bureau of Reclamation (BOR) began planning for the Weber Basin Project in 1942, and Congressional authorization of the project was received in 1949. A decree of the Second District Court of Utah created the Weber Basin Water Conservancy District (WBWCD) on June 26, 1950 under the guidelines of the Utah Water Conservancy Act. WBWCD acted as the local sponsor of the federal project to further supply water resources to the population within its boundaries.

Today, WBWCD covers over 2,500 square miles within five counties: Davis, Weber, Morgan, Summit, and a part of Box Elder. WBWCD's jurisdiction covers all the unused flows of streams in the natural drainage basin of the Weber River, including the basin of the Ogden River, which is the Weber River's principal tributary. The Weber Basin Project also includes areas lying between the west slope of the Wasatch Mountains and the east shore of the Great Salt Lake (GSL). WBWCD's service area is shown in Figure 1-1.

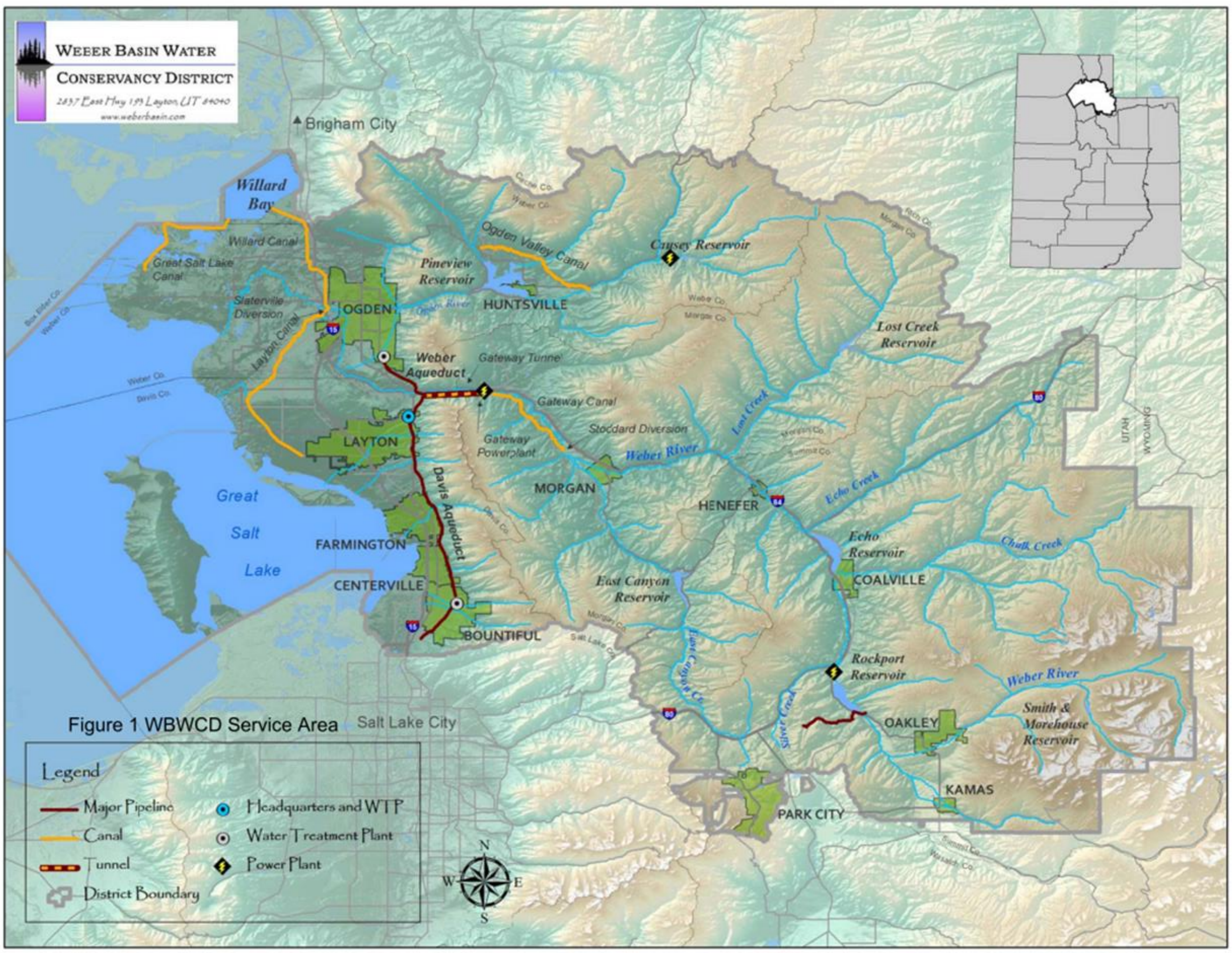


Figure 1- 1: WBWCD Service and Planning Area

Water resources of the area were extensively developed before the initiation of the Weber Basin Project. Numerous private developments pre-date the Federal projects. Prior Federal reclamation developments include the Weber River Project, with its Echo Reservoir on the main stem of the Weber River, and the Ogden River Project, with its Pineview Reservoir on the Ogden River. Under the Weber River and Provo River Projects, water is diverted from the high reaches of the Weber River for multiple uses on the Provo River. The Weber Basin Project supplements all earlier undertakings and operates concurrently with them in approaching full practicable development of the area’s water resources.

The project was planned to regulate stream flow with four new reservoirs, two enlarged reservoirs, and the correlated operation of project reservoirs and the old Echo Reservoir (owned by the Weber River Project). Three of the six project reservoirs (Rockport, Lost Creek, and enlarged East Canyon), along with Echo Reservoir and Smith and Morehouse Reservoir (built by WBWCD in 1983), regulate the flow of the Weber River before it emerges from its mountain watershed to the Wasatch Front, where the principal water utilization occurs.

Two project reservoirs, Causey and Pineview (enlarged), regulate the flow of the Ogden River before it emerges from the mountains to join the Weber River just west of Ogden City. Willard Reservoir (off stream) is the lowest reservoir of the system and receives water from the Weber River that is diverted below the mouth of the Ogden River at Slaterville Diversion Dam and conveyed through the Willard Canal. If needed, water is returned to the Weber River from the Willard Reservoir over the same route facilitated by the two Willard pumping plants.

The reservoirs on the Weber River and its tributary creeks (Wanship, Lost Creek, East Canyon, and Smith and Morehouse) are operated to supply water for irrigation, municipal, and industrial purposes on the Wasatch front and for power production at the Gateway and Wanship power plants. Causey Reservoir on the Ogden River side has also been upgraded by WBWCD to produce power. In addition, the reservoirs are operated to provide supplemental irrigation water and replacement water for residential purposes in mountain valleys along the Weber River and its upper tributaries. The reservoirs are also used to provide flood control and for the maintenance of stream flows to support recreational fishing.

Stoddard Diversion Dam, located on the Weber River about 4 miles downstream from Morgan, Utah, diverts water into the Gateway Canal, which extends 8.5 miles westward on the south side of Weber Canyon. The canal has a capacity of 700 cubic feet per second (cfs) and delivers water to the Gateway Power Plant, which can utilize up to 400 cfs. The remaining water is conveyed through the 3.3-mile long Gateway Tunnel to the west face of the Wasatch Mountains. There, the bifurcation structure directs water north via the Weber Aqueduct and south via the Davis Aqueduct.

The Weber Aqueduct is 5 miles long, with a capacity of 80 cfs, which conveys irrigation water to lands on the Uintah Bench, and municipal and industrial water to Ogden and its adjacent communities in Weber County. Part of the irrigation water is pumped to lands above the aqueduct, and the remainder is delivered by a high-pressure distribution system. At the terminal of the aqueduct, water is delivered to WBWCD's Weber South Water Treatment Plant, from which the water is distributed to Ogden City and surrounding communities.

The Davis Aqueduct extends to the south about 23 miles to North Salt Lake along the foot of the Wasatch Mountains, and has an initial capacity of 355 cfs. Part of the water is pumped for irrigation of lands above the aqueduct; the remainder of the water is sold by WBWCD to irrigation companies, improvement districts, sub-conservancy districts, other conservancy districts, and individual landowners. The remaining water is processed through WBWCD's Davis North Water Treatment Plant for distribution to communities in North Davis County, and through the Davis South Water Treatment Plant for communities in the south end of Davis County. A large block of treated and untreated industrial water is also delivered to industrial users in the extreme south end of Davis County.

Project laterals from these aqueducts include pipe systems that distribute irrigation water to farmland and suburban areas. The project includes the Willard Canal, extending north from the Weber River, and the Layton Canal, extending south, in conjunction with other canals, to serve the lower project lands adjacent to the GSL. The project also includes drains for lower lands in the east shore area. Twenty deep wells relieve water shortages in dry periods and meet peak water demands. Streams flowing from the face of the Wasatch Mountains toward the GSL contribute small quantities of water for project use. The Ogden Valley Canal distributes Ogden River water to mountain valley lands near Huntsville and Eden.

1.2 Authorization and Construction

Congress authorized the Weber Basin Project in 1949, and construction funds were first appropriated in 1952. Before the year ended, a contract was awarded to the Utah Construction Company to build the Gateway Tunnel. During 1954, construction started on the Davis Aqueduct, the Wanship Dam, the Gateway Canal, and the Weber Aqueduct. In 1955, construction starts included the Willard Dam, Pineview Dam enlargement, and the Bountiful Drain. The Wanship and Gateway power plants and switch yards were started in 1956. By July 8, 1957, the Davis and Weber Aqueducts were all completed and began operating to deliver project water from the Weber River.

1.3 Operating Agency

WBWCD is the wholesale water provider for the people in the five-county area of the project. The counties involved include Davis, Morgan, Summit, Weber, and part of Box Elder. The District administers the sale and delivery of project water, operates and maintains the project facilities, and has contracted with the U.S. Government for repayment of reimbursable costs of the Weber Basin Project.

1.4 Customers

WBWCD wholesales water and develops additional suppliers for cities, districts, and companies in five Utah counties. Those agencies in turn distribute and retail to their respective customers. WBWCD provides many categories of water including drinking water, urban secondary water, agricultural irrigation water, and industrial water. Originated by the federal Weber Basin Project, WBWCD has developed water supplies well beyond the original project with the addition of another dam and reservoir, a hydropower generation plant, drinking and irrigation water transmission systems, and groundwater wells.

1.5 Recent Drought History (1971 - Present)

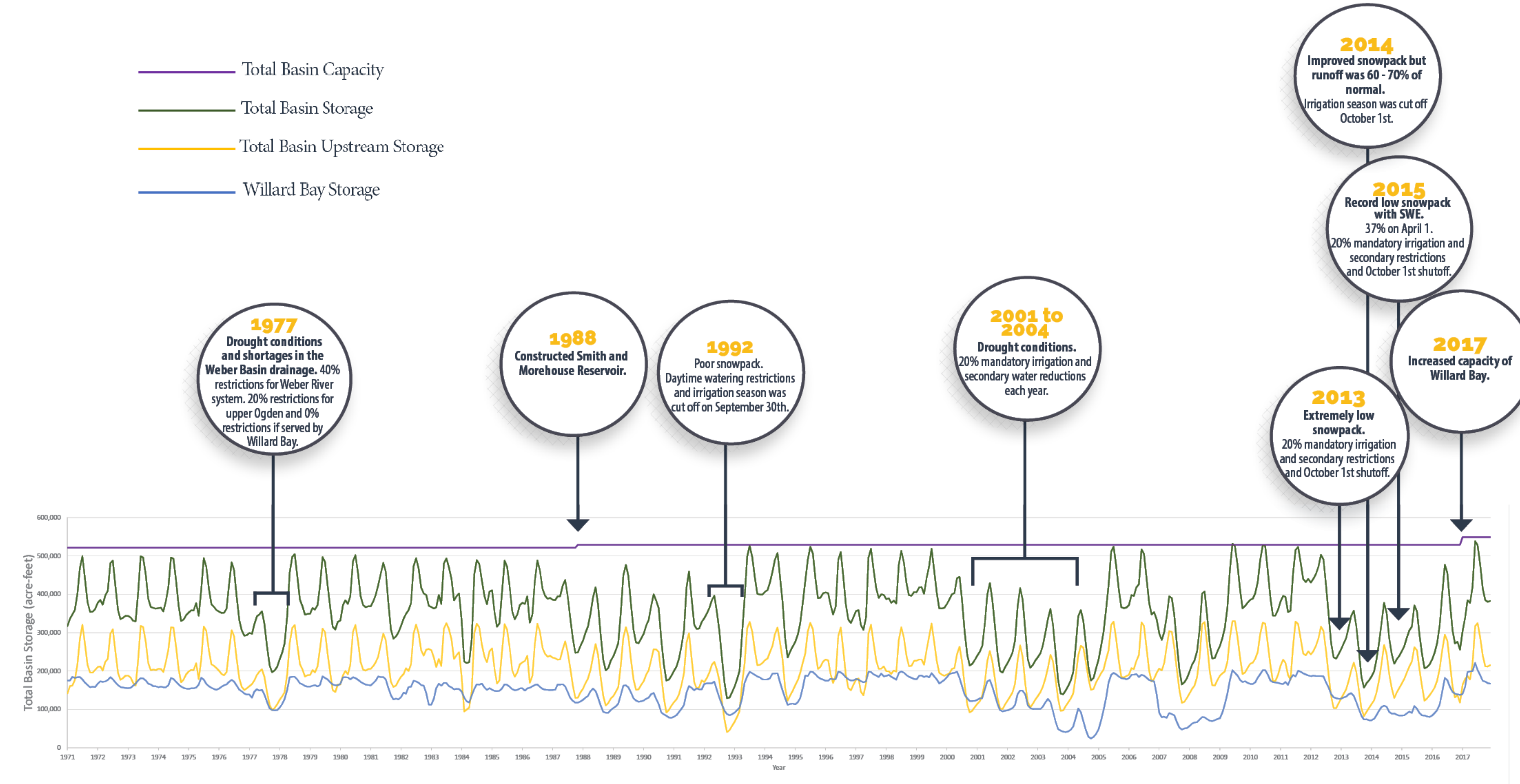
Utah has experienced periods of water shortages since the pioneers first settled in the Salt Lake Valley. The lengthy droughts of the 1930s and 1950s caused significant economic problems for the state. While the drought of 1976-77 was not as long, the consequences were still intense and costly.

Precipitation fluctuates greatly in Utah's relatively arid climate. As the demand for water continues to increase, even temporary shortages in supply can be disruptive to the normal process in urban and rural environments. Two or more consecutive years of significant reduction in precipitation – particularly snow pack – can significantly impact the available water supply.

Since its formation, WBWCD has been impacted by drought many times. WBWCD has had to reduce water deliveries during previous water shortages and droughts; for example, in 2013 and 2015, WBWCD experienced reductions in reservoir storage. In response, WBWCD shorted the irrigation season by two weeks and reduced the water delivery on contracts by 20 percent. WBWCD had to reduce water deliveries by 40 percent during droughts in 1961 and 1977.

A brief summary of historical events is shown on the following page in Figure 1-2, based on the storage history recorded by WBWCD. A more detailed list of historical events is given in Appendix 1-A.

Figure 1- 2: Recorded Storage History



When droughts or other events that cause major water supply shortages occur, the state and regional water suppliers, such as WBWCD, could experience a variety of problems. If identified and evaluated, problems can be resolved in an organized and cost-efficient manner. The most significant impacts relate to agriculture, municipal water supplies, tourism, and wildlife preservation. Electric power generation and water quality may also be adversely affected.

1.6 Purpose of Drought Plan

A critical issue provides context to the importance and purpose of the Drought Contingency Plan (DCP): WBWCD is a junior water rights holder, but it is also a major municipal water supplier. This paradoxical combination of low-priority water rights and high-priority water delivery creates potential challenges and opportunities; thus, there is a need for a DCP to resolve ambiguities and create certainty for both water users and suppliers. The objectives of this plan are listed in Figure 1-3.

Plan Objectives

- Engage stakeholders throughout the process to inform the plan and meet objectives
- Understand past drought history and drought\vulnerabilities
  - Evaluate historic tree ring records and model past stream and reservoir levels
- Evaluate WBWCD drought vulnerabilities and risks
  - Identify potential future climate scenarios
  - Model river with future climate scenarios
  - Complete a risk evaluation
- Establish drought levels and their associated triggers
- Formalize the process used to monitor for drought
- Identify and prioritize drought mitigation measures
- Develop a drought response plan
- Formalize drought administrative framework

Figure 1- 3: Plan Objectives

The DCP addresses drought-related vulnerabilities through consideration of drought response actions and mitigation measures. The DCP is not a water supply master plan to accommodate growth; however, the strategies considered in this plan may provide ancillary benefits for emergency response, replacement, or alternative supplies.

The DCP provides an effective and systematic means for WBWCD to manage emergency supply conditions within its service area. This plan is intended to augment and support WBWCD's Water

Conservation Plan, and other District policies for the management of water supply and delivery in the event of severe or prolonged drought.

The intent of this plan is to reduce risks to public health from water shortages while also minimizing impacts to agricultural, industrial, and environmental water uses. Potential risks include issues of water quality, water quantity, sanitation, economic impacts, and environmental concerns.

If there is a temporary water shortage emergency as declared by the governor, the use of water for drinking, sanitation, and fire suppression has preferential right over any other water right for the duration of the temporary water shortage. A temporary water shortage emergency may not exceed in duration more than two consecutive calendar years (U.C.A. 73-3-21.1).

1.7 DCP Plan Outline

The DCP includes the sections below as the framework of this report. WBWCD preferred the vulnerability assessment section listed before the drought monitoring section due to the process that was used in obtaining information and guidance for this report. By doing the vulnerability assessment first the stakeholders and Technical Team were able to gain information and insight that helped guide the way WBWCD determined how to monitor for future droughts. This perspective allowed for better discussions with stakeholders and an awareness of needs as they moved into considering the best ways for evaluating and monitoring for future droughts and notifying stakeholders of the process.

Section 1 - Introduction

Section 2 - Stakeholder Involvement

Section 3 - Vulnerability Assessment

Section 4 - Drought Monitoring

Section 5 - Mitigation Measures

Section 6 - Response Actions

Section 7 - Operational and Administrative Framework

Section 8 - Drought Contingency Plan (DCP) Update Process

Section 9 - Conclusions and Recommendations

1.8 Project Technical Team

This plan is the result of the joint efforts of WBWCD Staff and a consultant team, as outlined in Figure 1-4. This team worked together and collaborated with the stakeholders to develop the DCP.

Technical Team

WEBER BASIN WATER CONSERVANCY DISTRICT

Owner/Data Collection and Drought Monitoring

- Derek Johnson
- Darren Hess
- Chris Hogge

J-U-B ENGINEERS, INC.

Stakeholder Involvement, Risk & Mitigation, Plan Development

- Chris Slater
- Cindy Gooch
- Josh King

WESTERN WATER ASSESSMENT

Climate Change Analysis

- Seth Arens

UTAH STATE UNIVERSITY

Historic Drought Analysis

- James Stagge
- David Rosenberg

DWRe

River Modeling

- Scott McGettigan
- Tony Melcher
- Candice Hasenyager

Figure 1- 4: Technical Team

2 STAKEHOLDER INVOLVEMENT

2.1 Introduction

WBWCD understands the need for public involvement as opposed to merely conducting a public relations campaign. Public involvement is a process that involves stakeholders in the development of an array of alternatives and decision-making processes for the purpose of selecting a solution. In contrast, public relations is the process of gaining public acceptance of a predetermined solution. Effective public involvement focuses on gaining public input to develop an acceptable solution, whereas public relations focuses on gaining approval of a solution. Public involvement tends to gain stronger support from stakeholders than mere public relations.

WBWCD does not have control over how all the water is managed within its boundaries. As such, it is very important that water users from all the major sectors be included. The major sectors in the WBWCD service area are:

Agricultural: Irrigation and ditch companies, farms, and dairies.

Municipal: Residential indoor and outdoor culinary water, residential secondary water, and commercial and industrial users.

Environmental: Recreational entities, fish and wildlife, and GSL industries (water users that rely on water in the GSL for business).

2.2 Key Person Interviews

Key people were selected to be interviewed from each of the major sectors. Following is a list of people who were interviewed during the drought planning process and the organizations they represent. The sectors that each person is part of are given in parentheses:

1. Ben Quick and Mike Scott – Pineview Water Systems (Municipal Sector)
2. Cary Southworth, Justin Reichert, Kent Koford, Gary Henry, and Jared Hansen – BOR (All Sectors)
3. Candice Hasenyager – Division of Water Resources (All Sectors)
4. Cole Panter – Weber River Commission (All Sectors)
5. Joe Havasi – Compass Minerals/Great Salt Lake Minerals (Environmental Sector)
6. Kenton Moffett – Ogden City (Municipal Sector)
7. Laura Ault and Laura Vernon – Utah Division of Forestry, Fire and State Lands (Environmental Sector)
8. Mark Hodson – Ogden River Water Users Association (Municipal and Agricultural Sectors)
9. Mark Slagowski – Bountiful City Water (Municipal Sector)
10. Matt Peterson – Ogden Bay Produce (Agricultural Sector)
11. Paul Burnett – Trout Unlimited (Environmental Sector)
12. Paul Thompson – Utah Division of Wildlife Resources (Environmental Sector)

13. Rick Smith – Davis and Weber Counties Canal Company, Weber River Water Users (Agricultural and Municipal Sectors)
14. Rodney Banks – Roy Water Conservancy District (Municipal Sector)
15. Scott Hodge – Clearfield City (Municipal Sector)
16. Theo Cox – Hooper Irrigation (Agricultural and Municipal Sectors)
17. Wess Wight – Bountiful Irrigation District (Municipal Sector)
18. Woody Woodruff and Staff – Layton City (Municipal Sector)

2.2.1 Key Person Interview Themes and Insights

The key person interviews provided an initial understanding of the key drought concerns, as well as potential strategies to mitigate the effects of drought and ways to respond to drought. Table 2-1 summarizes the interviews, themes, and overall insights.

THEMES	INSIGHTS
INFRASTRUCTURE & OPERATIONS	Maximizing the efficiency and capacity of the existing system through strategies such as improved metering, canal lining, aquifer storage and recovery and wastewater reuse will improve drought resiliency.
ENVIRONMENT	Water operations strategies such as pulsing water through the system during wet years or improving the connectivity of fish habitats should be evaluated and coordinated to minimize negative environmental impacts during droughts.
DATA, COMMUNICATION & COLLABORATION	Improved communication and collaboration through strategies such as; public notification of current drought level status, delivery of water consumption reports to users, creation of water sharing agreements between water entities, interconnection agreements between cities and cooperation between all water users will improve drought resiliency and ability to respond to drought conditions.
DROUGHT WATER PRIORITIES AND RESTRICTIONS	A detailed drought plan is needed to prioritize water restrictions for future drought periods, set expectations with water users for drought responses and develop drought messaging.

Table 2- 1: Summary of Interviews, Themes, and Overall Insights

A more detailed table with more specific insights and information from the interviews is included in Appendix 2-A.

2.2.2 Key Person Interview Poll

The key persons that were interviewed were asked to provide responses to a few key questions; for example, one of the questions asked was, “How would you prioritize the following drought mitigation actions?” Those interviewed responded high, medium, or low. The actions were then scored based on the following weighted average point system:

- High Priority = 3
- Medium Priority = 2
- Low Priority = 1

Figure 2-1 summarizes the responses to this question. A complete summary of the questions and the responses is included in Appendix 2-B.

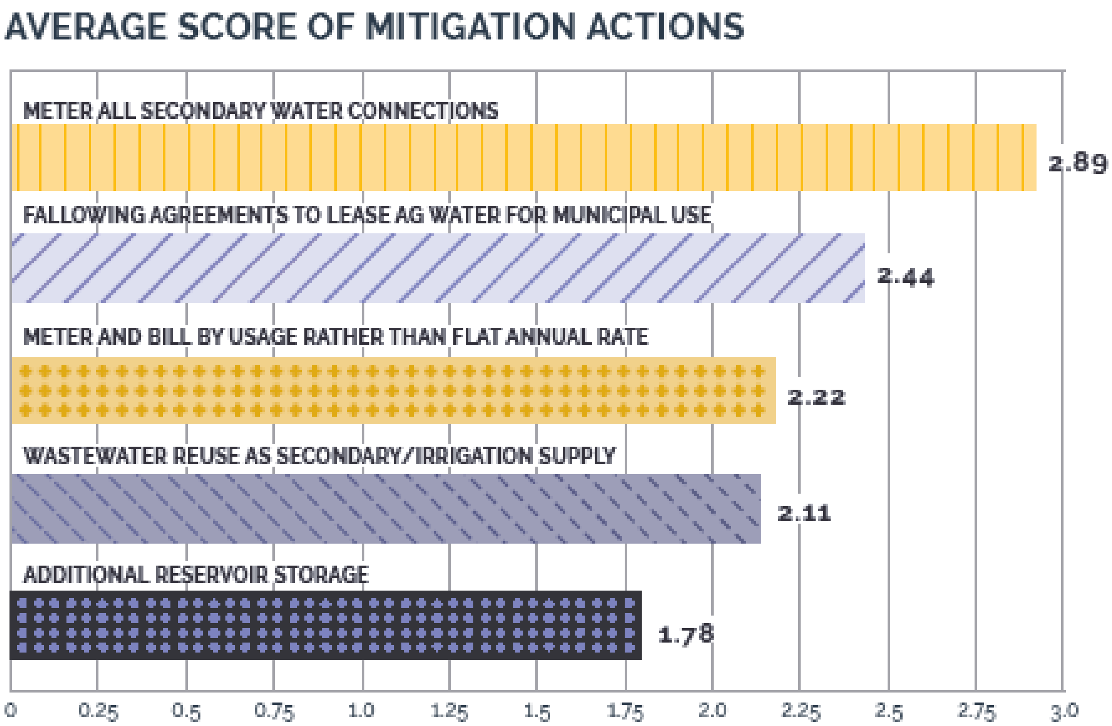


Figure 2- 1: Summary of Poll Results

These questions were asked of the stakeholders early in the process to begin to understand and develop some of the key themes with regards to drought and how WBWCD can mitigate and respond to droughts. The complete definitions and evaluations of drought mitigation and response actions are given in Sections 5 and 6 respectively.

2.3 Task Force and Advisory group

The Task Force consisted of the key stakeholders who represented the water sectors. Many of the stakeholders that were interviewed also participated as members of the Task Force. The following are the Task Force members and the organizations and sectors that they represent:

TASK FORCE

- Kenton Moffett - Ogden City (Municipal)
- Steve Jackson - Layton City (Municipal)
- Rick Smith - Davis & Weber Counties Canal Co. and Weber River Water Users Assoc. (Agricultrural and Municipal)
- Paul Thompson - Utah Division of Wildlife Resources (Environmental)
- Candice Hasenyager - DWRe (All)
- Paul Burnett - Trout Unlimited (Environmental)
- Cole Panter - Weber River Commission (All)
- Ben Quick - Pineview Water Systems (Municipal)
- Kent Kofford - US Bureau of Reclamation (All)
- Cary Southworth - US Bureau of Reclamation (All)
- Justin Record - US Bureau of Reclamation (All)
- Gary Henrie - US Bureau of Reclamation (All)
- Grant Cooper - Davis & Weber Canal Board (Agricultural and Municipal)
- Theo Cox - Weber River Water Users Assoc. (Agricultural and Municipal)

The purpose of the Task Force was to collaborate with WBWCD and the consulting team to develop the DCP.

The Advisory Group was a larger group of stakeholders made up of Task Force members and additional stakeholders from a diverse background, including each of the three major sectors –Agricultural, Municipal, and Environmental. The Advisory Group met together, collected data and research, learned different approaches, and collaborated with interested stakeholders. The following individuals participated in the Advisory Group along with the Task Force members:

ADVISORY GROUP

- Blake Carlin - Bona Vista Water District (Municipal)
- Bobby Boone - Trout Unlimited (Environmental)
- Clint Brunson - Utah Division of Wildlife Resources (Environmental)
- Clint McAffee - Park City (Municipal)
- Connely Baldwin - Pacificorp (Agricultural and Municipal)
- Craig Miller - DWRe (All)
- Derrick Radke - Summit County (Municipal)
- Holly Lopez - Park City Public Utilities (Municipal)
- Jamie Barnes - Utah Division of Forestry, Fire and State Land/DNR (Environmental)
- Jerry Allen - Bona Vista Water District (Municipal)
- Kamilla Schultz - Clearfield City (Municipal)
- Laura Ault - Utah Division of Forestry, Fire and State Lands (Environmental)
- Laura Vernon - Utah Division of Forestry, Fire and State Lands (Environmental)
- Lily Boone - Trout Unlimited (Environmental)
- Marcell Shoop - National Audubon Society (Environmental)
- Mark Slagowski - Bountiful City (Municipal)
- Rodney Banks - Roy Water Conservancy District (Municipal)
- Sam Christiansen - North Salt Lake City (Municipal)
- Scott Hodge - Clearfield City (Municipal)
- Skye Sieber - National Audubon Society (Environmental)
- Stacy Majewski - Layton City (Municipal)
- Tony Melcher - DWRe (All)
- Wes Adams - Layton City (Municipal)
- Wess Wight - Bountiful Irrigation District (Municipal and Agricultural)

Initially, the Task Force and Advisory Group met separately. Task Force members considered the information, ideas, and input generated by the Advisory Group as they evaluated and studied the issues and developed the Plan with WBWCD and the consulting team. After the first Task Force meeting, the Task Force and Advisory Group met together, and all who wanted to participate were invited as the "Advisory Group."

The Technical Team considered the information, ideas, and input generated by the Task Force and Advisory Group as they evaluated and studied the issues and developed the DCP. This extensive stakeholder involvement provided an excellent foundation for the more in-depth work required to formulate an all-inclusive DCP.

2.4 Task Force and Advisory Group Meetings

The following Task Force and Advisory Group meetings were held during the creation of the DCP:

- Task Force Meeting (Meeting #1): May 3, 2017
- Advisory Group Meeting (Meeting #2): August 29, 2017
- Advisory Group Meeting (Meeting #3): January 31, 2018
- Advisory Group Meeting (Meeting #4): June 20, 2018

2.4.1 Meeting #1

Meeting #1 was held on May 3, 2017. The Task Force members and the Technical Team members were introduced to each other. This meeting only included the Task Force Members. The following items were covered in this meeting:

- Review of plan purpose and goals; schedule for the project.
- Key person interview overview by The Langdon Group (J-U-B).
- Task Force discussion on key person interview regarding missed items.
- Report by DWRe on river model progress.
- Review of the paleo flow river results by USU.
- Discussion on potential climate change scenarios.
- Discussion on the current reservoir management process.

The minutes from this meeting are included in Appendix 2-C.

2.4.2 Meeting #2

Meeting #2 was held on August 29, 2017 and included the Task Force members and the Advisory Group members together. The following items were covered in this meeting:

- Review of purpose and role of stakeholders in the DCP.
- Review of key themes from additional interviews with key stakeholders.
- Summary of historical droughts, and comparison of recent 2013 drought to historical droughts by USU.
- Overview of future climate change scenarios by Western Water Assessment.

- Large and small group brainstorm discussions about drought risks and possible mitigation measures. See Appendix 2-D for key takeaways from the brainstorm discussions.

The detailed meeting agenda, presentation slides, and minutes from this meeting are included in Appendix 2-D.

2.4.3 Meeting #3

Meeting #3 was held on January 31, 2018 and included the Task Force members and the Advisory Group members together. The following items were covered in this meeting:

- WBWCD current water situation report.
- WBWCD planned drought monitoring process.
- Summary of results from sector meetings, and summary of demand reduction goals.
- Discussion about mitigation measures and process to evaluate measures.
- Review of the DCP schedule.

The meeting presentation slides and meeting minutes are included in Appendix 2-E.

2.4.4 Meeting #4

Meeting #4 was held on June 20, 2018 and included the Task Force members and the Advisory Group members together. This meeting was used to present information included in the draft DCP report. The following items were covered in this meeting:

- Recent past drought history.
- Drought plan objectives.
- Key insights from stakeholder process.
- Paleo drought history.
- Climate projections.
- Established drought levels.
- Drought monitoring plan.
- Recommended drought mitigation measures.
- Recommended drought response actions.
- Specific strategies to meet demand reduction targets and stakeholder poll.

The meeting presentation slides and meeting minutes are included in Appendix 2-F.

2.5 Sector Meetings

Three groups were created from the Advisory Group to represent each of the three major sectors:

1. Municipal
2. Agricultural
3. Environmental

Each of the three sectors met on the following dates:

- Municipal Sector Meeting: November 1, 2017
- Agricultural Sector Meeting: November 13, 2017
- Environmental Sector Meeting: November 16, 2017

The information gathered from the sector meetings was key to identifying risks and establishing demand reduction target goals.

2.5.1 Municipal Sector Meeting

The municipal sector meeting was held on November 1, 2017. Some of the key topics of the meeting included:

- Review of recent drought history and discussion on projected drought possibilities.
- Review of potential risks that could happen during a drought, such as inability to provide culinary water that cities purchased form Weber Basin, cities having the ability to manage a prolonged drought, and health and sanitation issues.
- Discussion on the importance of public education and other drought mitigation strategies; getting people in the habit of conserving water even on a good water year.
- Review of preliminary drought levels and associated triggers.
- Evaluation of water reduction targets for different drought levels (see meeting presentation slides for discussed target values).

The meeting presentation slides and meeting minutes are included in Appendix 2-G.

2.5.2 Agricultural Sector Meeting

This meeting was held on November 13, 2017. The same items that were discussed in the municipal sector meeting were discussed in this meeting. Some additional items of discussion included:

- WBWCD creating agreements for agriculture users to include incentives for farmers to water less or fallow for the season.
- Being proactive with mitigation measures, such as fallowing agreements, instead of being reactive if and when a drought hits.

The meeting presentation slides and meeting minutes are included in Appendix 2-H.

2.5.3 Environmental Sector Meeting

The Environmental meeting was held on November 16, 2017. The same items that were discussed in the municipal and irrigation sector meetings were discussed in this meeting. Some additional items of discussion included:

- Concern about agriculture not getting their share of water because it can negatively affect the GSL and fisheries.
- During a drought, it would benefit fisheries and local economies to do frequent water flushes.
- Communication would be key to everyone during a drought, not just to fisheries.

The meeting presentation slides and meeting minutes are included in Appendix 2-I.

3 VULNERABILITY ASSESSMENT

3.1 Overview

A broad evaluation process was implemented by WBWCD to identify key drought vulnerabilities and to understand the susceptibility to future droughts, based on history and projected future climate conditions. The vulnerability assessment drove the development of potential mitigation and response actions that are discussed later in this report. This process included six major components:

1. Identification of Key Drought Vulnerabilities (Technical Team and Advisory Committee).
2. Paleohydrology Study (USU).
3. Hydrologic Model (DWRe).
4. Establishment of Drought Levels and Triggers (WBWCD).
5. Future Climate Change Scenarios (Western Water Assessment).
6. Drought Risks (Technical Team).

3.2 Identification of Key Drought Vulnerabilities

Specific potential vulnerabilities were identified during the stakeholder involvement process and are listed by sector in Table 3-1.

Drought Impacts by Sector		
Municipal	**Agricultural**	**Environmental**
• Inability to collect fees due to inability to deliver water	• Inability to deliver water to users	• Impact to fisheries
• Lost revenue for industrial companies	• Loss of crops or crop reductions	• Bluehead sucker impacts
• Loss of trees	• Impacts to dairies	• Decline of native and wild trout
• Drops in the aquifer levels/increase well pumping costs	• Irrigation diversions may not work	• Avian and brine shrimp issues
• Lost revenue for system operation and maintenance	• Loss of income	• Air quality
• Growth and increased water demands	• Loss of clients	• Water quality
• Overuse of water for yards		• GSL industry
		• Recreation
		• Skiing
		• Boating
		• Kayaking

Table 3- 1: Drought Impacts by Sector

The specific impacts were categorized into the following broader key drought vulnerabilities:

Available Water Supply During Drought (Junior Water Rights) – WBWCD water rights are junior to agricultural water rights in general, and a plan is needed to allow for the continued supply of drinking water during droughts.

Wasteful Watering – Wasteful watering (over watering of lawns) during drought can add to water shortages for agricultural, environmental, and municipal needs.

Inability to Operate and Maintain Water Systems – Reductions in water supply and use during droughts will lead to reduced revenue for system operation and maintenance for WBWCD and retail water suppliers. A secondary related possible impact is a reduction in income through hydro-power generation.

Lack of Drought Information to Water Users – Water users cannot respond to drought effectively if they don't understand the needs or the response methods. It is very important that the water users in WBWCD boundaries are aware of the current drought level status and what they should be doing to adjust their water usage.

Environmental and Recreational Impacts – Droughts will affect fisheries, bird habitats, recreation, and the GSL brine shrimp industry due to lower river flows.

Agricultural Impacts – Reduced income for farmers during times of drought.

Some of the key vulnerabilities affect more than one of the sectors. Table 3-2 lists the key vulnerabilities and the sectors affected by each vulnerability.

Key Summary Drought Vulnerabilities	Municipal	Agricultural	Environmental
Available Water Supply During Drought (Junior Water Rights)	x	x	x
Wasteful Watering	x	x	x
Inability to Operate and Maintain Water Systems	x	x	
Lack of Drought Information to Water Users	x	x	x
Environmental and Recreational Impacts			x
Agricultural Impacts		x	

Table 3- 2: Vulnerabilities and Affected Sectors

3.3 Paleohydrology Analysis

Paleohydrology is the study of the evidence of the movement of water and sediment in stream channels before the time of hydrologic recorders, direct measurements, or historical observation.

Understanding the past flows in the Weber River is critical to understanding how vulnerable WBWCD is to future drought. WBWCD has observed storage records from the present back to 1971. This is a relatively short period of time to gain a good understanding of past drought history because of the long periods of time between past droughts. A longer period of water history is needed to understand how frequently droughts have occurred in the past, as well as other statistics such as past drought durations and intensities.

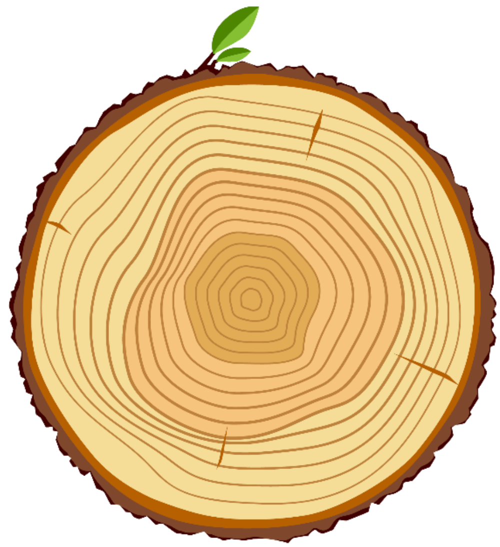


Figure 3- 1: Ring Study

Tree rings can be seen in cut tree stumps, which tell how old a tree is and what the weather was like during each year of the tree's life. Tree rings usually grow wider in wet years and thinner in dry years. A tree will likely grow very little during periods of drought. Rings from modern trees can be compared with local precipitation measurements to understand how much the local trees grow during various types of water years. Very old trees can offer clues about how wet or dry a year was that occurred long before precipitation measurements were recorded.

In 2014, a research paper published in the Journal of American Water Resources Association used dendrochronology (tree ring studies) to reconstruct stream flows for the Weber River Basin. This paper provided valuable insight on the intensity, duration, and frequency of droughts and wet periods over the past 576 years in the Weber River Basin. Utah State University (USU) utilized the annual data from the study and created a monthly record of stream flows back to 1429. The estimated historical flows from the tree ring study are referred to as paleo flows. Plots of the Weber River paleo flows at the Oakley stream gage location can be viewed online at http://www.paleoflow.org/. This website can be used to view monthly flow plots of both the observed flows from the United States Geological Survey (USGS) flow monitor and the paleo flows.

USU identified important features for the Weber Basin water system by reconstructing monthly stream flows on the Weber River, clustering droughts, and using stream flows projected for future climate scenarios with perturbed precipitation and temperature:

1. Recent droughts are not anomalies. These droughts have many analogues in the reconstructed paleo record with similar drought durations and low stream flows.
2. There are numerous droughts within the paleo and observed records that persisted for four years or longer with extremely low flows.

A more detailed description of work done by USU is included in Appendix 3-A.

3.4 Hydrologic Model

Figure 3- 2: Hydrologic Model Sample

A model was needed to simulate how the reconstructed stream flows generated from the paleohydrology evaluation would affect water storage in the WBWCD boundaries. DWRe maintains a computer hydrologic model (Weber River Model) that is currently built with Riverware software. The model is mainly a water supply model with the intended purpose to explore how different past and future scenarios may impact water storage levels and supplies. A sample image of the model is shown in Figure 3-2.

The entire river was modeled from top to bottom and was constructed of the major reservoirs, reaches, and water users on the system. Many water users were combined into aggregate groups on sections of the river, especially higher in the system where there is a greater number of individual users. Large canal diversions, most of which are lower in the system, were typically modeled individually. Major tributaries were identified as single inflows while smaller ones were combined into single reach gains that accumulate down-stream between gauges. Figure 3-3 shows a snippet of the model space illustrating the described layout.

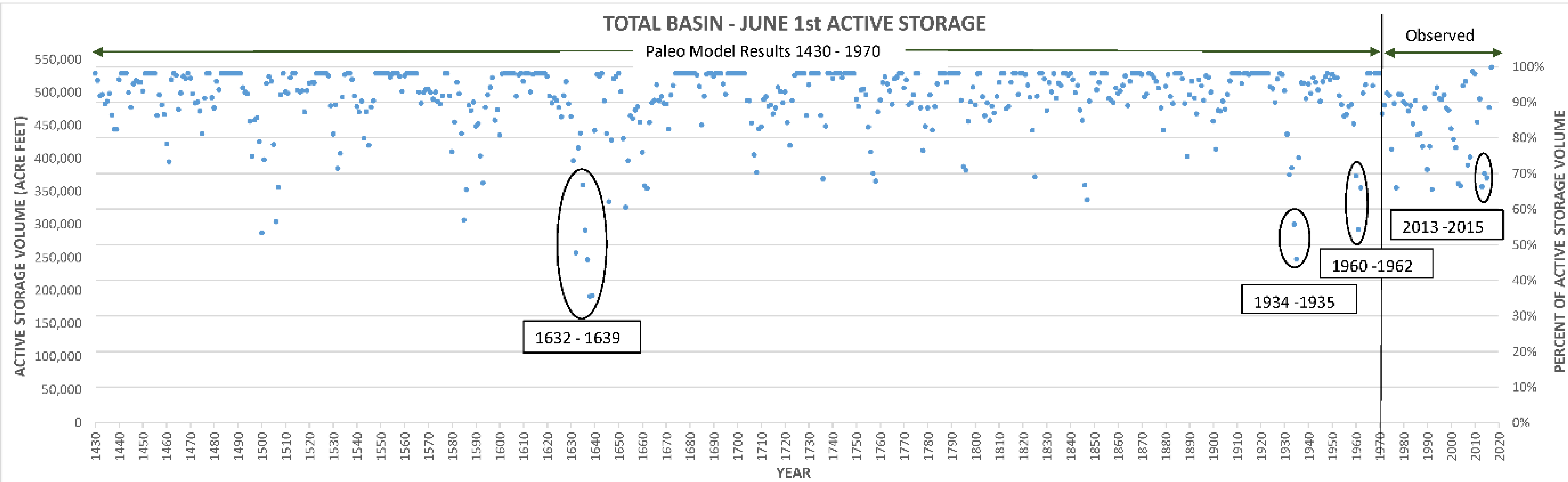
Figure 3- 3: Schematic of the Basin Hydrologic Model

DWRe utilized historic river flow data from the paleo study to model the entire system and identified the historic storage volume in the existing WBWCD reservoirs for each of the years in the paleo record from 1430 through 1970. WBWCD has records of observed storage from 1970 through the present. The model scenarios are based on total basin storage, which includes all the stored water that WBWCD owns, as well as water owned by irrigation companies and other water users. A more detailed description of the process followed by DWRe to create the model and various model scenarios is given in Appendix 3-B.

The key indicator of the water supply for WBWCD is the projected June 1st storage each year. The maximum storage volume for each year will be reached near this date and varies depending on multiple factors. The total maximum active storage volume in the basin is approximately 529,000-acre feet.

Figure 3-4 shows a single dot for each year that corresponds with the historic June 1st total storage volumes for the entire basin. A few notable multi-year periods of low storage are circled for reference. A very extreme and long duration drought occurred in the 1630s. The dust bowl drought of the 1930s is noted along with another drought of the 1960s. 2013 through 2015 was a less severe period of drought, but provides a recent frame of reference to compare with droughts that occurred further back in history.

Figure 3- 4: Total Basin Storage



3.5 Establishment of Drought Levels

WBWCD completed an evaluation of the historic June 1st storage volumes from the observed storage record based on the paleo model results back to 1430. WBWCD then established the total basin storage volumes that define a moderate, severe, or extreme drought based on the past recurrence intervals and water restrictions needed for recent moderate drought events. The volumes for each drought level are shown on the following page in Figure 3-5.

Figure 3- 5: Total Basin Storage Drought Levels

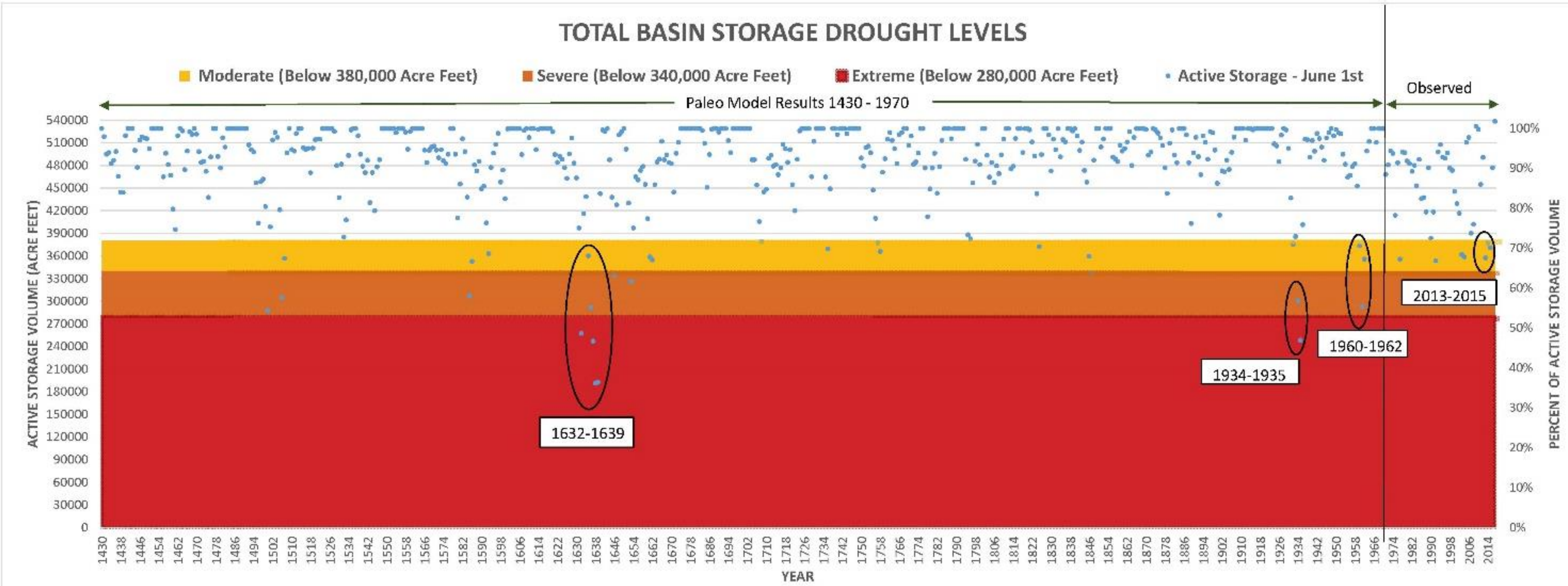


Table 3-3 provides the total storage volumes and percentages of active storage associated with each of the three drought levels. The average number of years between past droughts are included in the table based on the identified drought levels.

Historic Drought

	PROJECTED JUNE 1ST TOTAL BASIN STORAGE		AVERAGE NUMBER OF YEARS BETWEEN EVENTS	
Drought Level	Acre-Feet	% of Total Basin Storage Capacity	1430 - 1970	1971 - 2017
Moderate	340,000 to 380,000	64% - 72%	36	7
Severe	280,000 to 340,000	53% - 64%	60	No Events
Extreme	Less than 280,000	Less Than 53%	135	No Events

Table 3- 3: Historical Drought Table

3.5.1 Evaluation of Key Historic Droughts

The paleo record and Riverware models allowed for comparisons of recent droughts, that many people remember, to past large drought events that occurred further in the past. The recent 2013 through 2015 drought (2013 drought) is classified as a moderate drought. WBWCD implemented 20 percent reductions in irrigation water contracts in 2013 and 2015 and shortened the irrigation season by two weeks from 2014 -2016 in response to this drought. Davis and Weber Counties Canal Company also had water supply reductions. This drought can be used as a baseline event to compare to past historic drought events.

The following graphs (Figure 3-6, Figure 3-7, and Figure 3-8) compare the active storage volumes recorded during the 2013 drought event with the other drought events that were identified through Riverware modeling using the tree ring data. The graphs provide a way to compare the droughts in terms of duration and intensity. The colored horizontal lines indicate the drought levels that were established and that are based on the June 1st active storage for each year. The peaks in the graphs indicate the June 1st active storage that was recorded or recreated based on the tree ring data.

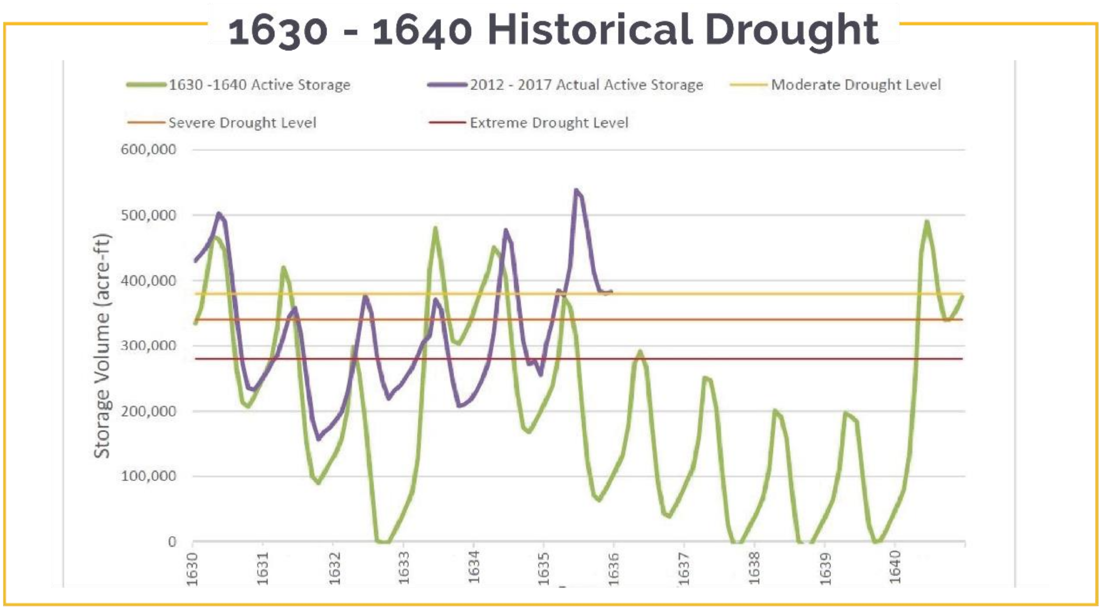


Figure 3- 6: 1630-1640 Historical Drought

The drought from the 1630s was much longer and much more intense than the 2013 drought.

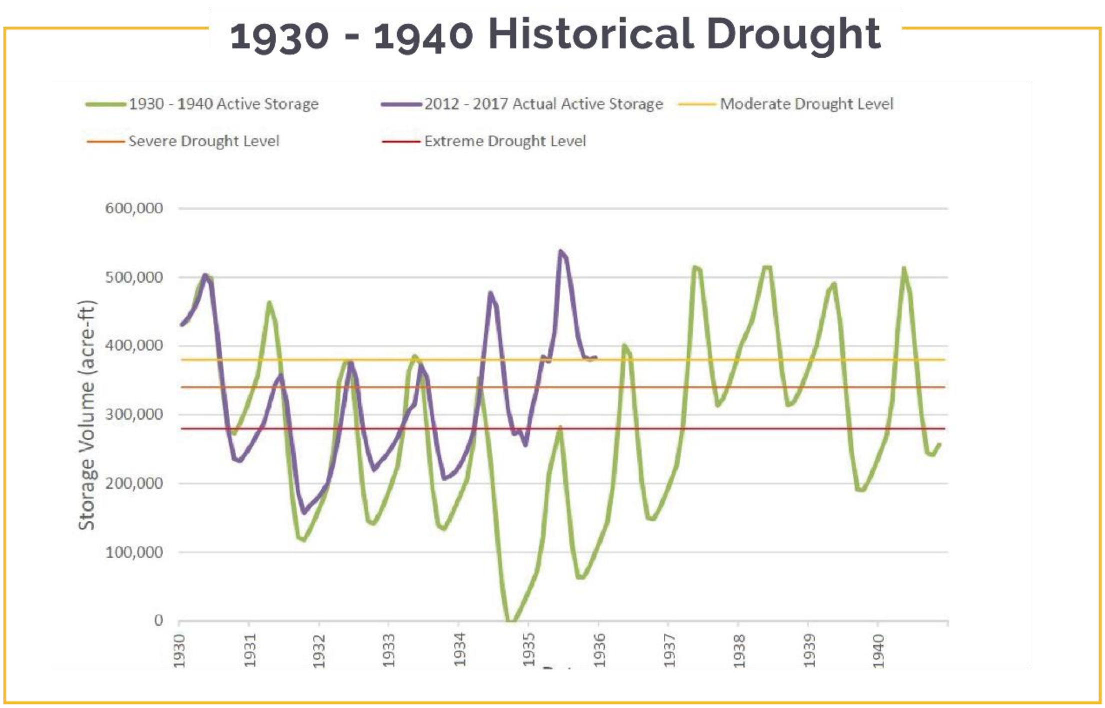


Figure 3- 7: 1930-1940 Historical Drought

The drought from the 1930s was similar to the 2013 drought for the first few years, but then dropped into an extreme level for a year before improving.

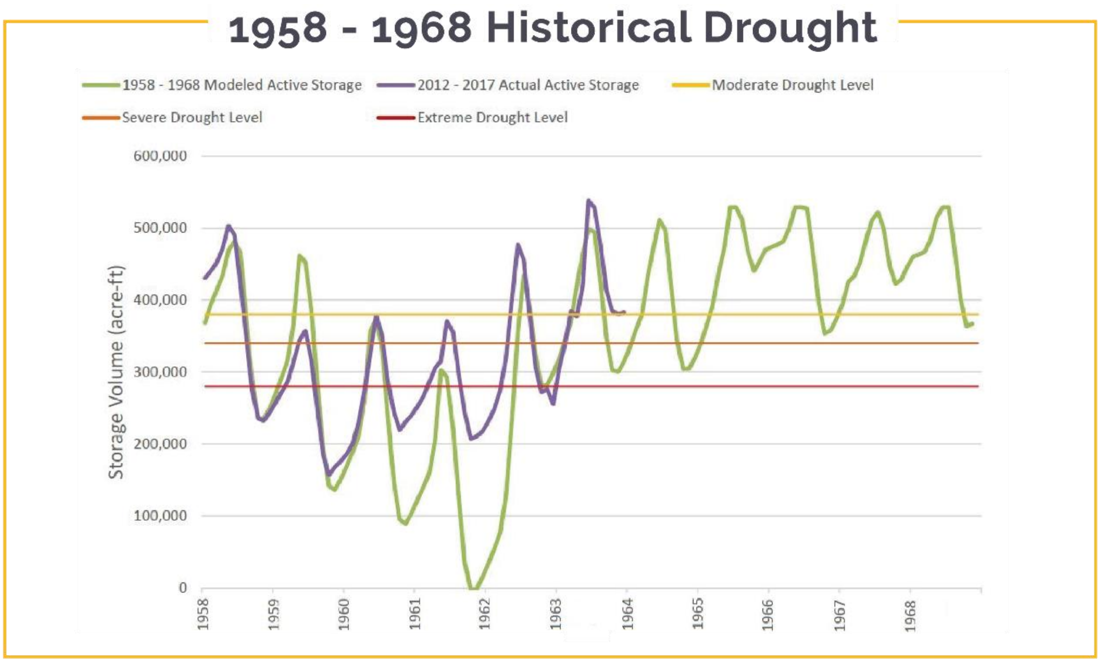


Figure 3- 8: 1958-1968 Historical Drought

The drought during the 1960s was similar in duration to the 2013 drought, but did have a year in the middle of the drought that dropped well into the severe drought level.

3.5.2 Drought Duration Versus Minimum Storage

The WBWCD water storage supplies provide more than one year of storage. This is evident in the graph shown in Figure 3-9, produced from the Riverware modeling results and based on the paleo records. Storage levels hold well through one and two-year duration droughts; however, storage levels are typically very low for droughts that last three years or longer.

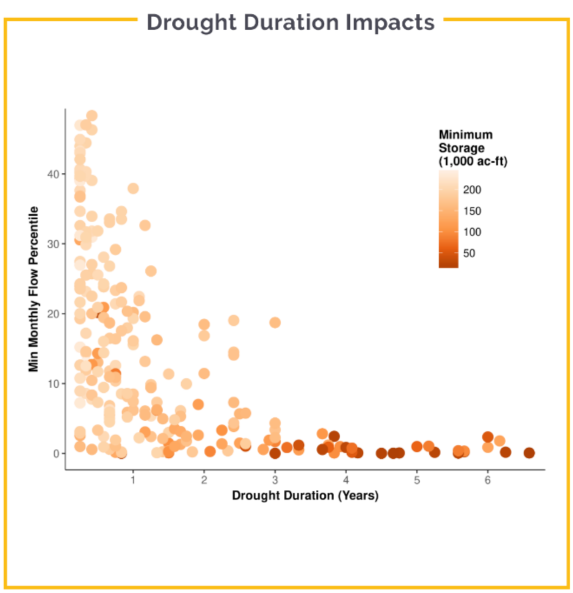


Figure 3- 9: Drought Duration Impacts

Figure 3-10 illustrates how multiple drought years in succession can affect WBWCD supplies and the ability for WBWCD to meet water demands over time. The large drought from the 1630s is compared to the period of 1999 to 2007 for this illustration.

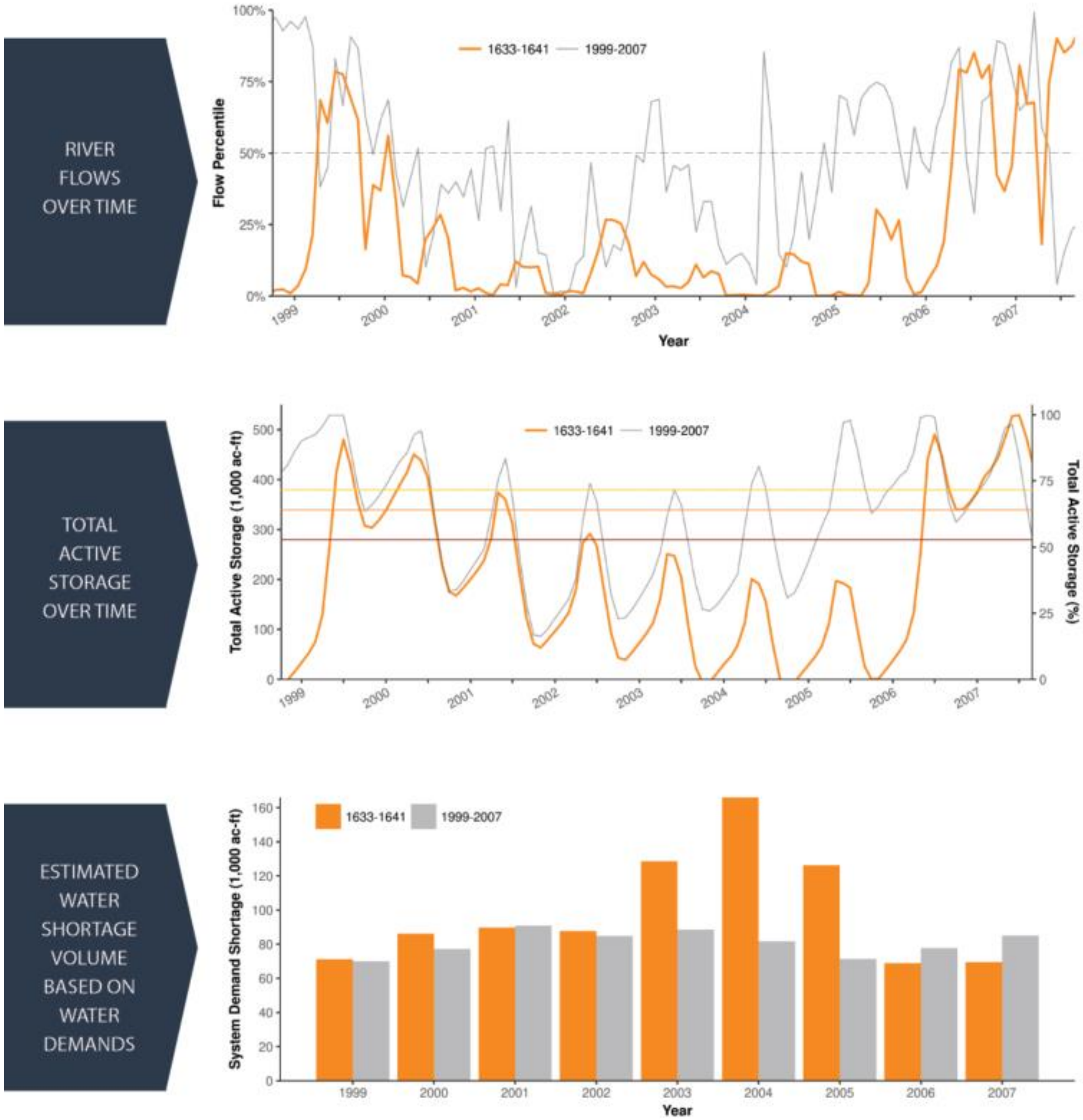


Figure 3- 10: Drought Years in Succession

The first graph in the figure is a plot of the river flows over time. The second graph is a plot of the total active storage versus time. The third graph illustrates the estimated water shortage volume based on water demands. A key trend is observed based on these graphs. During extended multi-year droughts, river flows may drop off first, followed by a drop-in reservoir storage after the first couple of years. Demand shortages are greatly increased multiple years into the actual drought.

3.6 Future Climate Change Scenarios

3.6.1 Overview

Drought impacts the availability of water in the Weber River Basin and affects the ability of WBWCD to supply water to its customers. Understanding the impact of drought on WBWCD's ability to provide water for its customers requires looking critically at the incidence of drought; both in the past and in the future. Future conditions may change and may hinder the ability of WBWCD to deliver adequate water supplies.

Western Water Assessment completed an evaluation of potential future climate change scenarios to identify the possible climate effects on future water supplies. Projected future flows are based on four climate change scenarios.

The analyses conducted were two-fold. One was the development of downscaled climate projections of temperature and precipitation for the Weber River Basin for 2050. The second was a projection of future Weber River flows using the Colorado Basin River Forecast Center (CBRFC) hydrological model and monthly projections of future temperature and precipitation. The results from the CBRFC hydrological model were projections of Weber River flows for 2050 and were then used as an input for the Weber River Basin systems model.

The climate change projections completed for this DCP are based on phase 5 of the world Climate Research Programme Coupled Model Intercomparison Project (CMIP5). In the future, these regional projections will be updated to become more localized. WBWCD will be completing a localized climate change vulnerability study with USU and Western Water Assessment to downscale future climate scenarios to be more specific to Weber Basin. A summary of the Global Climate Model (GCM) climate change evaluation and scenarios is included in the following sections. The full climate change report prepared by Western Water Assessment is included in Appendix 3-C.

3.6.2 Climate Scenarios

There is not a single answer to the question of what future climate in the Weber River Basin looks like. Different climate models simulate a range of future climates in the Basin, and different future emissions scenarios alter the output from each climate model. In order to convey the range of projected changes in climate and runoff in the Weber River Basin, a scenario planning approach was used. Five scenarios were chosen from 234 monthly runs of downscaled GCMs under three emissions scenarios. Five scenarios were chosen from 234 monthly model runs that represent the median, or central tendency, of model results and the 10^{th} and 90^{th} percentiles of temperature increase and precipitation change. Five individual monthly model runs that were closest to each of the five scenarios were averaged to obtain an exact temperature increase and precipitation change. These five scenarios are:

1. Central Tendency (median model results).
2. Warm and Wet (10^{th} percentile temperature, 90^{th} percentile precipitation).
3. Warm and Dry (10^{th} percentile temperature, 10^{th} percentile precipitation).

4. Hot and Wet (90th percentile temperature, 90th percentile precipitation).
5. Hot and Dry (90th percentile temperature, 10th percentile precipitation).

These scenarios take the 30-year period from 1980 to 2010 and project water conditions for future years 2034 to 2064. Table 3-4 shows the projected increase in annual average temperature and annual average precipitation for each scenario. The projected monthly changes in precipitation and temperature were calculated for each of the five scenarios. Monthly temperature increases and precipitation changes for each scenario were used to project monthly Weber River flows using the CBRFC hydrological model.

CLIMATE CHANGE SCENARIOS		
Scenario	Temperature Change (Fahrenheit)	Precipitation
Central Tendency	+4.1	+4%
Warm and Wet	+2.3	+12.7%
Warm and Dry	+2.2	-5.9%
Hot and Wet	+5.6	+10.2%
Hot and Dry	+5.8	-6.2%

Table 3- 4: Temperature and Precipitation Change for 2050 Compared to 1981-2010

Precipitation for three of the five scenarios is projected to increase. The Warm and Dry and the Hot and Dry scenarios show projected decreases in precipitation.

3.6.3 Projected Peak Runoff

Monthly climate data from water years 1981-2010 at the Weber River Oakley flow gauge were adjusted to reflect each future climate scenario. Each of the five scenarios were run in the hydrological model, and daily stream flows at Oakley were outputted. Daily stream flows for each of the five future climate scenarios were aggregated into monthly flows. An examination of projected monthly flows at the Weber River Oakley flow gauge highlights general changes in the availability and timing of runoff. Figure 3-11 plots average monthly cumulative stream flows at Oakley for the five future climate scenarios against the historical conditions.

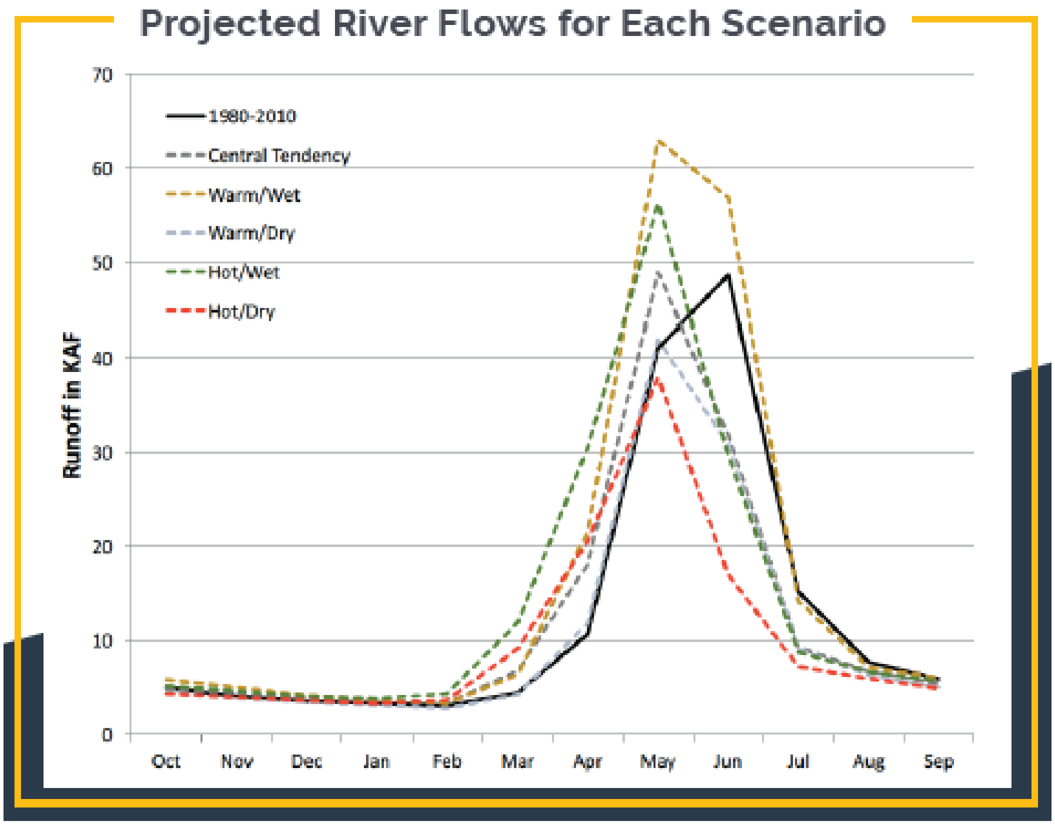


Figure 3- 11: Projections of 2050 (2035-2064) monthly Weber River streamflow at Oakley, UT

Peak flows occur earlier in the year (May) for all the evaluated future climate scenarios compared to historical peak flows (June). Peak flows are higher in the warm/wet and the hot/wet scenarios compared to historical peak flows, while peak flows for the hot/dry and warm/dry scenarios are lower than historical peak flows.

3.6.4 Storage Projections

Projected monthly flows for each climate scenario were then used as inputs in the Weber River systems model to assess the impact of future changes in climate on water availability, reservoir storage, and the incidence and severity of drought in the Weber River Basin.

Figure 3-12 shows how four of the evaluated potential climate change scenarios may affect the total storage in the Weber River Basin. The black line represents the past thirty years of storage, and the colored areas represent what the future storage is projected to be for each scenario.

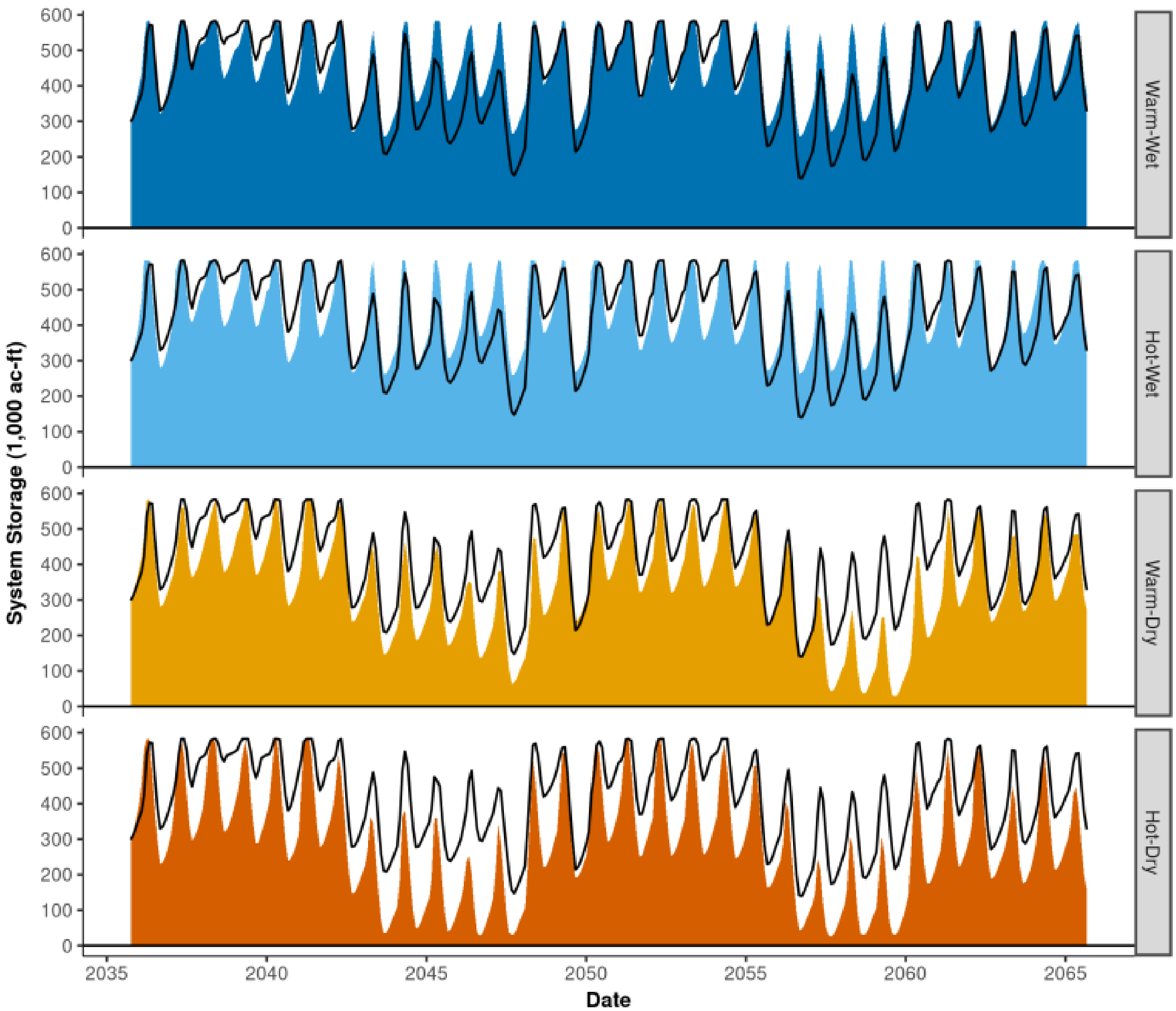


Figure 3- 12: Four Evaluated Potential Climate Change Scenarios

Some general observations related to the climate change evaluation are:

- Climate change produces higher flows for all scenarios during April and for the Warm-Wet, Warm-Dry, and Hot-Wet scenarios in May. This effect is most significant for the wet scenarios and is far less significant for the dry scenarios.
- Except for the Warm-Wet scenario, flow is projected to be much lower during June and July.
- The Hot-Dry scenario has the largest decrease in May, June, and July; therefore, it is considered the most severe scenario.
- In the Hot-Wet, Warm-Dry, and Hot-Dry scenarios, the high flow period is often shifted one month earlier, from June to May. The lowest flow period also starts earlier, often in June. For the Hot-Dry scenario, nearly all flows are below the historical median from June until September.
- The Warm-Dry and Hot-Dry scenarios produce much more severe and sustained volume deficits, while the Warm-Wet and Hot-Wet scenarios produce less severe deficits.

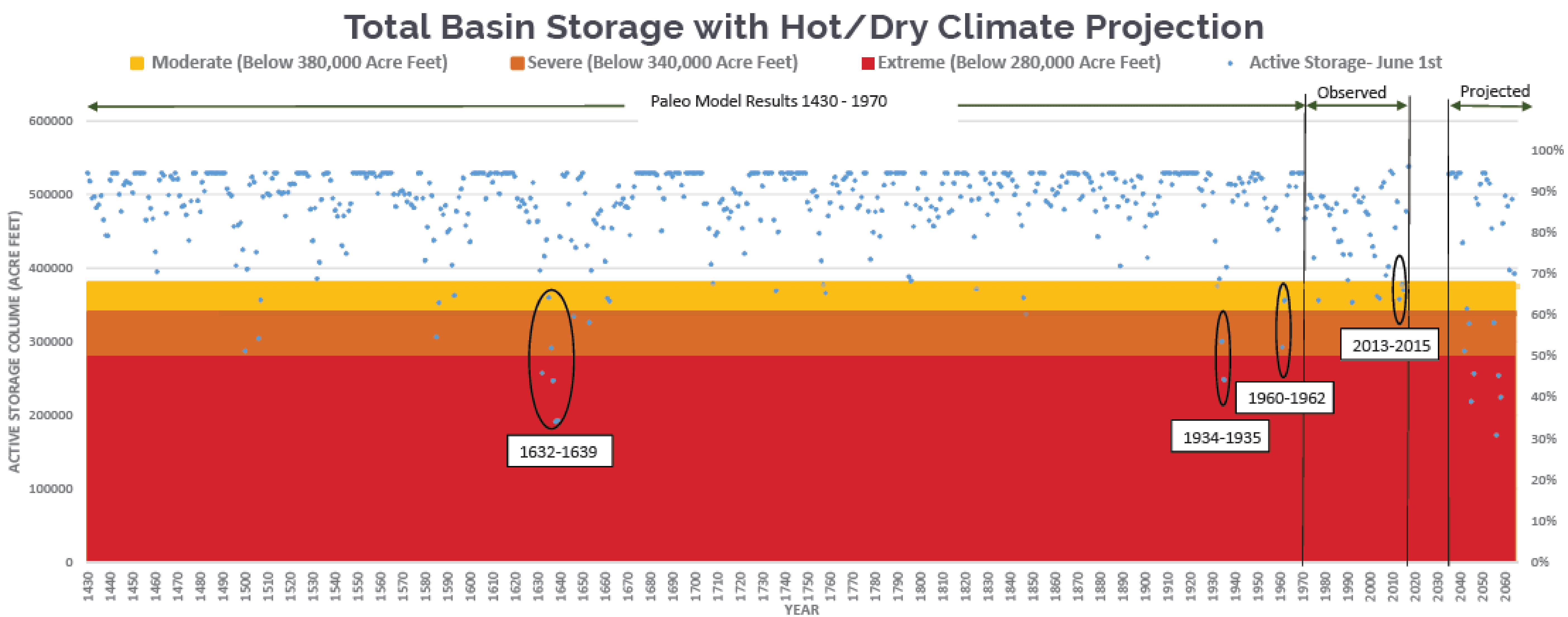
3.6.5 Future June 1st Storage Projections

Projected monthly river flows for each climate scenario were used as inputs in the Weber River systems model to assess the impact of future climate changes on water availability, reservoir storage, and the incidence and severity of drought in the Weber River Basin.

The warm-wet and the hot-wet future model scenarios did not create any projected drought years for years 2034 through 2064 in terms of water supply (storage). The central tendency scenario may be closer to what future conditions will be but has only one projected moderate drought year. The warm-dry scenario has two projected severe and three projected extreme drought years. The hot-dry future scenario is the worst-case scenario in terms of water storage. It projects one moderate, three severe, and four extreme drought years for the same projection period.

The hot-dry scenario should be considered as a possibility of what the future may bring. Figure 3-13 on the following page shows the past June 1st reservoir levels as well as the projections for the Hot-Dry scenario.

Figure 3- 13: Total Basin Storage with Hot/Dry Climate Projection



While the hot-dry scenario is the worst–case scenario, the drought years projected under this scenario are not outside the realm of possibility. There are nine total drought years projected for the hot-dry scenario. These nine drought years could be split into two multi-year droughts that would be similar to the 1632-1639 drought that is circled in Figure 3-13.

Graphs showing the projected June reservoir levels for all five evaluated climate scenarios are found in Appendix 3-D.

Table 3-5 gives the estimated number of drought events listed by drought level for the future hot-dry scenario as compared to the past drought history. Under this scenario, it appears that many of the moderate level droughts experienced since 1970 will happen again, but may be intensified to severe levels, with three occurring in the future 30-year period. Under this scenario, there are an estimated six extreme droughts projected during the future 30-year-long period.

Hot/Dry Projected Drought

	PROJECTED JUNE 1ST TOTAL BASIN STORAGE		AVERAGE NUMBER OF YEARS BETWEEN EVENTS		
			PAST		PROJECTED
Drought Level	Acre-Feet	% of Total Basin Storage Capacity	1430 - 1970	1971 - 2017	Future Hot-Dry Climate Scenario (2036 - 2065)
Moderate	340,000 to 380,000	64% - 72%	36	7	30
Severe	280,000 to 340,000	53% - 64%	60	No Events	10
Extreme	Less than 280,000	Less Than 53%	135	No Events	6

Table 3- 5: Hot/Dry Projected Drought

A summary table showing the projected average number of years between drought events for each of the evaluated climate scenarios is given in Appendix 3-E.

3.6.6 Climate Change Findings

This climate change study was based on large scale inputs and data, but demonstrated that variations in the future climate could have very significant impacts on the water supply. A climate change study that is based on local inputs should be completed to gain a better understating of how the WBWCD water storage will be affected by potential changes to the climate.

Although this climate change study was based on global inputs and not specific to the WBWCD service area, it gave some additional perspective and insight into some of the vulnerabilities identified during the stakeholder process.

Available Water Supply During Drought (Junior Water Rights and Climate Change) – Changes to the climate could potentially impact the available water supplies and increase the possibility of having a drought. If the hot-dry scenario evaluated in this study actually occurs, WBWCD would have two multi-year droughts that would be similar to the 1632-1639 drought, and June 1st storage volumes could be less than 200,000 acre feet.

Wasteful Watering – There will not be enough stored water supply to water lawns with culinary or secondary water during nine of the thirty years evaluated under the hot-dry future climate scenario.

Lack of Drought Information to the Water Users – Water users need to understand to what extent climate changes could impact water supplies in order to understand why outdoor water use and other water use reductions will need to occur in future drought periods.

3.7 Specific Risks Identification

3.7.1 Background

Two risk assessment workshops were held during the DCP creation with the Technical Team. The workshops allowed for group brainstorming about some more specific potential risks associated with the drought vulnerabilities. The Technical Team listed risks and then assigned a risk level to each risk based on a combination of the likelihood of the risk occurring and the potential impact or consequences. The risks were categorized according to the table shown in Figure 3-14.

Risk Levels

Likelihood of Occurrence \ Impact of Consequence of Occurrence	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	LOW	MODERATE	HIGH	HIGH	HIGH
Likely	LOW	MODERATE	HIGH	HIGH	HIGH
Unlikely	LOW	LOW	MODERATE	MODERATE	HIGH
Very Unlikely	LOW	LOW	LOW	LOW	HIGH

Figure 3- 14: Risk Levels - Likelihood and Impact

3.7.2 Specific Risks Summary

Key Drought Vulnerabilities are summarized in Table 3-6 with their associated risks and risk levels.

Key Drought Vulnerability	Risks Associated with Vulnerabilities	Risk Level
Available Water Supply During Drought (Junior Water Rights)	Failure to enter into agreements	High
	Loss of Echo holdover water	High
	Failure to deliver culinary water	High
	Increased wildfires	High
	Hot-dry climate	High
	Inability to utilize Larrabee water right	Moderate
Wasteful Watering	Excessive use of water resources	High
	Inability to deliver 50% of secondary water	Moderate
	Inability to deliver 100% of secondary water	Low
Inability to Operate and Maintain Water Systems	Failure to maintain existing storage and delivery facilities	Moderate
	Loss of power generation at plant in Weber Canyon	Moderate
Lack of Drought Information to the Water Users	Failure to collaborate and educate	High
Environmental and Recreational Impacts	Decreases in stream flows and storage. Reduced GSL levels	High
Agricultural Impacts	Inability to deliver 50% of agriculture water	High
	Inability to deliver 100% of agriculture water	High

Table 3- 6: Key Drought Vulnerabilities and Associated Risks/Risk Levels

Following is a more detailed description of each of the risks evaluated in the risk assessment workshops.

Available Water Supply During Drought (Junior Water Rights)

- **Failure to Enter into Agreements –** General lack of ability to have agreements or memorandums of understanding in place to supplement water supplies during drought periods.
- **Loss of Echo Holdover Water Option –** Every year in the fall, WBWCD has the option to purchase holdover water from Weber River Water Users; however, during a very dry year, Weber River Water Users may choose to not sell the holdover water to WBWCD.
- **Failure or Inability to Deliver Culinary Water –** WBWCD is obligated to meet the needs of the culinary water customers, and drought conditions hinder the ability to do so.
- **Increased Wildfires –** During droughts, the potential for wildfires will increase greatly, and available water supplies to fight fires will be limited.
- **Hot-Dry Climate –** A change in climate that is similar to the evaluated hot-dry climate scenario would greatly reduce available water stored in the reservoirs.
- **Inability to Utilize Larrabee Water Right** – The Larrabee water right is an undeveloped, WBWCD-owned storage right for 10,000-acre feet of water on the Weber River.

Wasteful Watering

- **Excessive Use of Water Resources –** Excessive use or waste of water resources hinders the ability to supply needed water during droughts.
- **Failure or Inability to Deliver Half of Secondary Water (50 percent) –** Failure or inability to deliver 50 percent of lawn and garden/secondary water during a drought. It is assumed that agriculture water would also be reduced by 50 percent for this scenario.
- **Failure or Inability to Deliver all Secondary Water (100 percent) –** Failure or inability to deliver all of lawn and garden/secondary water during a drought.

Inability to Operate and Maintain Water Systems

- **Failure to Maintain Infrastructure –** Failure to maintain existing water storage and delivery facilities.
- **Power Generation Loss –** Loss of all, or severe reduction in power generation.

Lack of Drought Information to the Water Users

- **Failure to Collaborate and Educate –** Inability to work with retail water users and other water users in the service area.

Environmental and Recreational Impacts

- **Decreases in Stream Flows and Storage –** Total storage in March is less than 50 percent, and stream flows are decreased.

Agricultural Impacts

- **Failure or Inability to Deliver Agriculture Water (50 percent) –** Failure or inability to deliver 50 percent of agriculture water.
  Failure or Inability to Deliver Agriculture Water (100 percent) – Failure or inability to deliver all agriculture water.

The key drought vulnerabilities and risks identified during the vulnerability assessment were used in the remainder of this plan to evaluate mitigation and response actions, as described in Sections 5 and 6 of this report.

4 DROUGHT MONITORING

4.1 Overview

Understanding how to measure and monitor key indicators of drought is critical to being prepared for future droughts. A robust monitoring system will allow WBWCD to respond sooner to drought events and allow other water systems in the WBWCD boundaries to respond effectively. Timely response to drought conditions is key to minimizing drought impacts. This plan identifies quantifiable and easily tracked key metrics and triggers that define the drought status throughout the calendar year.

4.2 Drought Monitoring Levels

There are five water supply conditions (drought levels) as listed below:

Level 1 – Normal (Blue).

Level 2 – Advisory (Gray).

Level 3 – Moderate (Yellow).

Level 4 – Severe (Orange).

Level 5 – Extreme (Red).

4.3 Drought Level Triggers

The drought levels are determined by three triggering criteria:

1. Projected June 1st Total Basin Active Storage.
2. Projected June 1st Upstream Basin Active Storage.
3. U.S. Drought Monitor Classification (only a trigger for the advisory level).

4.3.1 Total Basin Active Storage

WBWCD monitors storage levels regularly throughout the calendar year. Storage volumes fluctuate significantly within the reservoirs during each year. Storage volumes are highest during the snow runoff period and are subsequently drawn down during the summer irrigation season. The peak storage achieved in any calendar year is the most critical in terms of water supply. The time that peak storage is achieved each year is typically close to June 1st, sometimes it occurs earlier and sometimes later. The projected June 1st storage is a key indicator of how much water will be available for use through the summer and into the next runoff season.

Total Basin Active Storage is the usable storage within the Weber River Basin, including storage owned by WBWCD and others, with a maximum volume of 529,000 acre feet. There are many years when the maximum storage is not reached.

4.3.2 Upstream Basin Active Storage

The Upstream Active Storage is the same as the Total Basin Active Storage, excluding the water that is stored in the Willard Bay Reservoir. The maximum upstream active storage that can be achieved in a given year is 326,679 acre feet. It is important to monitor this because the storage that is downstream of the mouth of Weber Canyon cannot be as easily treated or utilized to meet WBWCD needs throughout heavily populated areas.

4.3.3 U.S. Drought Monitor Intensity Classification

Another tool used only to help establish the normal and advisory drought levels is the U.S. Drought Monitor Intensity Classification. This tool was created by the National Drought Mitigation Center (University of Nebraska) and is found at http://drought.unl.edu/monitoringtools/usdroughtmonitor.aspx. It provides a summary of drought conditions across the United States and is updated weekly by combining a variety of data-based drought indices and indicators and input from local experts. A copy of this tool from May 8, 2018 is shown in Figure 4-1.

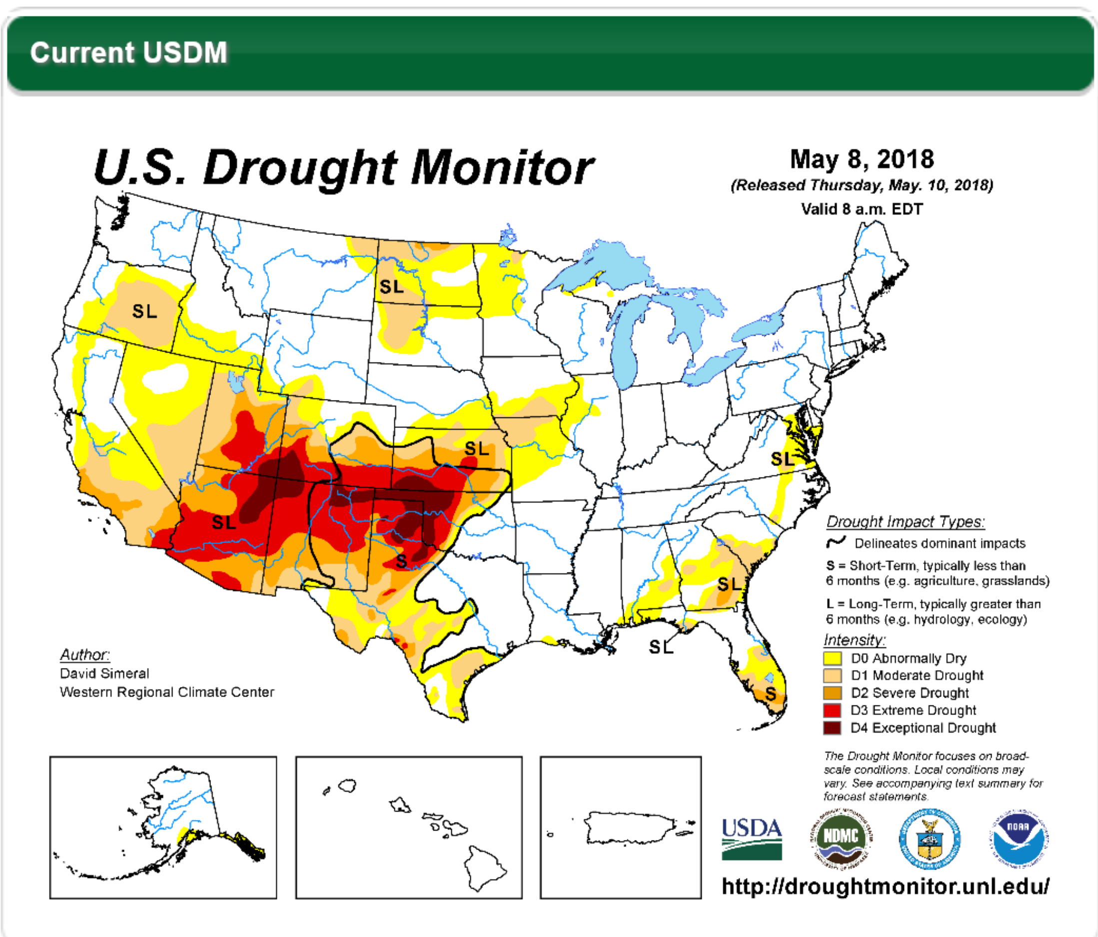


Figure 4- 1: Drought Monitor Intensity Classification

4.3.4 Drought Level 1 (Normal)

Drought Level 1 is referred to as Normal and indicates a state of adequate water supply and is not technically a drought condition. The normal level requires a projected June 1st Total Basin Storage greater than 380,000 acre-feet, and a projected June 1st Total Upstream Basin Storage greater than 245,000 acre-feet. It also requires no drought intensity classification or a D0 classification per the U.S. Drought Monitor Intensity Classification system.

4.3.5 Drought Level 2 (Advisory)

Drought Level 2 is referred to as Advisory and requires a projected June 1st Total Basin Storage greater than 380,000 acre-feet, a projected June 1st Total Upstream Basin Storage greater than 245,000 acre-feet, and a drought intensity classification of D1 (or more severe). The advisory drought level is for situations when the projected reservoir storage volumes of the current year will be close to full, based on good snowpack and runoff from the previous years, but the current year has been a poor precipitation year. The advisory level allows WBWCD to begin taking actions to reduce water use in case a second poor precipitation year follows the first poor year.

4.3.6 Drought Levels 3,4 and 5 (Moderate, Severe and Extreme)

Levels 3, 4, and 5 are referred to as moderate, severe, and extreme respectively. These drought levels are classified by the worst (lowest) projected June 1st storage of the two storage triggers, and are not based on the U.S. Drought Monitor Intensity Classification. For example, if the projected June 1st Total Basin Storage is 345,000 acre-feet (Moderate), and the projected June 1st Total Upstream Basin Storage is 195,000 acre-feet (Severe), the drought level would be Level 4 (Severe).

Table 4-1 lists the WBWCD drought levels along with the triggers for each level. The names for the WBWCD drought levels are different than those given on the U.S. Drought Monitor Intensity Classification.

Drought Levels		[4]Drought Level Triggers		
Response Level	Water Shortage Description	[1]Projected June 1st Total Basin Storage (Acre Feet)	[2]Projected June 1st Total Upstream Basin Storage (Acre Feet)	[3]U.S. Drought Monitor Intensity Classification
1	Normal	Greater than 380,000	Greater than 245,000	No Drought Intensity Classification or D0 (Abnormally Dry)
2	Advisory	Greater than 380,000	Greater than 245,000	D1 (Moderate Drought) or more severe
3	Moderate	380,000 to 340,000	245,000 to 200,000	U.S. Drought Monitor is not a trigger for this response revel
4	Severe	340,000 to 280,000	200,000 to 160,000	U.S. Drought Monitor is not a trigger for this response revel
5	Extreme	Less than 280,000	Less than 160,000	U.S. Drought Monitor is not a trigger for this response revel

[1]Active storage (Total Basin Storage)

[2]Active storage excluding Willard Bay (Total Upstream Basin Storage)
[3]National Drought Mitigation Center:
http://drought.unl.edu/monitoringtools/usdroughtmonitor.aspx
[4]See Section 4.3.4 through 4.3.6 for detailed explanations of how the three triggers are used together to determine the drought level

Table 4- 1: Drought Levels

4.3.7 WBWCD Storage

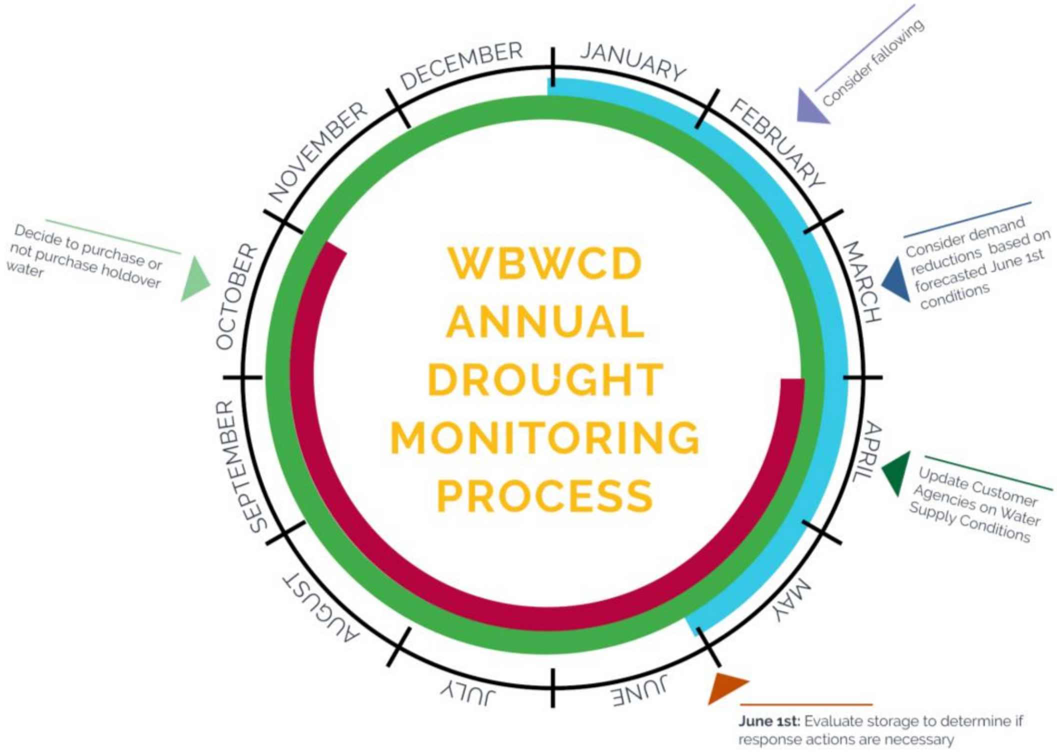
As already stated, the drought levels and triggers listed above are based on the total basin storage; however, in the past, WBWCD has evaluated and will continue to evaluate the storage that is actually owned by WBWCD throughout each year as part of its supply assessment.

4.4 Drought Monitoring Process

WBWCD follows an annual drought monitoring cycle to establish the current drought status in the District, based on the drought level triggers. Beginning in January of each year, WBWCD begins to project how much water will be stored in the basin on or near June 1st. The annual process is based on past procedures utilized by WBWCD and includes proposed actions that have been identified in this DCP.

The Natural Resources Conservation Service (NRCS) and Colorado Basin River Forecast Center (CBRFC) provide volumetric projections on the potential runoff during the April through July period at key locations along the river drainages. Those projections are updated at least every month until June to relate potential runoff to the Snow Water Equivalent (SWE) of the snowpack and related historical and modeling data. These projections are analyzed by WBWCD, along with the current reservoir levels, associated storage space available, historical storage, inflow, and release data at each reservoir; as well as soil moisture and peak flood probability. WBWCD makes an estimation of water available to store after satisfaction of prior water rights on the drainage. In wet years, routing of flood waters to minimize downstream flooding significantly impacts system operation and time required to fill each of the reservoirs. The annual monitoring process is shown and outlined in Figure 4-2.

Figure 4- 2: Drought Monitoring Process



EVERY MONTH

Water Manager prepares a water supply report including:

- Reservoir Levels: Percent of capacity compared to other years
- Groundwater levels
- Review historic storage graph

JANUARY - JUNE

- Gather runoff and snowpack forecasts from Natural Resource Conservation Service (NRCS)
- Gather runoff and snowpack forecasts from NOAA's Colorado Basin River Forecast Center (CBRFC)

FEBRUARY

- Decision for whether to initiate fallowing of agricultural lands
- Develop contact list of willing customers
- Execute agreements, as needed

MARCH

- Board of Trustees decides whether to initiate demand-reduction procedures.
- Issue press release and/or letter to wholesale customers
- Add notification to District website
- Notify retail customers
- Provide status report to irrigation companies & wholesale customers

APRIL - OCTOBER

Enforce restrictions as approved by the Board. Monitor usage and modify restrictions as needed.

APRIL

- If drought level is Moderate, Severe, or Extreme: Meet with advisory group stakeholders to discuss specific drought response actions

JUNE

- Evaluate storage in each of the reservoirs
- Final review of forecasts

OCTOBER

- Determine whether holdover water is needed.
- If needed, execute purchase agreements

4.4.1 Additional Storage Projection Tools

Another resource that WBWCD utilizes to project storage levels is the Intermountain West Drought Early Warning System (IMW DEWS); https://www.drought.gov/drought/dews/intermountain-west. The IMW DEWS grew out of the Upper Colorado River Basin DEWS (UCRB), which was established in 2009 as the first NIDIS DEWS in the U.S. The IMW DEWS incorporates the states of Arizona, Colorado, western New Mexico, Utah, and Wyoming, with the goal of fostering interstate coordination to cope with future droughts, growing water demands, and supporting increased communication and collaboration between scientific and water management communities.

A list of other useful drought websites that WBWCD may utilize to help project June 1st storage, is included in Appendix 4-A.

4.4.2 Unforeseen Circumstances

There are events and circumstances that often cannot be foreseen, but which could impact WBWCD's water supplies and worsen the effect of drought conditions. They include the following:

1. Natural disasters.
2. Human impacts.
3. Capacity restriction or failure.
4. Outlet control works failure.
5. River diversion works failure.
6. Canal or tunnel failure.
7. Aqueduct or aqueduct control equipment failure.
8. Contamination of water from a spill; highway, railway, or similar event.
9. Water treatment plant failure or contamination.
10. Major supply line failure.

4.5 Drought Database and Internet Water Supply Dashboard

The collected drought data from the monitoring process can be compiled into an interactive data visualization software. This database and software will allow WBWCD to better analyze, compare, and understand conditions that existed prior to previous droughts and how the reservoirs and infrastructure in the basin were operated in those dry years. This will allow WBWCD to respond to drought in a timelier manner.

The data collected for the database can be used to create drought indicator dials on an internet dashboard that can be viewed by water users in and out of WBWCD. WBWCD can develop dial-indicators as measures for reporting each of the drought stages on an online water supply dashboard. WBWCD could provide one summary dial indicator with other dial indicators:

After securing funding from Reclamation for the effort, WBWCD is planning to develop dial-indicators as measures for reporting each of the drought stages. As part of this effort, WBWCD is considering providing snapshot (static), dial indicator readings for the needle at various levels. Then, WBWCD could use logic-based inputs to select the correct snapshot, static reading (image) to display on its website to convey the current water conditions in WBWCD.

WBWCD could provide one summary dial indicator with four other dial indicators:

- Summary (total system status).
- Groundwater.
- Runoff (April to July).
- Snow Pack.
- Projected June 1st Storage.

An example of the major items that could be shown on the dashboard is shown in Figure 4-3.

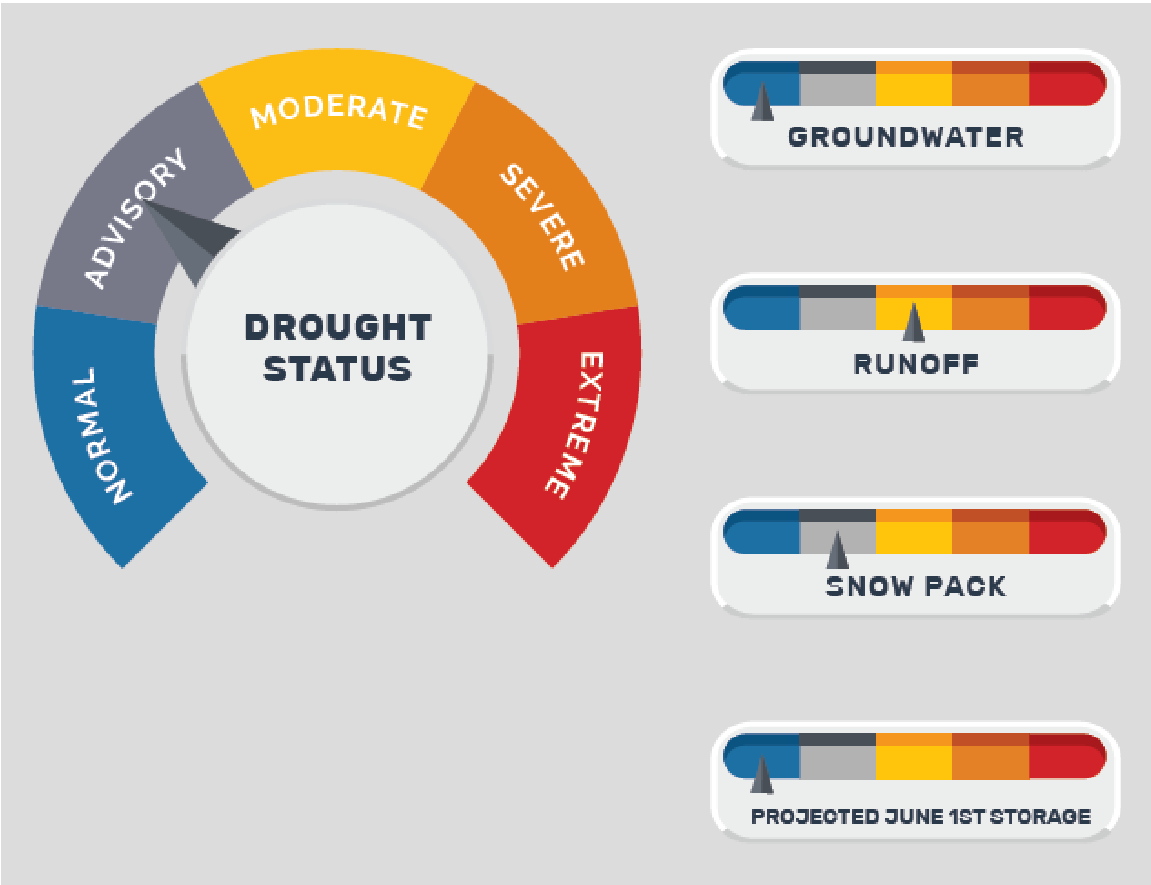


Figure 4- 3: Drought Status Dashboard

Other information could be added to the dashboard over time to help the water users have a better understanding of the current water supply conditions. During the June 20, 2018 Advisory Group meeting, attendees were asked what features, data, and capabilities they would like to see on this dashboard. Responses included:

- Sub-basin information.
- Soil moisture.
- End user actions.
- Recommended irrigation schedules.
- Actual June first storage .
- Drought monitor link.
- Link to historical drought levels and other internet links.
- Possibility shortages.
- Water use restrictions (if necessary).
- Slider bar to see recent/historical drought levels.
- Interactive dashboard (For example: if this…then what).
- An opportunity to comment and ask questions.
- List of suggested conservation actions to reduce consumption.
- Definitions.
- Make the dashboard unique with information you can’t find on other websites.
- Updated probabilities, average projections
- Make it specific to Weber Basin.
- Define, extreme, severe, and moderate (definitions) so people don’t misinterpret or mix up with different drought levels identified in other DCPs or indices.

4.6 Annual Forecasting Tool

Over time, WBWCD will build the drought database, which will contain information that allows them to more accurately forecast the June 1st storage levels beginning in January of each year. WBWCD plans use the data to create a storage volume forecasting graph or graphs like the conceptual graph shown in Figure 4-4.

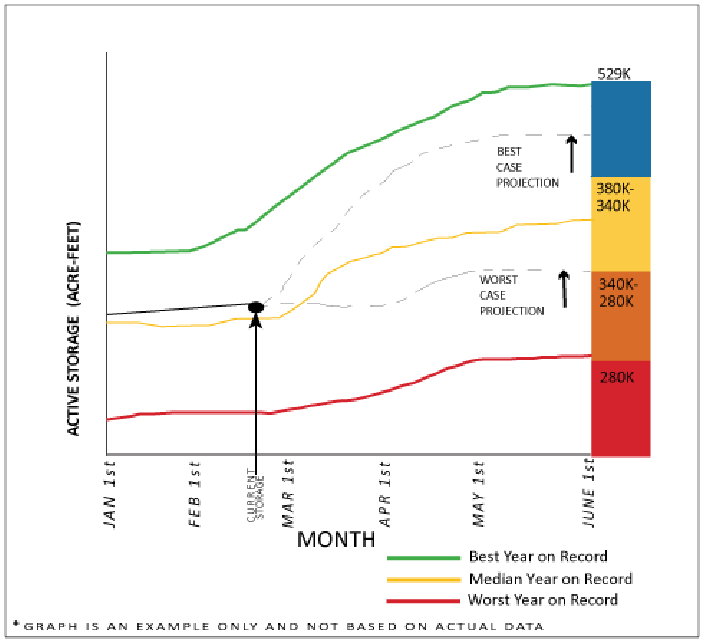


Figure 4- 4: Storage Volume Forecasting Tool (sample)

The graphs will show the best, worst, and median storage year on record compared to the current year up to the current day of the current year. It can then show forecasts or predictions of the upcoming June 1st storage, assuming water conditions that match the worst and best water years on record. June 1st storage predictions will improve as more and more data is added to the database.

5 MITIGATION MEASURES

5.1 Overview

An effective drought mitigation plan identifies, evaluates, and prioritizes mitigation measures and activities that will build long-term resiliency to drought and mitigate the potential risks. Typically, mitigation measures are anticipatory actions, programs, and strategies, implemented before droughts occur to address potential risks and impacts. Mitigation measures lessen the potential impact of perceived risks. These actions are outside of regular water management activities and are intended to decrease sector vulnerabilities and reduce the need for drought response actions.

Mitigation measures are actions taken prior to a drought to help lessen the impacts of drought within Weber Basin.

5.2 Specific Mitigation Measures

The findings from the vulnerability assessment provided the information needed to evaluate specific mitigation actions. After listing and categorizing the key vulnerabilities and associated risks during the vulnerability assessment, the workgroup brainstormed some general potential mitigation measure ideas to address each of those risks. The mitigation ideas identified during the brainstorming session are listed in Appendix 5a, and are categorized as high, medium, and low.

These mitigation ideas were used, along with other input that had been received by stakeholders through interviews and other meetings, by the Technical Team and the Advisory Group to develop a list of specific mitigation measures to evaluate and prioritize based on a set of objectives. Table 5-1 shows the identified mitigation measures to address the risks associated with the vulnerabilities.

Vulnerability	Risks Associated with Vulnerabilities	Possible Mitigation Measures
Available Water Supply During Drought (Junior Water Rights)	Failure to enter into agreements	Weber Canyon ASR Develop Larrabee Storage South Davis ASR Study Develop Bear River Allocation Short Term Transfer Agreements Water Sharing Agreements Ogden City Pineview Water Sharing Agreement Water Reuse Tiered Rates & Short Term Transfer Water Fund Salt Lake Interconnect Feasibility Study Line and Expand Capacity of Willard Canal Salt Lake Metro Holdover Water Agreement Change Echo Reservoir Water Use to Include M&I Purchase Water from Neighbor District Purchase Millcreek Water Rights Create a Wildfire Prevention Coalition Connect Farmington Wells to Culinary System Improve Willard Bay Siphon
	Loss of Echo holdover water	
	Failure to deliver culinary water	
	Increased wildfires	
	Hot-dry climate	
	Inability to utilize Larrabee water right	
Wasteful Watering	Excessive use of water resources	WBWCD Secondary Water Metering Other Systems Secondary Water Metering Drought Surcharge Fees Tired Rates & Short-Term Transfer Water Fund Replace Leaking Infrastructure
	Inability to deliver 50% of secondary water	
	Inability to deliver 100% of secondary water	
Inability to Operate and Maintain Water Systems	Failure to maintain existing storage and delivery facilities	Drought Surcharge Fees Purchase Weber Canyon Plant
	Loss of power generation at plant in Weber Canyon	
Lack of Drought Information to the Water Users	Failure to collaborate and educate	Drought Surcharge Fees Education Drought Plan Results Internet Water Supply Dashboard Assistance for Other Secondary Systems
Environmental and Recreational Impacts	Decreases in stream flows and storage. Reduced GSL levels	Habitat Advisory Group Meetings
Agricultural Impacts	Inability to deliver 50% of agriculture water	Short Term Transfer Agreements Tiered Rates & Short-Term Transfer Water Fund
	Inability to deliver 100% of agriculture water	

Table 5- 1: Identified Mitigation Measures to Address Risks Associated with Vulnerabilities

5.3 Mitigation Measure Objectives

The Technical Team developed a list of objectives, based on the stakeholder input and the vulnerability assessment, to assess how well specific mitigation measures will address the key vulnerabilities, be cost effective, and be implementable. The objectives were divided into the following main types:

- Supply.
- Finance.
- Implementation/Risk Reduction.
- Environment.

Within each of the objective types are multiple more specific mitigation objectives. The objectives used to evaluate the mitigation measures were not weighted because of the diversity of the stakeholders. What is very important to one stakeholder may not be as important to another stakeholder; however, during the stakeholder input process, it became evident which objectives were important to include.

Most of the mitigation objectives used in the evaluation are directly related to the key drought vulnerabilities that were identified in the vulnerability assessment, as shown in Table 5-2.

Key Drought Vulnerabilities	Mitigation Objectives	Objective Type
Available Water Supply During Drought (Junior Water Rights and Potential Climate Change)	Increase annual WBWCD water supply for drought years	Supply
	Improve mobility of water supplies	Supply
Wasteful Watering	Reduce annual water usage in drought years	Supply
Inability to Operate and Maintain Water Systems	Maintain revenue during drought	Finance
Lack of Drought Information to the Water Users	Improve communication / available information	Implementation/Risk Reduction
	Prepare communities to respond quickly to drought	Implementation/Risk Reduction
Environmental and Recreational Impacts	Minimize drought impact to industry	Environment
	Minimize impact to aquatic ecosystems	Environment
	minimize impact to recreation	Environment
Agricultural Impacts	Improve coordination with agricultural users	Implementation/Risk Reduction

Table 5- 2: Mitigation Objectives

Other objectives that were identified as important to WBWCD were used in the evaluation of mitigation measures. These are listed in Table 5-3.

Other Objectives used to Evaluate Mitigation Measures	Objective Type
Minimize costs	Finance
Obtain funding assistance	Finance
Reduce high drought risks	Implementation/Risk Reduction
Focus on actions that are easier to implement	Implementation/Risk Reduction

Table 5- 3: Other Objectives

5.3.1 Water Conservation

Improved water conservation is a general key drought mitigation objective. The State of Utah has a state-wide goal that was set in year 2000 to reduce water consumption by 25 percent by 2025. Water consumption per capita has been reduced greatly and needs to continue to be reduced. Reductions in demands through conservation efforts will help reduce the impacts that are felt during future drought events. Many of the mitigation measures that are described in this report will help improve water conservation, even though they are not specifically listed as water conservation measures.

5.4 Metrics

Metrics define how well a given alternative meets each objective. Some objectives have more than one metric. Table 5-4 shows the objectives used in the evaluation and the corresponding metrics.

	OBJECTIVE	METRIC (METHOD OF MEASUREMENT)
SUPPLY	Increase Annual WBWCD Water Supply for Drought Years or Reduce Usage in Drought Years	WBWCD Supply Added/Reduced Usage (Acre Feet)
		Additional Years that Increased Water Will be Available During a Multi-Year Drought (Years)
	Improve Mobility of Water Supplies	Mobility Improvement
FINANCIAL	Minimize Costs	*Capital Cost to Develop Water, or Cost to Reduce Usage
		*Annual O&M Cost
		*Debt Service and Operation and Maintenance Costs for 50 Year Life Cycle
	Obtain Funding Assistance	Grant Availability (Likelihood)
	Maintain Revenue During Drought	Improved Potential to Maintain Revenue During Drought
IMPLEMENTATION & RISK REDUCTION	Reduce Drought Risks	High Risks from Risk Assessment that are Reduced (Number)
	Focus on Actions that are Easier to Implement	*Policy Change/ Political Pushback (Magnitude)
		*Time to Complete (Years)
	Prepare Communities to Respond Quickly to Drought	Communities that are Educated about Drought (Number)
	Improve Communication/ Available Information	Increase in Drought Level Knowledge of Water Users in the District
	Improve Coordination With Agricultural Users	Level of Improved Coordiantion Between WBWCD and Agricultural Users
ENVIRONMENT	Minimize Impacts to Industry	Additional Flows in Weber River Near the Great Salt Lake During Drought
	Minimize Impacts to Aquatic Ecosystems	Additional Flow in the River at Critical Times (cfs)
		*Potential Level of Adverse Impacts to Ecosystems
	Minimize Impacts to Recreation	Additional Water Volume in Reservoirs During Drought (Acre Feet)

Table 5- 4: Metrics (Method of Measurement)

5.5 Types of Mitigation Measures Evaluated

The mitigation measures were placed into the following major types.

- Storage/Source.
- Agreements.
- Flow Measurement.
- Rate Structures.
- Water Re-use.
- Education.
- Habitat Improvement.
- Distribution.

Symbols and color coding were assigned for the types of mitigation measures that were evaluated, as shown in Figure 5-1.

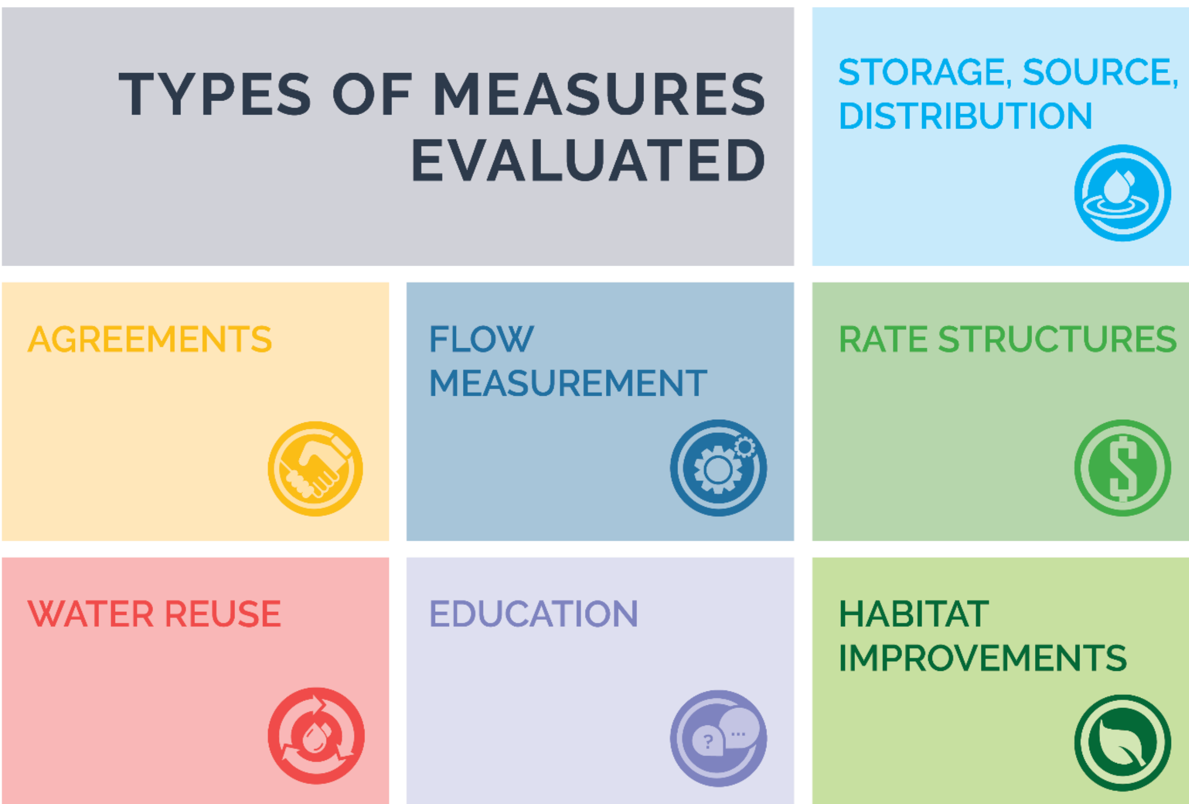


Figure 5- 1: Mitigation Measure Types

5.6 Explanation of Evaluation of Mitigation Measures Table

Table 5-5 was created to evaluate the specific mitigation measures that fall within the types of measures to determine which specific measures should be focused on. The specific measures that were evaluated are listed down the left-hand side of the table and are sorted by type. The objectives are listed across the top of the table.

DWRe ran scenarios in the Riverware model to understand how possible supply and reuse mitigation measures could improve water supplies during drought. This understanding was then used during the evaluation of mitigation measures. A description of the model scenarios and the modeling results is included in Appendix 3-B. Some of the mitigation measures that were modeled are included in Table 5-5

There were other mitigation measures evaluated that are not shown in the table and that were removed from the table during the evaluation process because they clearly did not meet many of the objectives; or were already being done or were not feasible. Some of these non-evaluated mitigation measures are listed in Appendix 5-B.

The mitigation measures that were evaluated are listed down the left-hand side of the Table 5-5 and are sorted by the type of project.

The objectives are listed across the top of the table and are categorized as follows:

- Supply (shown in blue).
- Finance (shown in purple).
- Implementation/Risk Reduction (shown in red).
- Environment (shown in green).

The metrics for each objective are listed across the top of the table just below the objectives.

Table 5- 5: Mitigation Measure Evaluation

		Increase Annual WBWCD Water Supply for Drought Years or Reduce Usage in Drought Years		Improve Mobility of Water Supplies	Minimize Costs			Obtain Funding Assistance	Maintain Revenue During Drought	Reduce Drought Risks	Focus on Actions that are Easier to Implement		Prepare Communities to Respond Quickly to	Improve Communication/ Available Information	Improve Coordination With Agricultural Users	Minimize Impacts to Industry/Great Salt Lake (GSL)	Minimize Impacts to Aquatic Ecosystems		Minimize Impacts to Recreation
		METRICS																	
		WBWCD Supply Added/Reduced Usage (Acre Feet)	Additional Years that Increased Water Will be Available During a Multi-Year Drought (Years)	Mobility Improvement	*Capital Cost to Develop Water, or Cost to Reduce Usage ($/Acre Foot)	*Annual O&M Cost ($/Acre Foot/Year)	*Debt Service and Operation and Maintenance Costs for 50 Year Life Cycle ($/Acre Foot/Year)	Grant Availability (Likelihood)	Improved Potential to Maintain Revenue During Drought ($)	High Risks from Risk Assessment that are Reduced (Number)	*Policy Change/ Political Pushback (Magnitude)	*Time to Complete (Years)	Communities that are Educated about Drought (Number)	Increase in Drought Level Knowledge of Water Users in the District	Level of Improved Coordiantion Between WBWCD and Agricultural Users	Additional Flows in Weber River Near the GSL During Drought (cfs)	Additional Flow in the River at Critical Times (cfs)	*Potential Level of Adverse Impacts to Ecosystems	Additional Water Volume in Reservoirs During Drought (Acre Feet)
		Less than 1,000	Less than 2	None	More than $4000	More than $250	More than $400	None	None	1	High	More than 10	None	None	None	None	None	High	None
		1,000 to 9,999	2 -3	Low	$2,001 to $4,000	$101 to $250	$201 to $400	Low	Low	2	Medium	6 to 10	1 to 2	Low	Low	Low	Low	Medium	Low
		10,000 to 30,000	4 - 5	Medium	$250 to $2,000	$25 to $100	$50 to $200	Medium	Medium	3	Low	1 to 5	3 to 4	Medium	Medium	Medium	Medium	Low	Medium
	MITIGATION MEASURES	More than 30,000	More Than 5	High	Less than $250	less than $25	Less than $50	High	High	More than 3	None	Less than 1	More than 4	High	High	High	High	None	High
ID	**Storage/Source**																		
1	**Weber Canyon ASR** - Develop additonal ASR near mouth of Weber Canyon. Use purchased Echo or East Canyon water in wet years to be used later during drought	10,000	2 -3	Medium	$ 600	$ 60	$ 90	High	Low	2	Low	1 to 5	1 to 2	Low	None	Low	Low	Low	Low
3	**Larrabee Storage** - Develop Larrabee storage right somewhere in the Wasatch Back (Maybe Chalk Creek)	10,000	2 -3	Medium	$ 3,800	$ 10	$ 180	None	Medium	4	High	More than 10	1 to 2	Low	None	Low	Medium	Medium	Low
4	**South Davis ASR Feasibility Study**- A feasibility study to treat water and do ASR in the winter, pull water out in the summer. Provides more groundwater source for south end of service area and aqueduct redundancy.	Less than 1,000	2 -3	Low	**STUDY COST $191,000 TOTAL (SEE FOOTNOTE #2)	n/a	n/a	High	Medium	2	Medium	6 to 10	1 to 2	Low	None	None	None	None	None
5	**Bear River Storage Allocation** - Develop Bear River allocation.	50,000	4 - 5	Low	$ 374,266,000.00	$ 1,512,700	$ 18,840	Low	Medium	6	High	More than 10	1 to 2	Low	None	Low	None	High	More than 20,000
24	**Connect Farmington Wells to Culinary System** - Install transmission line to connect existing wells in Farmington to WBWCD culinary water transmission system	3,260	4 - 5	High	$ 1,500	$ 102	$ 170	High	Medium	3	Low	1 to 5	1 to 2	Low	Low	None	None	Low	Low
	Agreements																		
6	**Short-Term Transfer Agreements** - Create a program and get contracts in place to compensate large agricultural users to fallow land or plant drought tolerant crops when asked.	1,000 to 9,999	More Than 5	High	$ 20	$ 10	$ 110	Low	Medium	3	High	More than 10	None	Medium	High	Low	None	Medium	Medium
7	**Water Sharing Agreements** - Create inter-agency agreement with customer agencies within the district boundaries to purchase some water during drought years.	2,500	More Than 5	High	$ 20	$ 5	$ 190	None	Medium	2	High	1 to 5	None	Low	Low	None	None	None	None
8	**Ogden City Pineview Water Sharing Agreement** - Coordinate with Ogden City to determine if 4,500 shares of water in Pineview are available to purchase or lease from Ogden. Ogden owns 10,000 acre feet, but only about 4,500 acre feet are available for use. Ogden typically uses WBWCD water instead of this Pineview water. The Pineview water is a very high priority right. Determine if an agreement can be reached to purchase or lease the water for drought mitigation.	4,500	More Than 5	High	$ 3	n/a	$ 180	None	Medium	4	High	1 to 5	1 to 2	Low	None	None	None	Medium	None
	Flow Measurement																		
10	**WBWCD Secondary Water Metering** - Meter all secondary WBWCD water users and provide usage reports to the users. Save 35% average when going to meters. 11,000 services left to meter at a cost of $1,200 per service.	4,000	More Than 5	Medium	$ 4,600	$ 50	$ 264	High	Medium	3	Medium	6 to 10	More than 4	High	None	Medium	None	Low	Medium
11	**Other Systems Secondary Water Metering** - Start a WBWCD program to provide secondary water metering technical assistance and meter installation assistance for secondary systems in the district boundaries, but not owned by the District. Assume 80, 000 meters added.	28,000	More Than 5	None	$ 4,600	$ 50	$ 265	High	Medium	3	Medium	More than 10 (Approx. 25 years)	More than 4	High	None	Medium	None	Low	Medium
	Rate Structures																		
12	**Drought Surcharge Fees** - Study and develop a secondary water drought surcharge fee structure for Weber Basin to utilize during drought periods. Fee structures will provide revenue needed for system operation and maintenance and to fund response actions during droughts. (assume all secondary connections are metered)	31,000	More Than 5	None	*STUDY COST $135,000 TOTAL SEE FOOTNOTE #2	n/a	n/a	None	High	3	Medium	1 to 5	None	Medium	None	Low	None	None	Medium
13	**Create New Tiered Rate Structure and Short Term Transfer Water Fund** - Create a fund prior to a drought to purchase water through short term transfer agreements during times of drought. Use overage fees from water users that exceed a certain level of water use in any given month.	5,200	More Than 5	None	$ 20	n/a	$ 7	None	Medium	3	Medium	1 to 5	None	Medium	None	Low	None	None	Medium
	Water Re-use																		
14	**Water Reuse Project** - Create a re-claimed water reuse agreement with one of the treatment facilities located in the district. Build infrastructure needed to utilize reclaimed water for secondary water.	8,000	More Than 5	Medium	$ 4,700.00	$ 340	$ 560.00	Medium	Medium	3	High	6 to 10	None	Low	None	None	None	High	High
	Education																		
15	**Drought Surcharge Fees Education** - Educate cities and the public about rate structures, Prepare a sample ordinance to provide for cities for drought water rate adjustments. Visit cities to explain the rate structures and the benefits (50 customer agencies).	Less than 1,000	More Than 5	None	$ 19	n/a	$ 0.86	None	High	3	Medium	More than 10	More than 4	High	None	Medium	None	None	Low
16	**Drought Plan Results** - Present the drought plan process findings and recommendations to cities and irrigation companies in the district by visiting city council meetings and irrigation meetings. Education about useage reductions that will be needed during different drought stages.	Less than 1,000	Less than 2	None	STUDY COST $87,000 TOAL SEE FOOTNOTE #1	n/a	n/a	Low	Medium	3	None	Less than 1	More than 4	High	High	None	None	None	None
17	**Internet Water Supply Dashboard** - Create a web based system that reports current performance of system and drought levels and informs people what water conservation actions they should be implementing.	1,000 to 9,999	More Than 5	None	$ 20	$ 0.15	$ 1.00	Med	Low	4	None	1 to 5	More than 4	High	Low	Low	None	None	Medium
22	**Assistance for Other Secondary Systems** - Help secondary distribution system managers (retail systems) manage their systems more efficiently to conserve water.	Less than 1,000	Less than 2	None	$ 120	n/a	$ 0.06	Low	None	1	Medium	More than 10	More than 4	Medium	None	Low	Low	None	None
	Habitat Improvement Collaboration																		
19	**Advisory Group Meetings** - Meet regularly with Utah Division of Wildlife Resources, Trout Unlimited, Utah Division of Forestry, Fire, and State Lands, other advisory group stakeholders and key habitat stakeholders to coordinate drought strategies including river operation strategies that will make the river more drought resilient. Strategies may include river braiding, connectivity improvements for better habitat, Improved management of water during wet years for more consistent flows and better GSL industry, water pulsing through the river to clean channels during wet years, etc.	Less than 1,000	Less than 2	None	MEETING COST $5,000 PER YEAR (SEE FOOTNOTE #1)	n/a	n/a	None	None	3	None	Less than 1	None	Low	Low	High	High	None	Medium
23	**Wildfire Prevention Coaltion** - Coordinate with the other water conservancy districts, municipalities, and counies along the Wasatch Front to develop a coalition to help prevent wild fires.	Less than 1,000	Less than 2	None	MEETING COST $5,000 PER YEAR (SEE FOOTNOTE #1)	n/a	n/a	None	None	2	None	Less than 1	None	None	None	None	None	None	None
	Distribution																		
20	**Salt Lake Interconnect Feasibility Study** - Do a study to determine the feasibility of making an agreement and a physical connection between the WBWCD system and the Salt Lake City or Jordan Valley Water Conservancy District System. An interconnection would provide some redundancy on the south end of the WBWCD service area.	Less than 1,000	Less than 2	Medium	STUDY COST $71,500 TOAL SEE FOOTNOTE #1	n/a	n/a	High	Low	2	Low	1 to 5	None	None	None	Medium	None	None	None
21	**Line and Expand Capacity of Willard Canal** - Line the remaining unlined portion of Willard Canal (approximatley 7 miles) with concrete. Assume 2,000 feet of canal lined each year for 19 years. Increases capacity of canal to 2,000 cfs	5,000	More Than 5	Low	$ 21,100	Medium	$ 980	High	Low	2	Low	More than 10	None	None	None	Low	Medium	Low	Low
25	**Improve Willard Bay Siphon** - Improve the existing siphon to allow reliable delivery of 25 cfs and enable WBWCD to access an additional 15,000 annual acre feet of storage	15,000	2 -3	Low	$ 139	$ 0.4	$ 10	High	Medium	1	Low	1 to 5	None	None	Low	Low	None	Low	None

Footnote #1 - *Low values are preferred for this metric. Footnote #2 - **This mitigation action does not develop water for use, but sets up other opportunities to do so. See individual cost spread sheet for costing information

5.6.1 Color Key

A color key is shown just below the metrics and gives four ranges of values for each metric. The measures were evaluated at a very conceptual level; therefore, there is a significant level of uncertainty in the values calculated for the evaluation. The four color levels indicate how well the objectives or goals are attained by a given alternative, with the darker colors indicating a higher level of attainment than the lighter colors.

5.6.2 Conceptual Costs

Cost estimates were created as part of the evaluation of most of the mitigation measures. All the costs are conceptual and were created solely as a tool to help evaluate and compare different types of mitigation measures. Three columns in the evaluation matrix include costs. One column gives the estimated capital cost per acre foot of water to complete a project. The second cost column gives the annual operation and maintenance costs of an alternative. The third column gives the 50-year life cycle cost per year per acre foot. All the estimates include a 35 percent contingency based on the uncertainty of the estimates. Summaries of the major assumptions that were used to create the conceptual cost estimates for the mitigation measures are found in Appendix 5-C.

5.6.3 Evaluation Uncertainty

As mentioned above, there is a level of uncertainty in the analysis done for the evaluation of the conceptual mitigation measures, such as:

- Unknown exact project locations.
- Number of communities that will choose to participate in a project.
- Amount of water that can be developed through a project.
- Exact costs that will be associated with each measure.

5.6.4 Evaluation

In the columns to the right of each listed alternative, numbers are given in cells to indicate the estimated value that each alternative has for each of the metrics. For metrics that could not be exactly quantified, without further evaluation, an assignment of “None,” “Low,” “Medium,” or “High” was given. Any cell that is labeled with “N/A” indicates that the metric in that column does not apply to the alternative listed on that row.

Each mitigation measure is bracketed into one of four levels of attainment for each objective because of the level of uncertainty in the evaluation of alternatives. The four levels are indicated by colors that are lighter for lower attainment levels and darker for higher attainment levels. The strength of a given mitigation measure can be determined by looking across a row for the given measure and comparing how dark the cells are for that measure with the cells for other evaluated measures. Measures that have darker cells are stronger than measures with lighter cells.

All the mitigation measures that are included in the evaluation matrix would help mitigate drought. A scoring system was used to help rank the mitigation measures to help WBWCD identify the measures that should be focused on first based on how well they meet the objectives. The scoring was based on the following points being assigned for the level of attainment reached by each measure.

Level of Attainment	Points
None	0
Low	1
Medium	2
High	3

All of the major objective categories (supply, financial, implementation/risk reduction, and environment) are considered equally important, so they were all weighted equally. This was done by calculating the average score of each mitigation measure by objective category, then summing the four average category scores to get a total score for each mitigation measure. Appendix 5-D shows the evaluation matrix along with the scores and ranking for each of the alternatives.

5.7 Priority Mitigation Measures

The ten mitigation measures that ranked the highest in the evaluation are listed in Figure 5-2. The top ten priority mitigation measures do not focus heavily on increasing water source/supply in WBWCD; however, WBWCD should not pass up future opportunities that may arise to increase existing water sources or improve supply redundancies if those opportunities are vetted out and found to be good opportunities based on WBWCD objectives.

Top 10 Mitigation Measures

1. **Internet Water Supply Dashboard** - Create a web based system that reports current performance of system and drought levels and informs people what water conservation actions they should be implementing.
2. **Drought Surcharge Fees** - Study and develop a secondary water drought surcharge fee structure for Weber Basin to utilize during drought periods. Fee structures will provide revenue needed for system operation and maintenance and to fund response actions during droughts. (Assume all secondary connections are metered)
3. **WBWCD Secondary Water Metering** - Meter all secondary WBWCD water users and provide usage reports to the users. Save 35% average when going to meters. 11,000 services left to meter at a cost of $1,200 per service.
4. **Short-Term Transfer Agreements** - Create a program and get contracts in place to compensate large agricultural users to fallow land or plant drought tolerant crops when asked.
5. **Other Systems Secondary Water Metering** - Start a WBWCD program to provide secondary water metering technical assistance and meter installation assistance for secondary systems in the district boundaries, but not owned by the District. Assume 80, 000 meters added.
6. **Drought Surcharge Fees Education** - Educate cities and the public about rate structures. Prepare a sample ordinance to provide for cities for drought water rate adjustments. Visit cities to explain the rate structures and the benefits (50 customer agencies).
7. **Connect Farmington Wells to Culinary System** - Install transmission lines to connect existing wells in Farmington to WBWCD culinary water transmission systems.
8. **Advisory Group Meetings** - Continue meetings with Advisory Group, Division of Wildlife Resources, Trout Unlimited, and other habitat stakeholders to better define strategies to make river habitat more drought resilient while still meeting water delivery requirements. Strategies may include stream connectivity improvements and water pulsing through the river to clean channels during wet years.
9. **Weber Canyon ASR** - Develop ASR near mouth of Weber Canyon. Use purchased Echo or East Canyon water in wet years to be used later during drought.
10. **Create New Tiered Rate Structure and Short Term Transfer Water Fund** - Create a fund prior to a drought to purchase water through short term transfer agreements during times of drought. Use overage fees from water users that exceed a certain level of water use in any given month.

Figure 5- 2: Priority Ranking for Mitigation Measures

Additional information about some of the top drought mitigation measures is provided in the following sections.

5.7.1 Internet Water Supply Dashboard

Information about the water supply dashboard is provided in Section 4.5.

5.7.2 Drought Surcharge Fees and Education

WBWCD should develop a secondary water drought surcharge fee structure to utilize during drought periods. Drought surcharges are often used on an emergency and temporary basis to pay for costs associated with purchasing emergency water supplies during a severe drought, or to support drought restrictions.

Surcharges during drought conditions can also be used to provide a price incentive for customers to reduce water demand. The surcharge can be in place while the drought conditions exist and can be removed once the drought has ended.

Drought surcharge fee structures are best when they are:

- Simple.
- Equitable for all users.
- Able to provide adequate, but not too much revenue for operation and maintenance during droughts.
- Able to effectively reduce short-term water demands.
- Easily implemented.

Drought rates can be based on fixed/flat rates or on a volumetric basis. The timing to implement the drought fees should be based on the drought stages identified in this DCP.

These drought surcharge fees concepts are explained in more detail in Chapter V.3 of AWWA Manual M1, which is included in Appendix 5-E.

WBWCD will need to educate the cities and the public about the rate structures as a surcharge fee structure is developed.

5.7.3 Secondary Water Metering

Two of the top ten mitigation measures are for metering of secondary water services. One measure is to finish installing meters on the services owned by WBWCD. WBWCD owns roughly 11,000 secondary water services that still do not have meters. A water use reduction of approximately 35 percent has been observed in the areas that have added secondary water meters.

WBWCD should also focus on promoting the installation of secondary water meters on secondary water systems owned by other companies within its boundaries. State laws are beginning to have more emphasis on the metering of secondary water services. WBWCD has experience in the installation of meters and can provide technical assistance for other systems that do not have experience.

5.7.4 Short-Term Transfer Agreements

For this plan, the definition of a short-term transfer agreement is: A written agreement between WBWCD and an owner of water rights or shares that allows WBWCD to compensate the owner for temporary use of the water associated with those rights during periods of drought.

Short-term transfer agreements were mentioned various times during the key person interviews as a potential mitigation measure, and were often referred to as fallowing agreements. Fallowing is the practice of plowing a piece of ground and not planting anything on that land. Short-term transfer agreements could be made with landowners to fallow their land for a period of time, or agreements could potentially be made that would allow the landowner to plant a drought resistant crop instead of a crop that needs to be irrigated more.

These agreements should be made soon, or at least before a significant drought occurs so that they are in place and ready to implement before a drought. These agreements should be mutually beneficial to the landowner and WBWCD. They should provide WBWCD with a more secure supply of water for critical needs during drought periods and allow the landowner to be fairly compensated.

The following steps may be utilized to implement a short-term transfer agreement program based on feedback gathered during the creation of this plan. The feedback includes information gathered during some specific conversations with key stakeholders about short term transfer agreements.

1. Identify Area Required.
2. Create a Draft Agreement.
3. Determine Incentives.
4. Assess Support.
5. Revise the Agreement.
6. Re-assess Support.
7. Execute Agreements.

5.7.4.1 Identify Area Required

Calculate the area of agricultural land that would be required in a fallowing program to achieve the desired results. Determine how much supplemental water WBWCD will need during droughts of the various identified levels. A total water volume of 2,500 acre-feet from fallowing was used for the evaluation of mitigation measures. Approximately 21 homes could be served with indoor use water for each acre of irrigated land, assuming three acre feet of water is used to irrigate an acre of the agricultural land. It is very possible that less than three acre feet of water will come from one acre of land. An example calculation is included in Appendix 5-F.

5.7.4.2 Create a Draft Agreement

Create a draft agreement based upon input from stakeholders. Some input has been received from stakeholders during the creation of the DCP. Some key points that the stakeholders have given with regard to these agreements are:

- The agreements will likely need to include the water user (shareholder) as well as the water right holder, which may be an irrigation company.
- It may be easier to create agreements with those who purchase water directly from WBWCD.
- Agricultural users need assurance that their water rights or shares are protected for future use.
- Agricultural users do not want to see water that is transferred being used to water lawns.
- A good and fair method for establishing the value for that water needs to be set. This may include compensation for secondary effects from not having the water. For example, there may be some increased costs associated with putting a piece of land back into production after it has been out of production for one or more seasons.
- It may be easier to create agreements for pieces of land that are used for alfalfa versus a piece of land that is used to raise produce. Agricultural users that raise and sell produce may feel that they have a duty to deliver produce to their customers as much as they possibly can, even during times of drought.
- WBWCD may want to set a minimum acreage for agreements to avoid a large amount of legal and paperwork associated with a large number of agreements.
- Provide multiple options for agreements such as:
    - Full fallow for entire season.
    - Full fallow after a certain date in the summer. This could allow for some crops to be harvested early in the year and then not water or grow crops later in the summer.
    - Planting of drought tolerant crops in place of a crop that requires a significant amount of irrigation water.

A sample agreement that is being used in Colorado is included in Appendix 5-G. A different agreement used in New Mexico is found in Appendix 5-H. An example agreement from Palo Verde Irrigation District is found in Appendix 5-I.

5.7.4.3 Determine Incentives

Assess the projected value of water during a future drought to determine what incentives should be provided to agricultural users to encourage participation in the fallowing program. Also, WBWCD may consider paying an annual consideration for persons that sign agreements. This would provide some income to the agricultural water user every year regardless of whether or not WBWCD decides to use the water.

5.7.4.4 Assess Support

Meet with agricultural users to inform them of the potential agreements, discover the level of support for water transfer agreements, identify points or areas of concern and identify other considerations to include in the agreements. The Farm Bureau has expressed interest in meeting and discussing these ideas further with those who could potentially enter into future agreements with WBWCD.

5.7.4.5 Revise the Agreement

Modify the draft agreement to address the concerns of stakeholders as information is collected.

5.7.4.6 Re-assess Support

Meet again with the agricultural users that express some interest to determine the level of support for updated agreements and identify and address any new concerns.

5.7.4.7 Execute Agreements

Memorialize the agreement in terms of a contract or memorandum of understanding with willing participants.

5.7.5 Connect Farmington Wells to Culinary System

Installing transmission lines to connect existing WBWCD wells in Farmington to the WBWCD culinary water transmission system would make more source water available for use during droughts. This would also provide culinary source redundancies in that area. Currently the only source of culinary water provided by WBWCD to this portion of Davis County comes from the Davis North Water Treatment Plant.

5.7.6 Advisory Group Meetings

Advisory Group meetings with wildlife habitat stakeholders and the other stakeholders will allow coordination of water resources to be better prepared for drought. Continued dialog with these stakeholders is important to help minimize the effects of drought on the environment.

5.7.7 Weber Canyon ASR

Construct the infrastructure needed to store water in the ground near the mouth of Weber canyon to remove during times of drought. The volume of stored ASR water available for use is reduced over time after it is put into the aquifer, based on a DWRi mandate. The mandated loss is calculated in this manner: The full amount of water is available after the first and second years of storage, and every subsequent year, any volume not used is assessed at a 50 percent loss.

This loss makes any stored ASR water less valuable for use during a long duration drought. WBWCD may want to investigate possibilities to adjust the mandate, if possible, to allow for the stored water to be used after a longer period of storage in the aquifer.

5.7.8 Create New Tiered Rate Structure and Short-Term Transfer Water Fund

WBWCD can develop a tiered rate structure that charges more for water once certain levels of use are surpassed each month. Tiered rate structures can help promote a more efficient use of water supplies. Users that use very large amounts of water could pay a higher rate for excessive use of water. The extra revenue that is generated by those that use more water could be placed in a fund for the implementation of water transfer agreements.

5.7.9 Present Drought Contingency Plan Results

This mitigation measure is not in the top ten priorities, but did rank 11^{th} in the evaluation. WBWCD should present the results of the DCP to the cities and irrigation companies within the WBWCD boundaries. Presenting the results and findings will help those entities prepare for future droughts. They will understand the DCP and may update or create their own DCPs.

5.8 Vulnerabilities Addressed by Top Ten Mitigation Measures

The top ten mitigation measures address the key vulnerabilities that were identified in the vulnerability assessment. Table 5-6 shows the mitigation measures that correspond to the key drought vulnerabilities.

Key Drought Vulnerabilities	Top Mitigation Measures based on Evaluation of Objectives
Available Water Supply during Drought (Junior Water Rights)	Develop water transfer agreements between WBWCD and agricultural water users for use of agricultural water
	Create a tiered rate structure and short term transfer water fund
Wasteful Watering	Install secondary water meters and create drought surcharge fee structure. Present the drought plan findings and recommendations to cities and educate about drought rate structures
Inability to Operate and Maintain Water Systems	Create drought surcharge fee structures to implement during drought periods.
Lack of Drought Information to the Water Users	Create an internet water supply dashboard
	Create drought surcharge fee structures, educate cities and public about rate structures.
Environmental and Recreational Impacts	Continue meeting with Division of Wildlife Resources, Trout Unlimited, and other habitat stakeholders to better define strategies to make river habitat more drought resilient while still meeting water delivery requirements. Strategies may include stream connectivity improvements and water pulsing through the river to clean channels during wet years
Agricultural Impacts	Develop water transfer agreements between WBWCD and agricultural water users for use of agricultural water and compensation for agricultural users during times of drought.

Table 5- 6: Key Drought Vulnerabilities and Mitigation Measures

6 RESPONSE ACTIONS

6.1 Overview

A response action is a planned action that is taken after a trigger event occurs. Response actions are generally required where planned mitigation measures fail to reduce the severity of impact from a drought or a series of continuing drought-related events. The purpose of a response action is to manage the resulting impact of an adverse event.

Most of the drought mitigation measures that were selected through the evaluation explained in Section 5 are directly related to response actions that can be implemented during droughts. The objectives and metrics used to evaluate the mitigation measures also dictated which response actions will be implemented during future droughts. The response actions are made possible because of the mitigation work completed prior to a drought to be prepared to respond. For example, one of the identified mitigation measures is to establish a secondary water surcharge fee structure for WBWCD to utilize during droughts. In the future, when a drought occurs, WBWCD will respond by implementing the established rate structure based on the drought level.

Table 6-1 shows how the response actions are related to the evaluated mitigation measures.

Mitigation Measures	Corresponding Response Actions
Develop internet water supply dashboard.	Post current drought level on dashboard and increase public messaging as drought levels increase
Develop drought surcharge fees and educate water users.	Implement drought surcharge fees.
Install secondary water meters.	Reduce secondary water use and shorten irrigation season (verify through secondary metering).
Create short-term transfer agreements.	Implement short term transfer agreements.
Connect Farmington wells to culinary system	Utilize wells more in drought for indoor water needs.
Develop Weber Canyon ASR.	Recover stored ASR water.
Continue meeting with habitat stakeholders.	Meet more frequently with the Advisory Group as drought levels increase.
Create new tiered rate structure and short-term transfer water fund.	Use funds collected and saved from water usage overages to lease water through short-term transfer agreements.

Table 6- 1: Mitigation Measures and Corresponding Response Actions

A collaborative process with input from the Technical Team and the Advisory Group was utilized to develop the response plan that includes the following parts:

1. **Demand Reduction Targets** – Establishment of target demand reductions (in terms of percentages) for each drought level.
2. **Estimated Effectiveness of Demand Reductions** - Comparison of the total demand volume reduction achieved by reaching the target reductions with the estimated reduced volume of water that will be available each year for each drought level.
3. **WBWCD Response Actions** - Identification of the response actions that will be implemented for each drought level.
4. **Response Action Model Scenarios** - Results of Riverware model scenarios completed to estimate how implementation of the response plan may help during future droughts**.**
5. **Specific Water System Response Actions** - Identification of potential individual system response actions for water systems within WBWCD boundaries.

6.2 Demand Reduction Targets

The response actions promote reductions in water use during drought periods. The Technical Team and the Advisory Group worked together to establish some initial demand reduction targets for each drought level in terms of water use reduction percentages. The Advisory Group was split into the three main sectors to meet separately and discuss target demand reductions and other items for the DCP.

Each sector shared thoughts and proposed demand reductions for each of the following water-use categories for each of the drought levels:

- Secondary Water.
- Agricultural Irrigation.
- M&I Culinary Outdoor Water.
- M&I Culinary Indoor Water.

The demand reduction targets that were proposed by each sector are given in the meeting minutes (See Appendices 2-E, 2-F, and 2-G). The proposed demand reductions for the sectors were averaged. The average proposed reductions are shown in Table 6-2. Table 6-2 also gives the calculated total annual demand reduction, in terms of volume, achieved if the demand reduction targets are met.

Demand Reduction Targets

Drought Levels		Demand Reduction Targets				
RESPONSE LEVEL	WATER SHORTAGE DESCRIPTION	SECONDARY WATER[4]	AGRICULTURAL IRRIGATION[5]	M&I CULINARY OUTDOOR WATER[4]	M&I CULINARY INDOOR WATER[4]	TOTAL YEAR 2020 DEMAND REDUCTION (ACRE-FEET)[5]
1	Normal	0%	0%	0%	0%	0
2	Advisory	Reduce demands through messaging and general water conservation				0 to 43,000
3	Moderate	20%	20%	20%	0%	43,000
4	Severe	60%	40%	60%	10%	123,000
5	Extreme	95%	70%	95%	25%	206,000

[4]Assumed that water use reductions will be met across the entire WBWCD service area
[5]Assumed that only WBWCD agricultural supplies will be reduced. Does not include agricultural demands in the basin that are not managed by the District

Table 6- 2: Demand Reduction Targets

6.3 Effectiveness of Demand Reductions

A question was asked during the stakeholder process with regards to whether or not the reduced WBWCD water supplies would be adequate to serve the users during future droughts if the demand reduction targets are met. Table 6-3 compares the total demand volume reduction achieved by reaching the target reductions with the estimated reduced volume of water that will be available each year for each drought level.

Drought Levels		Demand Reduction Targets					Theoretical Balance	
RESPONSE LEVEL	WATER SHORTAGE DESCRIPTION	SECONDARY WATER[1]	AGRICULTURAL IRRIGATION[2]	M&I CULINARY OUTDOOR WATER[3]	M&I CULINARY INDOOR WATER[4]	TOTAL YEAR 2020 DEMAND REDUCTION (ACRE-FEET)[5]	NORMAL STORAGE VOLUME DEFICIT (ACRE-FEET)[6]	NET WATER VOLUME DIFFERENCE (ACRE FEET)[7]
1	Normal	0%	0%	0%	0%	0		
2	Advisory	Reduce demands through messaging and general water conservation				0 to 43,000		
3	Moderate	20%	20%	20%	0%	43,000	40,000	3,000
4	Severe	60%	40%	60%	10%	123,000	100,000	23,000
5	Extreme	95%	70%	95%	25%	206,000	190,000	16,000

Table 6- 3: Reduction Targets with Theoretical Balance

The normal storage volume deficit column in Table 6-3 quantifies how much additional water would need to be stored in a drought year to achieve normal storage levels (no drought). The net water volume difference column shows how the difference between how much the demand volume will be reduced if the demand reduction targets are met, and the projected storage deficit for each drought level. For example, if the secondary water, agricultural irrigation, and the M&I outdoor water demands are all reduced by 20 percent in a moderate drought, then 43,000 acre-feet of water will be saved. This is 3,000 more acre-feet than the 40,000 acre-feet of storage volume deficit that is anticipated in a moderate drought. If the demand reduction targets are met for drought levels 3, 4, and 5, the net storage volume is positive. This indicates that achievement of the demand reduction goals would make up for the storage volume shortages (deficits).

6.4 WBWCD Response Actions

Response actions will be required to reach the WBWCD demand reduction targets for each drought level. The objectives and metrics used to evaluate the mitigation measures dictated which response actions will be implemented during future droughts. Response actions were prioritized based on the key drought vulnerabilities and the amount of water use reduction needed to achieve the target reduction goals for each drought level.

Table 6-4 provides response actions for WBWCD to implement for each demand reduction target. Response actions should be monitored to evaluate the effectiveness of achieving the desired results (e.g. stakeholder input through public involvement).

WBWCD Drought Response Actions

Drought Levels: Response Level	Drought Levels: Water Shortage Description	Response Actions
1	Normal	Continue current conservation efforts to meet statewide goal to reduce usage by 25% between year 2000 and 2025
2	Advisory	Begin messaging to inform the public that water shortages are possible if drought conditions continue and that additional conservation efforts are needed.
3	Moderate	Increased messaging, implement yellow drought rates and shortened irrigation season, and increased advisory group meetings.
4	Severe	Increased messaging, implement orange drought rates, exercise fallowing agreements, cut watering of lawns in half, reduce agricultural water use, start indoor water reduction strategies, and increased advisory group meetings.
5	Extreme	Increased messaging, implement red drought rates, exercise fallowing agreements, no residential lawn watering (trees and gardens yes), and increased advisory group meetings.

Table 6- 4: WBWCD Drought Response Actions

Table 6-5 shows how the response actions relate to the key drought vulnerabilities and specifies at which drought levels the response actions are to be implemented.

Key Drought Vulnerabilities	Related Responses	Drought Levels
Available Water Supply during Drought (Junior Water Rights)	Implement water transfer agreements	Severe and Extreme
	Use income generated from wasteful water users to compensate agricultural water users	Severe and Extreme
Wasteful Watering	Implement drought surcharge fee based on current drought level	Moderate, Severe, and Extreme
Inability to Operate and Maintain Water Systems	Implement drought surcharge fee based on current drought level	Moderate, Severe, and Extreme
Lack of Drought Information to the Water Users	Post the current drought level on the dashboard	All Levels
Environmental and Recreational Impacts	Maintain contractual minimum flows and reservoir levels, increased communication with stakeholders	Moderate, Severe, and Extreme
Agricultural Impacts	Implement water transfer agreements	Severe and Extreme

Table 6- 5: Key Drought Vulnerabilities and Related Responses

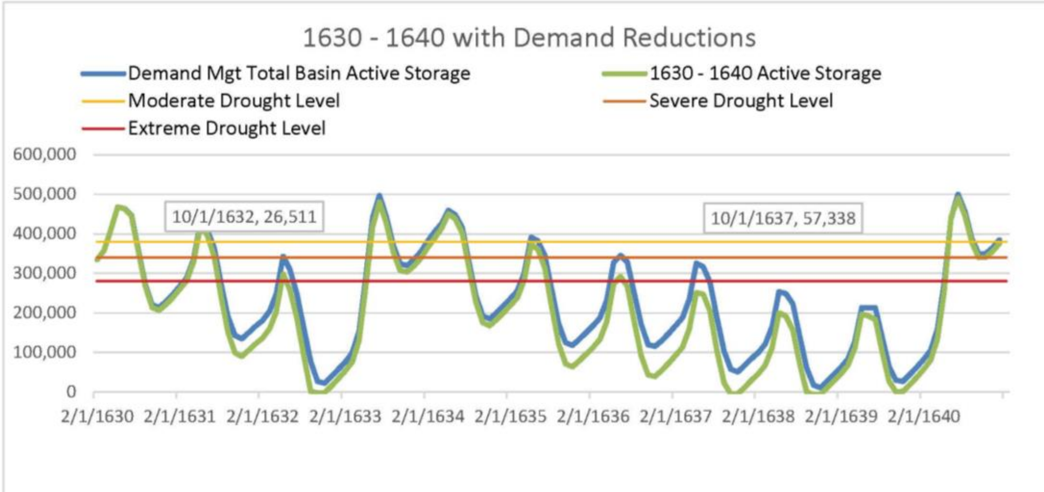
6.5 Response Action Model Scenarios

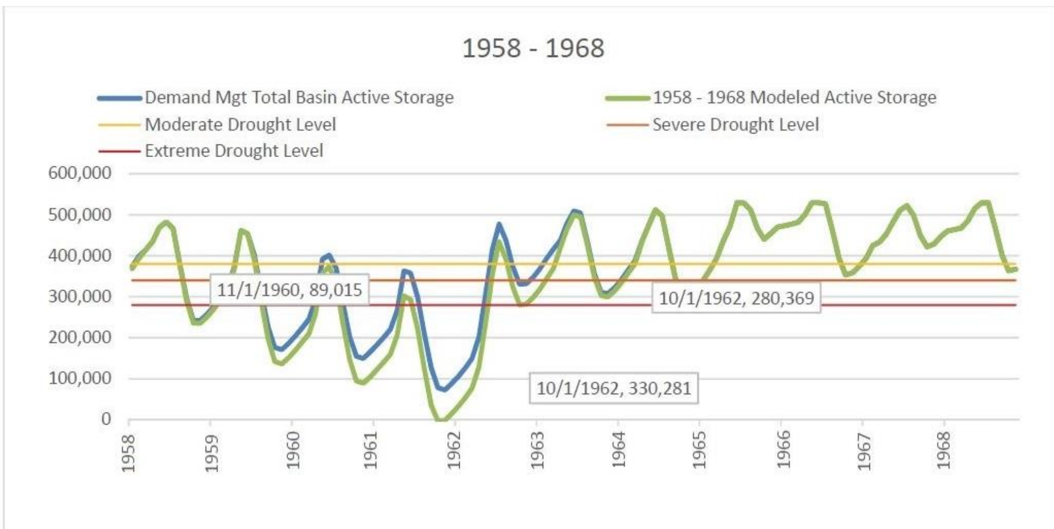
DWRe also created scenarios in the Riverware model to help gain some understanding about how some response actions may help in future droughts. One model scenario was created specifically to estimate how well the demand reductions would have improved the total basin storage over the modeled historic period during past droughts. This scenario is described in further detail in Section 6.4.1. A summary of all of the model scenarios created by DWRe is found in Appendix 3-B.

6.5.1 Demand Reduction Scenario

Most of the assumptions established for this scenario were derived based on the demand reductions required for each drought level. The three graphs in Figure 6-1 compare the historical storage volumes during past drought periods with the reduced demand storage volumes during the same drought period. The reduced demand storage volumes are based on the assumption that the demand reductions established in this DCP would have been implemented during the droughts.

The demand reductions improved storage volumes significantly in the model for the shorter duration droughts that occurred in the 1960s and in the 1930s. However, with the longer drought that occurred in the 1630s, the demand reductions helped for the first years but by the last year of the drought storage volumes were close to the same with or without the demand reductions. Based on the modeling results, The demand reduction targets may not be adequate for long duration and severe droughts that persist more than 3 or 4 years in a row. WBWCD should monitor how well response actions help in maintaining storage volumes during droughts to determine if the target reductions should be adjusted in the future.





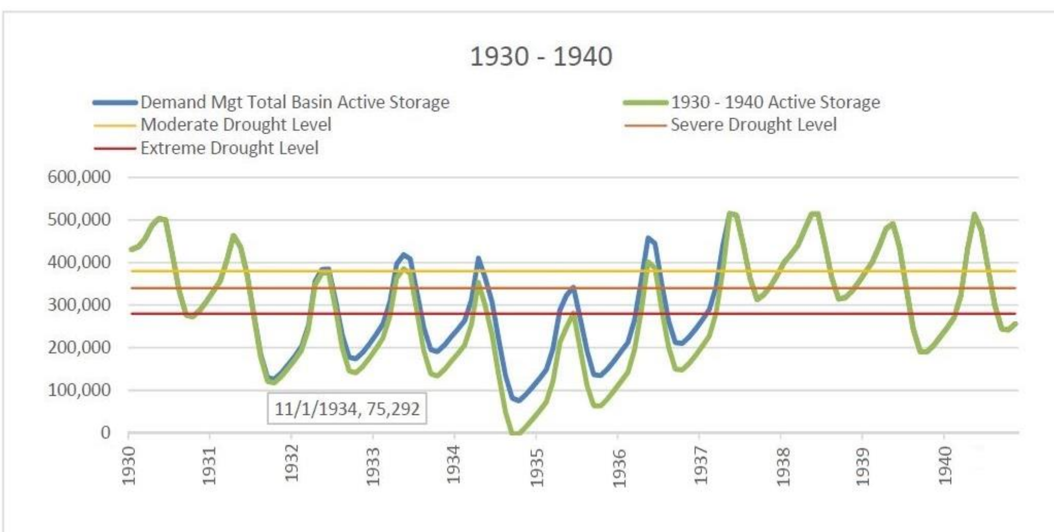


Figure 6- 1: Historical and Same Drought Period Storage Volumes

6.6 Specific Water System Response Actions

Some specific response action objectives were discussed with the stakeholders because of the many entities that use and sell water within WBWCD boundaries. Specific actions from each of the water systems will be needed to reach the demand reduction targets for each of the drought stages. The actions should focus on:

- Improving communication about the current drought conditions.
- Managing available water supplies more efficiently.
- Reducing water demands.

Specific actions could include but are not limited to:

- Coordination with UDOT and commercial advertisers to spread drought condition messages using variable message boards.
- Implementation of water patrols.
- Stopped use of water to clean sidewalks, walkways, driveways, parking lots, or other hard-surfaced areas.
- Shortening of the irrigation season.
- Reduced washing of vehicles.
- Discontinued watering of parks, athletic fields, or golf courses.

Implementation of specific actions will differ depending on the varying circumstances of each system and the drought severity. Variations of these actions or other actions could be used. The Advisory Group was polled about when they felt each of the specific actions listed above should be implemented during the June 20, 2018 Advisory Group meeting. The poll results are found in Appendix 2-F.

7 OPERATIONAL & ADMINISTRATIVE FRAMEWORK

7.1 Overview

The operational and administrative framework identifies the roles, responsibilities, and the procedures to:

- Conduct drought monitoring.
- Implement drought mitigation measures.
- Initiate drought response actions.

The implementation of the DCP will be led by WBWCD, which has an established administrative framework.

7.2 Drought Monitoring

WBWCD will follow the drought monitoring process that is outlined in Section 4.5 of this plan. The process will be administered by WBWCD staff members. The Water Supply Manager plays a key role in monitoring water supplies and determining the current drought level based on the available data and monitoring tools. The monitoring roles, responsibilities, and procedures are given in Table 7-1.

Drought Monitoring Implementation		
Person or Group	**Roles and Responsibilities**	**Procedures**
WBWCD Water Supply Manager	Monitor the current and projected water supply for the year to establish the drought level. Provide monthly reports to the WBWCD Assistant General Manager.	Document reservoir and groundwater level every month with comparison to other years. Review U.S. Drought Monitor report. For the months January through June, prepare summaries of runoff, snowpack and the other metrics for June 1st storage projections. Update the drought dashboard after approval from the Board of Trustees.
WBWCD Assistant General Manager (Operations)	Oversee water supply and drought level monitoring done by the Water Supply Manager and report monthly to the General Manager.	Review monthly water supply forecast report and current drought level classification with water supply manager.
WBWCD General Manager	Report the drought level to the Board of Trustees monthly at the Board meetings.	Report water supply and drought level to the Board of Trustees based on report from Assistant General Manager.
WBWCD Board of Trustees	Make water management decisions based on drought level reports from the General Manager.	Meet monthly as part of regular Board of Trustees meetings to receive drought level report from General Manager. Approve updates to drought dashboard.

Table 7- 1: Drought Monitoring Framework

7.3 Mitigation Measure Implementation

The framework for the implementation of drought mitigation measures is provided in Table 7.2.

Drought Mitigation Measure Implementation		
Person or Group	**Roles and Responsibilities**	**Procedures**
WBWCD Engineering Department Manager, WBWCD Water Supply Manager, WBWCD Conservation Department	Implement the drought mitigation measures prioritized in the DCP.	Mitigation measures will be implemented by the appropriate department (infrastructure projects by Engineering Manager, education by Conservation Department, and agreements by Water Supply Manager)
WBWCD Assistant General Managers (Operations, Engineering & Strategic Initiatives)	Manage and lead the implementation of drought mitigation measures as coordinated with the General Manager.	Educate and inform the public about drought, create partnerships/agreements, obtain mitigation funding, plan and complete priority measures, design and construct mitigation projects as funding allows.
WBWCD General Manager	Propose mitigation measures to the Board of Trustees.	Meet regularly with the Assistant General Manager to review and select mitigation measures to present to the Board of Trustees.
WBWCD Board of Trustees	Authorize implementation of specific mitigation measures.	Meet at regular Board of Trustee meetings to review proposed mitigation measures for approval prior to implementation.

Table 7- 2: Mitigation Measure Implementation Framework

7.4 Drought Response Initiation

The framework for the initiation of drought responses is provided in Table 7-3.

Drought Response Initiation		
Person or Group	**Roles and Responsibilities**	**Procedures**
WBWCD Water Supply Manager & WBWCD M&I Manager	Notify customer agencies of drought status and implement restrictions on water deliveries as directed by the Assistant General Manager.	Meet with Assistant General Manager to receive direction for implementation of various response actions and restrictions.
WBWCD Assistant General Manager (Operations)	Assist with communication and implementation of drought response actions. Implement water restrictions with the Water Supply Manager and implement other response actions.	Meet regularly with the General Manager during drought periods to review the response actions that are needed and implement the response actions.
WBWCD General Manager	Manage public messaging and other response actions.	Meet at regular Board of Trustee meetings to review needed response actions for approval prior to implementation.
WBWCD Board of Trustees	Approve implementation of responses actions.	Review and approve response actions as presented to the board by the General Manager.
DCP Task Force (Advisory Group)	Assist WBWCD in response to moderate, severe or extreme droughts.	Meet to initiate drought messaging, implementation of drought rates and specific drought response actions during moderate, severe or extreme droughts.

Table 7- 3: Drought Response Initiation Framework

WBWCD will enforce the demand reductions for each drought level by reducing the amount of water it delivers to its customers based on the current drought level.

8 DROUGHT CONTINGENCY PLAN (DCP) UPDATE PROCESS

8.1 Overview

WBWCD is currently implementing the recommendations found in this DCP. This DCP needs to be evaluated and monitored on a regular basis to integrate needed changes or updates that are identified based on data gathered in future droughts, or additional information that is gathered over time. New changes could come in the form of new technology, laws, or political leadership.

8.2 Ongoing DCP Monitoring

WBWCD will monitor and make minor adjustments periodically, as needed, based on new information or changes that occur related to droughts or drought monitoring in its boundaries. These changes will be made under supervision of the Assistant General Manager based on input from the Water Supply Manager.

8.3 Post-Drought Evaluations

The Water Supply Manager will meet with the Assistant General Manager and supporting WBWCD technical staff following any drought event. These meetings will be held to evaluate and asses the effectiveness of the DCP mitigation actions that were implemented prior to the drought, and to assess the effectiveness of the response actions implemented during the drought. These assessments will help identify if any adjustments are needed for the drought response levels or response actions, or if any additional mitigation actions should be implemented prior to future droughts. The Advisory Group will be involved when any significant changes are discussed or are made to the DCP.

8.4 DCP Updates

Approximately every 5 years, WBWCD will evaluate the need for an update to the DCP, whether or not a drought has occurred. The Assistant General Manager, the Water Supply Manager (Operations), and WBWCD technical staff will decide if an update is needed under the direction of the General Manager. It is important to continually evaluate changing vulnerabilities and identify ways to reduce risks associated with drought. New information and technologies become available that can be integrated into the DCP. The Advisory group will be included in the update process if a major DCP update is made.

9 CONCLUSIONS & RECOMMENDATIONS

This planning process has allowed WBWCD to identify key insights and strategies to improve drought resiliency within its boundary.

Conclusions:

- Improved communication and cooperation between all water users will improve drought resiliency and the ability to respond to drought conditions.
- Multiple moderate droughts have occurred in the recent past, and severe and extreme droughts have occurred in the last 400 years.
- Future climate changes will play a factor in available water supplies. Currently, many of the climate change projections are on a larger scale and not specific to the Weber Basin area.
- The WBWCD water system is less resilient to drought periods that are longer than 1 to 2 years in duration.
- The projected maximum storage for each calendar year is a key indicator of the drought status, especially in the year following a poor water year.
- Water operations can impact the environment and should be coordinated between WBWCD and water users (DCP Advisory Group) to minimize negative drought impacts.
- Optimizing the existing system will improve drought resiliency.

Recommendations:

- Create and maintain an internet water supply dashboard to inform the public of the current drought status and conservation actions to take.
- Develop a WBWCD secondary water drought surcharge fee structure and inform other water suppliers about drought fee structures.
- Install flow meters on all WBWCD secondary water connections and promote metering on all secondary connections within WBWCD boundaries.
- Cooperate with irrigation water users and companies to establish short term water transfer agreements for future drought periods.
- Connect existing wells in Farmington to WBWCD culinary water transmission system.
- Meet annually with Advisory Group stakeholders during drought conditions to consider operation strategies that benefit habitat while meeting water deliveries.
- Develop Aquifer Storage and Recovery (ASR) sites to allow for storage of water during good water years for utilization in drought years.
- Present DCP findings and recommendations to cities and irrigation companies within WBWCD boundaries and follow up.
- Continue to investigate feasibility of water re-use and Willard Bay siphon improvements.
- Finish a climate change study specific to the WBWCD service area to gain a better understanding on how storage levels may be impacted as a result of changes in the climate.
- Monitor how well response actions help in maintaining storage volumes during droughts to determine if the target demand reductions should be adjusted in the future.
- Update the DCP every 5 years.

Appendix 1-A

WBWCD Detailed Storage History

Year	Annual Summary Irrigation Report	Brief Summary	Delivery Restrictions	Seasonal Restriction
1971	No Information on Summary of Operations, Flood Control or Water Supply			
1972	No Information on Summary of Operations, Flood Control or Water Supply			
1973	No Information on Summary of Operations, Flood Control or Water Supply			
1974	The increase in deliveries was due largely to a drop in precipitation compared to 1973. The District's weather station recorded 8.82 inches of precipitation during June, July, August, and September in 1973 while only .75 inches were recorded during the same 1974 time period.			
1975	Unusually wet, cold spring.			
1976	19976 precipitation through the irrigation season totaled 9.12 inches, a factor which greatly affected District water deliveries. In 1975, during the irrigation season, the District's treatment plant recorded 13.37 inches of precipitation, 4.25 inches more than was received in 1976.			
1977	Because of drought conditions over the Weber Basin drainage area the reservoirs did not fill. The Board of Directors and Management determined there would only be 60% of a normal years supply on the Weber River storage system, the upper Ogden system had enough for an 80% supply and water users served from Willard Bay were allocated 100% supply for the year.	Drought conditions - the following restrictions were implemented to irrigation contracts: 40% restrictions for Weber River system, 20% restrictions to upper Ogden and 0% restrictions if served by Willard Bay.	40%, 20% & 0%	
1978	No Information on Summary of Operations, Flood Control or Water Supply			
1979	Dry soil and cool temperatures prevented run0off in Northern Utah to reach anticipated quantities.			
1980	January 1, 1980 Basin snow cover averages ranged from 58% on the Ogden Basin to 64% on the Weber and Provo Basins. April 1, 1980, that e peak Basin snow cover averages gained for the third successive month and ranged from 165% on the Ogden Basin to 141% on the Weber Basin.			
1981	February 1, 1981 snow cover ranged from 28% of average on the Ogden River to 43% on the Weber River. Most measurements averaged only 1.3 as much as February 1, 1980, but about 1-1/2 to 2 times as much as February 1, 1977. April 1, 1981 total snow cover on the Ogden River was 50% of average, which was not sufficient to fill Pineview Reservoir. Show cover on the Weber River Basin was 64% of average filling Echo and Wanship Reservoirs, Barely filling East Canyon Reservoir, and leaving lost Creek 2,000 acre-feet short of filling.			
1982	Accounting for the lower use was a very wet year. In 1982, 38.21 inches of precipitation fell, compared to the 5 year average of 25.33 inches at the District's weather station at treatment plant No. 3. The mean temperatures in degrees Fahrenheit also showed a decline of 2.3 degrees compared to 1981.			

Year	Annual Summary Irrigation Report	Brief Summary	Delivery Restrictions	Seasonal Restriction
1983	1983 was the wettest year recorded at Weber Basin's weather station, plant No. 3, in Layton. Precipitation recorded for the year was 44.99 inches, 6.78 inches more than 1983 and over 16 inches more than the 10 year average. 155 days of 1983 received some precipitation, resulting in a reduction of use of water. Flood control was of prime concern. The District released 90,339 AF of water from Weber River reservoirs for flood control and another 92,002 af from the Ogden River system.			
1984	In 1984 precipitation occurred on 122 days during the year, for a total of 26.3 inches. 1984 was the first year in the past four years to show a decline in total annual precipitation as recorded at Weber Basin's weather station located at the District's Water Treatment Plant in Layton, Utah. Water supplies during 1984 were abundant throughout the Weber-Ogden watersheds. As a result of heavy snowpack and unfavorable spring weather some minor flooding occurred for the second year in a row. Excessive streamflow's, some exceeding roads, bridges, farm land, and a few residential areas. Some streams and rivers in the Weber-Ogden watersheds had the highest flow volumes ever reported, dating back to the early 1900's. Wet regime continues to enhance runoff, which many stations in the Weber-Ogden basins reporting the last three years as the wettest three years on record. Summer precipitation during the past three years on record. Summer precipitation during the past three years has generally been 150 to 200 percent over the basins average, and has kept streamflow levels higher than normal as well as maintaining a high soil moisture and high ground water levels. on May 16, 1984 most of six flood control reservoirs in the Weber-Ogden basins hit their high inflows for the year.			
1985	Precipitation occurred on only 87 days during the year, for a total of 20.71 inches; a decline of 35 days and 5.59 inches of precipitation from 1984. Average measurements recorded at Weber Basin Weather station located at Plant #3 in Layton, for the past five years indicate a 33.42 average rainfall so 1985 was quite a dry year. Snow melt began earlier than normal in 1985 with all but the highest and most protected sites showing melt shortly after April 1st and finishing melt on the majority of courses well before June 1st.			

Year	Annual Summary Irrigation Report	Brief Summary	Delivery Restrictions	Seasonal Restriction
1986	Precipitation occurred in 119 days during the year, for a total of 30.26 inches; an increase of 32 days and 9.55 inches of precipitation from 1985 average measurements recorded at Weber Basin Weather Station located at Plant #3 in Layton, for the past five years indicate a 31.46 average rainfall so 1986 was an average year. Run-off can in a normal pattern except for mid-February, when rain on the heavy snow pack brought the rivers up to and over the banks. By February 20th Pineview dam had received 7.83 inches of rain and Wellsville, above Ogden's north fork received over ten of inches of rain. With all the rain and melted snow pack Pineview Reservoir had a peak inflow if 9070 af or 4537 cfs, which was rising the reservoir 3.5 feet per day. With 3.5 feet from full and one day before spill with 4537 cfs inflow, releases had to be increased to 1600 cfs in the Ogden River below Pineview Reservoir. The weather cooled and the rain stopped and one day later Pineview started decreasing. After the rain and the cooling weather all reservoirs on the Weber and Ogden Rivers filled in a somewhat orderly fashion.			
1987	April 1, 1987 is normally peak snow pack. This year, April 1 snow pack was 59& of normal on the Ogden River and 68% on the Weber River. Leaving Pineview, Lost Creek and East Canyon without sufficient water to fill.			
1988	Peak accumulation of snow water equivalent was obtained two weeks earlier than usual. Snow melt during April occurred at more than twice the rate of normal years. Mountain precipitation continued its unbroken string of below average leaving Pineview, Lost Creek, East Canyon and Willard Reservoirs without sufficient water to fill.			
1989	Precipitation for the year was 15.76 inches. This was the lowest amount recorded in almost 20 years and was only at 66% of the average precipitation for the past 5 years and 68%of 1988 totals. The year will be remembered as on of the direst on record which helps explain why 1989 was a record year for irrigation deliveries. The Weber River Watershed experienced more than three times normal snow water loss during April and May leaving the June 1 average on the Weber drainage only 5% of normal. Above Average temperatures during April & May precipitation of only 57% of normal at mountain stations led to the unusually heavy decline in the snowpack. Peak flow occurred as much s a month earlier than usually this season following the early melt. This is somewhat helpful in providing storage reserves in the reservoirs prior to the irrigation season but means low flows earlier in the growing season for those water users relying on natural flow.			

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Year	Annual Summary Irrigation Report	Brief Summary	Delivery Restrictions	Seasonal Restriction
1990	Completed Phase II of the restoration of AV Watkins Dike. With the heavy use of water from Willard Bay the last few years and the persistent drought, the water stored in the bay was depleted to just above 78,000 acre-feet. At the end of the year it looked doubtful the reservoir would fill in 1991. As the year came to a close, drought conditions still persisted in the Weber Basin drainage. Storage in the District reservoirs were at record lows, as water demands continue to increase. The District is working to develop all available sources at its disposal. Due to the water storage decrease over the last four or five years, water restrictions may become necessary in the 1991 irrigation season. In March 1990 an increase of only 1.3 inches was realized, 42% of normal. April 1st surveys indicated a snowpack with only 70% of normal water content. Melting began approximately two weeks ahead of normal. The early demise of the snow accumulation season was not only brought about by higher than normal temperatures, but much below average precipitation during March. Mountain precipitation for the month was only 55% of normal. Seasonal accumulation was down to 65% of normal Poor runoffs were forecasted for the spring and summer. Pineview Reservoir inflow was the worst of all reservoirs at 31% of average with Smith and Morehouse Creek the best at 76% of average.	As the year came to a close, drought conditions still persisted in the Weber Basin drainage. Storage in the District reservoirs were at record lows, as water demands continue to increase.		
1991	As the year 1991 began, drought conditions persisted in the Weber Basin drainage as storage in the District reservoirs were at record lows. Water restrictions were implemented resulting in a 50% allocation reduction to irrigation companies and farmers. Allocations to municipal water users were not to be effected. Homeowners were restricted to using secondary water for 3 hours, twice per week. The amount of snowmelt during April was only 40% of normal, thus leaving a better than expected snowpack at the end of April. The snowpack on May 1 was 89% of average. Mountain precipitation was slightly better than average during April, bringing the total for the water year to 79% of normal. Because of unexpected heavy rains in May, many water customers did not use water for six weeks allowing upstream reservoirs to hold the water. The District was able to fill 3 of its 6 upstream reservoirs making it possible to lift the water restrictions. A voluntary conservation program of not watering during the hours of 10:00 a.m. to 6:00 p.m. was implemented. Results were excellent and a good holdover of water in reservoirs existed at irrigation season's end.	Water restrictions were implemented resulting in a 50% allocation reduction to irrigation companies and farmers. Homeowners were restricted to using secondary water for 3 hours, twice per week. Because of unexpected heavy rains in May, the District was able to fill 3 of its 6 upstream reservoirs making it possible to lift the water restrictions.		

Year	Annual Summary Irrigation Report	Brief Summary	Delivery Restrictions	Seasonal Restriction
1992	As the 1992 year began, norther Utah was facing one of the lowest runoff seasons in recent memory. April snowpack's, traditionally the peak of the season, were the lowest on record for the Bear River watershed and second lowest on record over the Weber and Provo Basins. New record low snowpack was recorded at 22 northern Utah sites, and an additional 10 sites had their second lowest readings. March was also one of the warmest on record in northern Utah. The blistering temperatures and lack of precipitation contributed to the snowpack's early demise, leaving District reservoirs with the same water which was the carry-over from last year. With just enough carry-over water for one year's allotment, the District implemented a no watering restriction between the hours of 10 am and 6 pm every day of the week. With these restrictions and ending the irrigation season on September 30th, the District was able to get through the irrigation season with the previous year's carry-over stored water.	Poor snowpack resulted in relying on carry-over water. District implemented daytime watering restrictions and ended irrigation season on September 30th.		Cutoff September 30th
1993	By January 1, 1993, the snowpack on the Weber and Ogden watersheds was 40% to 50% greater than the past two years. Individual snowtel sites ranged from 80% to 140% of average. With the snowpack ranging well over 100% of average, this was good news for a watershed that was depleted of soil moisture and groundwater. By May 1, 1994, when most watersheds are virtually depleted, the Weber and Ogden basins remained approximately 140% of average. at mid and high elevations. At the end of runoff season all but on e of the Districts reservoirs had filled and spilled.			
1994	Snowpack's on the Weber and Ogden watersheds are near 70% of normal. This is about 50% of the snowpack of last year. Individual sites range from 0% to 143% of average. Late season storms have augmented snowpack's, slowed the melt rate and improved general runoff conditions. The runoff season will still produce below average seasonal flow. Mountain precipitation for April was 85% of normal, which brings the seasonal total (Oct-Apr) to 85% average. Reservoir storage is in excellent shape, near 1% of capacity compared to 73% last year and about 134% of average.	Record heat summer months.		
1995	Snowpack's on the Weber and Ogden watersheds are much above average at 351%, highest since 1986 and due mostly to delayed snowmelt. May continued the cool temperatures and stormy patters which have minimized snowmelt. Mountain precipitation for May was much above normal at 188%, which brings the seasonal total (Oct-May) to 125% of average. Precipitation for the first five days in June has been 3.7 times the average with more storms forecast. General water supply conditions are excellent, especially for flows later in the summer. Reservoir storage is near 91% of capacity.			

Year	Annual Summary Irrigation Report	Brief Summary	Delivery Restrictions	Seasonal Restriction
1996	snowpack on the Weber and Ogden watersheds is at 147% of average. Individual sites range from 0% to 271% of average, this is the best May 1 snowpack on the Weber since 1986. Precipitation during April was near average at 92%, bringing the seasonal accumulation (Oct-Apr) to 105% of normal. Reservoir storage on the Weber system is in excellent condition. General water supply conditions are also excellent with the prospect of having above average runoff this spring. Streamflow's will have higher peaks and longer duration than normal years.			
1997	Snowpack on the Weber and Ogden watersheds is at 180% of average. Individual sites range from 110% to 255% of average. The April snowpack decrease was only 53% of normal. Precipitation during April was near normal at 95% of average, bringing the seasonal accumulation (Oct-Apr) to 129% of average. Reservoir storage on the Weber system is at 63% of capacity. General water supply conditions are excellent. Stream flows could have much higher peaks and longer duration than normal, which a high potential for agricultural inundation.			
1998	Snow pack on the Weber and Ogden Watersheds is at 137% of average, up percentage wise 27% relative to last month but still just 76% of last year. A cool April resulted in a below normal (50%) snowmelt for the month. Individual sites range from)% to near 300% of average. Precipitation during April was below normal at 73% of average, bringing the seasonal accumulation (Oct-Apr) to 103% of average. Snow melt runoff conditions are very near average and near to above normal stream flows are expected. Reservoir storage on the Weber system is at 69% of capacity and all reservoirs should easily fill.			
1999	Snowpack on the Weber and Ogden Watersheds is at 121% of average, which is just 88% of last year. Individual sites range from 0% to near 233% of average. Low elevation snowpack is much below normal. A cool, wet April increased snowpack's instead of the normal melt scenario. Precipitation during April was much above normal at 134% of average, bringing the seasonal accumulation (Oct-Apr) to 98% of average. Reservoir on the Weber system is at 81% of capacity. General water supply conditions are slightly below normal and below normal runoff season is expected.			
2000				

Year	Annual Summary Irrigation Report	Brief Summary	Delivery Restrictions	Seasonal Restriction
2001	Snowpack for the 2000/2001 water year on the Weber and Ogden Watersheds was at 62% of average, about the same as last year. Individual sites ranged from 0% to 196% of average. The Weber lost 1/3 of its total snowpack during the last week of April. Snowmelt was over by the end of May. Precipitation during April was above normal at 120%, bringing the seasonal accumulation (October – April) to 82% of average. Reservoir storage was at 69% of capacity. Streamflow forecasts were much below average. Runoff began early, was very short in duration and had low peak flows. Even in the third year of drought level precipitation, the District was able to make full deliveries of all municipal water supplies. We express our thanks to the irrigation users who accepted a reduction in their deliveries to help safe guard against the possibilities of another less than normal water year.	Restrictions on irrigation water.	20%	
2002	2002 was another challenging year for our irrigation department. In the fourth year of drought conditions, our operators delivered 80% of irrigation and secondary water allotments to our customers. We also continued our efforts to educate our customers on water conservation and enforced the "no watering between 10:00 a.m. and 6:00 p.m." restriction. Due to drought conditions, our hydropower generation plants were only able to generate half of our pumping demand of 28 million KWHs. This deficit required the District to purchase over 14 million KWHs at market prices. The purchased power costs exceeded $1,000,000 for the year. Due to the dam safety modifications being constructed at Pineview Dam, the reservoir had to be lowered to the spillway seal by July 20, 2002. By doing this, the District had to exchange 39,000 acre-feet of water to the lower Weber River users. On July 20th, the District switched over from Pineview Reservoir to Willard Reservoir and pumped 32,000 acre-feet back to the lower users, making a total exchange of 71,000 acre-feet of water from the Ogden River and Willard Bay Reservoir to the Weber River. With this heavy exchange to the Weber River, the District ended the season with over 10,000 acre-feet more in storage than it had at the beginning of the season. This scenario illustrates the importance of the exchange concept, as envisioned by the Weber Basin Project designers, to our ability to maintain water supplies.	20% restrictions on irrigation and secondary water allotments	20%	

Year	Annual Summary Irrigation Report	Brief Summary	Delivery Restrictions	Seasonal Restriction
2003	Year 2003 marked the fifth straight year of drought conditions. During the irrigation season, our operators delivered 80% of irrigation and secondary water allotments as a 20% mandatory conservation reduction was implemented. Efforts to educate the public on water conservation continued as we strictly enforced the "no watering between 10:00 a.m. and 6:00 p.m." restriction. Our hydropower generation plants were able to generate 15 million KWHs of power through the year while the District's power demand was 33 million KWHs. This deficit required the District to purchase over 18 million KWHs at market prices. The purchased power costs exceeded $1.5 million for the year. In an effort to preserve upstream storage, the District exchanged 71,000 acre-feet of water from Pineview and Willard Bay to be used and stored on the Weber River. At Willard Bay, efforts to clean the inlet channel of many years of sediment after the irrigation season was successful to ensure additional pumping for 2004. With heavy exchanges to the Weber River, the District ended the season by only using 20% of the upstream storage it had available at the beginning of the season. This scenario illustrates the importance of the exchange concept, as envisioned by the Weber Basin Project designers, to our ability to sustain water supplies.	20% mandatory conservation reduction, pumping required for GSL siphon a Willard Bay due to low reservoir levels	20%	
2004	Year 2004 marked the sixth straight year of drought conditions. During the irrigation season, our operators delivered 80% of irrigation and secondary water allotments as a 20% mandatory conservation reduction was implemented. Efforts to educate the public on water conservation continued as we strictly enforced the "no watering between 10:00 a.m. and 6:00 p.m." restriction. Our hydropower generation plants were able to generate 15 million KWHs of power through the year while the District's power demand was 35 million KWHs. This deficit required the District to purchase over 20 million KWHs at market prices. In an effort to preserve upstream storage, the District exchanged water from Pineview and Willard Bay to be used and stored on the Weber River. At Willard Bay, efforts to clean the inlet channel of many years of sediment continued after the irrigation season to ensure the District's ability for future pumping.	Sixth straight year of drought conditions. 20% mandatory irrigation and secondary water reductions.	20%	

Year	Annual Summary Irrigation Report	Brief Summary	Delivery Restrictions	Seasonal Restriction
2005	Year 2005 brought an end to six years of drought conditions experienced by the District and its water users. The District was able to lift the mandatory 20% conservation reduction and our customers were allowed use of their full allotments while continuing efforts toward public education and sound conservation practices. All reservoirs on the Weber and Ogden Rivers filled during the runoff period, except for Lost Creek Reservoir which peaked approximately 2,000 acre-feet short of full. District hydropower generation plants at Wanship, Gateway and Causey were able to generate over 30 million KWHs of power while the District's power demand was slightly over 23 million KWHs. No pumping of water from Willard Bay was required in 2005, although the Drought Relief Pumps were used for over three months to pump up to 100 cfs from the Layton Canal to the Davis and Weber Counties Canal Company while repairs and slope stability work were completed near their canal in the South Weber area.	No restrictions - all reservoirs filled during runoff period except Lost Creek.		
2006	Year 2006 brought with it higher than normal snowpack and subsequent high runoff totals in the Weber and Ogden River drainages. All reservoirs on the Weber and Ogden Rivers filled and spilled. The offstream reservoir, Willard Bay, was utilized for flood control routing of high stream flows in the early spring and was held near capacity through the summer season. District hydropower generation at Wanship, Gateway and Causey generated over 32 million kWH while the District's power demand was approximately 19.7 million kWH during the year. In November, 2006, seepage from A.V. Watkins Dam required the emergency release of approximately 100,000 acre feet of water from Willard Bay. Department employees were directly involved in the emergency response and subsequent monitoring of the dam during the draining process.	All reservoirs filled and spilled. In November, 2006 seepage from A.V. Watkins Dam required emergency release of approximately 100,000 acre-feet of water from Willard Bay.		

Year	Annual Summary Irrigation Report	Brief Summary	Delivery Restrictions	Seasonal Restriction
2007	In 2007 the Weber and Ogden River drainages experienced snowpack and subsequent runoff totals at well below normal levels. The spring and summer seasons were generally warmer and drier than normal. These factors combined for low stream flows and early withdrawal of storage from District reservoirs. Additionally, Willard Bay levels were restricted as the investigation by the Bureau of Reclamation into the cause for leakage beneath the dam embankment continued. District hydropower generation at Wanship, Gateway, and Causey totaled 19.7 million kWH while the District's power demand was approximately 31.8 million kWH for the year as significant pumping of the District wells and the Willard No. 1 and 2 pumps were heavily utilized.	Level of Willard Bay restricted as the investigation by USBR into the cause for leakage beneath the dam embankment continued.		
2008	In 2008, the Weber and Ogden River drainages experienced somewhat below average runoff in spite of above normal snowpack by April 1st. These conditions were likely the result of a longer than normal cool spring, along with drier soil conditions which reduced the amount of water able to flow to the reservoirs. All reservoirs, except Willard Bay, filled and a reasonable holdover was retained at the end of the irrigation season. Willard Bay storage levels were held at less than 40% of capacity while work on the rehabilitation of a five mile section of the Willard Bay dike was underway. The cement-bentonite slurry wall was completed by late November, nearly a year ahead of schedule, allowing for the removal of storage restrictions for 2009. The District put into service the new West Haven Pumping Plant and Reservoir which takes delivery of District owned stock from the Wilson Canal into the West Haven secondary system. District personnel dismantled, rehabilitated and reassembled the Gateway hydroelectric generating unit #1 during the winter and spring. The combined power generation at the Wanship, Gateway, and Causey power plants totaled 22.7 million kWH, while the District's power demand was approximately 32.4 million kWH for 2008.	All reservoirs except Willard Bay filled and a reasonable holdover was retained at the end of the irrigation season. Willard Bay storage levels were held at less than 40% of capacity while work on the rehabilitation of a five mile section of the Willard Bay dike was underway. The cement-bentonite slurry wall was completed by late November, nearly a year ahead of schedule, allowing for the removal of storage restrictions for 2009.		

Year	Annual Summary Irrigation Report	Brief Summary	Delivery Restrictions	Seasonal Restriction
2009	In 2009 the Weber and Ogden River drainages experienced a near average snowpack with the runoff to the rivers and reservoirs coming off the drainages in very controllable flows with minimal flooding threat. Under these conditions, all of the District's reservoirs filled and spilled including Willard Bay which was filled for the 1st time since the completion of the cement-bentonite slurry wall repair on the A V Watkins dike in 2007 and 2008. An unusually wet June significantly reduced water usage during the early summer and thereby provided the District with a very healthy reservoir storage holdover at the end of the irrigation season. The combined power generation at the Wanship, Gateway and Causey power plants totaled 29.9 million kWH while the District's power demand was approximately 26.1 million kWH for 2009.	all of the District's reservoirs filled and spilled including Willard Bay which was filled for the 1st time since the completion of the cement-bentonite slurry wall repair on the A V Watkins dike in 2007 and 2008. An unusually wet June significantly reduced water usage during the early summer and thereby provided the District with a very healthy reservoir storage holdover at the end of the irrigation season.		
2010	In 2010, the Weber and Ogden rivers drainages experienced below average snowpack's (April 1 snowpack was 65% of normal overall). The runoff for most of the Weber and Ogden river drainages was uneventful. However, in early June, due to a cool May and early June rain, flood conditions on the upper Weber River in the Oakley area were experienced. Significant property damage was experienced by this event in the Oakley area. This event also required high releases out of Rockport and Echo reservoirs and resulted in some minor flooding below those reservoirs. All reservoirs filled in 2010 except Lost Creek which came within 1,000 acre-feet of full capacity.	All reservoirs filled in 2010 except Lost Creek which came within 1,000 acre-feet of full capacity.		

Year	Annual Summary Irrigation Report	Brief Summary	Delivery Restrictions	Seasonal Restriction
2011	The year 2011 will be remembered for the record setting runoff which resulted not only from well above normal snowpack accumulation in the winter months (>150% of normal April 1 snowpack) but also significant additional snowpack accumulated during the months of April, May and June. The resulting runoff, experienced from April through July, brought more than 240% of the historical average volume of water into each of the reservoirs on the Weber and Ogden river drainages. This runoff season resulted in many records being set for total inflow into the reservoirs of the Weber Basin Project. Although flooding was experienced to some degree in many localized areas up and down the river system, the capacity of the reservoirs to moderate peak flows prevented much more serious flooding. In the end, all reservoirs filled and significantly higher than normal reservoir storage holdover was maintained at the end of the irrigation season. The unusually large volumes of water available for generation purposes benefitted the District through increased combined power generation at the Wanship, Gateway and Causey power plants which totaled 45.6 million kWh. Additionally, the District's power demand was lower than normal at approximately 15.5 million kWh for 2011. The power use reduction was aided by the high stream flows through the summer and the reduced need for pumping during the wet spring season. Maintenance and upgrading of the District's aqueduct and irrigation systems was highlighted by installation of several hundred individual service meters on our irrigation system in the South Ogden and Washington Terrace areas. Additional metering of irrigation services are planned in the coming year. Additionally, a significant number of joints on the Davis Aqueduct pipeline were repaired in the Bountiful area both upstream and downstream of the Davis South Water Treatment Plant along with the cleaning of several thousand feet of the 48 inch portion of the aqueduct between the South Davis and Val Verde pumping plants. Significant work was also done by District personnel on the Gateway Canal lining and the cleanup of large quantities of sediment specifically at the Stoddard and Slaterville diversion dams.	from April through July, brought more than 240% of the historical average volume of water into each of the reservoirs on the Weber and Ogden river drainages. This runoff season resulted in many records being set for total inflow into the reservoirs of the Weber Basin Project.		

Year	Annual Summary Irrigation Report	Brief Summary	Delivery Restrictions	Seasonal Restriction
2012	In a nearly total reversal of the high snowpack and corresponding record runoff in 2011, the snowpack and runoff of 2012 was drastically below normal. The April 1 snowpack was measured at 56% of the 30 year average. The corresponding runoff and summer base river flows also proved to be dismal. Even though the holdover storage in the upstream reservoirs was excellent in the Fall of 2011 and all but Rockport Reservoir storage rights were fully satisfied by the meager runoff in 2012, a subsequent long, dry summer resulted in a heavy draw on District storage. The District has three hydro generation power plants that produce much of the power required to operate the Project. The combined power generation of the Wanship, Gateway, and Causey hydropower plants totaled 20.6 million kWH while the District's power demand was approximately 25.3 million kWH for 2012. Significant contributions have been made by many within the District in order to keep the critical facilities of the Weber Basin Project in sound and efficient working order. Within the irrigation system, efforts are made each year to proactively maintain and upgrade, where possible, the facilities that deliver District waters. Many of the pumps used in the system are gone through each year in an effort to minimize the potential for mid-season operational problems. Additionally, major overhaul of the two hydraulic screen rakes at Gateway was completed by District personnel. Repair and some replacement of concrete lining on the Gateway Canal was again completed in October and November in an effort to minimize water losses and maintain the integrity of the canal lining. Dredging of the Willard Bay Reservoir inlet channel was completed during the past year in order to restore the channel to near its original profile and remove a large quantity of sediment brought into the channel during flood control operations each year, especially during the high runoff of 2011. Additionally, the Layton Canal intake channel was completely concrete lined as was the upper segment of the Layton Canal from the Layton pumps to 1900 West. Work was also begun in the fall on the segment of the Willard Canal from the Slaterville Diversion to 12th street. All three of these projects were completed with the help of outside contractors and coordinated preparatory work by District personnel and equipment.	Poor runoff, but excellent holdover storage. Long, dry summer resulted in a heavy draw on District Storage.		

Year	Annual Summary Irrigation Report	Brief Summary	Delivery Restrictions	Seasonal Restriction
2013	In 2013, the Weber and Ogden River drainage suffered through a second extremely low snowpack and resulting runoff. Actual runoff results for the entire drainage were observed to be about 40 percent of the 30 year historical average. This was the second year in a row of less than 50% runoff, and the District's ability to store additional water during the runoff period was significantly hampered due to low river flows and prior appropriation: senior right holders in the Ogden and Weber Rivers had first call for available water to store or to make use of in priority. As a result, the District was able to store a very minimal amount of storage in its upstream reservoirs and Willard Bay. Excluding the relatively small reservoirs at Causey and Smith and Morehouse, no reservoirs on the Weber Basin Project filled. The extreme shortage of storage water available required the District as well as many other water users to place restrictions on irrigation water usage during the summer months. The District placed a 20% restriction on irrigation water contracts, and the irrigation season was shortened by 2 weeks at the end of the summer. This effort was closely coordinated, and major users were regularly advised of their remaining allotments in an effort to minimize damage to crops, lawns, and gardens. In 2013, the combined power generation of the Wanship, Gateway, and Causey hydropower plants totaled 13.55 million kWH (approximately 34% less than in 2012) while the District's power demand was approximately 31.3 million kWH (approximately 24% more than 2012). The two major factors influencing the District's generation and power use was the very low runoff resulting in approximately 37% less water available for hydropower generation and, in an effort to conserve upstream storage, increases in pumped water from Willard Bay and from District wells.	20% restriction on irrigation water contracts and irrigation season shortened by 2 weeks at the end of the summer. -- Second year of extremely low snowpack and resulting runoff. District was only able to store a very minimal amount in upstream reservoirs and Willard Bay. Excluding the relatively small reservoirs at Causey and Smith and Morehouse, no reservoirs on the Weber Basin Project filled.	20%	Cutoff October 1st

Year	Annual Summary Irrigation Report	Brief Summary	Delivery Restrictions	Seasonal Restriction
2014	The Weber and Ogden River drainages experienced an improved snowpack in the Spring of 2014 with snow water equivalents (SWE) near 100% of normal on April 1. However, due to a combination of conditions, included some soil moisture deficit and a dryer than normal spring, actual runoff results for the entire drainage were observed to be approximately 60 to 70 percent of normal. In spite of a below normal runoff, the District was able to gain a little over 100,000 AF of water in all of its reservoirs combined between January and June. Excluding relatively small reservoirs at Causey and Smith and Morehouse, no other reservoirs of the Weber Basin Project filled. Even though most reservoirs did not reach a full status, they were improved from the very low holdover conditions experienced at the end of the 2013 irrigation season. The District did cut off irrigation water deliveries on October 1 in an effort to conserve additional water as holdover for the coming 2015 season. Holdover in all reservoirs was much improved over the 2013 season holdover due to conservation efforts, a shortened irrigation season and reduced late season demand due to above normal rainfall. In 2014 the combined power generation of the Wanship, Gateway, and Causey hydropower plants totaled 16.31 million kWH (approximately 20% more than in 2013) while the District's power demand was approximately 23.1 million kWH (approximately 26% less than 2013). The two major factors influencing the District's generation and power use was a somewhat improved, yet still below normal runoff, and a lower pumping demand due to available instream flows and the occurrence of significant rainstorms in August and September which reduced late season water demand.	Improved snowpack but a below normal runoff. District was able to gain approximately 100,000 acre-feet of water in all its reservoirs from January to June. The District did cut off irrigation water deliveries on October 1 in an effort to conserve additional water as holdover for the coming 2015 season. Holdover in all reservoirs was much improved over the 2013 season holdover due to conservation efforts, a shortened irrigation season and reduced late season demand due to above normal rainfall.		Cutoff October 1st

Year	Annual Summary Irrigation Report	Brief Summary	Delivery Restrictions	Seasonal Restriction
2015	The snowpack accumulation for the Weber and Ogden River drainages experienced record lows in the late Winter and Spring of 2015 with snow water equivalents (SWE) averaging 37% of normal on April 1. The April 1st projections for runoff during the April through July time period ranged between 15% and 50% of normal with the driest drainages being East Canyon Creek, Lost Creek and the Ogden River. Fortunately, the month of May was much wetter than normal with rainfall amounts commonly ranging from 4 to 8 inches. This rainfall was very timely in that it met the needs of both the agricultural interests as well as the secondary water users making it possible for the District to hold previously stored water and even store more water that otherwise would have gone to use during the month of May. This month-long wet pattern significantly improved on the bleak outlook in April and helped the District get through the summer without more extensive shortages. The above described events allowed for the filling of Echo along with the smaller Smith and Morehouse and Causey reservoirs. The filling of Echo also allowed the District to fully retain the holdover water acquired from the Weber River Water Users Association at the end of the 2014 irrigation season. In an effort to conserve water for future use, the District placed a 20% restriction on all irrigation and secondary water contracts and shortened the irrigation delivery season to October 1st. The District storage facilities were able to end the irrigation season with approximately 40% holdover. In 2015 the combined power generation of the Wanship, Gateway, and Causey hydropower plants totaled 15.4 million kWH (approximately 5% less than in 2014) while the District's power demand was approximately 27.7 million kWH (approximately 20% more than 2014). The relative low runoff and the necessary pumping increases due to the required moving of stored water to where it is needed were the two major factors influencing the District's generation and power use.	Record lows snowpack in late Winter and Spring 2015. April 1st projections for runoff during the April through July time period ranged between 15% and 50% of normal. Fortunately, the month of May was much wetter than normal with rainfall amounts commonly ranging from 4 to 8 inches. This rainfall was very timely in that it met the needs of both the agricultural interests as well as the secondary water users making it possible for the District to hold previously stored water and even store more water that otherwise would have gone to use during the month of May. This month-long wet pattern significantly improved on the bleak outlook in April and helped the District get through the summer without more extensive shortages. District placed a 20% restriction on all irrigation and secondary water contracts and shortened the irrigation delivery season to October 1st.	20%	Cutoff October 1st

Year	Annual Summary Irrigation Report	Brief Summary	Delivery Restrictions	Seasonal Restriction
2016	The snowpack accumulation for the Weber and Ogden River drainages experienced another year of below average snowpack and runoff for the Winter and Spring of 2016 with snow water equivalents (SWE) averaging near 85% of normal on April 1. The April 1st projections for runoff during the April through July time period ranged between 60% and 85% of normal with the Ogden River drainage on the high end of the projected runoff. The above described conditions allowed for the filling of Pineview, Echo, Smith and Morehouse and Causey reservoirs. The filling of Echo also allowed the District to fully retain the holdover water acquired from the Weber River Water Users Association at the end of the 2015 irrigation season. The District was able to provide a full allocation of contracted water available to its customers with no contract restrictions or shortening of the irrigation season. The District storage facilities ended the irrigation season with approximately 56% holdover. In 2016 the combined power generation of the Wanship, Gateway, and Causey hydropower plants totaled 19.2 million kWH (approximately 24% more than in 2015) while the District's power demand was approximately 28.6 million kWH (approximately 3% more than 2015). Overall, the power picture was somewhat improved although total power use remained on the higher side with the necessary pumping to move delivery/exchange water as needed.	Better conditions than previous years, but below average snowpack and runoff. No restrictions.		

Appendix 2-A

Key Person Interview Summary

Drought Concerns

Economic
- Impacts on fisheries
- Inability of water suppliers to collect fees due to inability to deliver water
- GSL industry
- Some industries will go away and some companies may go out of business
- Cost of water → drought will drive up costs
- Billing structures
- Power generation

Recreational
- Impacts on fisheries
- Blue Ribbon status at stake
- Skiing
- Boating
- Kayaking

Environmental/Habitat
- Stream beds drying up. Irrigation diversion.
    - Decline of native and wild trout in tributaries
    - Bluehead Sucker impacts - ESA
    - Low river flows affecting water temperatures
    - Fish populations decline and 5-year process to rebuild
    - Echo to Stoddard is a sensitive area for habitat
- Hydrology
- Weather predictability
- Aquifer dropping
- Avian and brine shrimp issues with a declining lake level
- Water quality

Population
- Enforce conservation
- Storage
- Growth

Infrastructure
- Earthquake impacts
- Maintenance of head gates (e.g., algae clogs)
- Loss of water, delivery efficiency

Behaviors/Perspectives
- Overuse and waste of water
- People not being okay with their lawns dying
- Belief that any water going to the GSL is a waste so let's use it
- Public right vs. private right
- Generational differences

- Resident’s do better with a water meter

Planning and Process
- Design parameters – The GSL was below the design parameters for certain industries
- Contingency planning
- Consider operations and management during wet years also and how resiliency for drought years can be mitigated with actions in wet years

Agriculture
- Drip Irrigation
- System augmentation
- Water motion sensor
- Farmers are misinformed (fear of “use it or lose it”)
- Farmers are motivated by incentives (Contracts/Lease agreements)
- Cutting water off early wouldn’t hurt farmers
- Where is agriculture wasteful?
- Irrigation waste is significant
- Farmers are the key to the Great Salt Lake
- Priority in Hooper

The Great Salt Lake
- Inability for mineral operation
- Bird population
- Lake could be lowered significantly
- Boats can’t get in and out of marina
- Water banking
- Cloud seeding
- Air Quality
- Lake effect
- If water gets conserved it won’t go to the lake

Pineview
- Create agreements

Political
- Low income population impacts when billing rates increase
- Provo River Basin
- Bear River Project

Policy
- Water law
- Municipal and county development regulations
- HOA policies

Drought Plans
- Bountiful relies heavily on Weber Basin (has no drought plan)

- Create a committee to change Utah laws
- Roy has a healthy supply of water
    - Could help if close cities were in a drought
- Be able to show beneficial use of water

Current Drought Monitoring Methods and Processes Identified

Sources of data

- Chris Hogge
- Forecast meetings and weather meetings
- Assessment and monitoring of reservoir levels
- USGS flow gauges
- Deputy commissioners
- State's website (State's model)
- Weber River Model – Cole Panter

Data needed/helpful

- Document credits and debits each year for reservoirs
- Historically what has the total yield been
- Senior right holders' use (could any get by less)
- Purchase holdover from Provo River year to year
- Online portal to communicate status of the reservoirs, snow pack, etc.
- Integrated resource model

Building resiliency to drought: Mitigation and Response Actions

Themes and Insights	**Mitigation**	**Response**	**Storage**	**Demand Mgmt.**	**System Aug/Optimzn**	**Other**
Infrastructure and Operations						
Restoring and improving canals; weed control	**x**					**x**
Add gauges for better monitoring (e.g., East Canyon Creek)	**x**			**x**		
Better measurement – System tracking – technology and better metering	**x**					
Subsidized program to install technology to conserve	**x**					
Strategy/legal work to convert Echo to M&I	**x**		**x**			
Divert water from Willard canal to other canals		**x**			**x**	
Storm water permits – store and put in wetlands	**x**		**x**			
Take water right from Willard Bay and put in ASR	**x**		**x**		**x**	
Water reuse as secondary	**x**				**x**	
Pulsing water through the system to clean the channels during the wet years	**x**				**x**	
Insight Statement: Maximizing the efficiency and capacity of the existing system through strategies such as improved metering, canal lining, aquifer storage and recovery and wastewater reuse will improve drought resiliency.						

Environment						
Reintroduce beavers	x		x			
Help connect habitats so the fish can move	x				x	
Phragmites removal	x				x	
Insight Statement: Water operations strategies such as pulsing water through the system during wet years or improving the connectivity of fish habitats should be evaluated and coordinated to minimize negative environmental impacts during droughts.						
Data, Communication, and Collaboration						
Provide reports to show the transparency and the status of the snow pack	x			x		
Secondary water metering and reporting to user • Use and provide data and info to help users and public	x			x		
Create Interference Agreement – Capture the water under WBWCD Right	x		x			
Complete detailed master plans utilizing all water sources and uses	x		x	x	x	
Water sharing plans	x	x	x	x		
Water leasing/marketing - Buy/sell water rights • Collaborate with senior water rights holders • Water banking	x	x			x	
Explore and create Inter-local agreements	x				x	
Collaborate with all water sources into the GSL	x	x	x	x	x	
Collaborate with all water sources into the Bear River and the BR Project	x	x	x	x	x	
Collaborate with all water sources into the Provo River	x	x	x	x	x	
Explore potential of agreements and be proactive	x	x				
Increase connections between cities/systems	x	x			x	
3-year Irrigation contracts	x		x	x		
Insight Statement: Improved communication and collaboration through strategies such as: public notification of current drought level status, delivery of water consumption reports to users, creation of water sharing agreements between water entities, interconnection agreements between cities and cooperation between all water users will improve drought resiliency and ability to respond to drought conditions.						
Priorities, Water Priorities and Restrictions						
Secondary water metering	x			x		
Provide incentives to install meters	x			x		
Water use restrictions	x	x		x		
Modify/educate state water law (use it or lose it) • Some feel that municipalities sometimes inflate their numbers because they don't want to lose the water right. This can make it difficult to plan.	x		x	x		
Replace leaking infrastructure	x				x	
Communicate and set expectations with users • Branding/messaging • Provide data and real-time updates	x	x		x		
Provide incentives for land owners to take parts of their property out of irrigation	x	x				
Prioritize use and users: Culinary, agriculture, secondary, environmental	x	x		x		
Priority cuts based on flow levels	x			x		
Insight Statement: A detailed drought plan is needed to prioritize water restrictions for future drought periods, set expectations with water users for drought responses and develop drought messaging.						

Preliminary Ranking of Mitigation and Response Action Strategies

Strategy	1st	2nd	3rd
Storage	xxxx		x
System Augmentation	x		xxxx
Demand Management	x	xxxx	x

Others to involve

Water Right Holders

- Haights Creek
- Roy WCD
- Hooper Irrigation – Rely on natural flow
- Salt Lake Metro
- Central Utah Water Conservancy District
- South Ogden Conservation District
- Western Irrigation
- North Ogden Irrigation
- Marriott Slaterville
- Canal Companies – Change their bylaws

Political

- Legislature - Tim Hawks is currently running a bill about instream flow.
- Jerry Stevenson
- Stuart Adams instigated the tax.
- Brad Wilson on the House Side – Developer

Program

- Keith Denos (Provo River Water Users)
- Forestry, Fire, and State Lands (Laura Alt)
- Claudia Condor (Pacificorp)
- Bear River Basin Rep
- Steve Thurin (HDR, Provo River model work)
- Utah Farm Bureau (UFB)
- Great Salt Lake Advisory Council
- Joshua Palmer (conservation)
- Rachel Shilton (conservation)
- Dave Humphries (Pineview Board)
- Steve Clay (Water Rights)

Policy

- Great Salt Lake Advisory Council
- Municipalities

Public

- Friends of the GSL (Lynn De Freitas)
- Farmers
- Industry/refineries
- Bryan McInerney
- Ogden River Water Users Association
- Mike Shultz – Developer
- Jodi Williams
- Stan Fowlers – Onion & grain farmer
- Lin Kurkmen – Alfalfa & field corn farmer

Appendix 2-B

Key Person Question Response Summary

Q1 Name

Answered: 11 Skipped: 0

#	Responses	Date
1	Kent Kofford	5/2/2017 9:43 AM
2	Cole Panter	5/2/2017 8:40 AM
3	Candice Hasenyager	5/2/2017 6:35 AM
4	Gary Henrie	5/1/2017 4:27 PM
5	Joseph Havasi	5/1/2017 12:22 PM
6	Paul Burnett	3/27/2017 5:26 PM
7	Paul Thompson	3/13/2017 12:46 PM
8	Cary Southworth	3/13/2017 11:08 AM
9	Rick Smith	2/27/2017 2:17 PM
10	Kenton Moffett	2/23/2017 1:45 PM
11	Ben Quick	2/23/2017 11:08 AM

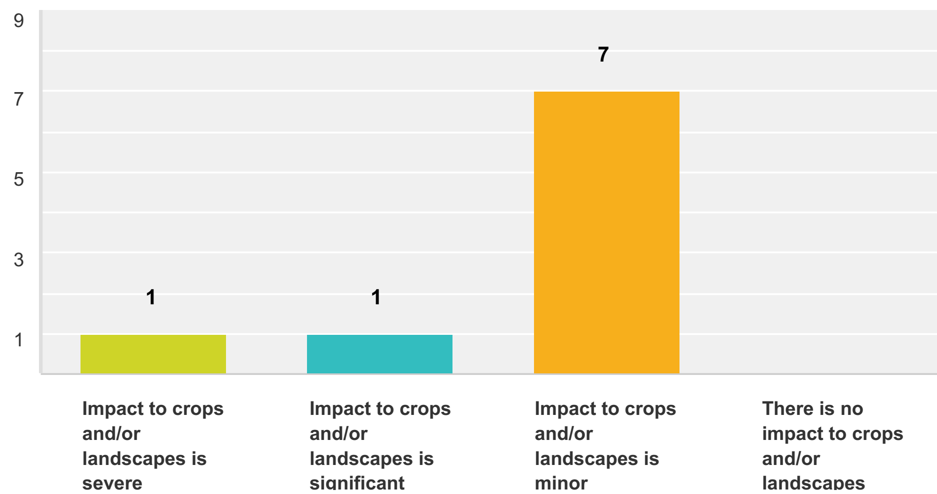
Q2 Organization

Answered: 11 Skipped: 0

#	Responses	Date
1	Reclamation	5/2/2017 1:43 AM
2	Utah Division of Water Rights	5/2/2017 12:40 AM
3	Utah Division of Water Resources	5/1/2017 10:35 PM
4	Reclamation	5/1/2017 8:27 AM
5	Compass Minerals	5/1/2017 4:22 AM
6	Trout Unlimted	3/27/2017 9:26 AM
7	Utah Division of Wildlife Resources	3/13/2017 4:46 AM
8	USBR	3/13/2017 3:08 AM
9	WRWUA/DWCCC	2/27/2017 6:17 AM
10	Ogden City	2/23/2017 5:45 AM
11	Pineview Water Systems	2/23/2017 3:08 AM

Q3 Please indicate the level of impact you would typically expect when WBWCD shuts off irrigation water on October 1st rather than October 15th.

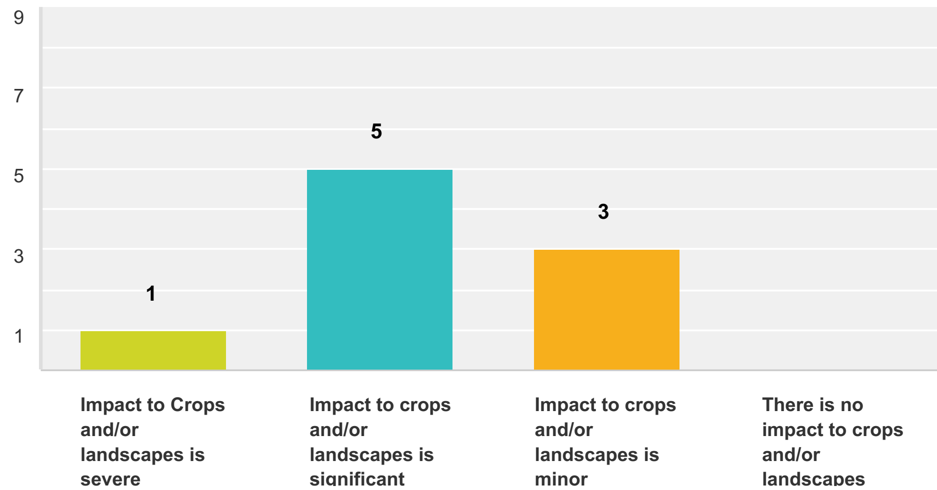
Answered: 9   Skipped: 2



Answer Choices	Responses	
Impact to crops and/or landscapes is severe	**11.11%**	1
Impact to crops and/or landscapes is significant	**11.11%**	1
Impact to crops and/or landscapes is minor	**77.78%**	7
There is no impact to crops and/or landscapes	**0.00%**	0
Total		**9**

Q4 Please indicate the level of impact you would typically expect when WBWCD reduces wholesale irrigation and secondary deliveries by 20%.

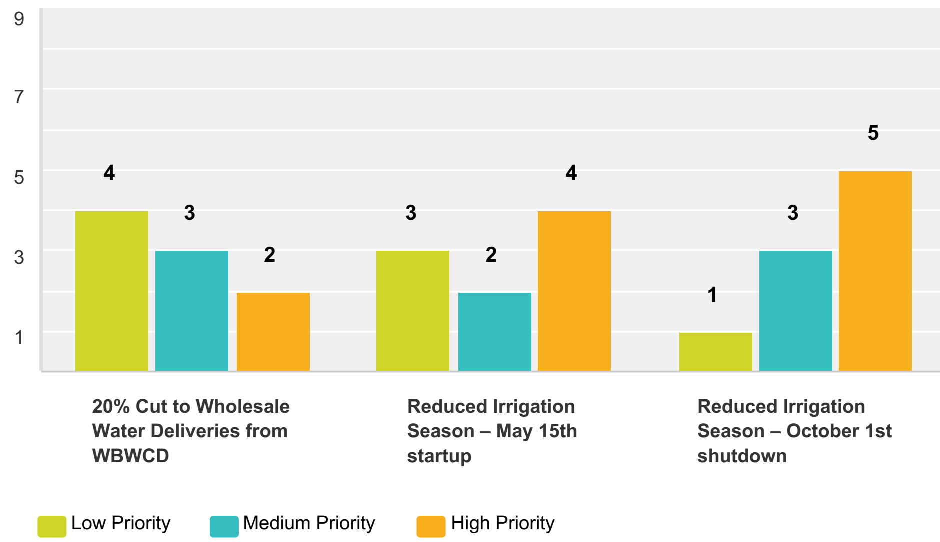
Answered: 9 Skipped: 2



Answer Choices	Responses	
Impact to Crops and/or landscapes is severe	**11.11%**	1
Impact to crops and/or landscapes is significant	**55.56%**	5
Impact to crops and/or landscapes is minor	**33.33%**	3
There is no impact to crops and/or landscapes	**0.00%**	0
Total		**9**

Q5 How would you prioritize the following drought response actions?

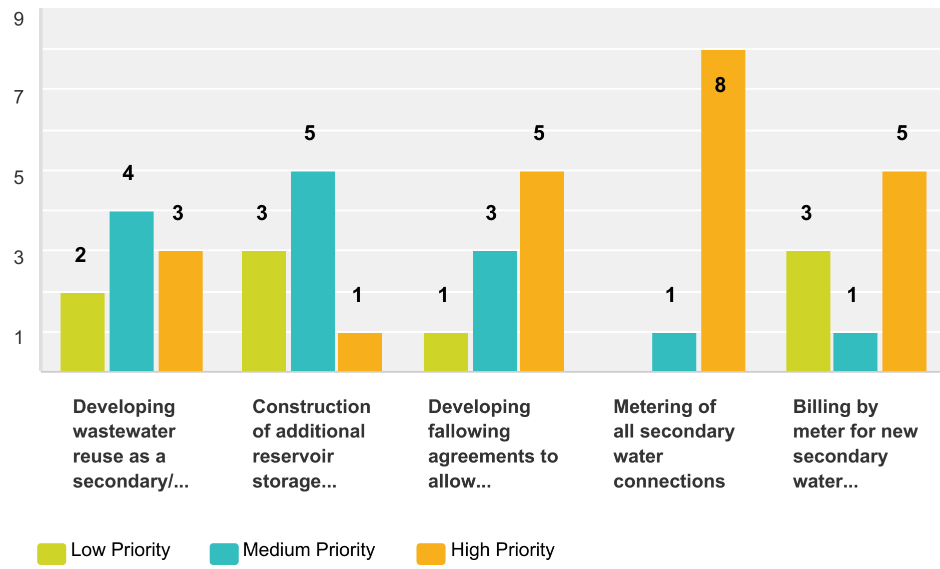
Answered: 9 Skipped: 2



	Low Priority	Medium Priority	High Priority	Total	Weighted Average
20% Cut to Wholesale Water Deliveries from WBWCD	**44.44%** 4	**33.33%** 3	**22.22%** 2	9	1.78
Reduced Irrigation Season – May 15th startup	**33.33%** 3	**22.22%** 2	**44.44%** 4	9	2.11
Reduced Irrigation Season – October 1st shutdown	**11.11%** 1	**33.33%** 3	**55.56%** 5	9	2.44

Q6 How would you rank the following drought mitigation actions?

Answered: 9 Skipped: 2



	Low Priority	Medium Priority	High Priority	Total	Weighted Average
Developing wastewater reuse as a secondary/irrigation water supply	**22.22%** 2	**44.44%** 4	**33.33%** 3	9	2.11
Construction of additional reservoir storage capacity	**33.33%** 3	**55.56%** 5	**11.11%** 1	9	1.78
Developing fallowing agreements to allow agricultural water to be leased for municipal supplies during drought years	**11.11%** 1	**33.33%** 3	**55.56%** 5	9	2.44
Metering of all secondary water connections	**0.00%** 0	**11.11%** 1	**88.89%** 8	9	2.89
Billing by meter for new secondary water connections (user pays based on amount used rather than a flat annual fee)	**33.33%** 3	**11.11%** 1	**55.56%** 5	9	2.22

Q7 Other comments:

Answered: 5 Skipped: 6

#	Responses	Date
1	Not knowing the impacts or potential water savings of different actions, I hesitate to qualify or rank them. Sorry for the blank survey.	5/1/2017 4:27 PM
2	Sorry, not really sure how to answer these questions. I am not expert on some of these matters.	5/1/2017 12:22 PM
3	I appreciate the opportunity to provide input and comments on the drought resiliency plan. I attended a conference at the U of U last week that provided some really interesting insight into water deliveries and efficiency among municipal users in the Colorado River Basin. One of the key takeaways was the point that overall water use has been greatly reduced even with population growth. This is important because it means we can affect water use. I think some key aspects of drought contingency should include: Coordination among water users, the Bureau or Reclamation and the irrigation districts to manage water on a system level. This coordination of resources could help with instream flow needs as well by being strategic about leases. I keep thinking about Echo Reservoir and how much of a difference a 10-20 cfs release would make. This equates to 1 week of irrigation releases or less than that of high water. It's all about the timing. Development of water markets, where upstream water could be leased for downstream uses. I think there is serious potential for this model to work. I think working on an incentive program for landowners to convert parts of their landscapes to waterwise gardens also has potential to save considerable amounts of water. One lesson learned from the conference I attended last week was that programs put in place require long term commitments from the water agencies. With those commitments, changes can occur. Thanks again for opportunity to provide input into this process.	3/27/2017 5:26 PM
4	It is difficult for the UDWR to answer the delay in irrigation season start and the reduced irrigation season end date change because some sections of the river get more water during irrigation season and some sections get more water when the irrigation season is over. Both scenarios have some benefits for fish depending on the river section.	3/13/2017 12:46 PM
5	Some responses may change based on the severity of drought and timing. May 15th startup depends if it's a dry winter/spring. If wet, it may not be an issue.	2/27/2017 2:17 PM

Appendix 2-C

Task Force/Advisory Group Meeting Minutes

May 3, 2017

Weber Basin Drought Contingency Plan
Task Force Meeting #1
5/3/17

Task Force:
Kenton Moffett *(Ogden City)*
Rick Smith *(D&W; Weber River Water Users)*
Cary Southworth *(Bureau of Reclamation)*
Kent Kofford *(Bureau of Reclamation)*
Paul Thompson *(Division of Wildlife Resources)*
Paul Burnett *(Trout Unlimited)*
Candice Hasenyager *(Division of Water Resources)*
Joe Havasi *(Compass Minerals)*

Excused/Absent:
Woody Woodruff (Layton City)
Ben Quick (Pineview Water Systems)
Cole Panter (Weber River Commissioner)
Davis County

Project Team:
Darren Hess *(Weber Basin)*
Derek Johnson *(Weber Basin)*
Chris Hogge *(Weber Basin)*
Jim Stagge *(Utah State University)*
David Rosenberg *(Utah State University)*
Scott McGettigan *(Division of Water Resources)*
Ashely Nay *(Division of Water Resources)*
Chris Slater *(J-U-B Engineers)*
Cindy Gooch *(J-U-B Engineers)*
Eric Stevens *(J-U-B Engineers)*
Marcus Murdock *(The Langdon Group)*
Josh King *(The Langdon Group)*

Meeting Minutes:
Task Force Member Introductions

Weber Basin Report and Discussion:
- Project purpose and introduction
    - Improve drought monitoring capabilities
    - Improve data availability
    - Assess how vulnerable we are to drought
    - Update Supply and Demand Study
    - How confident are we in the current water supply? How resilient are we with our current water supply?
    - What mitigation actions can be taken to help with drought?
    - Identify different response actions
- Schedule overview
    - River modeling
    - Vulnerability assessment
    - Interviews

The Langdon Group Report and Discussion:
- Interviewed all members of the task force
- Synthesized the data
- Gave an overview of what was heard in the interviews
- Gave an overview of the proposed mitigation actions and response actions heard in the interviews

What was missed or what do we need to explore further?

- Economic - Some industries will go away with drought and some companies may go out of business
- Environmental - Avian and brine shrimp issues with a declining lake level
- Perception - Public right vs. private right. People seem to struggle with understanding the difference between private goods and public goods
- Environmental - protecting the quality of the water
- Economic - Cost of the water must be considered. Droughts will drive costs up
- Economic - Money can be the enforcement for conservation
- Agricultural – Create new category. What concern does the ag. community have? Seem to already think the cost is too high. Should be considered a separate category. Need to better understand the economic ties to agriculture
- Water Recycling - understanding the benefits and costs
- Economic – “Cost of conservation.” Billing structures need to be set up so there is enough to maintain the system infrastructure
- Political – low income population impacts when billing rates increase
- Generational – older population that have had Weber water forever – “Weber Basin promised that they would never meter this water.” Customers are already screaming
    - Secondary metering - Starting with new construction to bill by the gallon and will eventually be phased to existing customers
- Two levels of impacts to fisheries:
    - Blue Ribbon status
    - Impact to the native fish - Bluehead Sucker
        - Endangered Species Act
- Population – Need to better understand where that growth is happening, density, landscaping, housing types, etc.
- Political - Provo and Weber issues; Bear River Project
- Economic – Power generation
- Prioritization of water
    - The water community in times of drought will be forced to prioritized where water goes
    - M&I water is a priority
    - Ag water is reduced after M&I
- Policy - Municipal and County development regulations
    - HOA policies that don’t support conservation
- Policy - Water Law – use it or lose it
    - Should be focused on at a local level – user’s behaviors
- The district has significant influence with local cities
    - Support of secondary meters or conservation
- Weber Basin isn’t the only basin so this plan needs to be coordinated with other basins because the Great Salt Lake is connected to many
- What are the current drought monitoring methods and processes?
    - Various forms of weather data
    - US Drought Monitor
    - Snotel Data
    - ET information
    - Integrated water resources model – GSL Basin
    - How do you understand all of this data? There needs to be someone to understand it and interpret it for everyone
    - Cole Panter tracks a weber river model and is available online

    - Weber Basin is currently pursuing a grant to create a dashboard that compiles the data
        - Ability to compare current conditions and history should be considered in the dashboard
- Building Resiliency in Drought
    - Most of the suggested actions were mitigation and very few were response actions
    - Thoughts and Insights overview
    - Infrastructure/Environmental – Pulsing the system – Environmental flows
- Who else should we be talking to?
    - Important to include others outside of the basin.
        - Provide an incentive for everyone to look at a greater GSL view
    - Bear River Basin Representative
    - Pacificorp – Claudia Condor
- Survey overview

Division of Water Resources Report and Discussion:

- Weber River Model
- Model Results Overview
- What are the inputs and outputs?
    - Stream gauges and back calculating
    - Correlate gauges with Weber and Oakley
- Is evaporation considered?
    - Data used from the old model and copied over
    - Temperature was a major driver of evapotranspiration
- Look back with tree ring study and look forward with climate change
- Need to incorporate the Provo side in the model
    - Provo river basin
    - Steve Thurin – HDR model work on the Provo side
    - Pro Sim Model
    - Design an interface to incorporate the Provo side
- Get a sense of the magnitude of how much difference you would make from year to year on the minimum side and the maximum side – modeling the canal
    - Evaporation of the reservoirs
    - Have another sentence that says, "This is how much it could affect the model." What is the low or the high?
- Steve Thurin will share the results of the model with Water Resources
- What interested parties could kill the project and the proposals?

Utah State University Report and Discussion:

- Extreme events are infrequent
- Mid-1970's drought and mid-1930's drought
- Tree ring studies are annual but our system models are based off monthly flows and monthly decisions
- Monthly Flow Reconstruction
- www.paleoflow.org website review with group
- Data shows that the basin has had longer and drier periods than we have experienced in the past 100 years
    - We currently have data that helps us look at flood probability. Is there a way to look at drought probability?
        - Yes, use the website to identify the estimated return period

- Can you select multiple months in the model?
    - Not currently, but it could be modified to allow multiple months
- Climate change discussions
- Infrastructure may not be set up to capture rain
  - Snow, adds to the predictability and can be measured
  - Snow provides for efficient run-off
  - Rain hydrology – longer growing season
- Discussion of reservoir management
  - Once base natural water rights are met, then you can store
  - Flood control

Appendix 2-D

Task Force/Advisory Group Meetings Minutes
August 29, 2017

WEBER
BASIN
WATER
CONSERVANCY
DISTRICT

AGENDA

WEBER BASIN DROUGHT CONTINGENCY PLAN

Meeting #2 Agenda

Tuesday, August 29, 2017 - 8:00 a.m. to 10:00 a.m. - Weber Basin Offices

- **Welcome and Introductions (Darren Hess 5 min)**
  - Explain purpose and goals of drought plan

- **Advisory Council Purpose and Role (Josh King 5 min)**
  - Explain Task Force vs Advisory Council
  - Communication ground rules
  - Expectations for Advisory Council
  - This is the first of three meetings that will cover the following items:
    1. Review past droughts and reservoir level history, discuss potential risks associated with drought and potential mitigation actions. Mitigation actions are measures taken before a drought to lessen the impact of a drought.
    2. Review drought levels and what triggers those drought levels, possible response actions for drought levels. Response actions are taken after an event begins to reduce the severity of the impact of the drought.
    3. Draft drought plan review, and discussion and input

- **Summary of Key Themes from Additional Interviews, (Josh King 5 min)**
  - Show key information gathered from additional interviews

- **Summary of Historical Droughts Based on USU Paleo Record Evaluation (Jim Stagge 15 min)**
  - Four main types of drought that have occurred and key insights from the data
  - Most recent drought in 2012
    - Review of 2012 drought with time line of events/operational changes etc. during the drought
      - What does advisory group remember from this drought?
    - Compare 2012 drought to longer historical droughts (1976, 1932)
  - Group discussion
    - What would be our situation here if we had a 10 to 12 year drought?

        - At what point do you as a water user or manager start getting concerned about drought?
        - What are key indicators?
            - Is it a certain drought duration, river level, snowpack, etc.?

- **Climate Change Overview and Future Scenarios (Scott and Seth 15 min)**
    - Seth – Brief explanation of climate scenarios evaluated
    - Show summary table of model results for each scenario that gives the scenario, brief description of inputs (i.e 2 degrees warmer) percentage of total storage, precip.
    - Show actual reservoir storage versus modeled storage

Break – (10 min)

- **Drought Risks and Mitigation Actions (Josh 50 min)**
    - Split into four pre-determined groups
    - Explain Risk
    - Brainstorming activity for each group to create a list of drought risks
    - Each group reports risks. Create a list on the board.
    - Explain Mitigation vs response actions
    - Brainstorming activity to create list of drought mitigation actions
    - Each group reports mitigation actions. Create a list on the board.

- **Meeting Close (10 min)**
    - Next Steps
    - The next meeting will be in January

Weber Basin Task/Advisory Force

August 29, 2017

Scott discussed the Hot/Dry, Warm/Dry, Warm/Wet, and Hot/Wet scenarios

- Overview of Weber River Model
- Discussing and compared the past to future scenarios
- Create a model that models the whole system
- Discussion of summer conservation and the tremendous impact it can have
  - Discussed conservation in farm areas

Jim Stagge discussed the 2012-2016 drought period

- The 2013 irrigation season was shortened by 2 weeks
  - Not much was done for mitigation
- In 2014, Davis and Weber Canal shortened their season by 2 weeks
- 1977 was an extremely dry year
- It's not impossible for Utah to see a drought like the 1930's drought
- Jim discussed the tree ring gauge
  - Climate change doesn't show up in the tree rings.
- Overview of the four types of droughts
  1. Long Rapid: Typical 4.6 years
  2. Long Gradual: Typical 4.2
  3. Moderate: 2-3 years
  4. Short: More than 1 less than 2
- Climate change: Future is going to be different than the past, long term
  - Change for the past
  - Past is not a 100 percent representation of the future
  - Looking at a risk (worst case scenario)

Discussion in Group #1

- Perception of the public
- What if it was only a one year drought?
  - Droughts aren't the norm for people to plan on
- **Question: What is the perception out in the public?**
  - *What is our risk?*
  - *When does Weber Basin make those restrictions? Now or wait a year?*
  - *What if there is not enough storage?*
  - *Farming community: Their livelihood is the water*
  - *Lawn and garden community: Think it's their livelihood*
    - Restrictions or meters to make them change something

- When we are in a longer drought, it seems like a lot of people get on board. Whether it is on purpose or not. They are using less. If there are no restrictions, it's hard to pick out if it is the metering efforts, publicity, or people just being more conscious.
    - When you try to guess the projected usage, it adds to the gray zone. What will the public do about it without big brother tapping on their shoulder?
        - 2017 is a good example of this
- Water right laws
    - If changes are made, there could be less of a demand
- Secondary water in a drought
    - In an extreme scenario the major risk is drinking water supply in years of droughts strung together
        - Would secondary water be restricted during droughts?
            - If Weber Basin doesn't put water in the ditch, there won't be secondary water
            - Agriculture would also be affected by these cuts
- Is there a risk that people won't follow the guidance?
    - Some residents struggle when there are reductions
    - Social normal now to be thrown off if someone is watering during the day

Drought Mitigation Measurements

- Important going forward - major water companies are all on a similar page
    - If we are going different directions with how we perceive a drought, it could confuse the public creating more risk and it could get to the point where Weber Basin is getting ignored
- Seems like the more water people have, the more they waste
- Incentivize conservation for farmers
    - How can this be beneficial to them
    - Water rights aren't set up for incentives
        - This needs to be changed
    - Possibility to create grants
- Change the agriculture crops
    - Use drip irrigation systems
    - Is there a big need for alfalfa?
        - Create a need or rule to only plant higher value crops
    - What drives people's crop choice?
        - How much water is available
            - Farmers prepare land for onions, if there isn't enough they will do grain (they are more water intensive, along with corn)
- Demand risk
    - More people

Reports

1st Group

- Water right laws
  - Farmers having the idea they need to take the water even if they don't need the water
  - How can we help farmers understand and have that discussions about water rights?
    - Just because you have priority doesn't mean you need to use it all
- Fallowing ground
- Metering

Discussion of Impacts

- Primarily concerned with lack of runoff in a year like 2014 & lack of storage
- Longer droughts are a concern. If they go over more than five years, management becomes really difficult.
  - There is a high likelihood to have another 2012-2015
    - Mitigation actions should be to shorten irrigation season and cut contracts by 20%
- Droughts have a huge impact to forestry/recreation, etc. because lack of water to lake. Bad impacts due to dry lakebed, economic impacts and dust suppression (using CA as example)
- Priority during a really extreme event must go to culinary and human needs. In that case, agricultural water rights would have to be compensated
- There is an opportunity for fallow crops temporarily, compensate the agricultural users for that temporary change
  - Could be possible to rotate farms
  - Agriculture will suffer the most impacts
- Part of issue is that you can't compensate industry in the same way as agriculture. Can't "fallow" industry
- Mitigation approaches
  - Fallowing agricultural land
  - Metering secondary water
  - Limit new connections, let new customers buy the older water
  - Partnership between owners and canal companies to cut down the water right early in the season when water is being diverted before irrigation is really up and running. Need to compensate for that change, let the users know that we are taking rights into account
  - Think there is a chance for Utah water right law to change, need to maintain rights, but better allow cooperation
  - Better forecasting or triggers to start modifying behavior for drought. If we agree on them ahead of time, it minimizes argument.
  - Go to municipal and tell them when they legally have to pull back on watering lawns, etc.
  - With better integrated models between Weber and Provo, do a combined project, you could have them work together to share.

2nd Group

- Variation in crops
- Public perceptions
    - When restrictions happen, are they seeing consistency and value in what is proposed?

3rd Group

- Habitat for fish during a drought
    - Want to continue to keep species healthy and don't want to get into a situation where species or habitats are being lost
- Loss of food and crops
- Bird refuge
- Health risks
- Inability to run business operations
- Loss of revenue
- Loss of jobs
- Loss of royalties to the state
- Low flow/warmer temps
- Loss of blue ribbon fisheries
- Loss of recreation/sport
- Brown lawn

Weber Basin Water Conservancy District

Drought Contingency Plan

Task Force Meeting

29 Aug 2017

AGENDA – TASK FORCE MEETING

1. **Welcome and Introductions (Darren Hess 5 min)**
2. **Advisory Council Purpose and Role (Josh King 5 min)**
3. **Summary of Key Themes from Interviews, (Josh King 5 min)**
4. **Climate Change Overview (Scott McGettigan 15 min)**
5. **Summary of Historical Droughts Based on USU Paleo Record Evaluation and Future Scenarios (Jim Stagge 25 min)**
6. **Break (10 min)**
7. **Drought Risks (Eric Stevens/Josh King 25 min)**
8. **Mitigation Measures (Chris Slater/Josh King 25 min)**
9. **Meeting Close (5 min)**

STAKEHOLDER INPUT – DROUGHT CONCERNS, THREATS, RISKS

- Economic
- Recreational
- Environmental/Habitat
- Population
- Infrastructure
- Behaviors/Perspectives
- Planning and Process
- Agriculture
- The Great Salt Lake
- Lack of Collaboration/Agreements
- Political Policy

Themes and Key Insights

Themes and Insights	Mitigation	Response	Storage	Demand Mgmt.	System Aug/Optimzn	Other
Infrastructure and Operations						
Restoring and improving canals; weed control	x					x
Add gauges for better monitoring (e.g., East Canyon Creek)	x			x		
Better measurement – System tracking – technology and better metering	x					
Subsidized program to install technology to conserve	x					
Strategy/legal work to convert Echo to M&I	x		x			
Divert water from Willard canal to other canals		x			x	
Storm water permits – store and put in wetlands	x		x			
Take water right from Willard Bay and put in ASR	x		x		x	
Water reuse as secondary	x				x	
Pulsing water through the system to clean the channels during the wet years	x				x	
Insight Statement:						
Environment						
Reintroduce beavers	x		x			
Help connect habitats so the fish can move	x				x	
Phragmites removal	x				x	

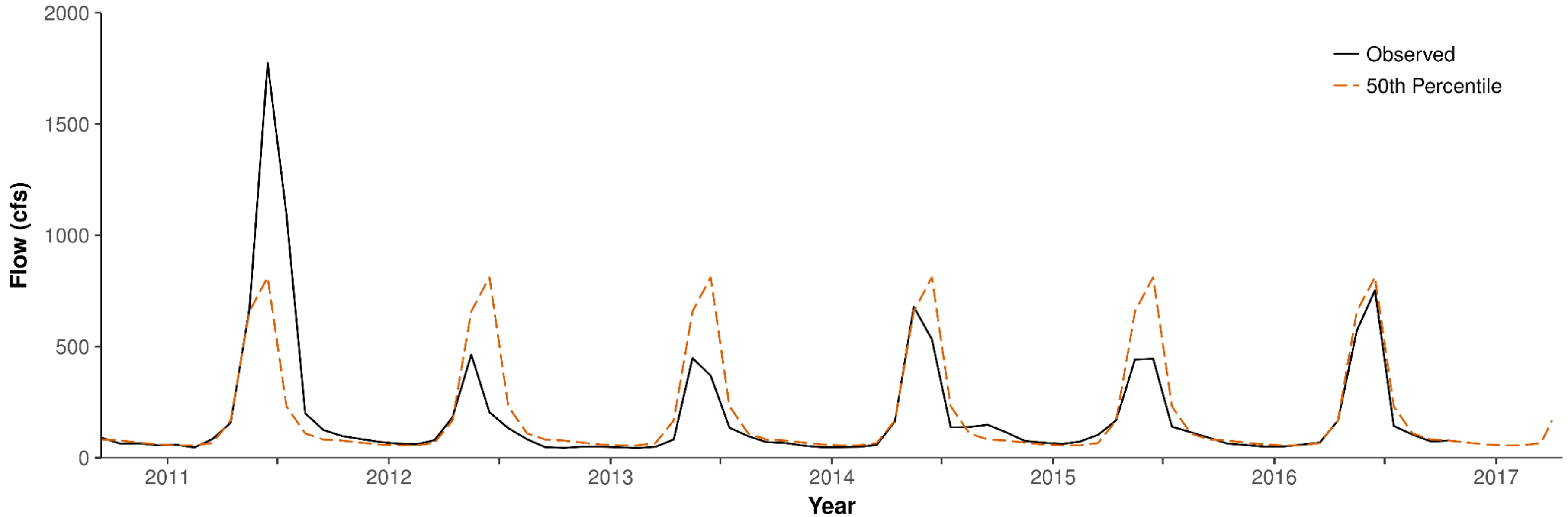
Themes and Key Insights

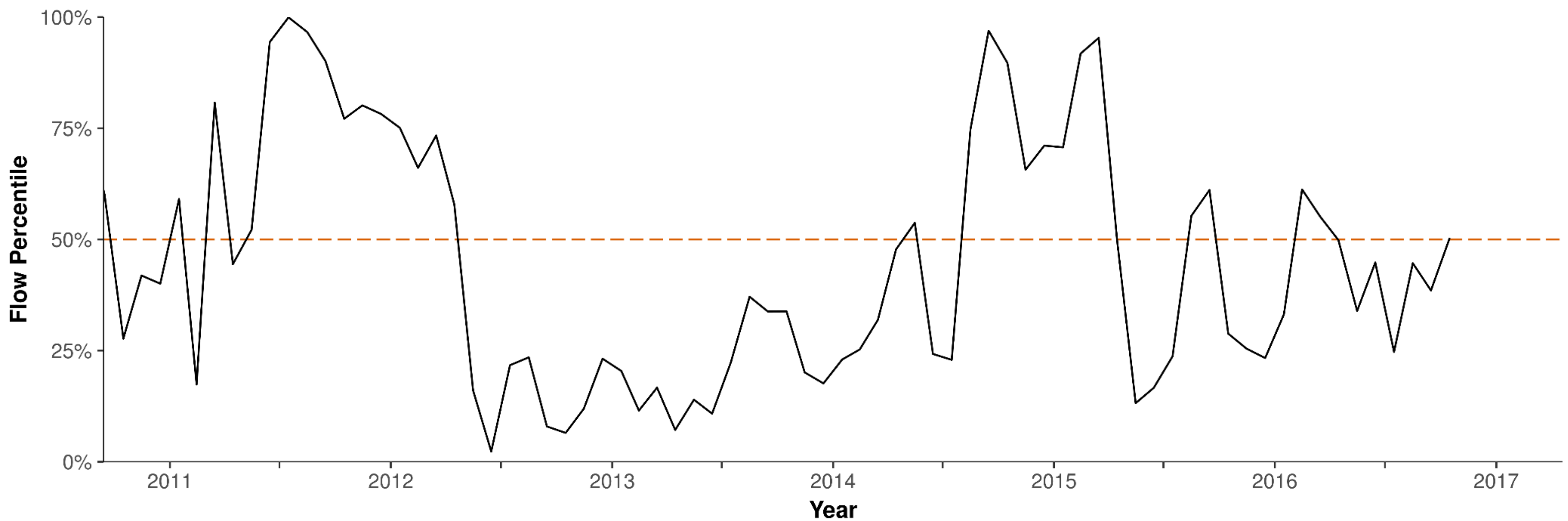
Data, Communication, and Collaboration						
Provide reports to show the transparency and the status of the snow pack	x			x		
Secondary water metering and reporting to user • Use and provide data and info to help users and public	x			x		
Create Interference Agreement – Capture the water under WBWCD Right	x		x			
Complete detailed master plans utilizing all water sources and uses	x		x	x	x	
Water sharing plans	x	x	x	x		
Water leasing/marketing - Buy/sell water rights • Collaborate with senior water rights holders • Water banking	x	x			x	
Explore and create Inter-local agreements	x				x	
Collaborate with all water sources into the GSL	x	x	x	x	x	
Collaborate with all water sources into the Bear River and the BR Project	x	x	x	x	x	
Collaborate with all water sources into the Provo River	x	x	x	x	x	
Explore potential of agreements and be proactive	x	x				
Increase connections between cities/systems	x	x			x	
3-year Irrigation contracts	x		x	x		

Themes and Key Insights

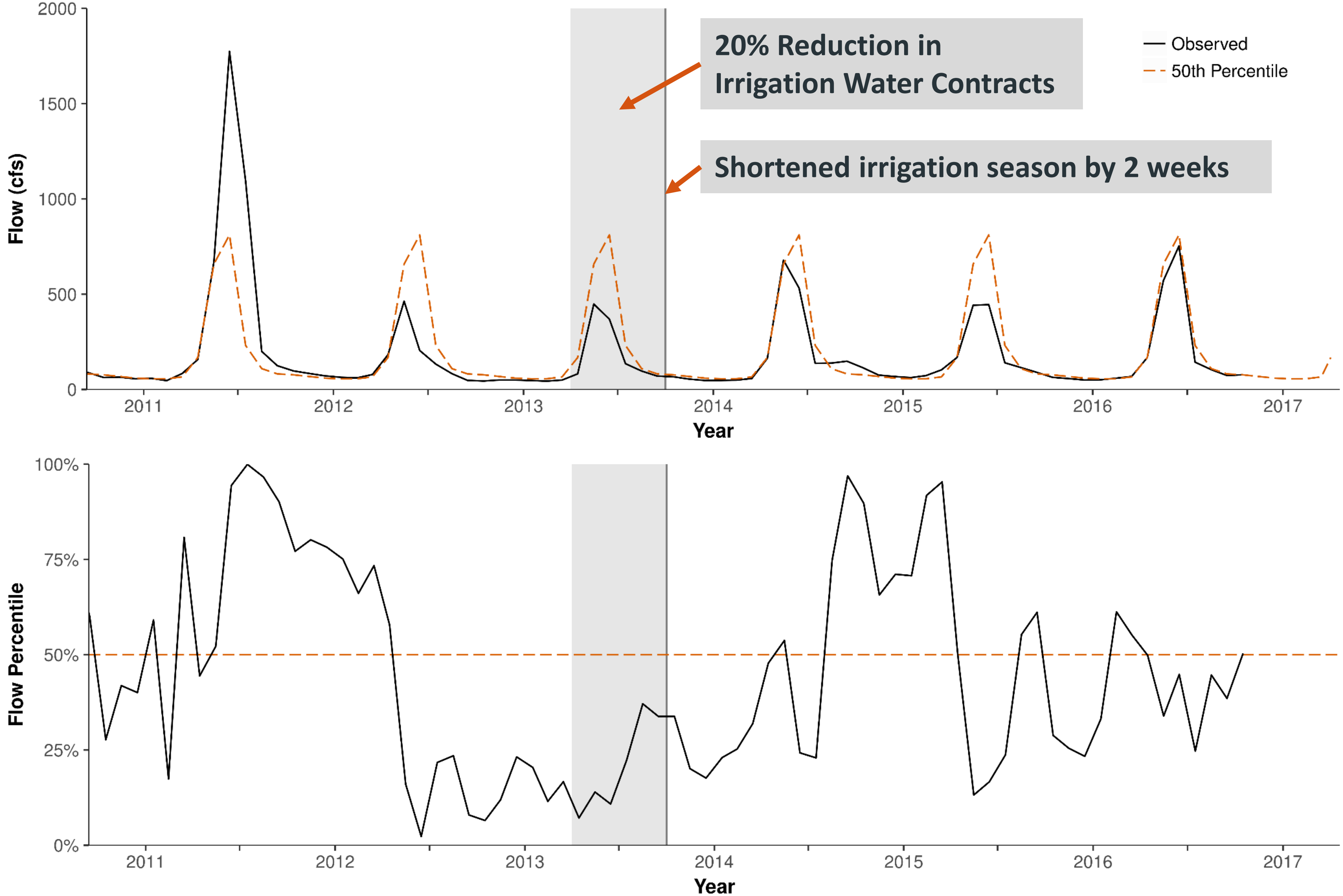
Priorities, Incentives, and Conservation						
Secondary water metering	x			x		
Provide incentives to install meters	x			x		
Water use restrictions	x	x		x		
Modify/educate state water law (use it or lose it) • Some feel that municipalities sometimes inflate their numbers because they don't want to lose the water right. This can make it difficult to plan.	x		x	x		
Replace leaking infrastructure	x				x	
Communicate and set expectations with users • Branding/messaging • Provide data and real-time updates	x	x		x		
Provide incentives for land owners to take parts of their property out of irrigation	x	x				
Prioritize use and users: Culinary, agriculture, secondary, environmental	x	x		x		
Priority cuts based on flow levels	x			x		

2012-2016 Drought Period





2012-2016 Drought Period



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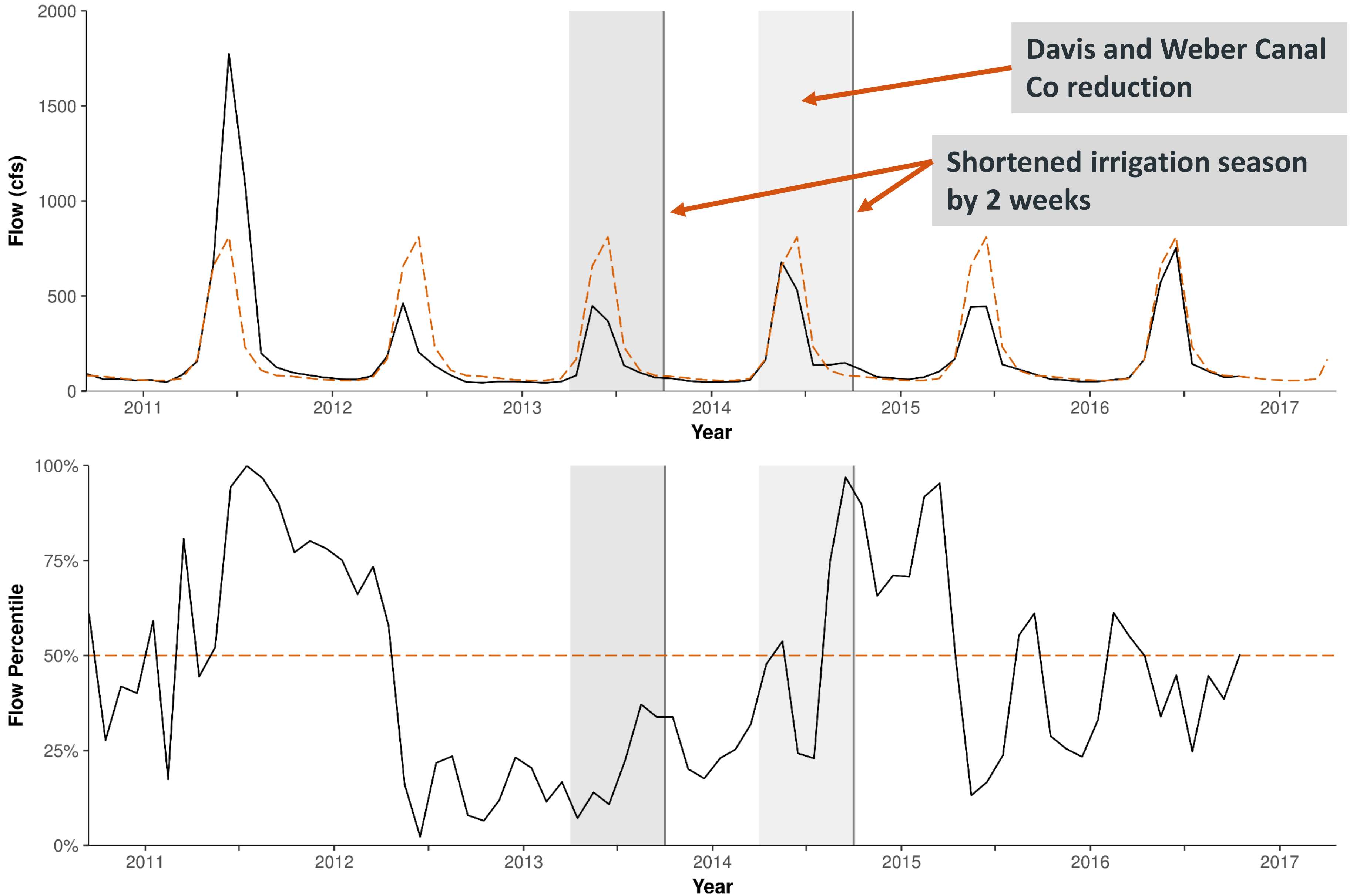
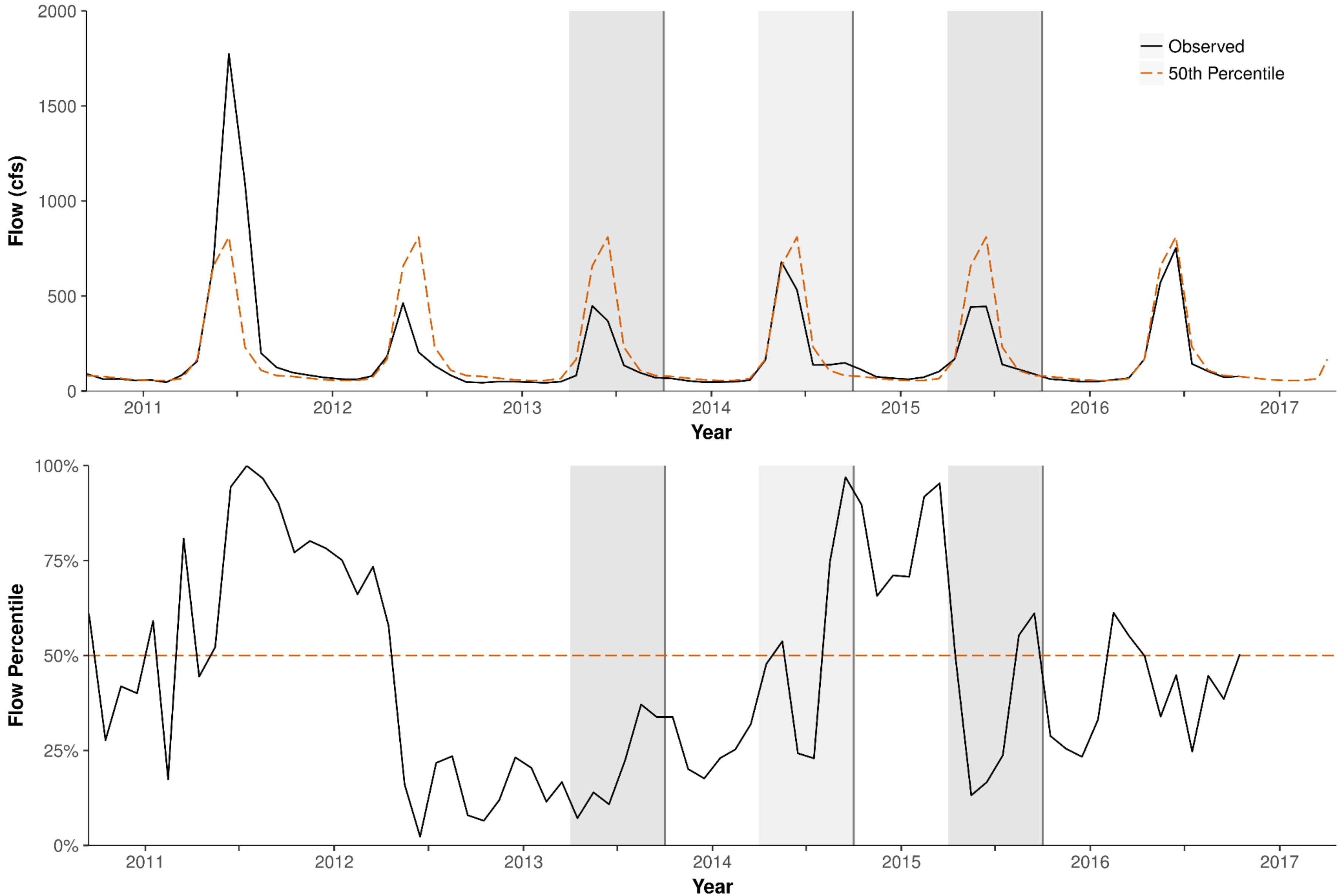
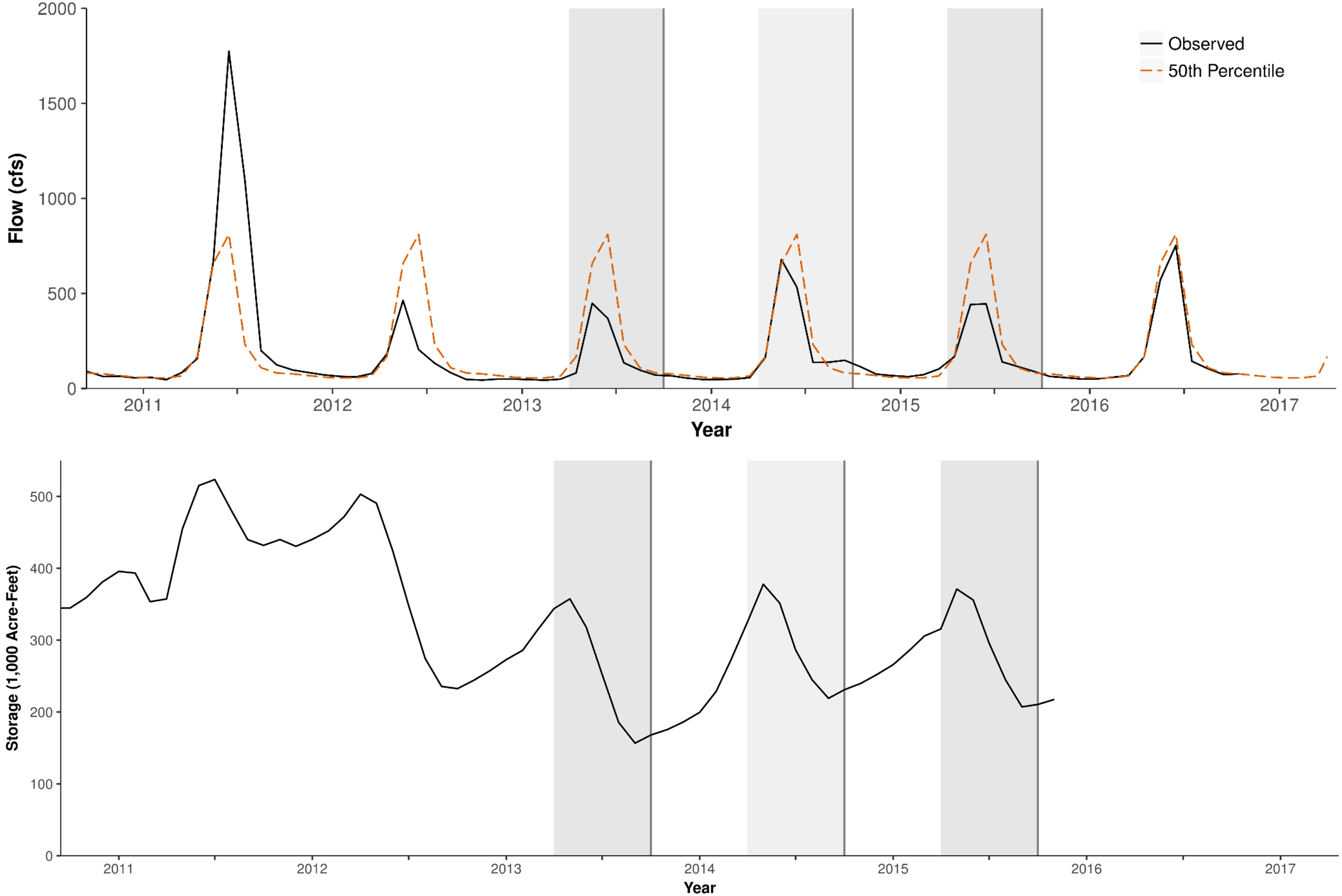


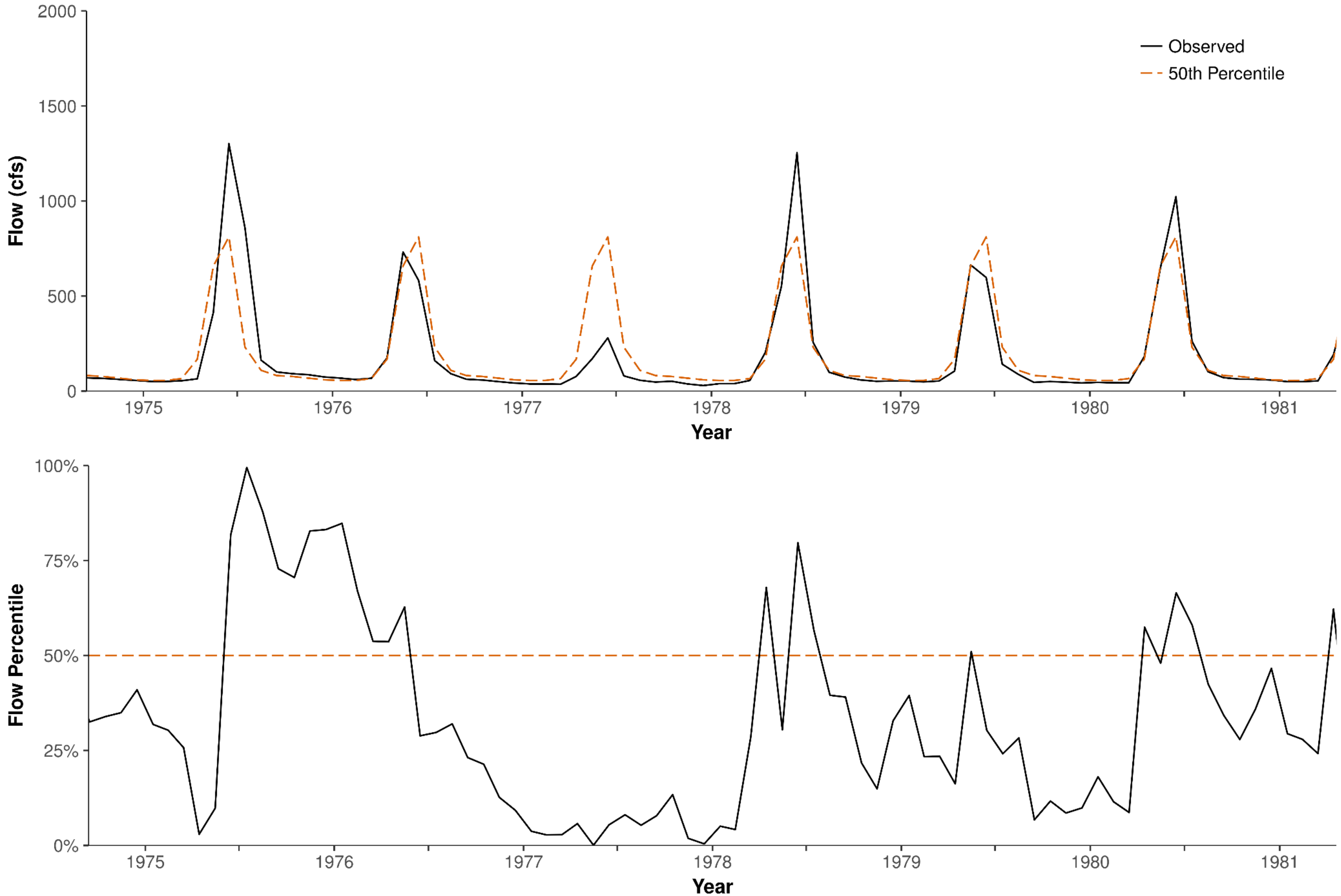
2012-2016 Drought Period



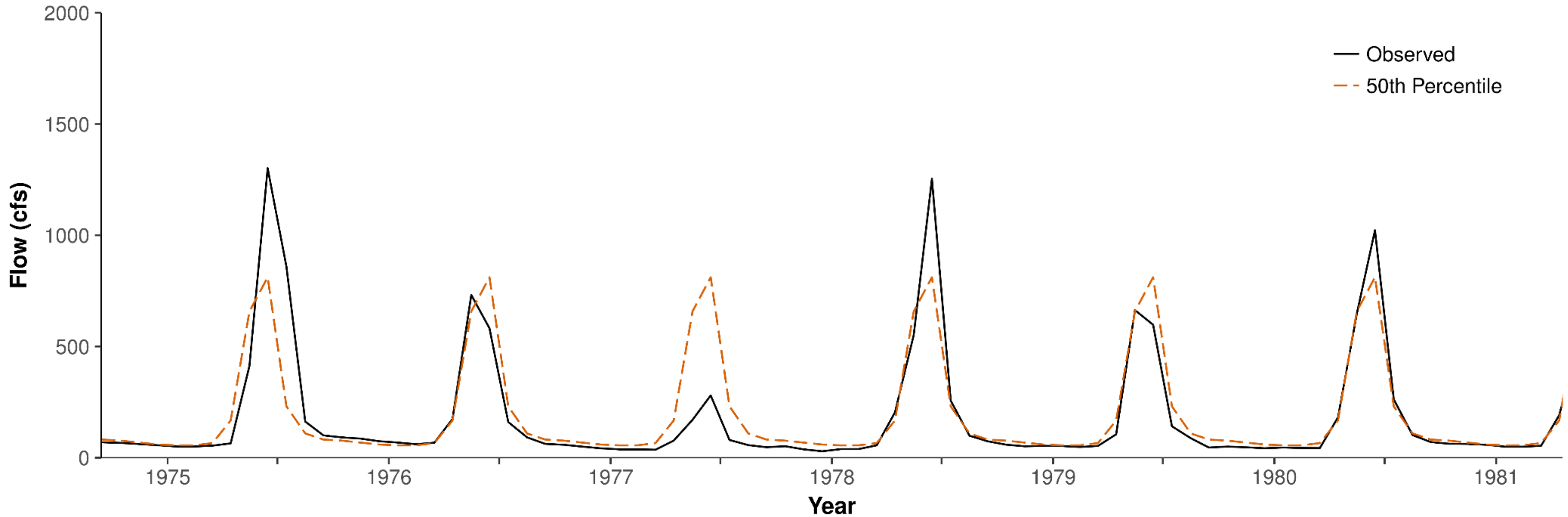
2012-2016 Drought Period

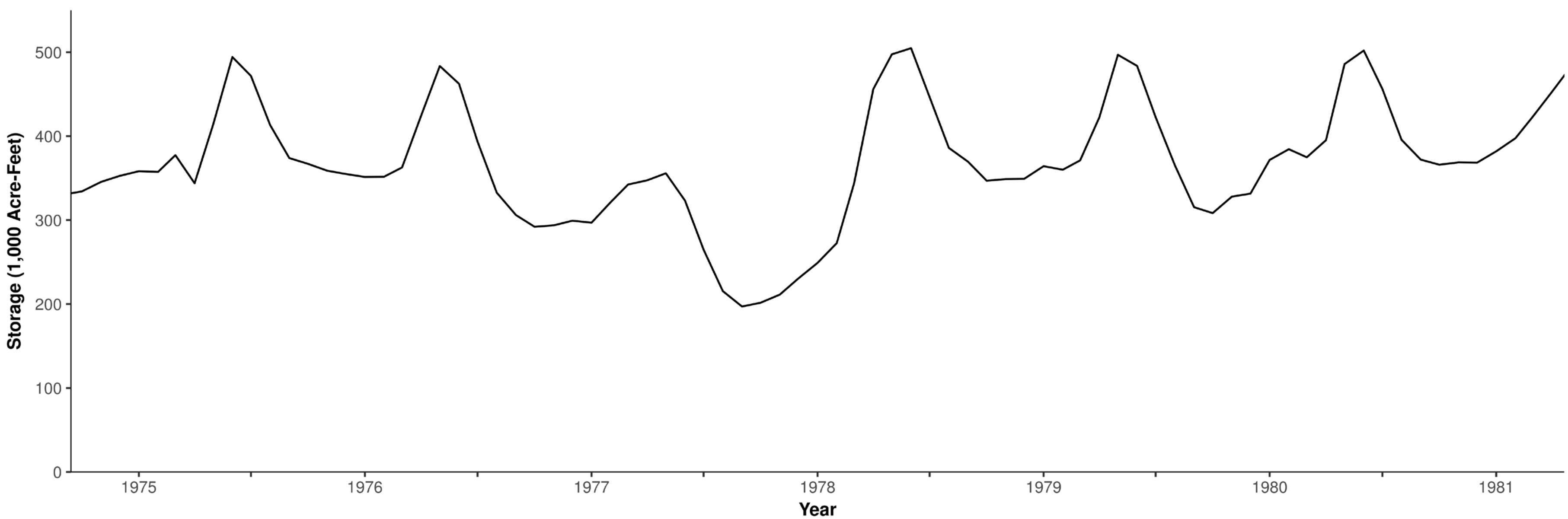


1976-1980 Drought Period

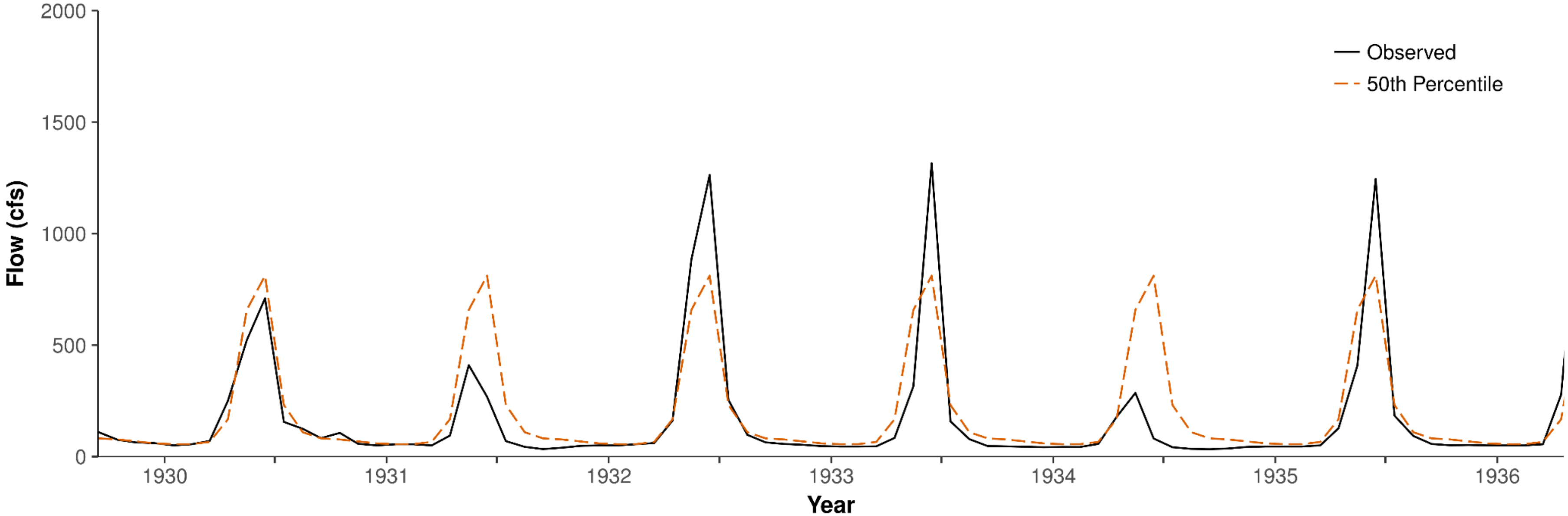


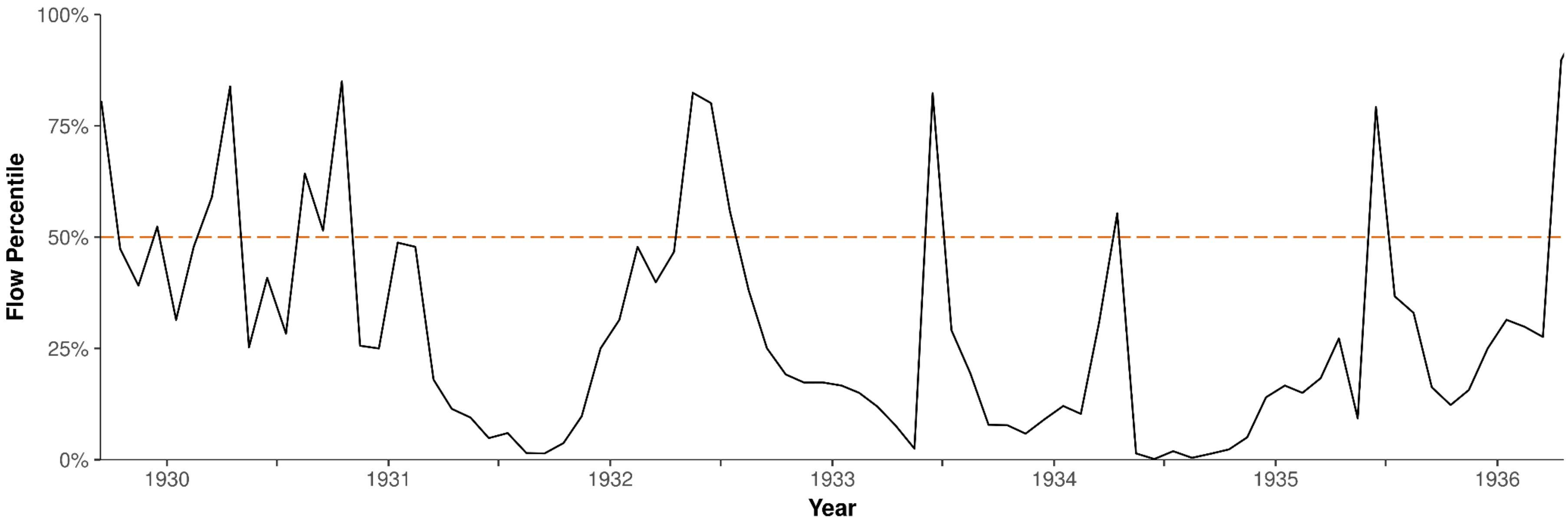
1976-1980 Drought Period





1931-1935 Drought Period





Newly Developed Monthly Reconstructions

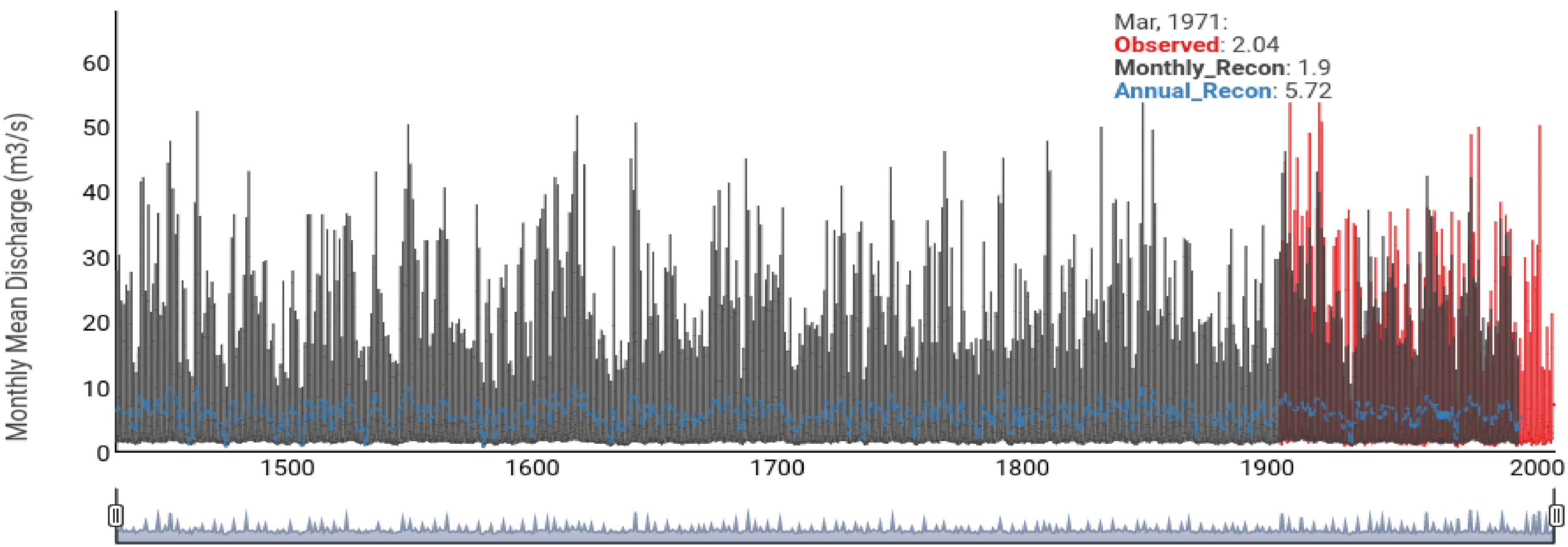
- **Reconstructed Flow at Oakley**

  Based on tree-ring growth, 576 Years (1429 - 2004)

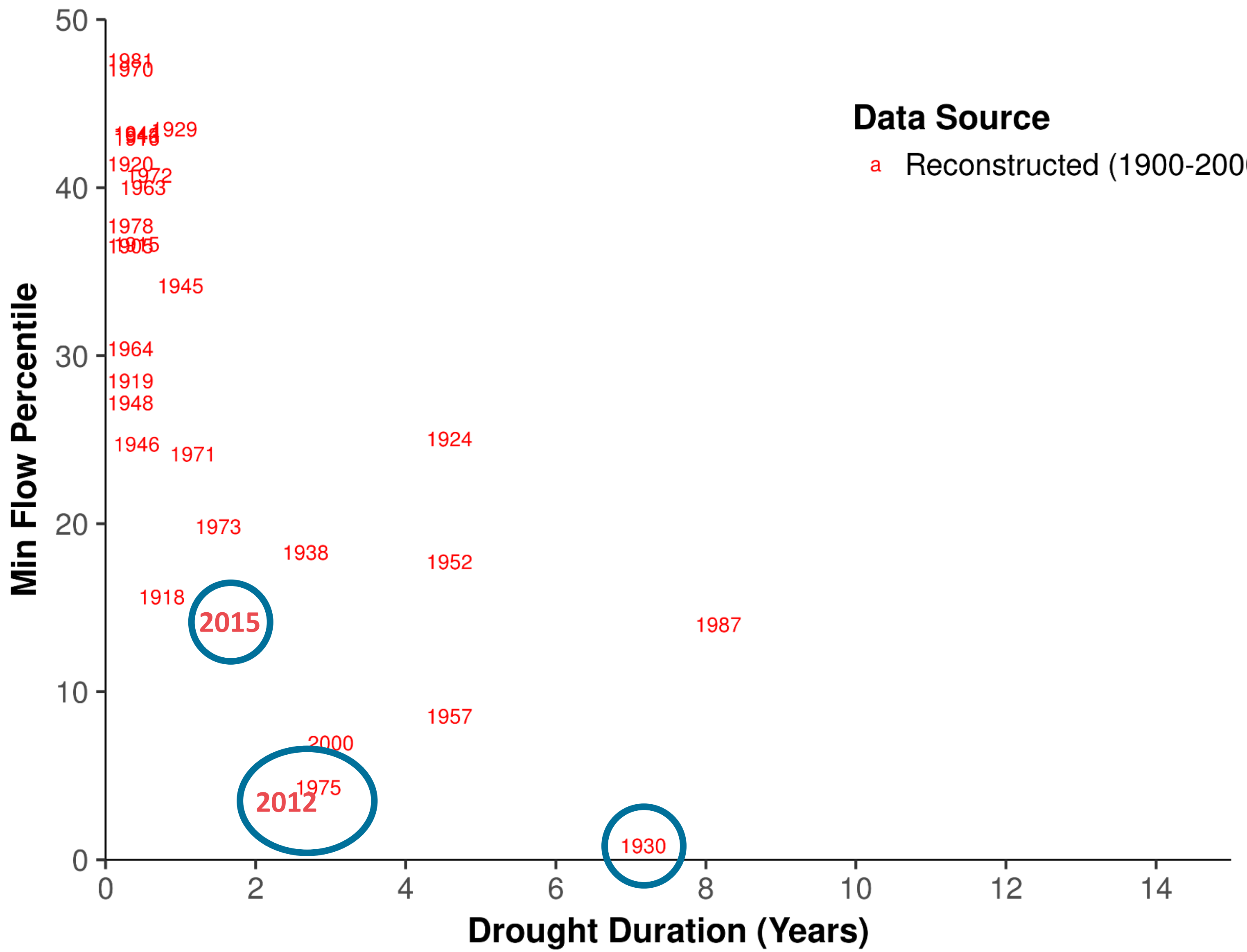
- **Definition of Drought Event**

  Flow < 50^{th} percentile

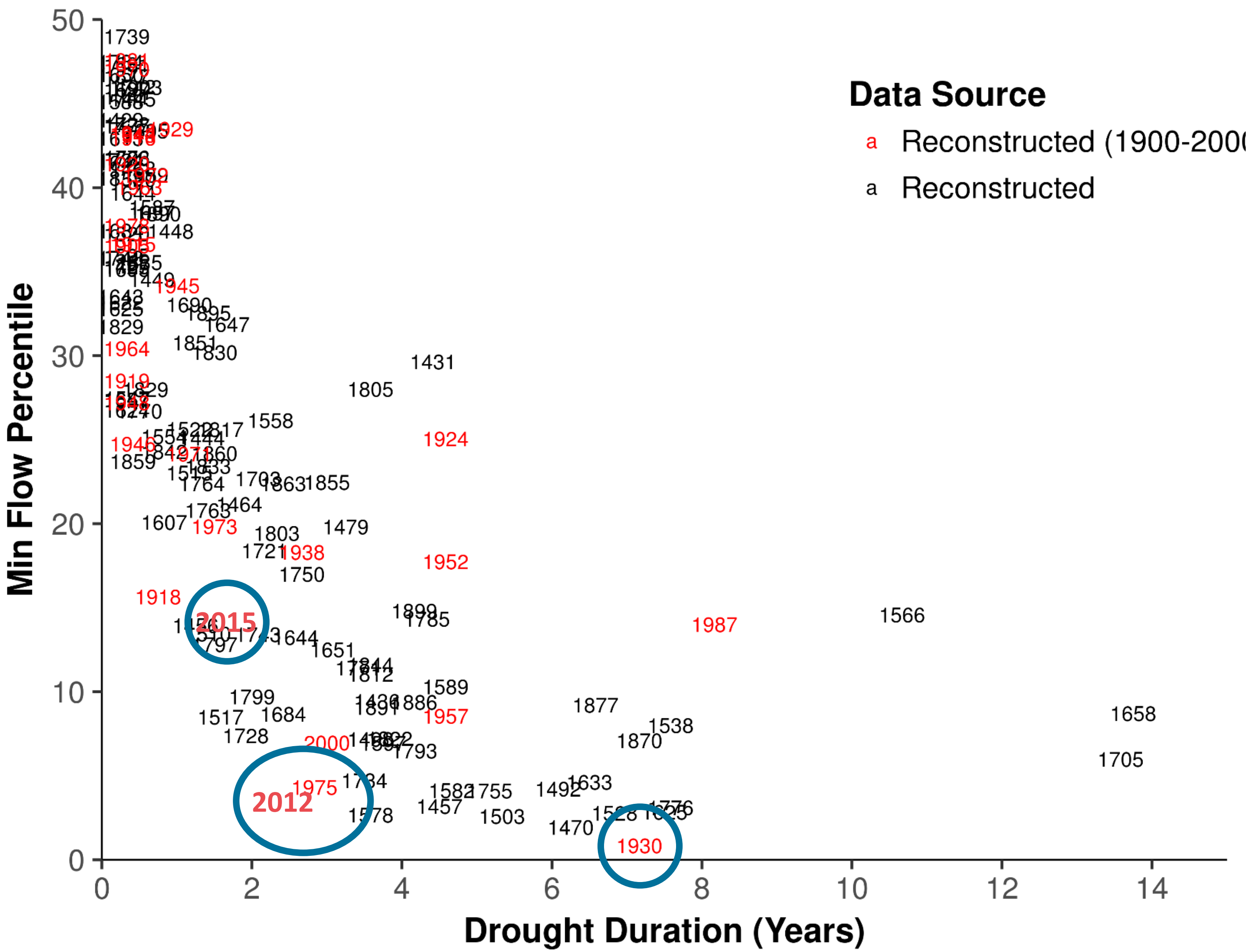
  For at least 3 contiguous months, 2 month gaps filled

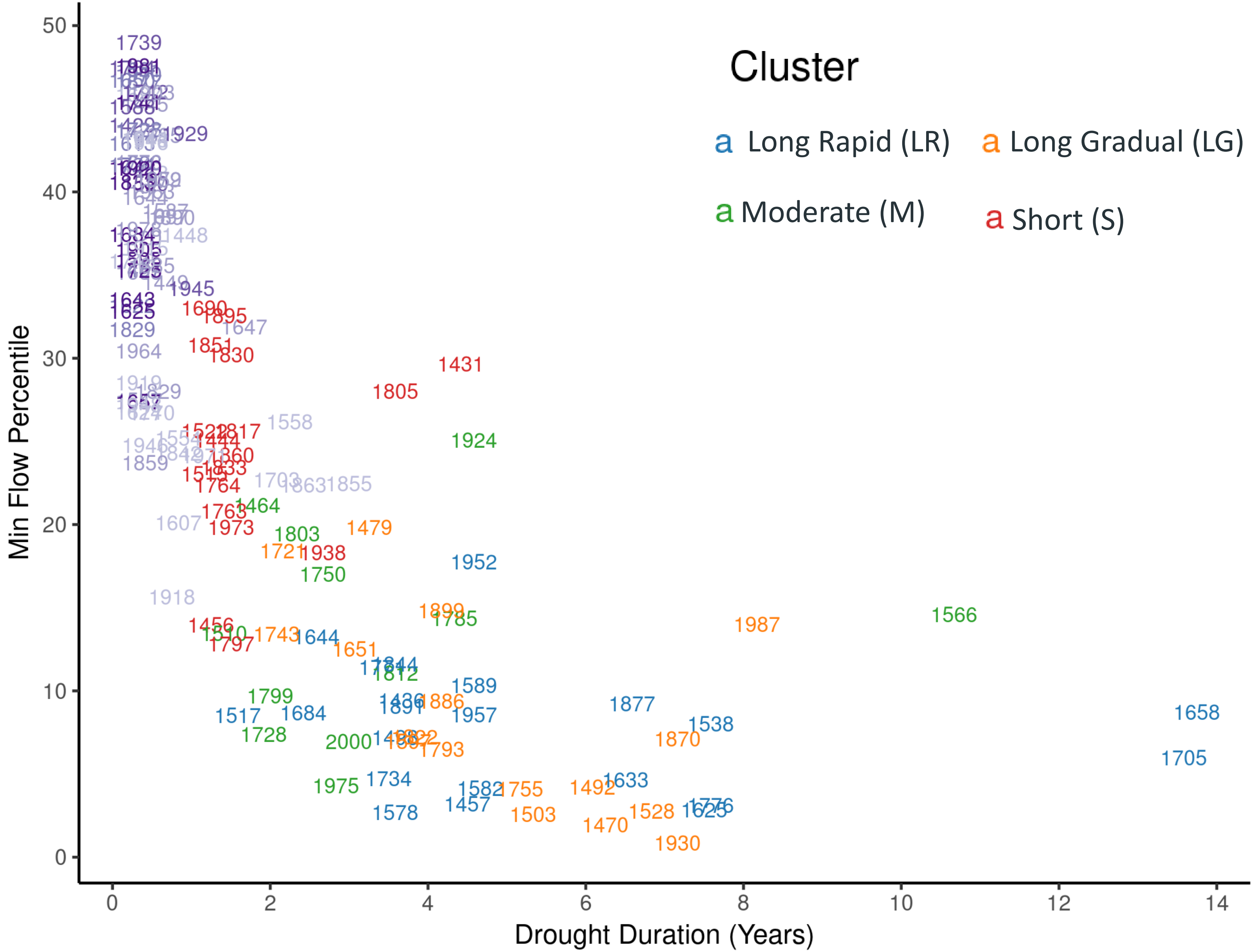


Newly Developed Monthly Reconstructions



Newly Developed Monthly Reconstructions





Cluster
a Long Rapid (LR)
a Long Gradual (LG)
a Moderate (M)
a Short (S)
Min Flow Percentile
Drought Duration (Years)
0
10
20
30
40
50
0
2
4
6
8
10
12
14
1739
1929
1634
1448
1945
1643
1625
1690
1895
1647
1829
1964
1851
1830
1431
1805
1558
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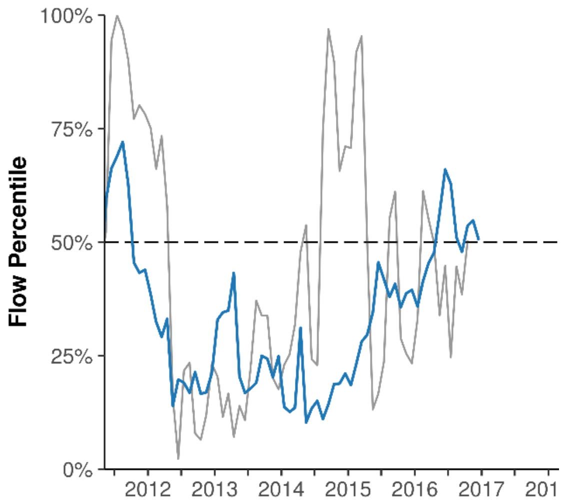
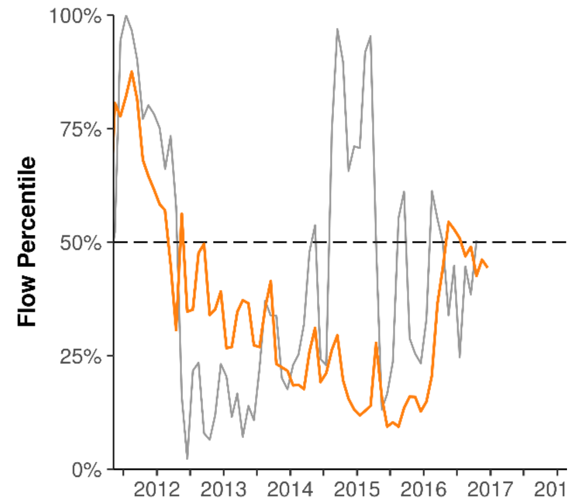
1658
1538
1728
2000
1793
1870
1705
1975
1734
1633
1582
1755
1492
1457
1578
1503
1528
1470
1930

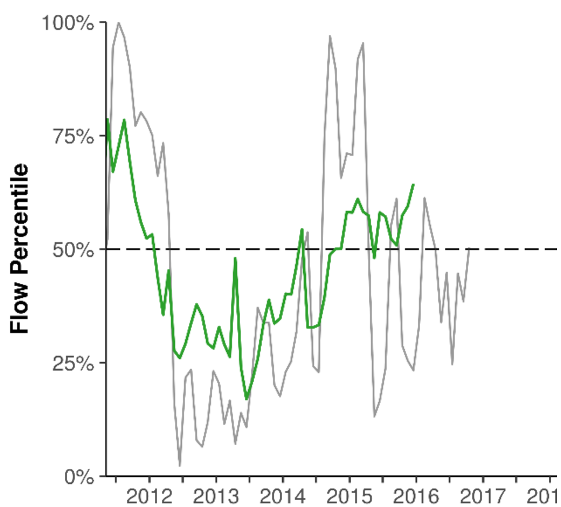
Long Rapid (LR)
Typical: 4.6 years, 10.3%
Recent: 10/1957 – 4/1962



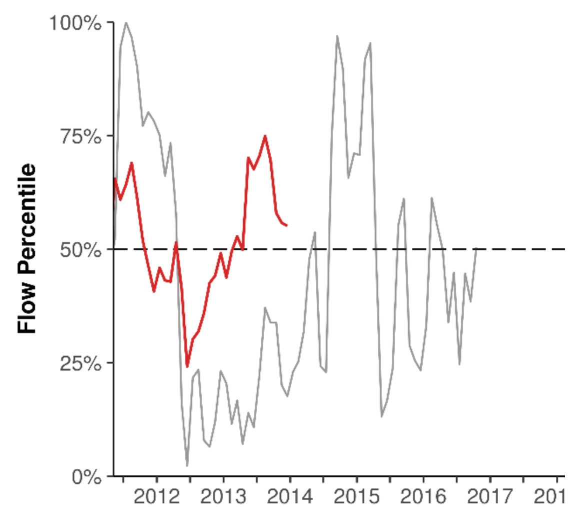
Long Gradual (LG)
Typical: 4.2 years, 9.4%
Recent: 3/1930 – 4/1937, 3/1987-4/1995



Moderate (M)
Typical: 2.7 years, 17.0%
Recent: 10/1975 – 7/1978, 1/2000 – 12/2002



Short (S)
Typical: 1.5 years, 24.2%
Recent: 11/1973 – 4/1975




Cluster
a Long Rapid (LR)
a Long Gradual (LG)
a Moderate (M)
a Short (S)
Min Flow Percentile
Drought Duration (Years)
0
10
20
30
40
50
0
2
4
6
8
10
12
14

Most Extreme Events

Longest Duration (1705)

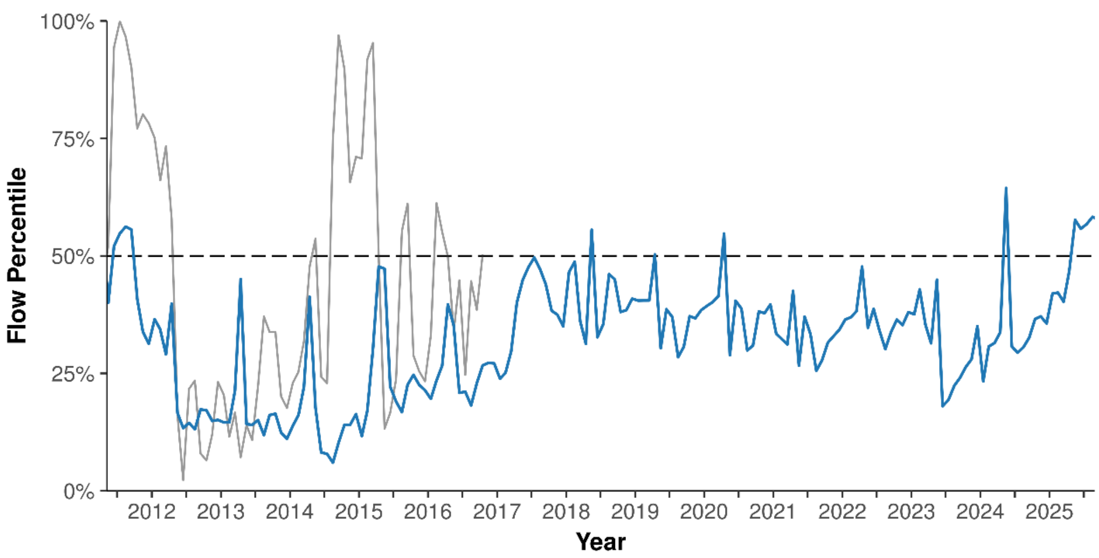
13.6 years

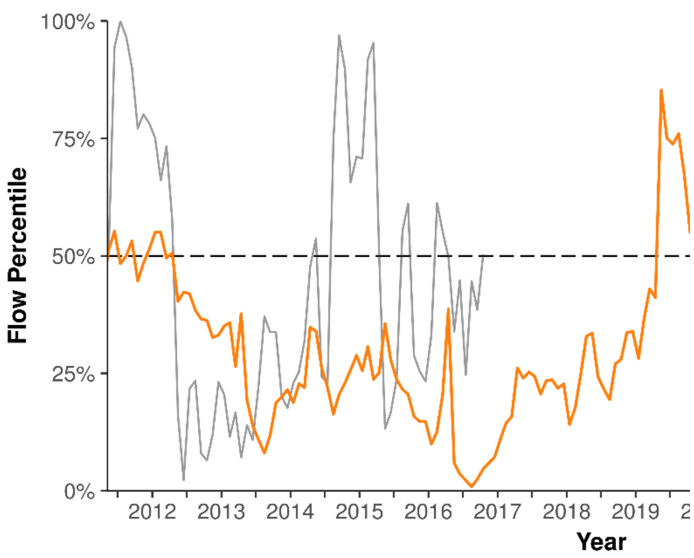
6.0% minimum

Worst Severity (1930)

7.2 years

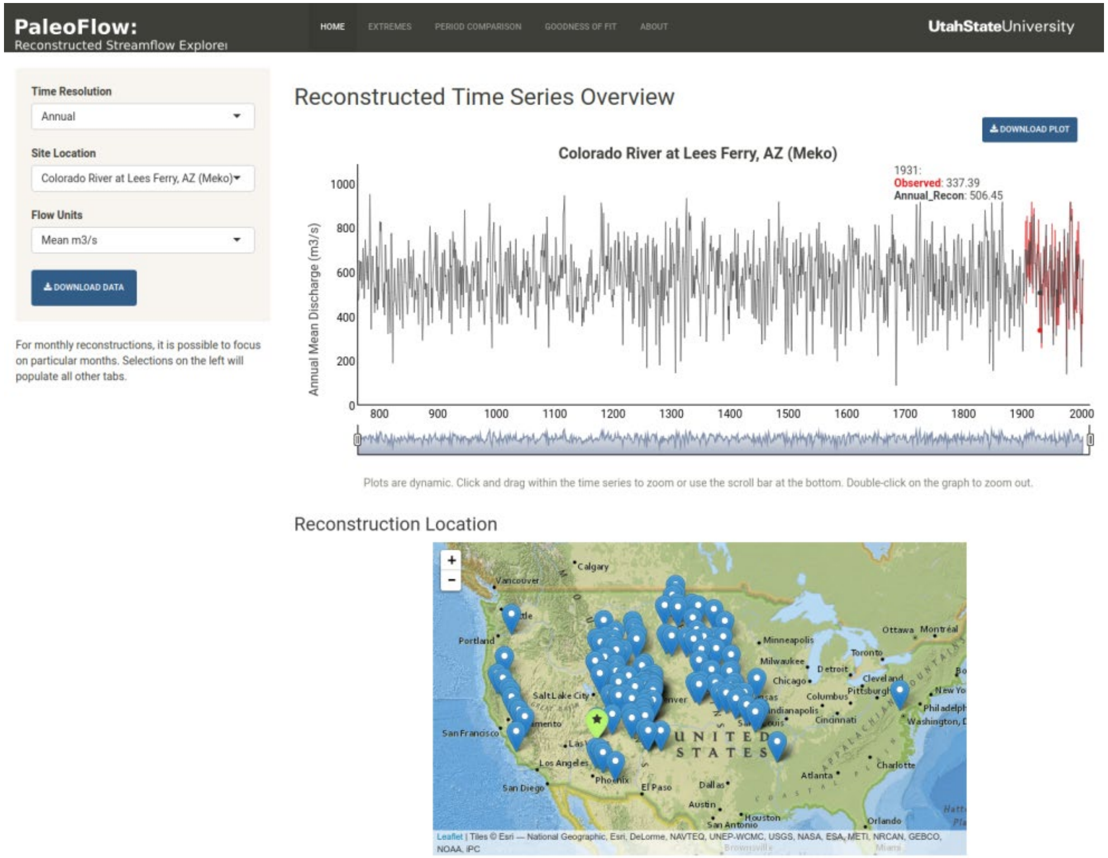
0.9% minimum





Paleoflow Website

- **View results at** www.paleoflow.org



SMALL GROUPS: RISK & MITIGATION

Risk Analysis - Steps

1. Identify risks (concerns of drought)
2. Identify likelihood of occurrence
3. Identify impact or consequence

Risk Level

Likelihood of Occurrence	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	Low	Moderate	High	High	High
Likely	Low	Moderate	High	High	High
Unlikely	Low	Low	Moderate	Moderate	High
Very Unlikely	Low	Low	Low	Low	High

Impact or Consequence of Occurrence

Risk Analysis - Definition

- Risks are uncertain events or conditions
- May have either positive or negative impact:
  - Positive impact = **opportunity** (e.g. sharing agreement)
  - Negative impact = **threat** (e.g. environmental minimum flows)

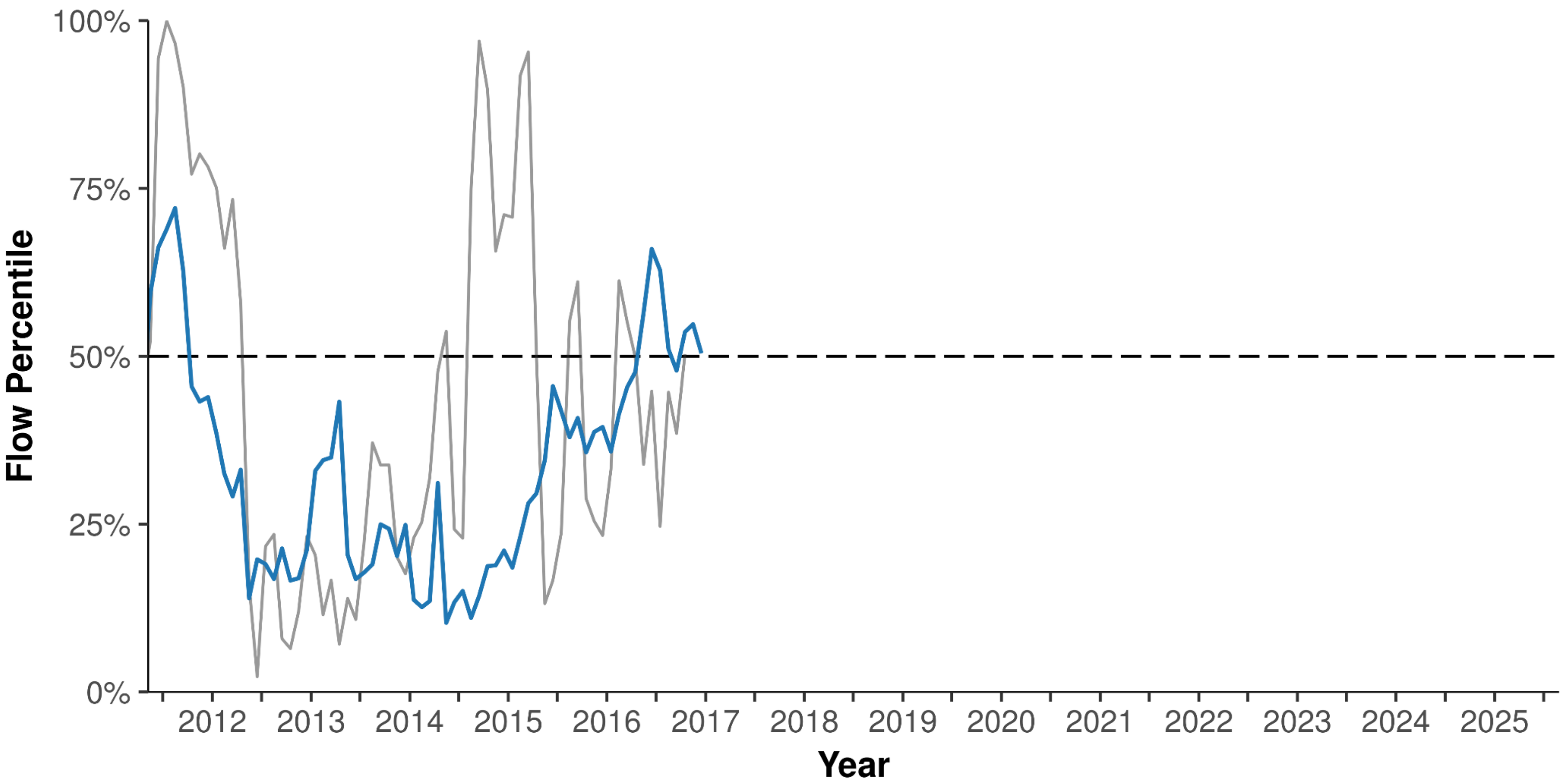
Drought Mitigation Measures

- Measures that we can take prior to a drought to help lessen the impacts of potential drought within Weber Basin.

- Examples:
  - Improved flow monitoring
  - Water transfer agreements
  - Aquifer Storage and Recovery

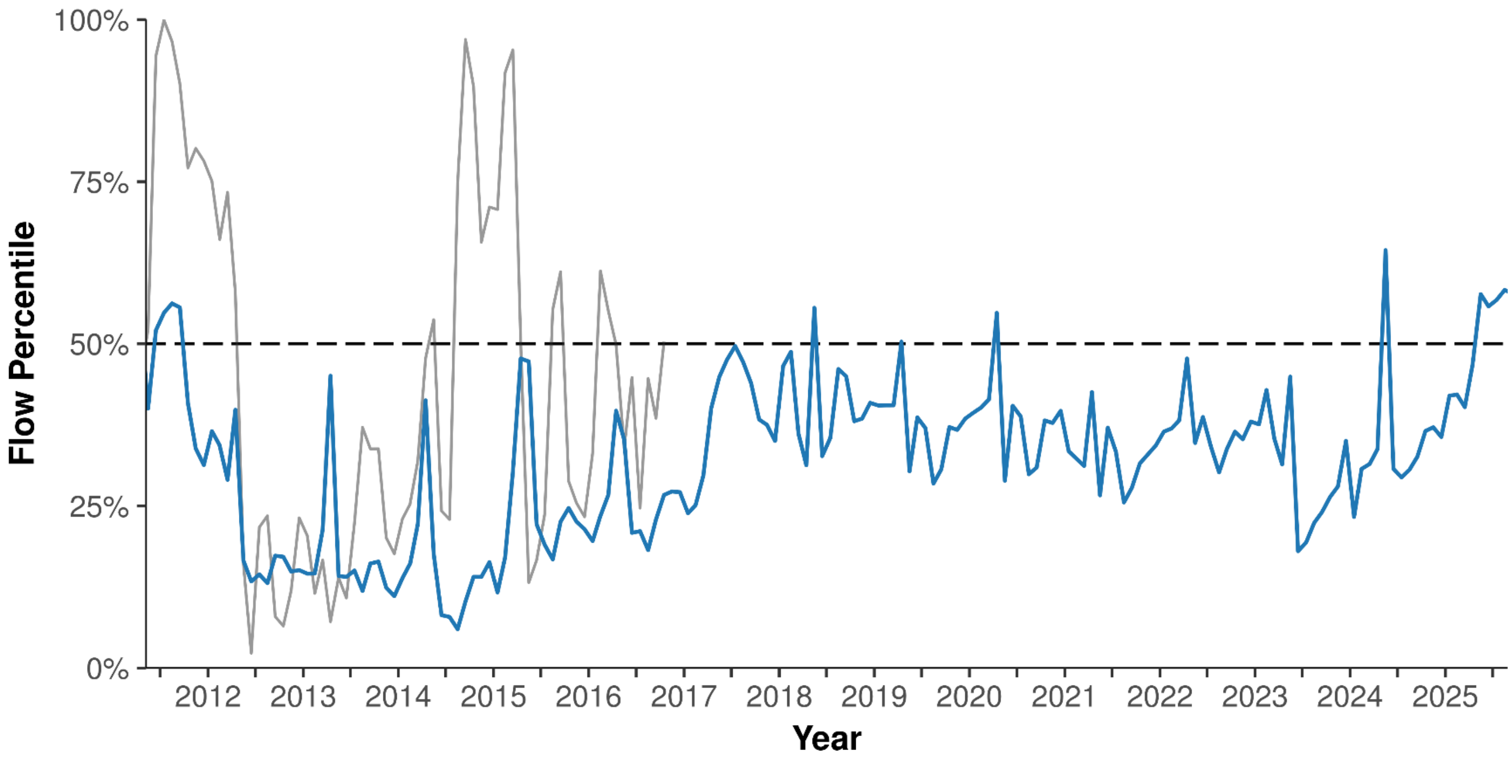
2012 DROUGHT & HISTORICAL DROUGHTS

1590



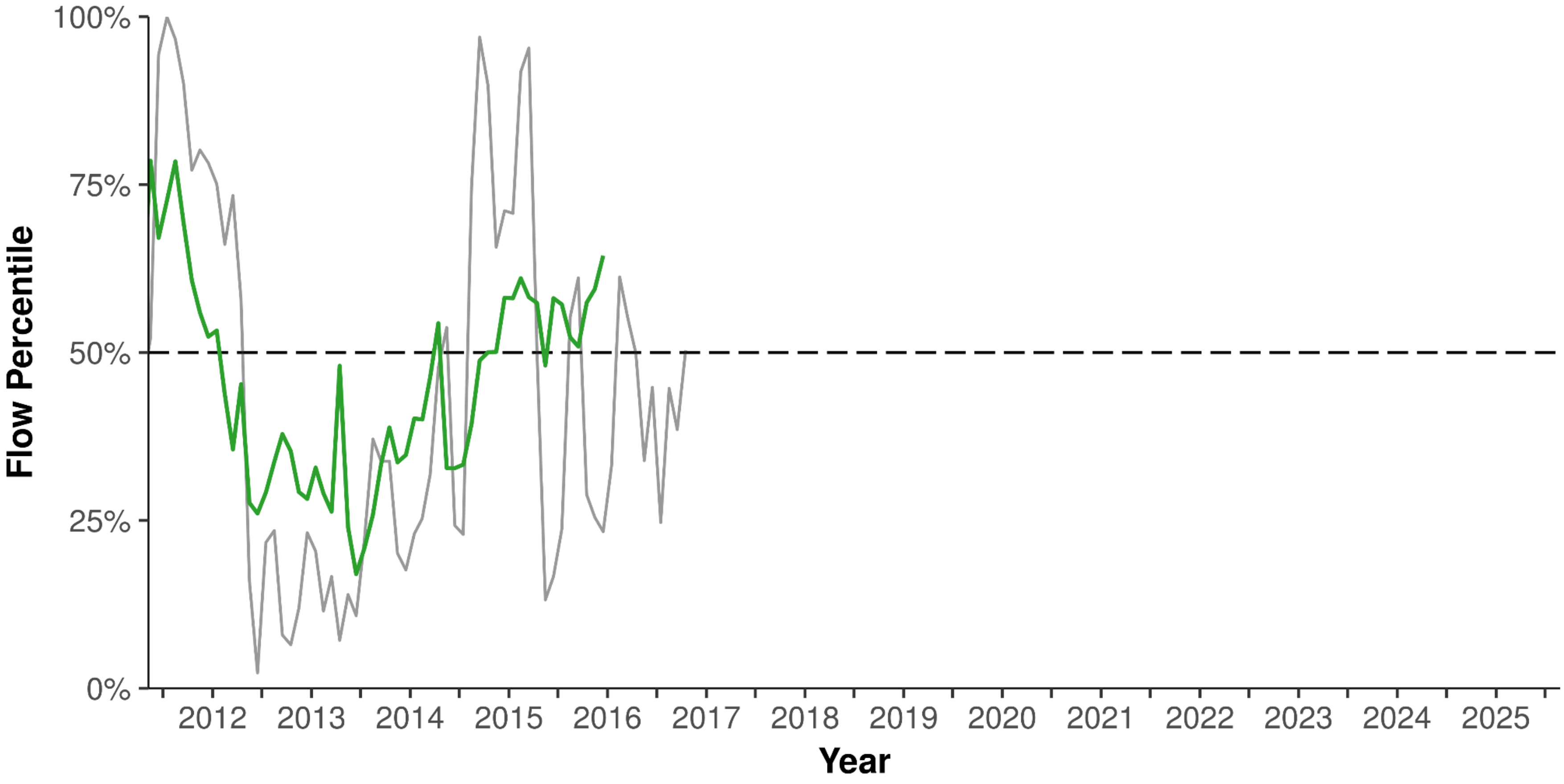
100%
75%
50%
25%
0%
Flow Percentile
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Year

1706



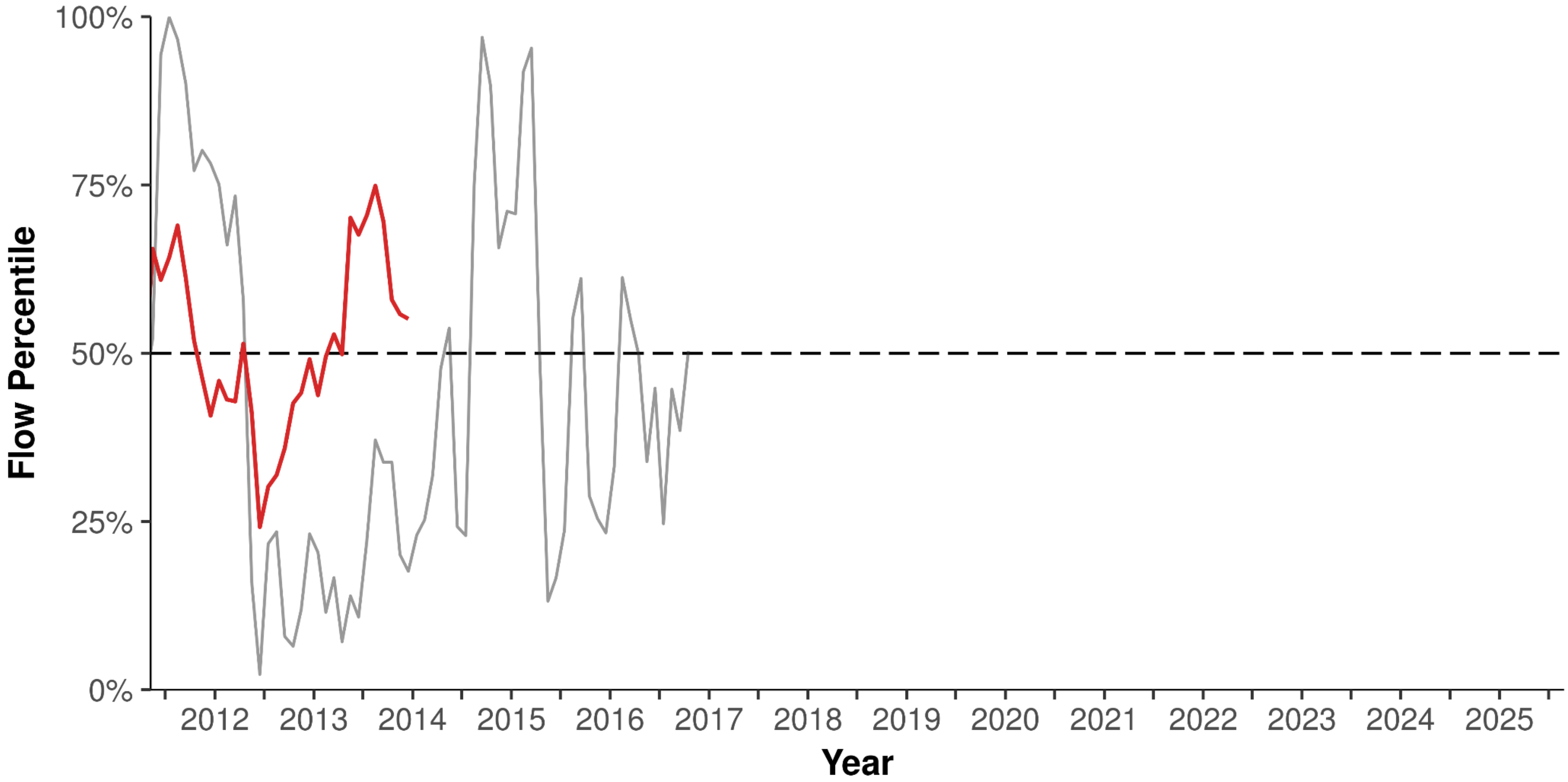
100%
75%
50%
25%
0%
Flow Percentile
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Year

1750



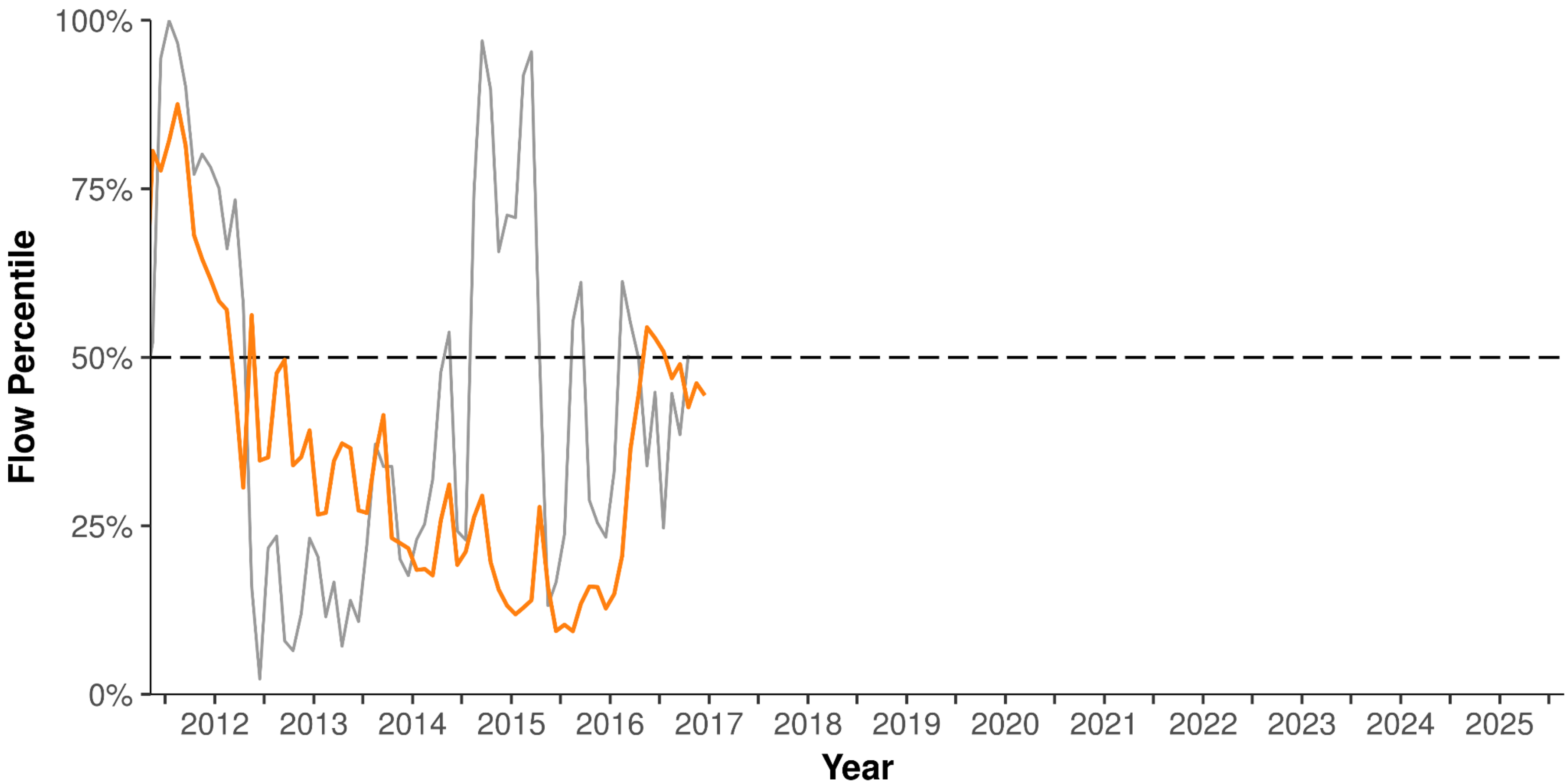
100%
75%
50%
25%
0%
Flow Percentile
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Year

1861



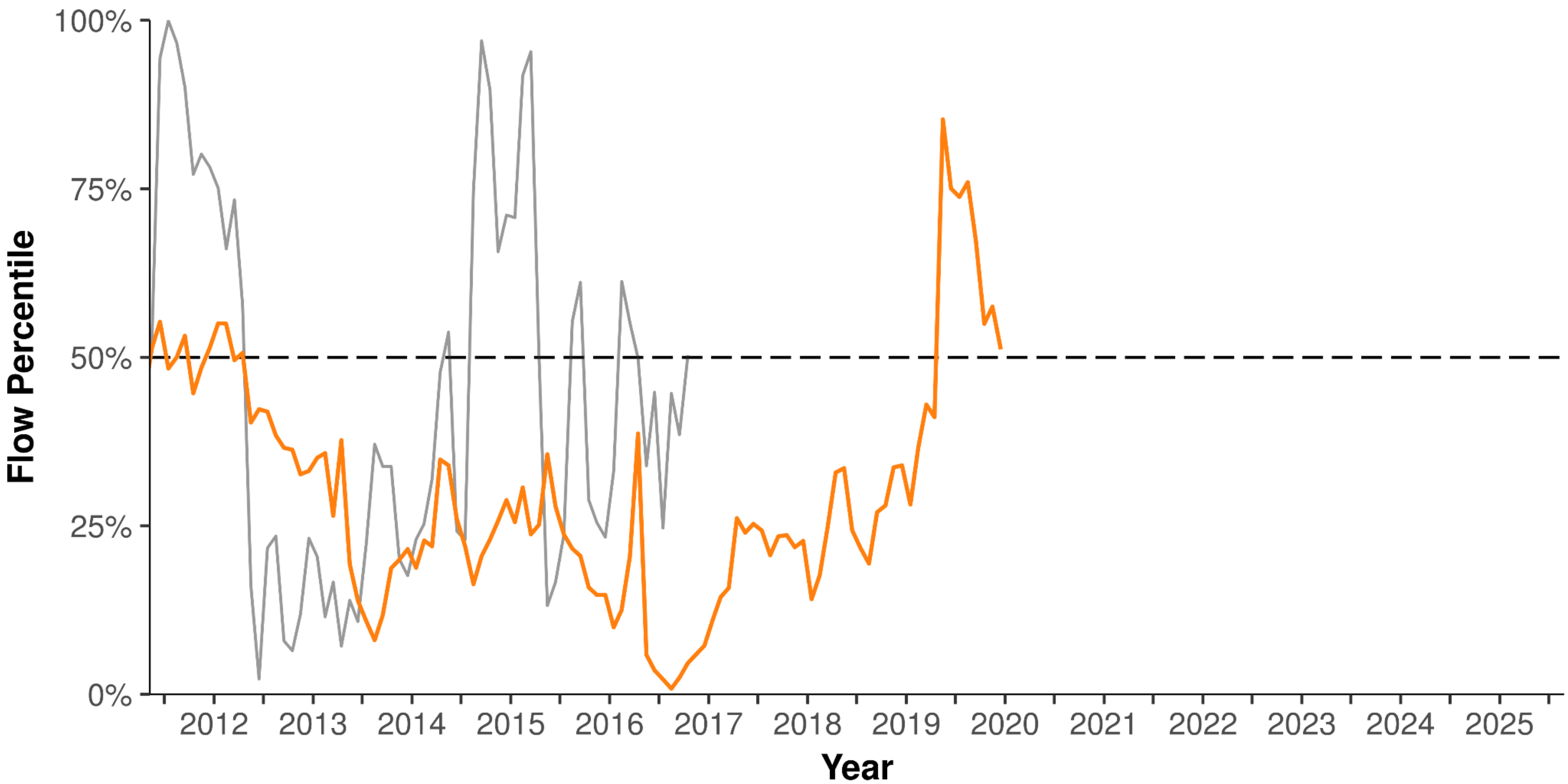
100%
75%
50%
25%
0%
Flow Percentile
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Year

1886



Flow Percentile
100%
75%
50%
25%
0%
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Year

1930



100%
75%
50%
25%
0%
Flow Percentile
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Year

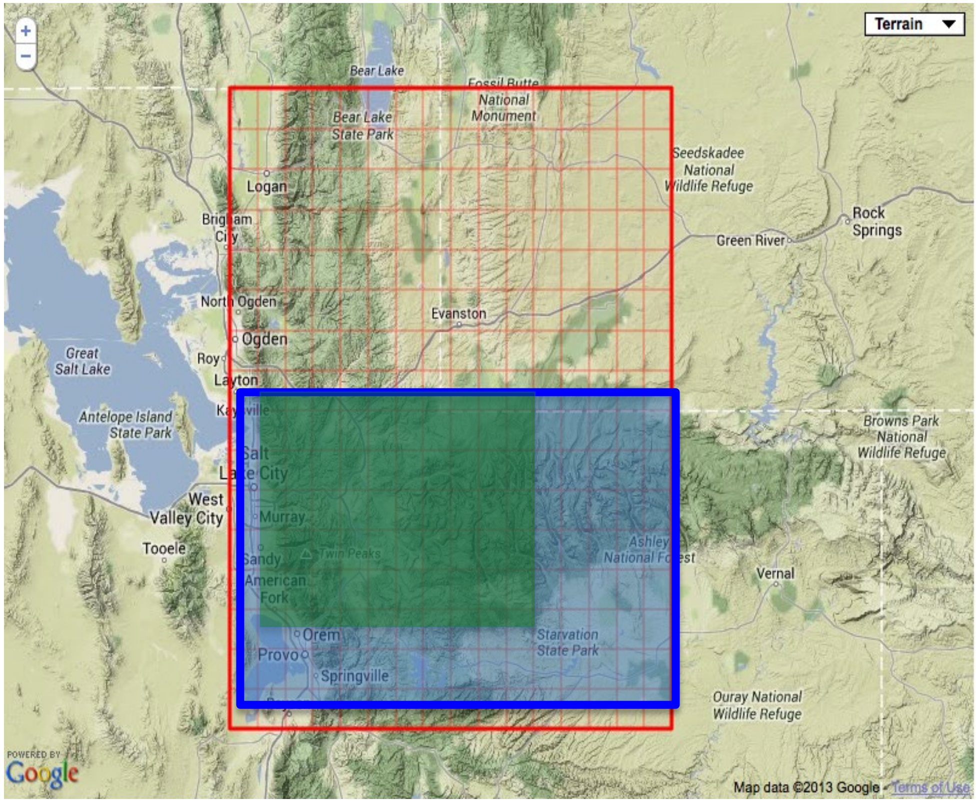
ADDITIONAL SLIDES

Climate Change and the Weber River

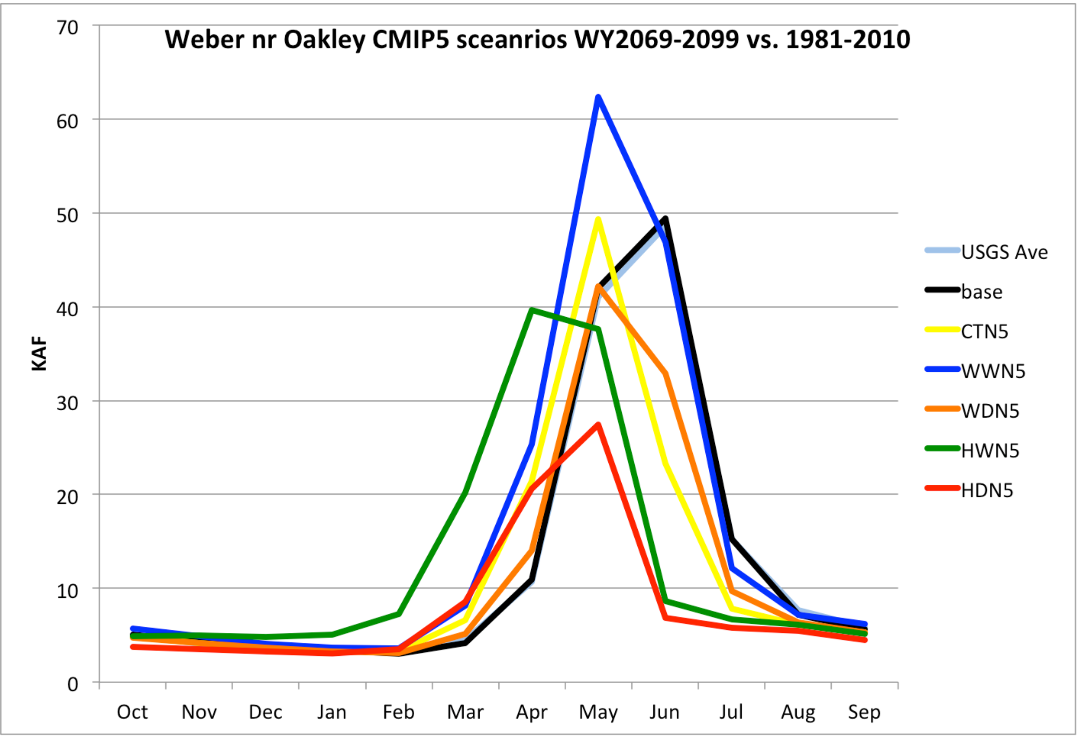
- How will future changes in temperature and precipitation alter Weber River flows?
- Data:
  - 75 climate models to project changes in future temperature and precipitation at moderate emissions
  - Colorado Basin River Forecast Center models used to project future river flows
- Temperature and precipitation sensitivity analysis of Weber River flows.
  - How will Weber River flows change if 2050 temperatures increase by 2° F and precipitation increases by 5%?

Scenario Planning

- All 75 climate models equally plausible, so…
- Chose 5 scenarios:
  - Central tendency of models (median)
  - Warm/Wet
  - Warm/Dry
  - Hot/Wet
  - Hot/Dry

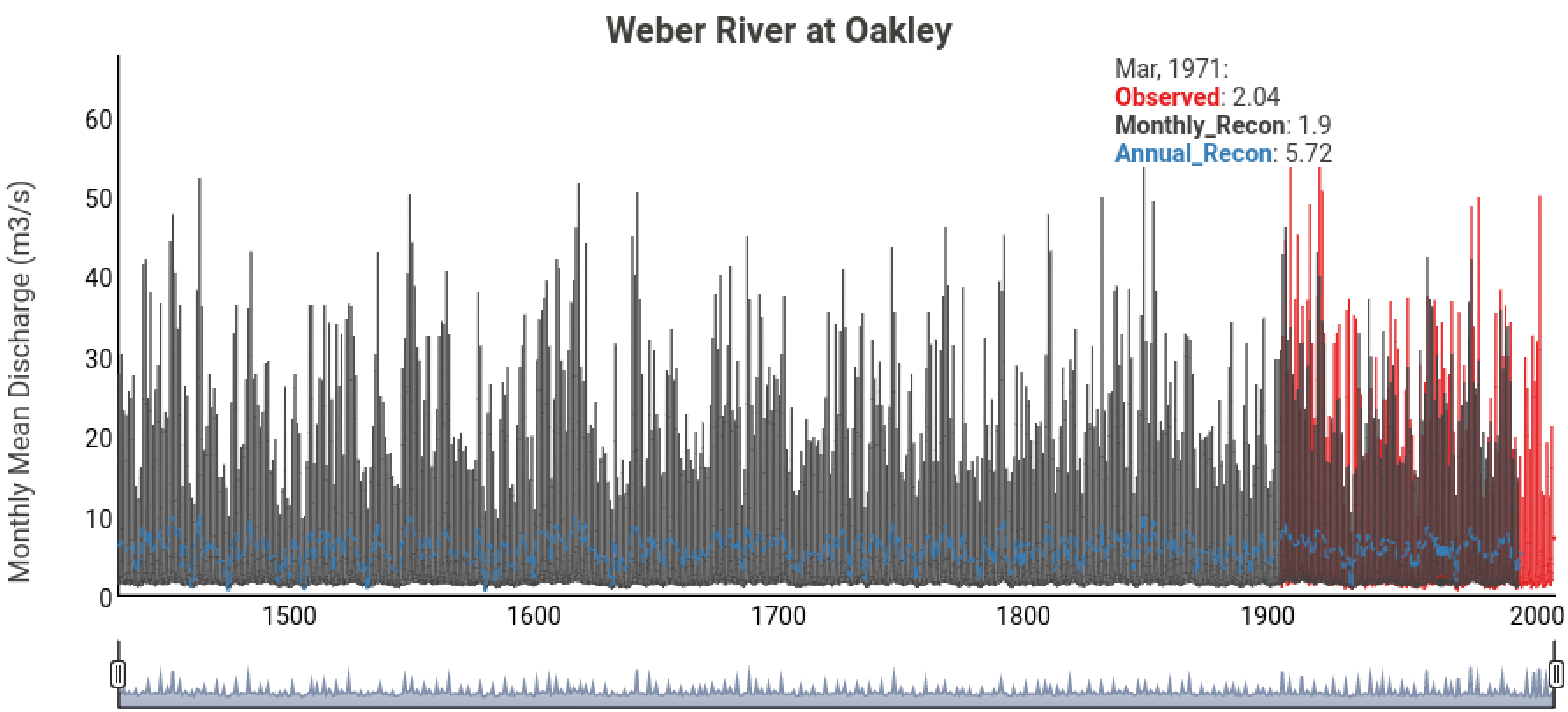


Scenario Planning



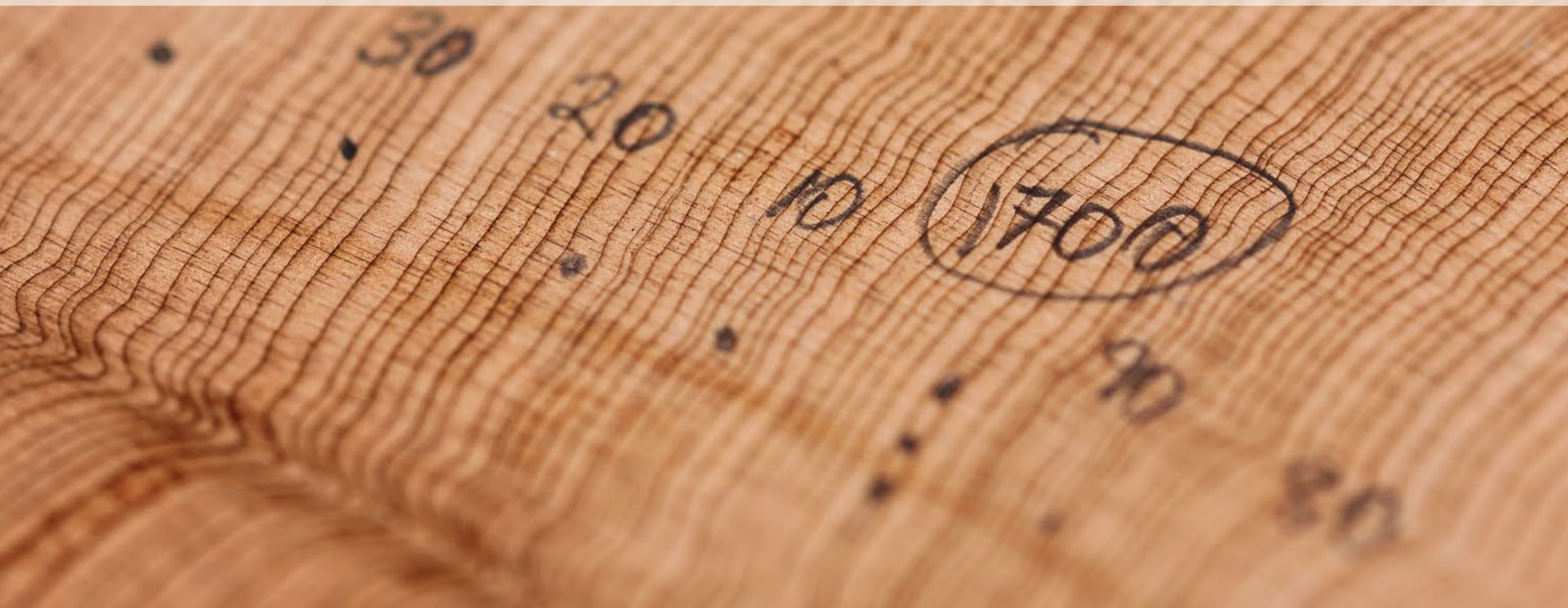
- Central tendency =
  - 2.3° F, +4% precip
- Warm/Wet =
  - 1.3° F, +13% precip
- Warm/Dry =
- 1.2° F, -6% precip
- Hot/Wet =
- 3.1° F, +10.2% precip
- Hot/Dry =
  - 2.3° F, -6% precip

New Challenge



Classification scheme for reconstructed streamflow droughts in northern Utah

Dr. James Stagge
Utah State University, Utah Water Research Laboratory
Dept. of Civil and Env. Engineering

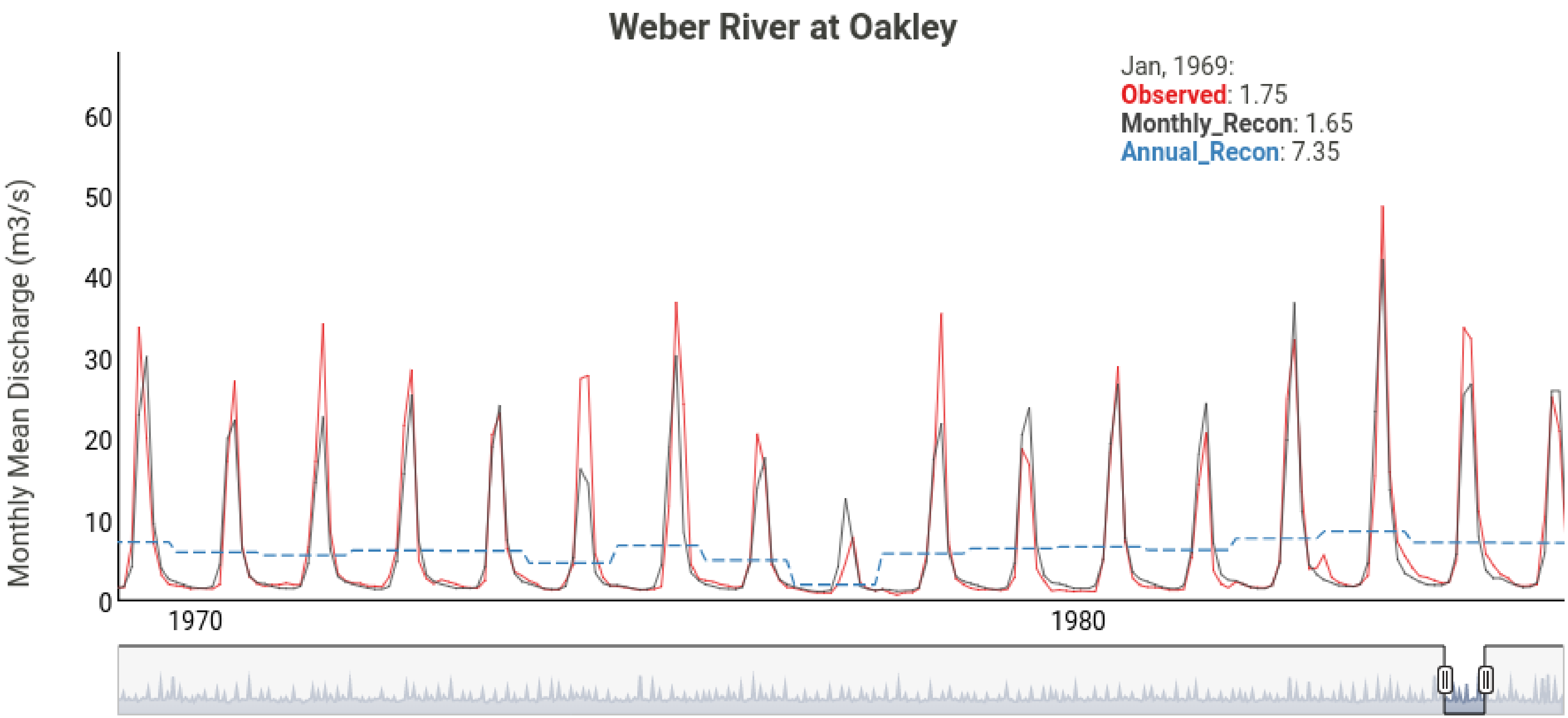


Objectives

1. Do reconstructed droughts in Utah group into distinct “types”?

2. Can we create a drought classification scheme?

Newly Developed Monthly Reconstructions



Drought Event Clustering

- **Hierarchical clustering**

  Agglomerative ("Bottom-up approach")

  Begin with 144 unique clusters, merge most similar

- **14 Drought Event Statistics using monthly scale**

  Duration

  Beginning/ending month

  Minimum flow

  Minimum percentile

  Prior year flow

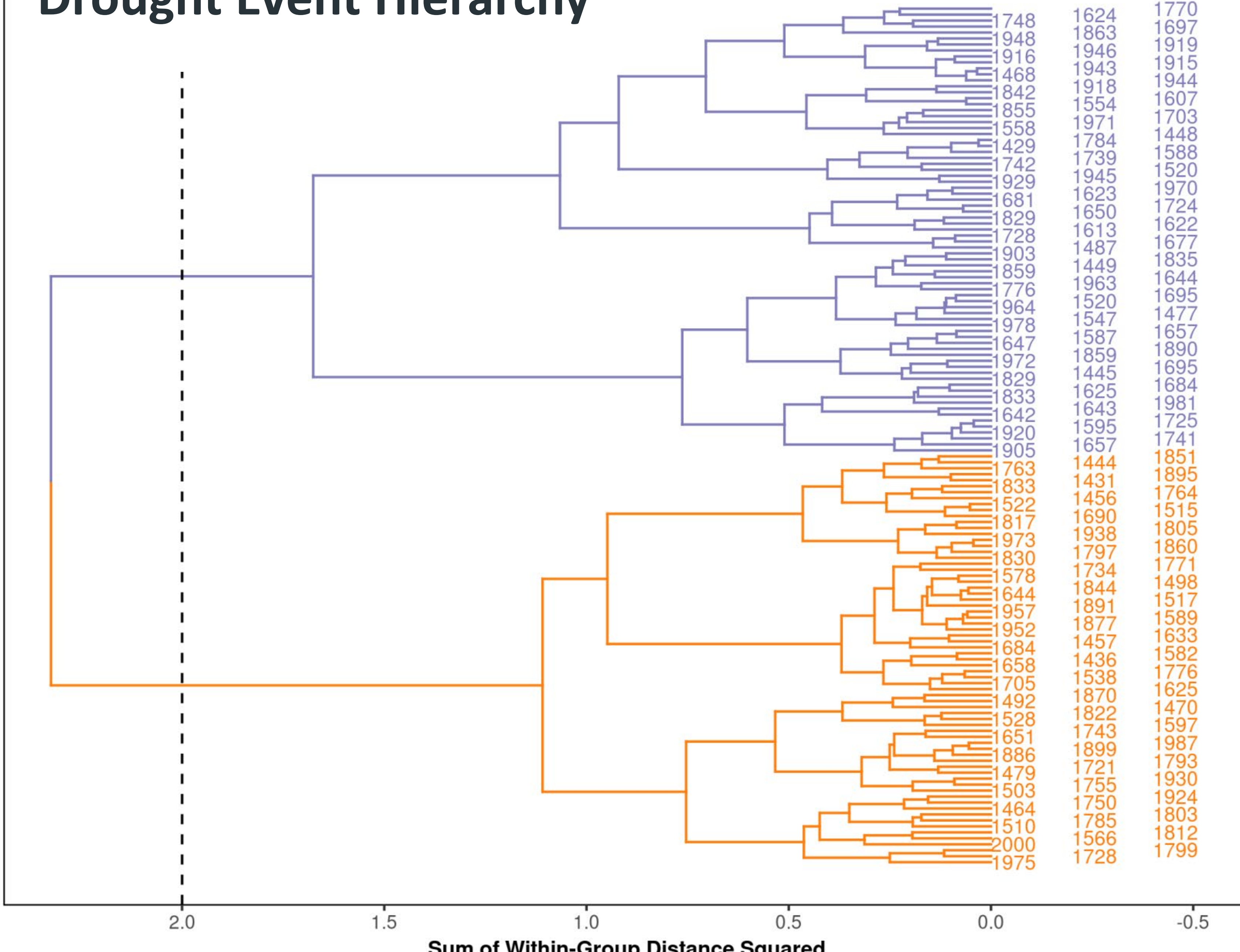
  Cumulative deficit

  Deficit center of Mass

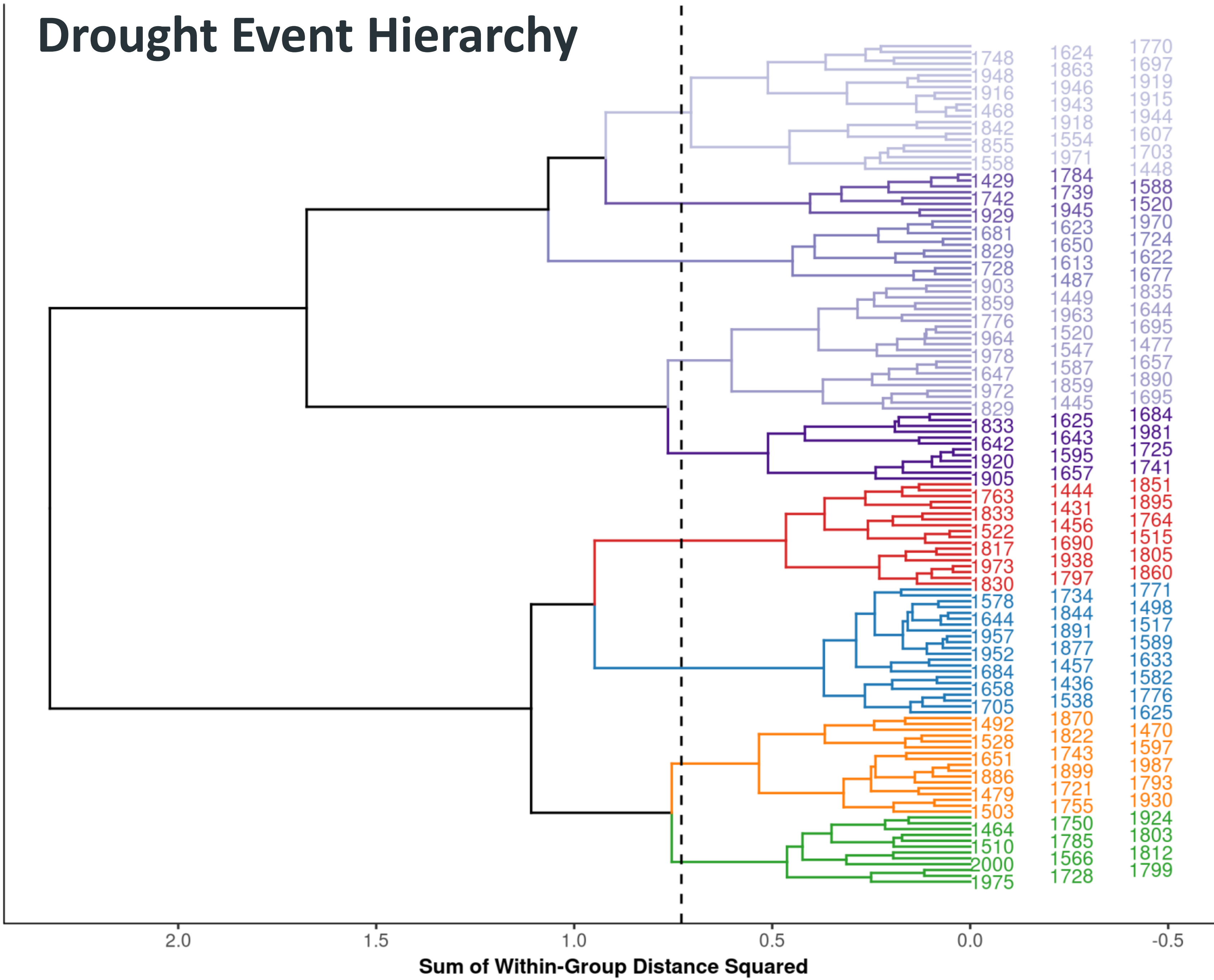
  Decrease rate

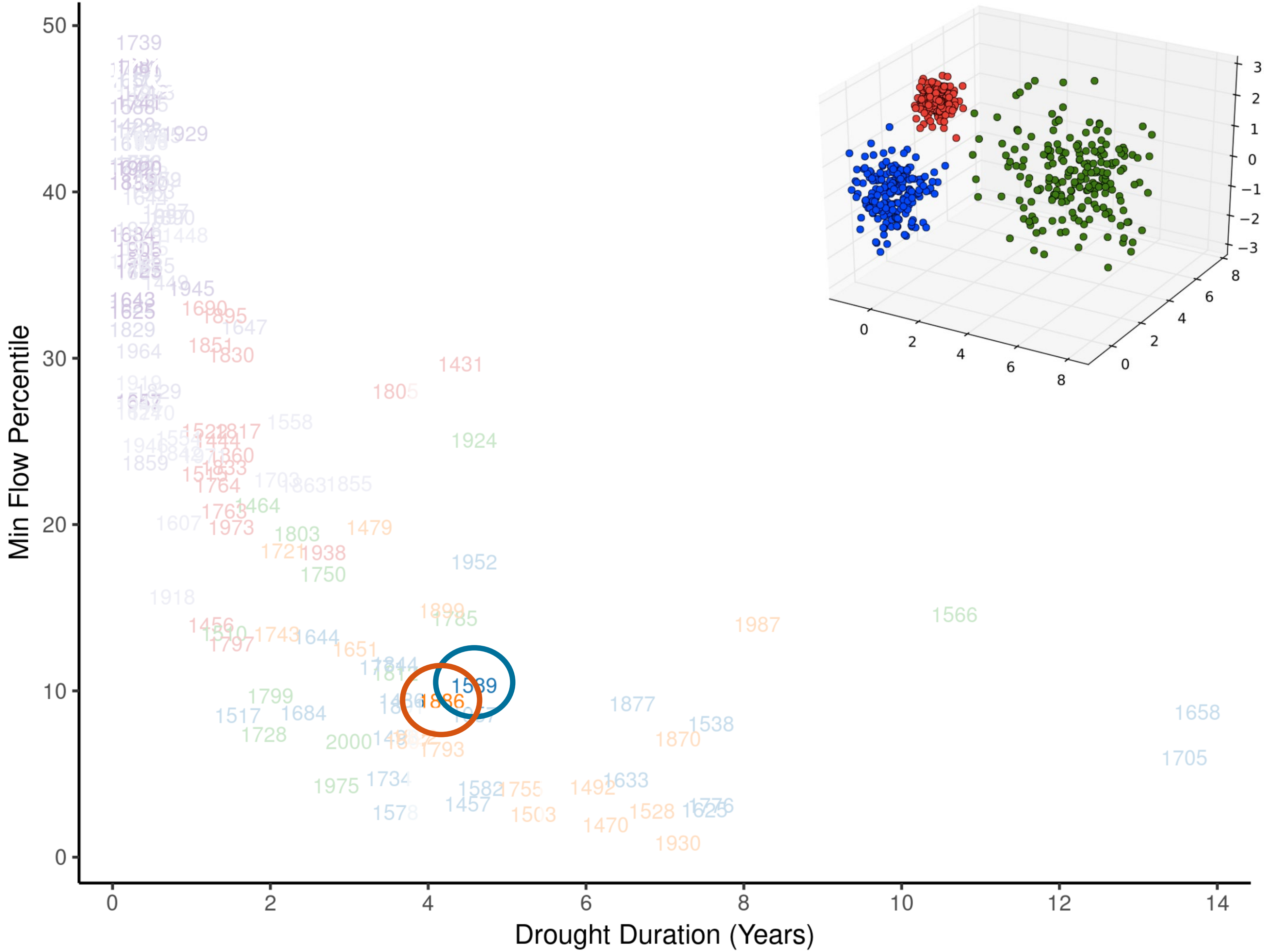
  Recovery rate

Drought Event Hierarchy



Drought Event Hierarchy





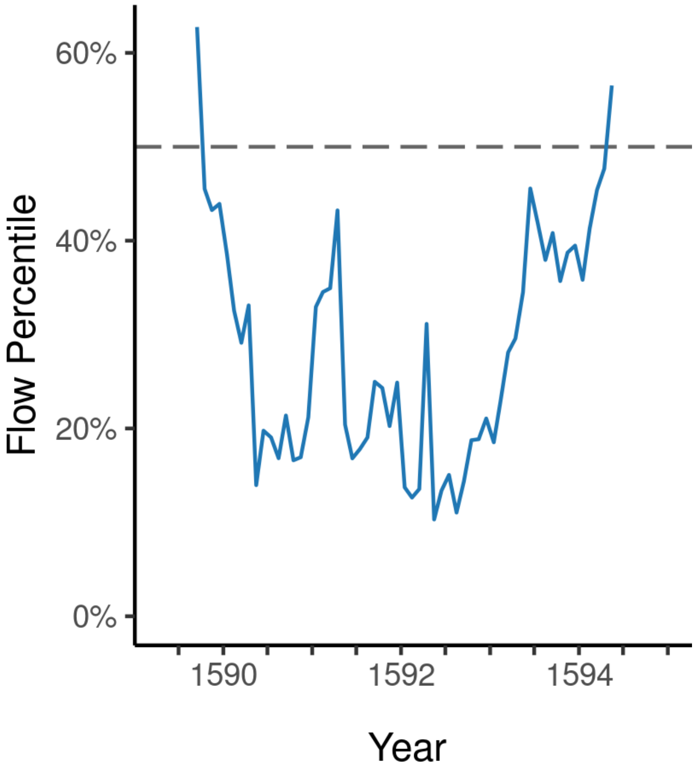
Min Flow Percentile
Drought Duration (Years)
0
10
20
30
40
50
0
2
4
6
8
10
12
14
1739
1945
1829
1964
1431
1805
1558
1924
1859
1764
1464
1607
1973
1803
1479
1938
1750
1952
1918
1899
1785
1987
1566
1456
1797
1644
1651
1539
1886
1877
1658
1517
1684
1799
1728
2000
1538
1870
1793
1705
1975
1633
1492
1755
1457
1503
1528
1470
1930

≈ 4 Year Duration Clusters

Cluster 1 (1589)

4.6 years

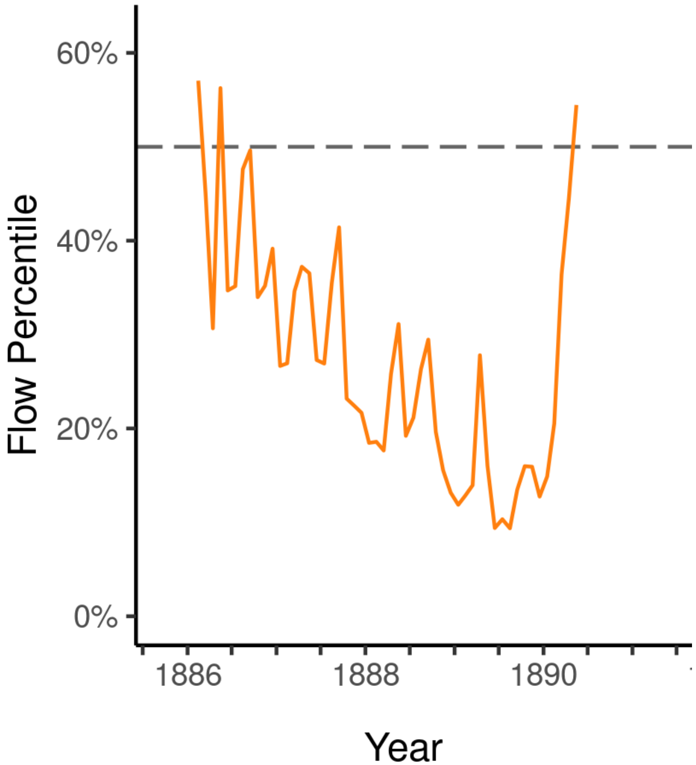
10.3% minimum



Cluster 4 (1886)

4.2 years

9.4% minimum



Conclusions and New Questions

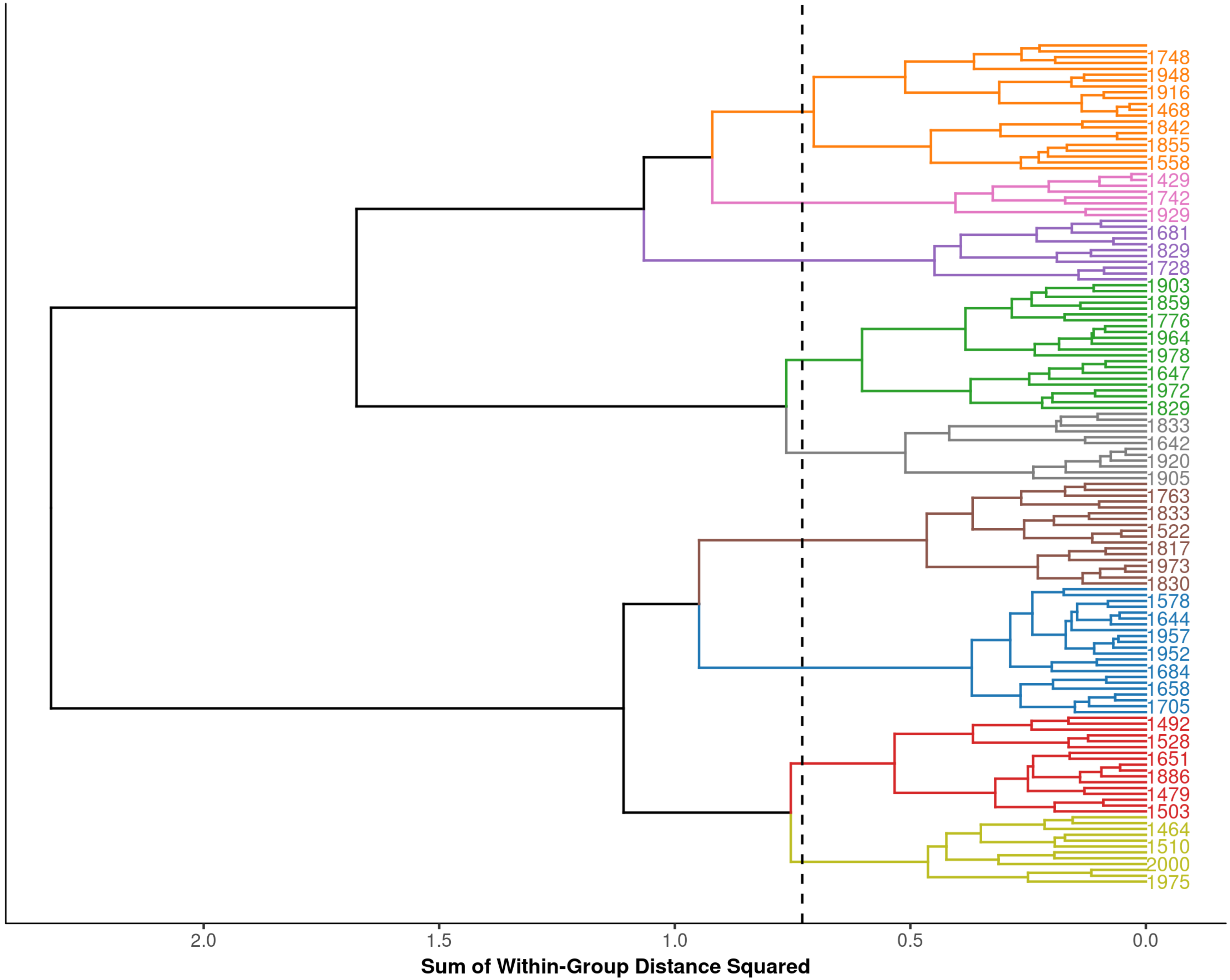
- **Monthly reconstructions allow drought classification**
- **4 major drought “types” for water managers**

Benefit to water managers

- Simulate water system performance/resilience
- Improve drought operations for each type

Future work

- Has the frequency of drought types changed?
- 100’s of existing annual reconstructions



1748
1948
1916
1468
1842
1855
1558
1429
1742
1929
1681
1829
1728
1903
1859
1776
1964
1978
1647
1972
1829
1833
1642
1920
1905
1763
1833
1522
1817
1973
1830
1578
1644
1957
1952
1684
1658
1705
1492
1528
1651
1886
1479
1503
1464
1510
2000
1975
2.0
1.5
1.0
0.5
0.0
Sum of Within-Group Distance Squared

Applications

- **2 parallel drought vulnerability studies**

  Extract events and run through systems model

  Hydroclimatology standpoint – answer questions like – have certain events gotten more frequent?

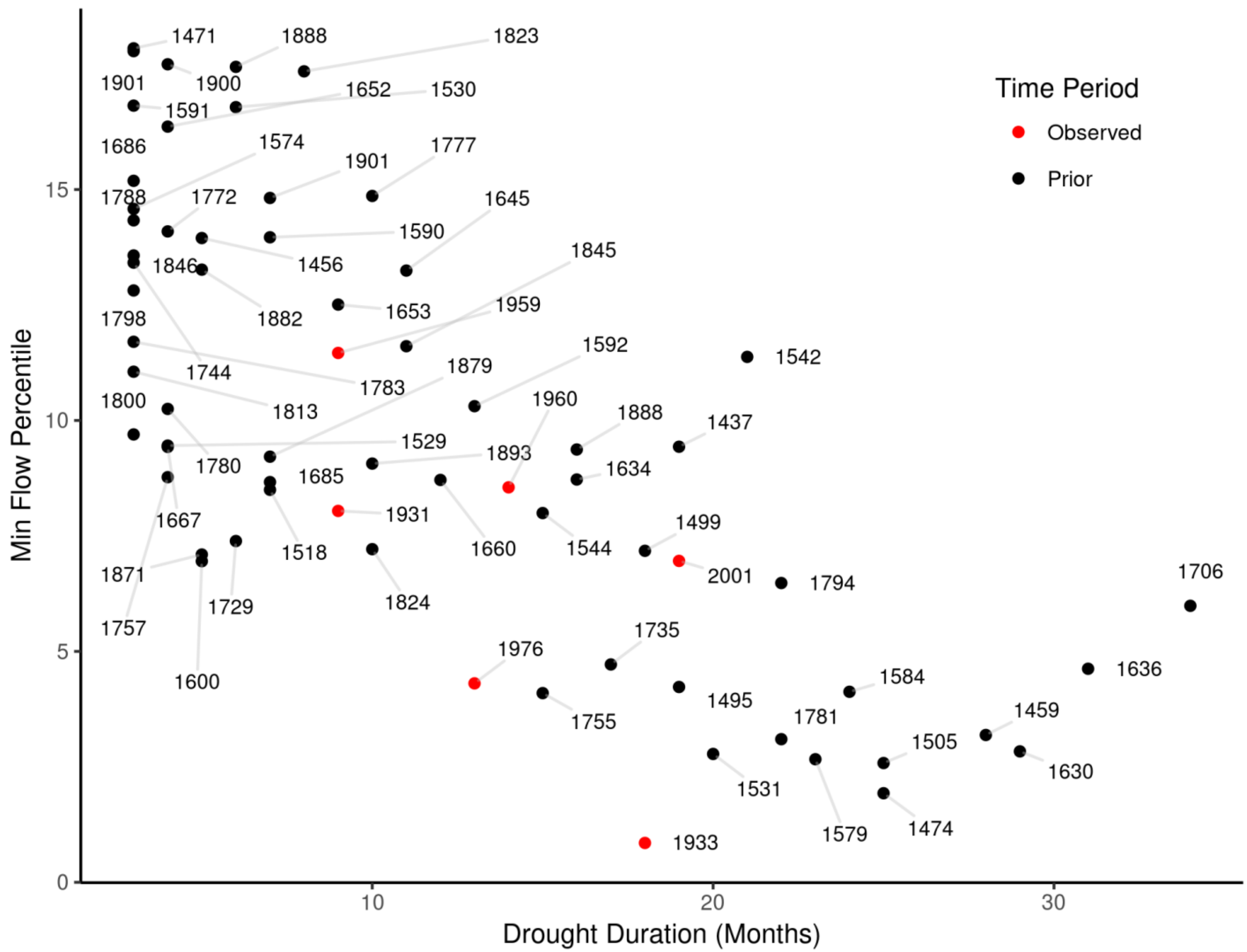
UtahStateUniversity

WAsatch Dendroclimatology Research (WADR) Group

Classification scheme for reconstructed streamflow droughts in northern Utah (1429-present)

Dr. James Stagge
Utah State University
Dept. of Civil and Env. Engineering

Applications



It’s the big one! … Or is it?

The San Diego Union-Tribune

State facing worst drought in history

Appendix 2-E

Task Force/Advisory Group Meeting Minutes
January 31, 2018

Weber Basin Water Conservancy District Drought Contingency Plan
Advisory Group/Task Force Meeting
1/31/18

Attendees:

Kenton Moffett *(Ogden City)*
Rick Smith *(D&W; Weber River Water Users)*
Blake Carlin *(Bona Vista Water District)*
Grant Cooper (*D+W CCC / LDS Church*)
Wesley White (*Bountiful Irrigation*)
Paul Thompson (Division of Wildlife Resources)
Cole Panter (*DWRI*)
Kamilla Schultz (*Clearfield City*)
Mark Hodson (*Pineview*)
Gary Henrie (*USBR*)
Kent Kofford (*USBR*)
Justin Record (*USBR*)
Paul Thompson *(Division of Wildlife Resources)*
Jamie Barnes (*Forestry, Fire & State Land/DNR)*
Jerry Allen *(Bona Vista Water District)*
Holly Lopez (*Park City Public Utilities*)
Tony Melcher (*Division of Water Resources*)
Clint Brunson (*Division of Wildlife Resources*)
Connely Baldwin (*Pacificorp*)
Scott Hodge (*Clearfield City*)
Stacy Majewski (*Layton City*)
Wes Adams (*Layton City*)
Steve Jackson (*Layton City*)
Rodney Banks (*Roy Water*)

Project Team Attendees:

Darren Hess *(Weber Basin)*
Derek Johnson *(Weber Basin)*
Chris Hogge *(Weber Basin)*
Scott Paxman *(Weber Basin)*
Brad Nelson *(Weber Basin)*
Jim Stagge *(Utah State University)*
Seth Arens (*Western Water Assessment)*
Mark Anderson (*Weber Basin Water Conservancy District*)
David Rosenberg *(Utah State University)*
Scott McGettigan *(Division of Water Resources*
Chris Slater (J-U-B Engineers)
Cindy Gooch (J-U-B Engineers)
Eric Stevens (J-U-B Engineers)
Josh King (The Langdon Group)
Zoe Rogich (The Langdon Group)

Meeting Minutes

Weber Basin Report and Discussion: Chris Hogge reported on Weber Basin's 2018 Water and Storage Report

- Weber Basin's overall storage is at 74% capacity due to a great water year in 2017
- Gave an overview of snowpack and run off for the coming year
- Snowpack on Jan 31, 2018 was at 58% (This time in 2017 snowpack was at 177%)
    - Every day without a storm the snowpack goes down by 1%
    - Runoff is expected to be less than 50 %this year
- Discussed Weber River Storage, Ogden River Storage and District Storage
    - Currently in a good position
    - Chris showed river storage from 2012 and compared results to 2018
- Ben Lomond Trail, Hardscrabble and Monte Cristo precipitation/snowpack overview
- Drought Monitor
    - Chris discussed the past three year drought results for the U.S.
        - Temperature wise: Utah is looking to be warmer than normal which is not good for snowpack or longevity
- Gave an overview of the 2018 U.S. seasonal drought outlook
- Gave an overview of soil moisture
- What's in front of us doesn't look the best. We need to conserve what we have and make the best use of it

Drought Monitoring: Derek Johnson reported on Weber Basins Storage

- Weber Basin's total storage is over 400,000 acre feet
    - Overview of Weber Basin's average storage from 2005-2017 and identified levels from past experience
        - Having the averages is a good benchmark for Weber Basin to show how things are going as far as water supply
        - It's expected to be around average when we get into the summer
        - One bad snow year brings us right back to average
        - As we use water in the summer and if a poor snow fall happens in the winter then the following year Weber Basin's storage would be below average
- Derek discussed the poor runoff that happened in 2013 and actions that Weber Basin took
    - Weber Basin did a 20% demand reduction in 2013 (contracts) and shortened irrigation season by two weeks
    - In 2015 Weber Basin had to cut contracts
        - These past experiences help identify triggers and response actions

The Langdon Group Reported the Demand Reduction Goals & Summary of Stakeholder Meetings

- Gave an overview of each of the three sub-workgroup's suggested demand reduction goals, demand reduction averages and the alignment seen between the three groups
    - Average reduction between the three groups (environmental, irrigation and agriculture) are given in the following table.

				Demand Reduction (Averages)			
Response Level	Advisory Code	Water Shortage Description	Triggering Criteria (percent of average storage recorded since 2005 for a given month of the year)	Secondary Water	Agricultural Irrigation	M&I Culinary Outdoor Water	M&I Culinary Indoor Water
1	Green	Normal	Normal variability: storage >= 70%	0	0	0	0
2	Yellow	Moderate	Moderately dry conditions: < 70% storage	20%	20%	20%	0%
3	Orange	Severe	Severely dry conditions: < 50% storage	60%	40%	60%	13%
4	Red	Extreme	Extremely dry conditions: storage < 25%	95%	70%	93%	33%

- Questions Discussedquestions:
    - are the demand reduction goals so severe that fruit trees and other valuable landscape items will be lost?
    - How many acre feet of water will be saved by reaching the reduction goals?
    - What actions will need to be made to meet the reduction goals? How can we reach the goals?

Derek Presented the Weber River Modeling Results

- Overview of the Paleo-flows from 1430-2002
    - Lowest storage years took place in 1499-1502, 1633-1639 and 1929-1937

- Discussed Weber Basin Project – Reservoir Operation Study (1959) Operation Study

J-U-B Engineers Presented Mitigation Actions

- Mitigation definition: Measures that we can take prior to a drought to help lessen the impacts of potential drought within Weber Basin
- Mitigation Actions Discussed:
    - Create fallowing agreements
    - Create inter-agency water sharing agreement
    - Create re-claimed water re-use agreement
    - Ground water recharge (ASR)
    - Increase storage
        - Want to find multiple actions that can be used together and work synergistically
            - How many of these do we need to apply to see benefits?
            - What triggers will be need to look for to start apply these?

Discussion about Possible Mitigation Plans/Actions

- Looking at water pricing
- Drought response pricing
    - Losing revenue during drought
- Political nature – cities will take a deep swallow when they see 95% cut. How will they implement a big cut?
    - Change ordinances? Change landscaping?
- Outside water sources (disaster level problem)
    - Bring water in from outside of the area
        - When we don't have water someone else may have too much water
- Secondary Metering
    - This will allow Weber Basin to know how much water people are using and then transition to a billing schedule
- Create incentives to conserve

Reviewed Project Schedule

Takeaways:

- Plan to educate the cities about the drought and mitigation actions
    - Present ideas to decision makers at the city
- Weber Basin to look into ways to preserve water supplies and what to keep in mind before reductions
    - What will happen to permanent plantings like orchards or trees?
    - How is Weber Basin planning on preserving water supplies?
        - Through behavioral shifts and actions
        - Education and outreach
        - Discussion of programs to buy more effective products for their homes and rebate programs
        - Short term reductions
        - Rebate commercial controllers for institutional property's (churches, schools)
        - People have a shared interest in conserving water moving forward. In a joint effort we can take short term strategies and goals and move together on them

- Consider picking a date such as June 1 as the trigger date and making decisions based on the anticipated storage at that date
- Implementing drought rate structures could be a good idea because it keeps the revenues up and encourages people to use less water
    - This could be really helpful in changing behavior and reducing indoor water use - the percentages assumed for indoor use were very attainable
    - Consider looking at actual indoor use reductions based on data so that we can back up the numbers that we come up with
- Look at East Bay MUD and Contra Costa Water District as they have had drought fallowing programs in place for quite a while. These agreements are setup such that farmers are paid a little bit every year just for having the contract in place, and during a drought year the contract option is exercised and the Districts can utilize the water.
- Will extreme secondary cuts make it so people lose fruit trees and other valuable landscapes? (How can we address this?)
- What is the actual AF that we think we will get from the response actions?
- Maybe consider coming up with specific demand reduction targets within the drought levels in order to target the storage that we want at the end of the season
- Will Weber Basin be willing to go on the road to sell the drought reductions to City Councils and decision makers?

DROUGHT CONTINGENCY PLANNING

Advisory Group Meeting

31 Jan 2018

Weber Basin Water Conservancy District

J·U·B

J·U·B ENGINEERS, INC.

THE LANGDON GROUP

GATEWAY MAPPING INC.

OTHER J-U-B COMPANIES

Chris Hogge, WBWCD

- Agenda Item 2:

  2018 WBWCD Water Supply Outlook

WEBER BASIN WATER CONSERVANCY DISTRICT
JANUARY, 2018 - WATER REPORT

					Current Reservoir Content				Historical Reservoir Content		
Reservoir	Total Capacity (AF)	Conservation or Dead Storage (AF)	Active Capacity (AF)	District Capacity (AF)	Accrued To District to Date (AF)	% of District Capacity	1/22/2018	% of Active Capacity	1/23/2017	1/26/2015	1/29/2014
Causey	7,870	1,000	6,870	6,870	5,120	75%	5120	75%	4610	5190	3950
E. Canyon	51,200	3,090	48,110	20,110	15,100	75%	37820	79%	23460	24500	20630
Echo	73,940	0	73,940	6,340	0	0%	49620	67%	29590	27500	21470
Echo holdover purchase remaining in Echo (estimate)											
Lost Creek	22,510	2,500	20,010	20,010	15,560	78%	15760	79%	12500	11010	8250
Pineview	110,150	0	110,150	66,228	48,080	73%	70690	64%	71390	58640	33540
Smith-More	8,351	751	7,600	6,560	3,987	61%	4120	54%	5000	6840	4000
Wanship	62,120	1,260	60,000	60,000	52,190	87%	54000	90%	31050	44290	31460
Willard	247,302	25,029	222,273	222,273	167,950	76%	167950	76%	153210	84400	75000
Total	**583,443**	**33,630**	**548,953**	**408,391**	**307,987**	**75%**	**405,080**	**74%**	**330,810**	**262,370**	**198300**
					Last Month	**76%**					

% Dist. Upstream Stor. **75%** **Last Month** **77%**

*** Note: 100% Is Equivalent To A Two Year Water Supply**

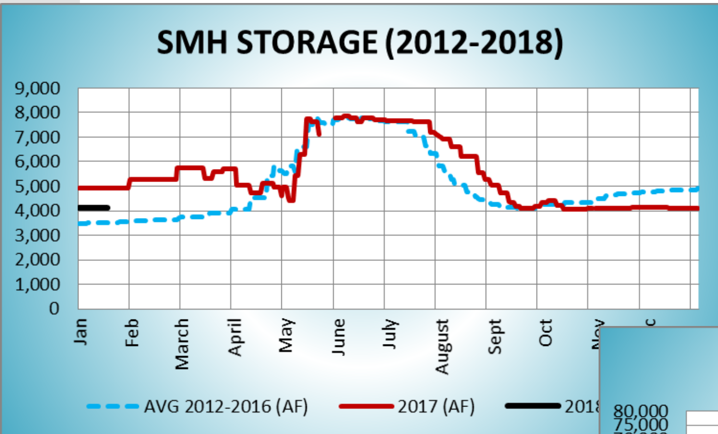
Drainage	District Capacity	Accrued To District To Date	% of District Capacity	Last Month
Weber	113,020	86,837	**77%**	**79%**
Ogden	73,098	53,200	**73%**	**74%**
Willard	222,273	167,950	**76%**	**75%**

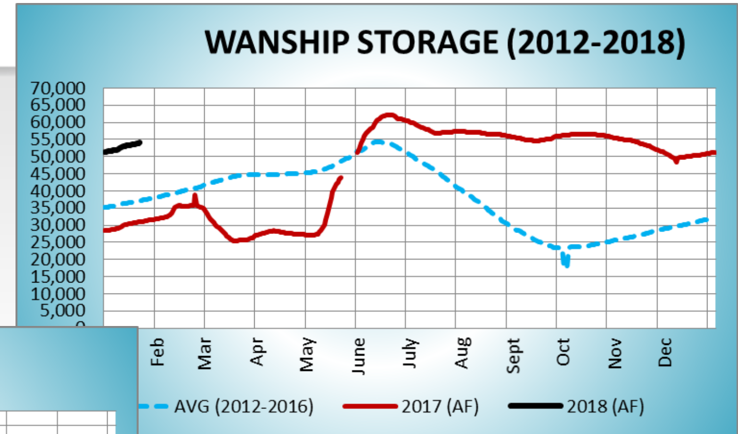
Notes: **177% SWE 1-24-17, 96% Apr 1, 30 yr Median**

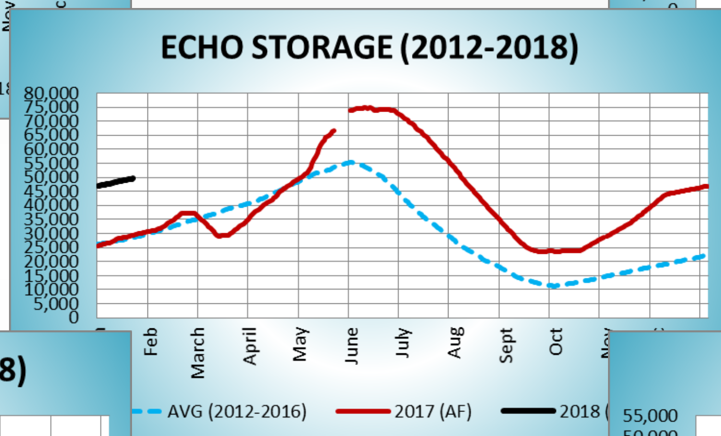
SNOTEL: 1/22/2018

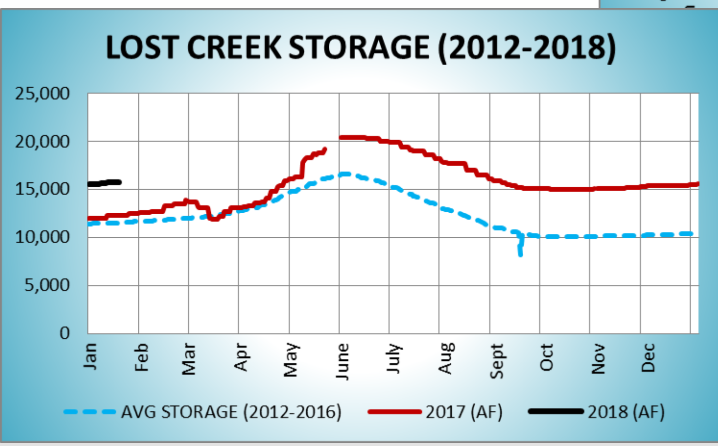
Site	Site Elevation	Snow Water Equiv (SWE-in.)	% Median (for this date)	SWE Median Peak (30 Yr. Period)	Apr 1 % Median Peak
Trial Lake	9,992	10.1	90	23	43.9
Thaynes Canyon	9,230	1.9	68	24	7.9
Chalk Creek #1	8,993	8.4	69	24.9	33.7
Monte Cristo	8,960	11.6	82	27.9	41.6
Dry Bread	8,350	7.1	66	18.3	38.8
Horse Ridge	8,160	8.1	68	21.9	37.0
Chalk Creek #2	8,158	4.9	59	16.5	29.7
Ben Lomond Peak	8,000	10.9	54	36.9	29.5
Farmington	8,000	10.1	59	35.4	28.5
Smith Morehouse	7,600	3.1	42	13.7	22.6
Parleys Summit	7,500	6.5	72	15	43.3
Hardscrabble	7,250	5.0	48	18.2	27.5
Ben Lomond Trail	5,829	4.0	37	19	21.1
OVERALL BASIN AVERAGE:			**63%**		**31%**

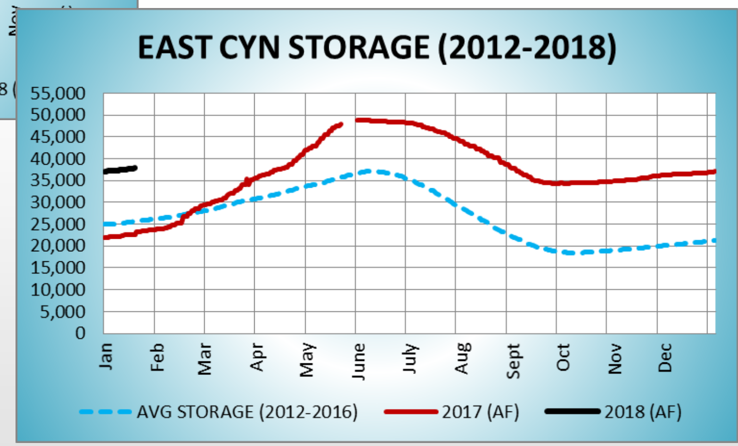
WEBER RIVER STORAGE

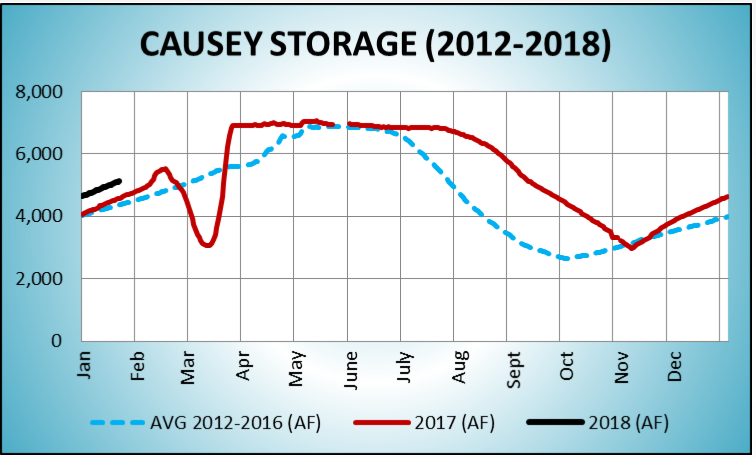




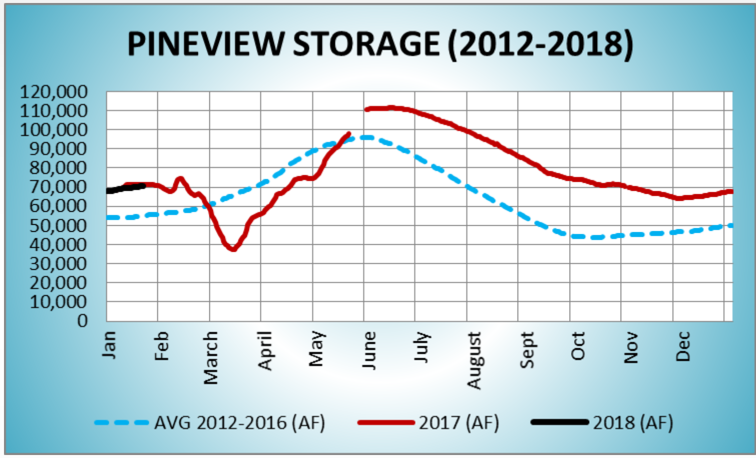


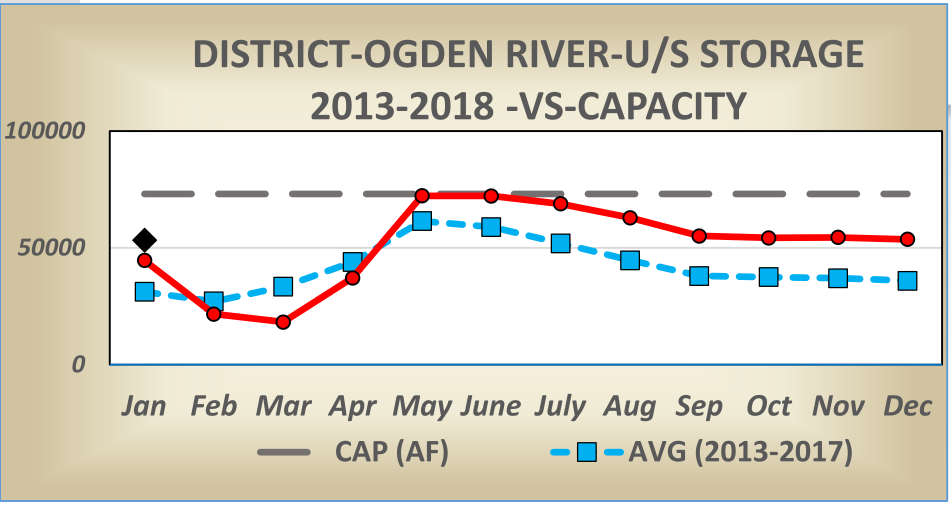


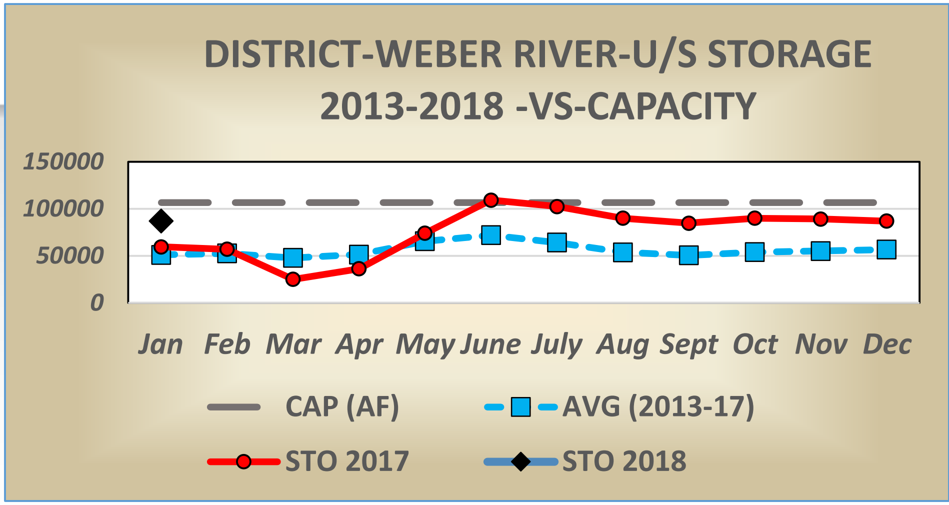




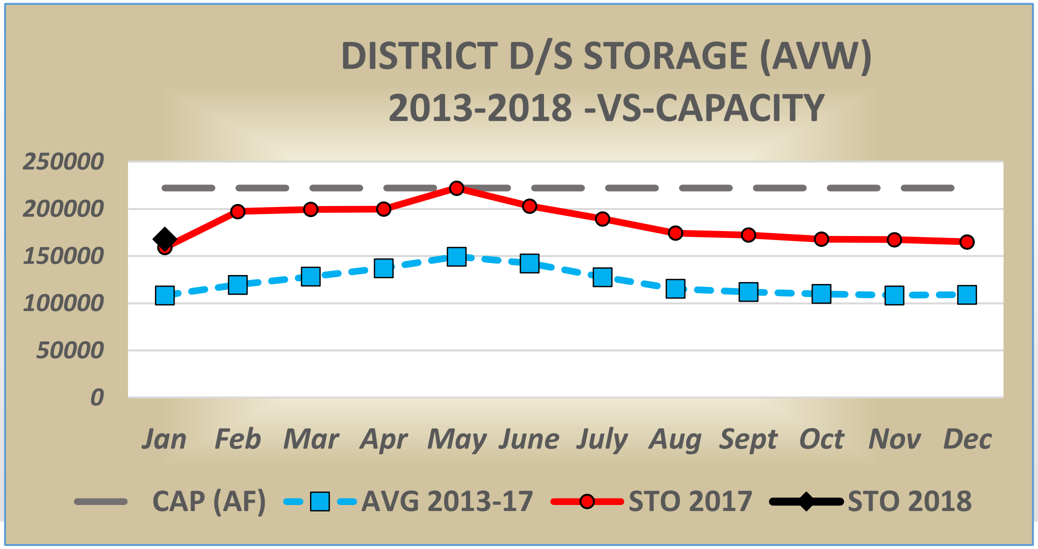
OGDEN RIVER STORAGE

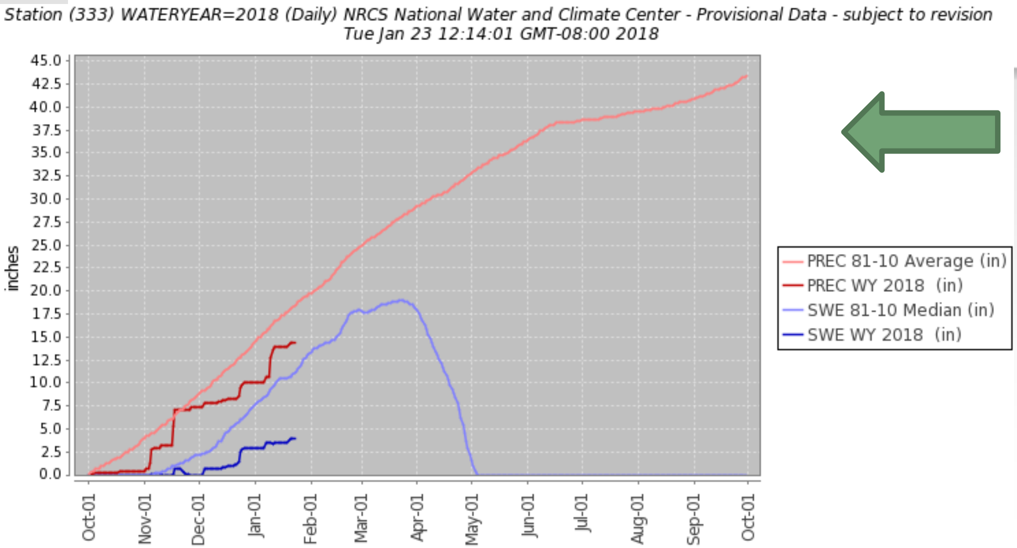






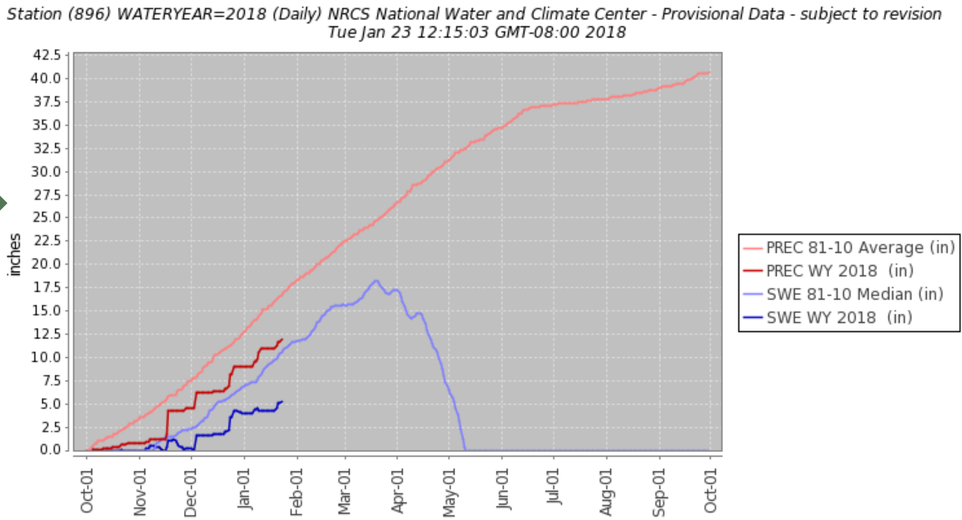
DISTRICT STORAGE

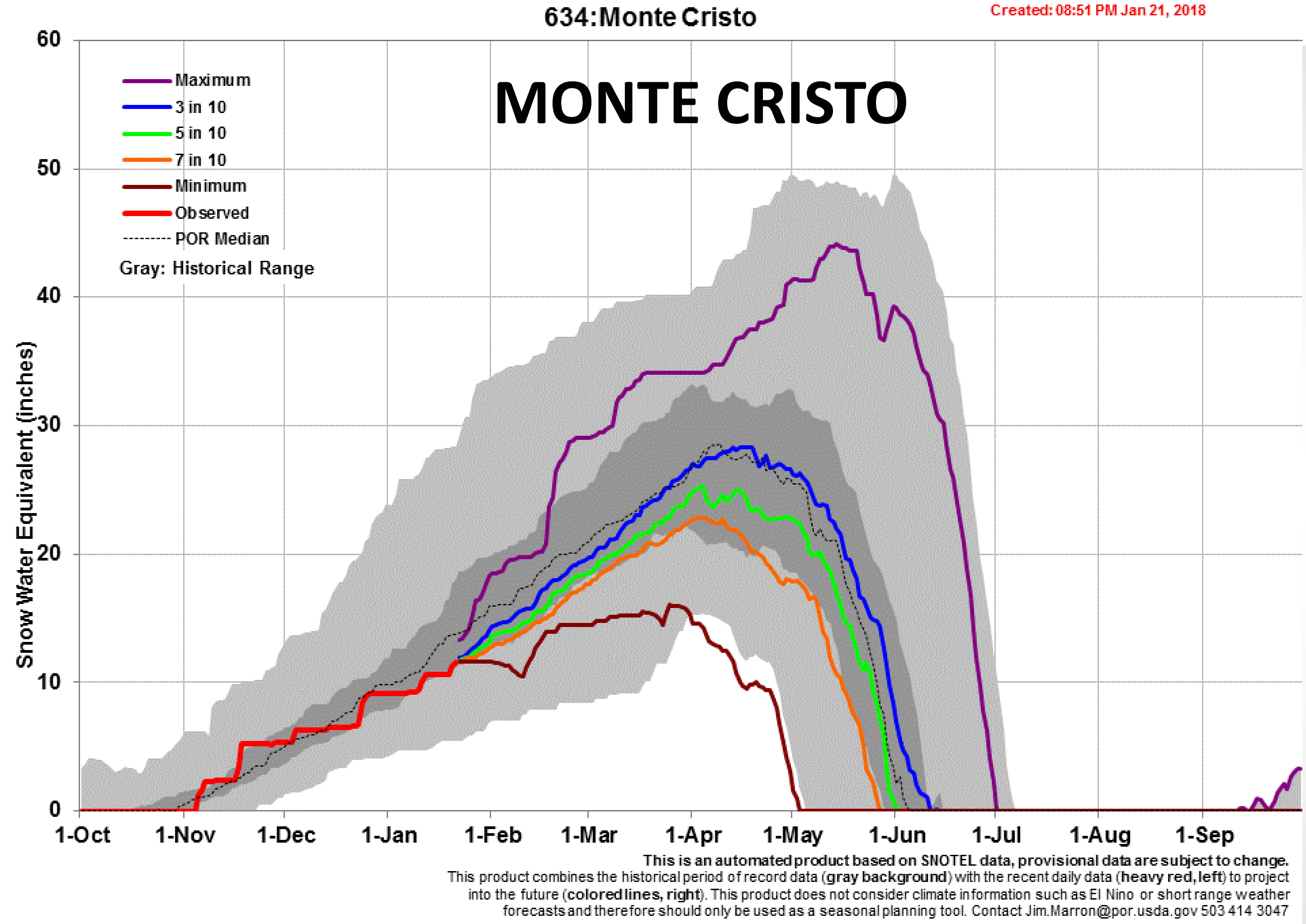


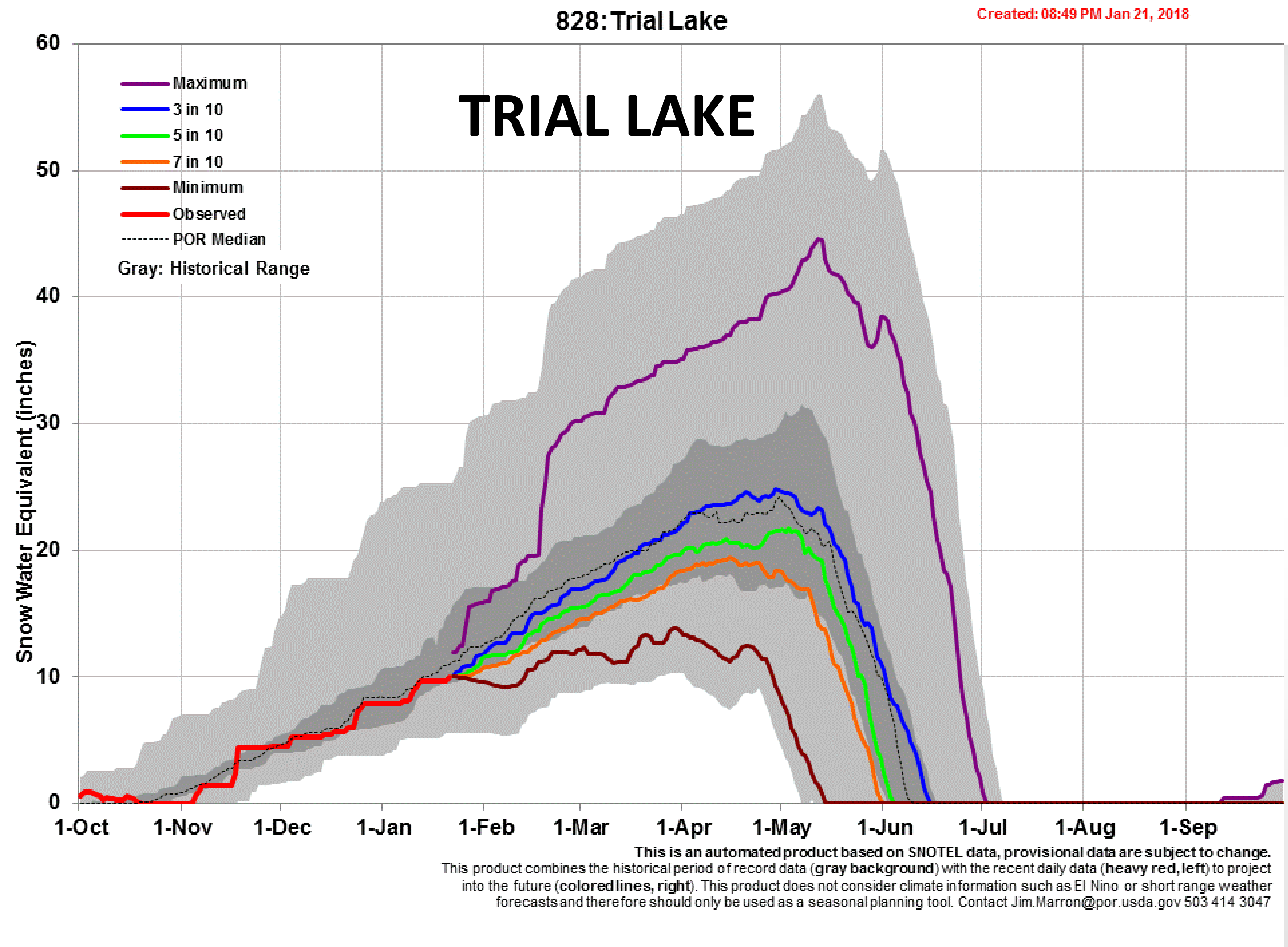


BEN LOMOND TRAIL

HARDSCRABBLE




634:Monte Cristo
Created: 08:51 PM Jan 21, 2018
MONTE CRISTO
Maximum
3 in 10
5 in 10
7 in 10
Minimum
Observed
POR Median
Gray: Historical Range
Snow Water Equivalent (inches)
0
10
20
30
40
50
60
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
This is an automated product based on SNOTEL data, provisional data are subject to change.
This product combines the historical period of record data (gray background) with the recent daily data (heavy red, left) to project into the future (colored lines, right). This product does not consider climate information such as El Nino or short range weather forecasts and therefore should only be used as a seasonal planning tool. Contact Jim.Marron@por.usda.gov 503 414 3047



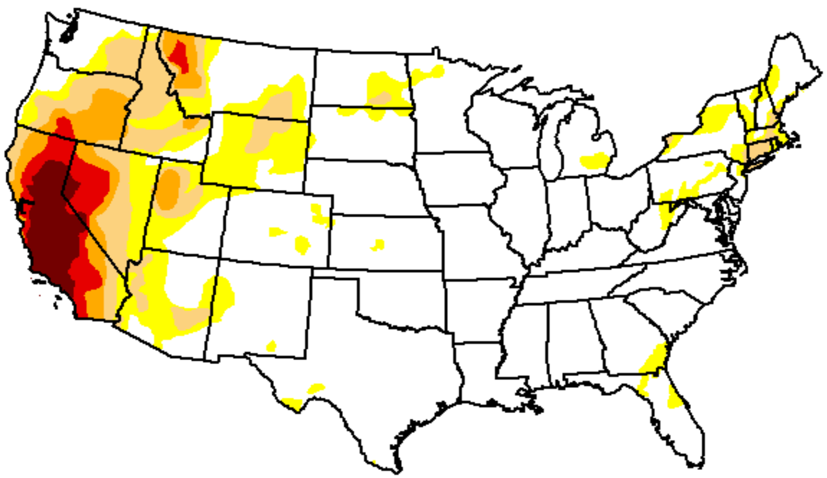
TRIAL LAKE
828: Trial Lake
Created: 08:49 PM Jan 21, 2018
Maximum
3 in 10
5 in 10
7 in 10
Minimum
Observed
POR Median
Gray: Historical Range
Snow Water Equivalent (inches)
0
10
20
30
40
50
60
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
This is an automated product based on SNOTEL data, provisional data are subject to change.
This product combines the historical period of record data (gray background) with the recent daily data (heavy red, left) to project into the future (colored lines, right). This product does not consider climate information such as El Nino or short range weather forecasts and therefore should only be used as a seasonal planning tool. Contact Jim.Marron@por.usda.gov 503 414 3047

U.S. Drought Monitor
CONUS

January 19, 2016
(Released Thursday, Jan. 21, 2016)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	71.24	28.76	16.37	8.51	4.84	2.42
Last Week *1/12/2016*	70.46	29.54	17.28	9.98	5.16	2.59
3 Months Ago *10/20/2015*	41.04	58.96	34.78	23.23	14.42	3.76
Start of Calendar Year *12/29/2015*	66.99	33.01	18.74	11.56	6.28	2.70
Start of Water Year *9/29/2015*	44.91	55.09	31.36	20.09	11.45	3.00
One Year Ago *1/20/2015*	53.60	46.40	28.18	16.97	8.88	2.91



Intensity:
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

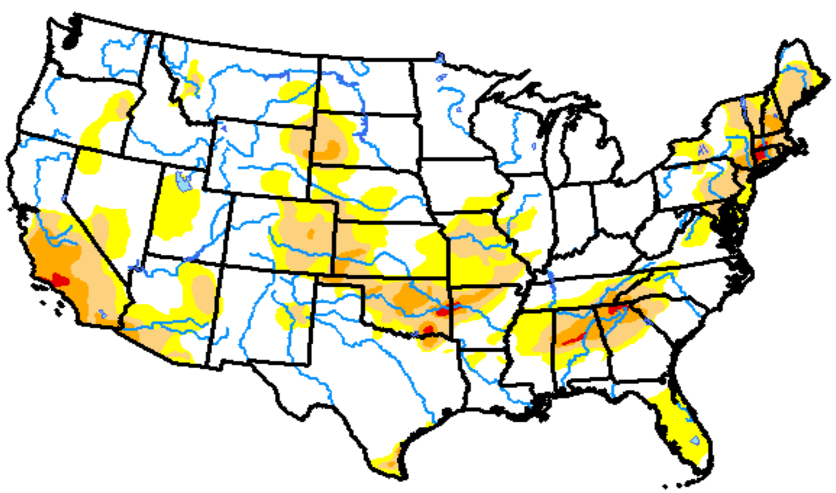
Author(s):
Mark Svoboda
National Drought Mitigation Center

http://droughtmonitor.unl.edu/

JANUARY19, 2016

U.S. Drought Monitor
CONUS

January 24, 2017
(Released Thursday, Jan. 26, 2017)
Valid 7 a.m. EST



Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	67.19	32.81	16.12	4.45	0.44	0.00
Last Week *01-17-2017*	60.50	39.50	19.26	6.77	2.39	0.11
3 Months Ago *10-25-2016*	55.68	44.32	23.92	10.25	4.08	1.54
Start of Calendar Year *01-03-2017*	53.89	46.11	22.53	8.63	3.15	0.96
Start of Water Year *09-27-2016*	53.60	46.40	18.96	8.10	3.20	1.16
One Year Ago *01-26-2016*	71.99	28.01	15.48	8.51	4.61	2.29

Intensity:
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

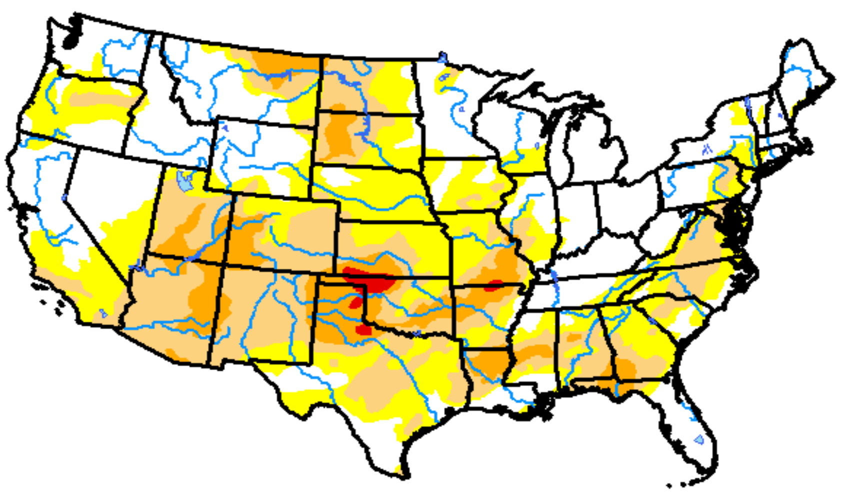
Author:
Richard Tinker
CPC/NOAA/NWS/NCEP

http://droughtmonitor.unl.edu/

JANUARY 24, 2017

U.S. Drought Monitor

Continental U.S. (CONUS)



January 16, 2018

(Released Thursday, Jan. 18, 2018)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	39.07	60.93	33.04	10.03	0.64	0.00
Last Week *01-09-2018*	42.20	57.80	32.07	8.70	0.46	0.00
3 Months Ago *10-17-2017*	62.25	37.75	12.48	2.98	0.82	0.00
Start of Calendar Year *01-02-2018*	44.46	55.54	27.70	7.46	0.83	0.00
Start of Water Year *09-26-2017*	63.07	36.93	13.81	4.99	2.36	0.87
One Year Ago *01-17-2017*	60.50	39.50	19.26	6.77	2.39	0.11

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

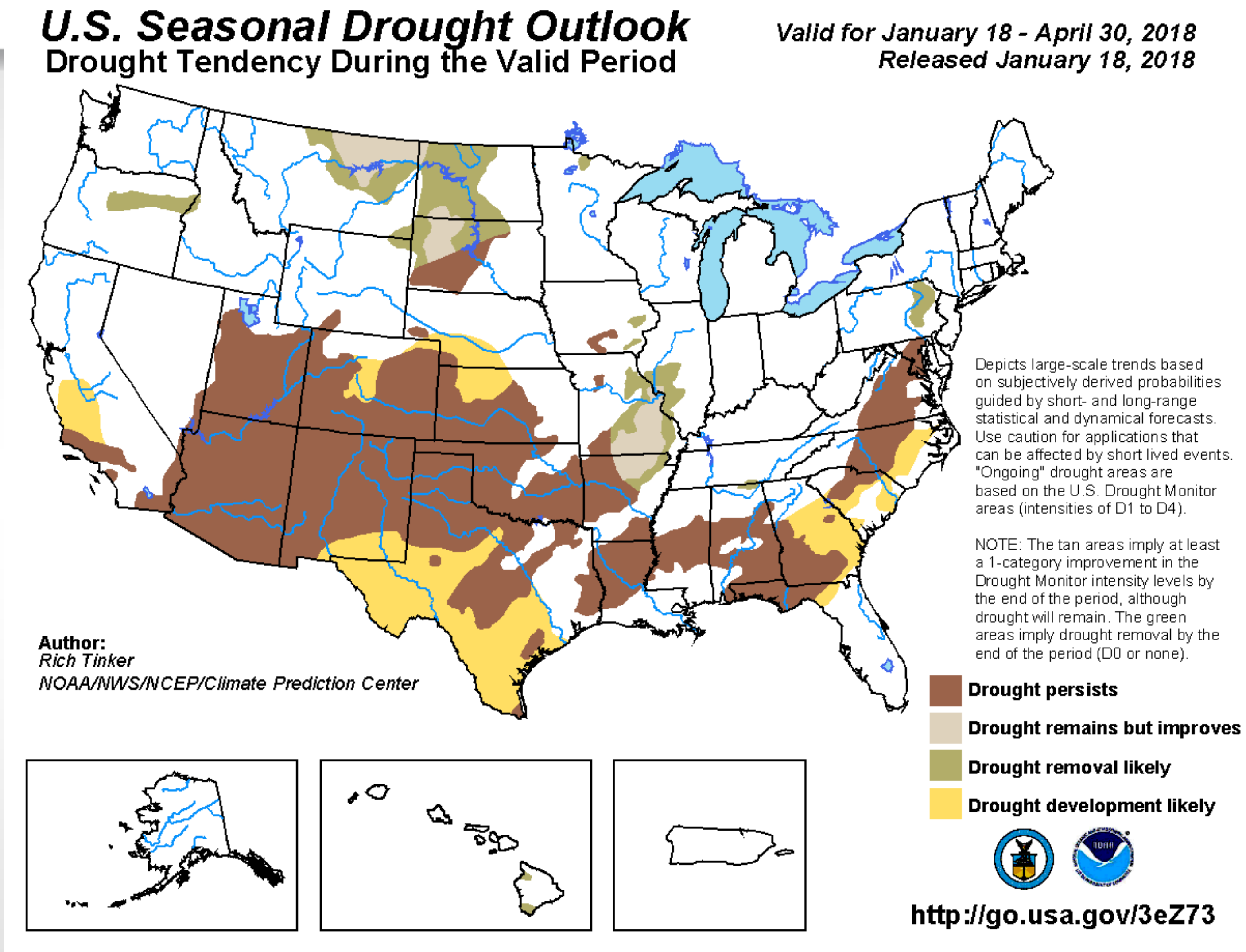
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

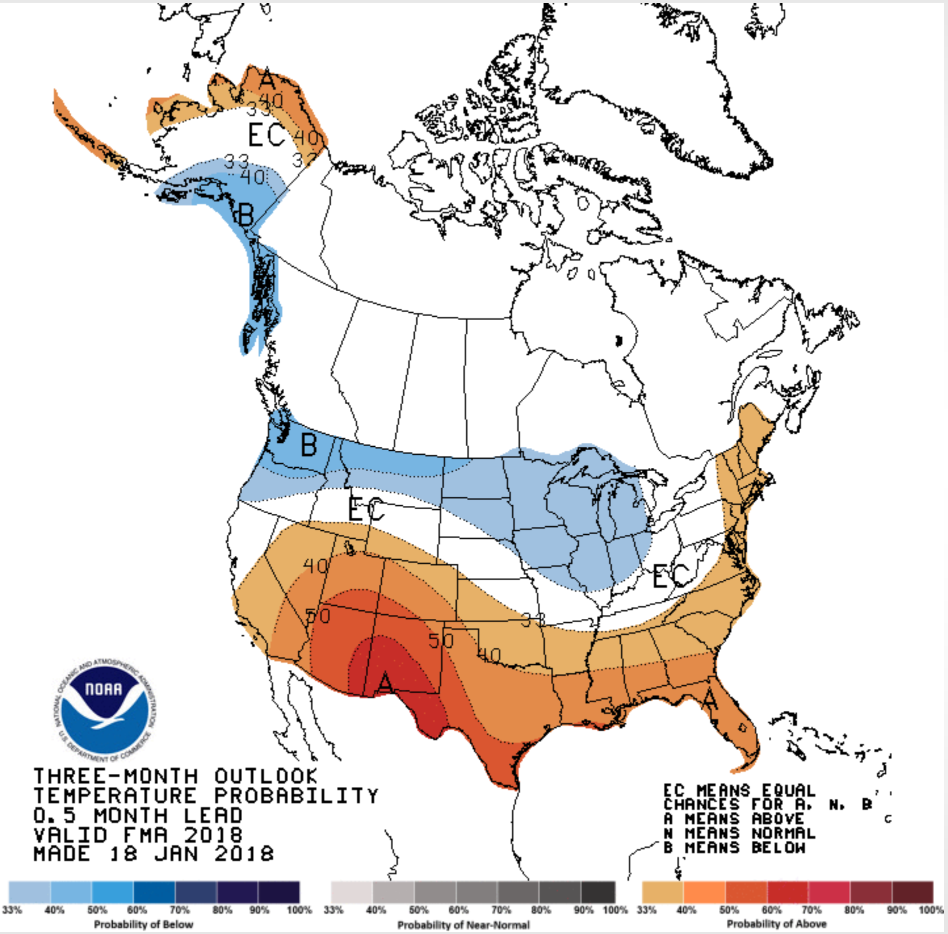
Author:

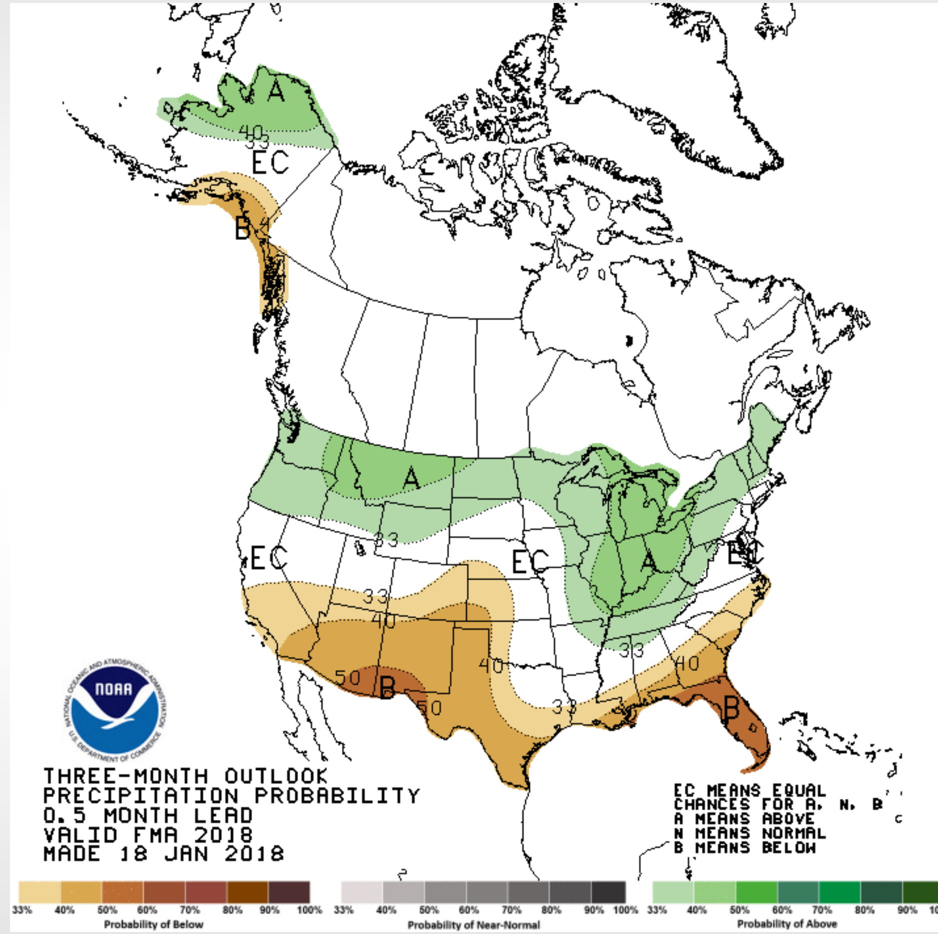
Brian Fuchs
National Drought Mitigation Center

http://droughtmonitor.unl.edu/

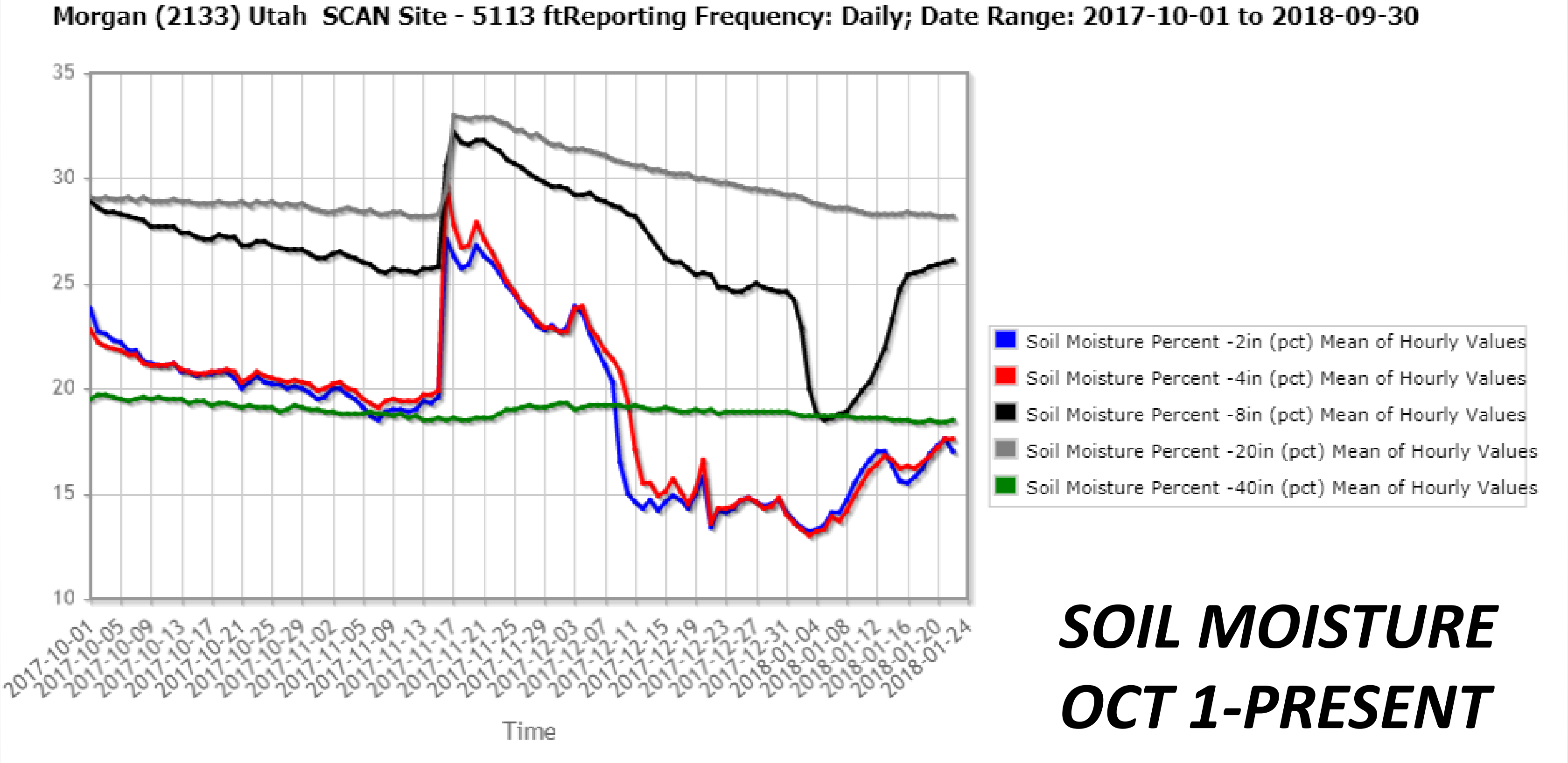
JANUARY 16, 2018


U.S. Seasonal Drought Outlook
Drought Tendency During the Valid Period
Valid for January 18 - April 30, 2018
Released January 18, 2018
Depicts large-scale trends based on subjectively derived probabilities guided by short- and long-range statistical and dynamical forecasts. Use caution for applications that can be affected by short lived events. "Ongoing" drought areas are based on the U.S. Drought Monitor areas (intensities of D1 to D4).
NOTE: The tan areas imply at least a 1-category improvement in the Drought Monitor intensity levels by the end of the period, although drought will remain. The green areas imply drought removal by the end of the period (D0 or none).
Drought persists
Drought remains but improves
Drought removal likely
Drought development likely
Author:
Rich Tinker
NOAA/NWS/NCEP/Climate Prediction Center
http://go.usa.gov/3eZ73


THREE-MONTH OUTLOOK
TEMPERATURE PROBABILITY
0.5 MONTH LEAD
VALID FMA 2018
MADE 18 JAN 2018
EC MEANS EQUAL
CHANCES FOR A, N, B
A MEANS ABOVE
N MEANS NORMAL
B MEANS BELOW
Probability of Below
Probability of Near-Normal
Probability of Above
33% 40% 50% 60% 70% 80% 90% 100%


THREE-MONTH OUTLOOK
PRECIPITATION PROBABILITY
0.5 MONTH LEAD
VALID FMA 2018
MADE 18 JAN 2018
EC MEANS EQUAL
CHANCES FOR A, N, B
A MEANS ABOVE
N MEANS NORMAL
B MEANS BELOW
Probability of Below
Probability of Near-Normal
Probability of Above
33% 40% 50% 60% 70% 80% 90% 100%

MORGAN



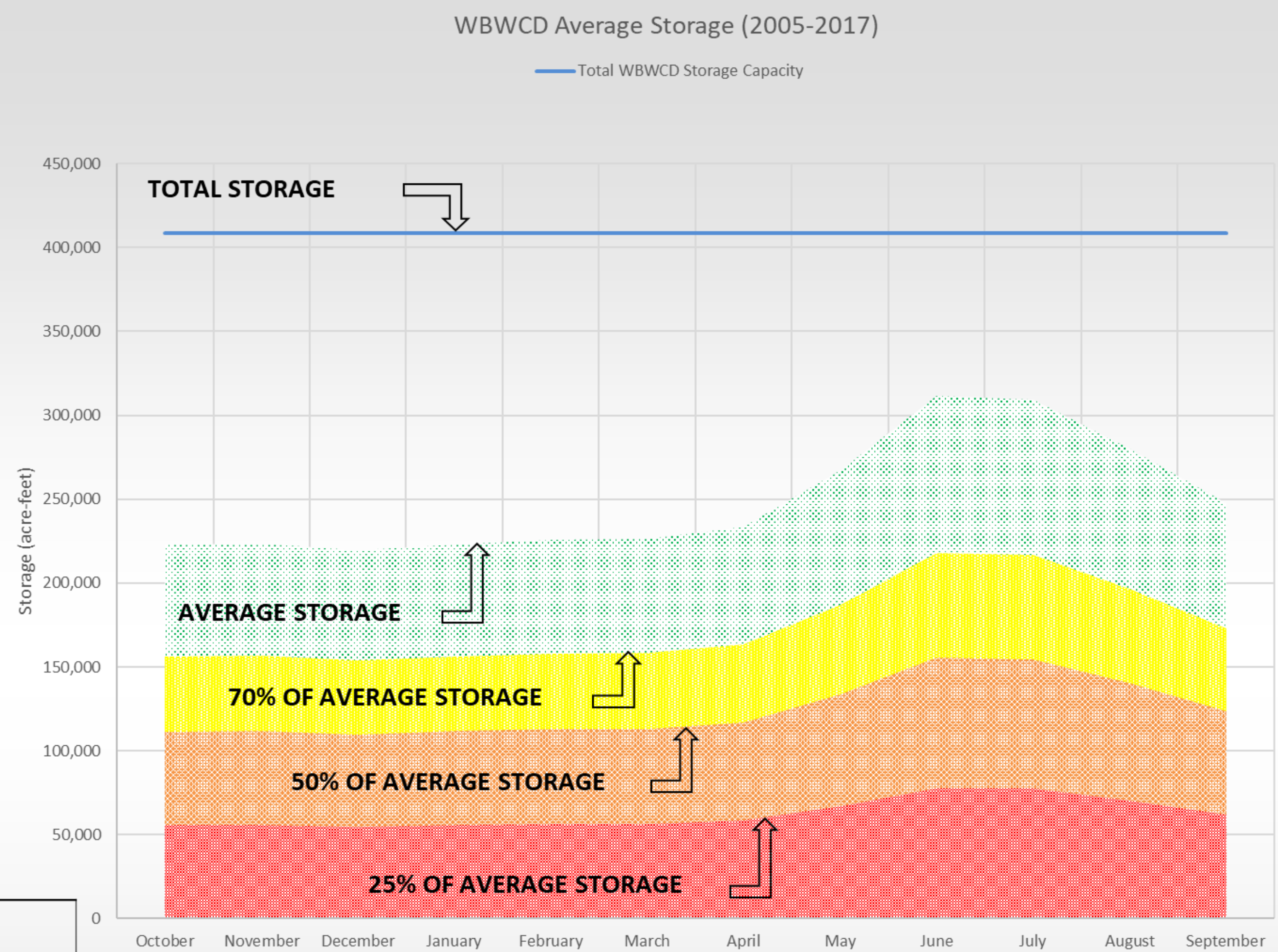
SOIL MOISTURE
OCT 1-PRESENT


Watch yer back …cuz what's in front of you don't look so good either…

Derek Johnson, WBWCD

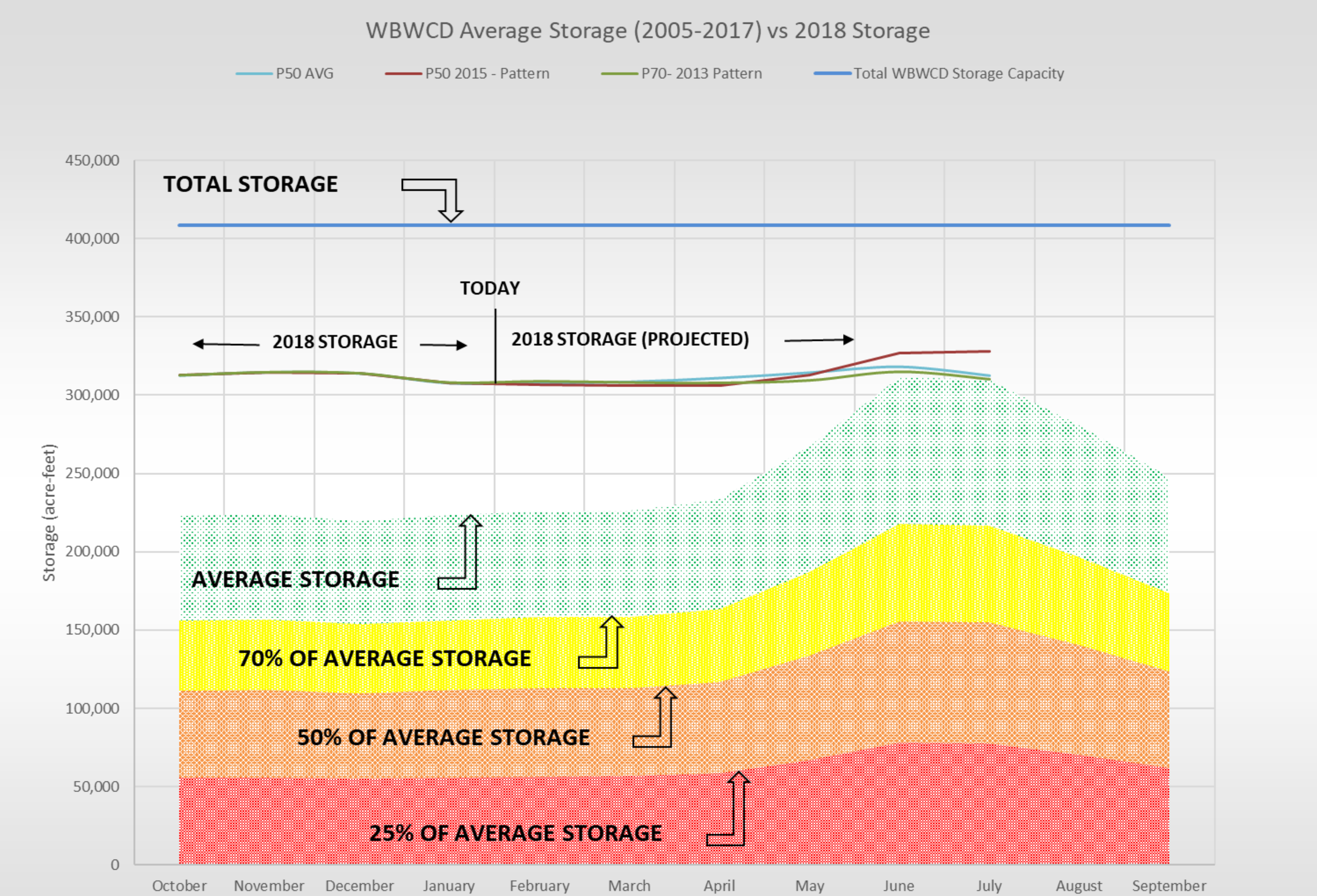
- Agenda Item 3:

  Drought Monitoring



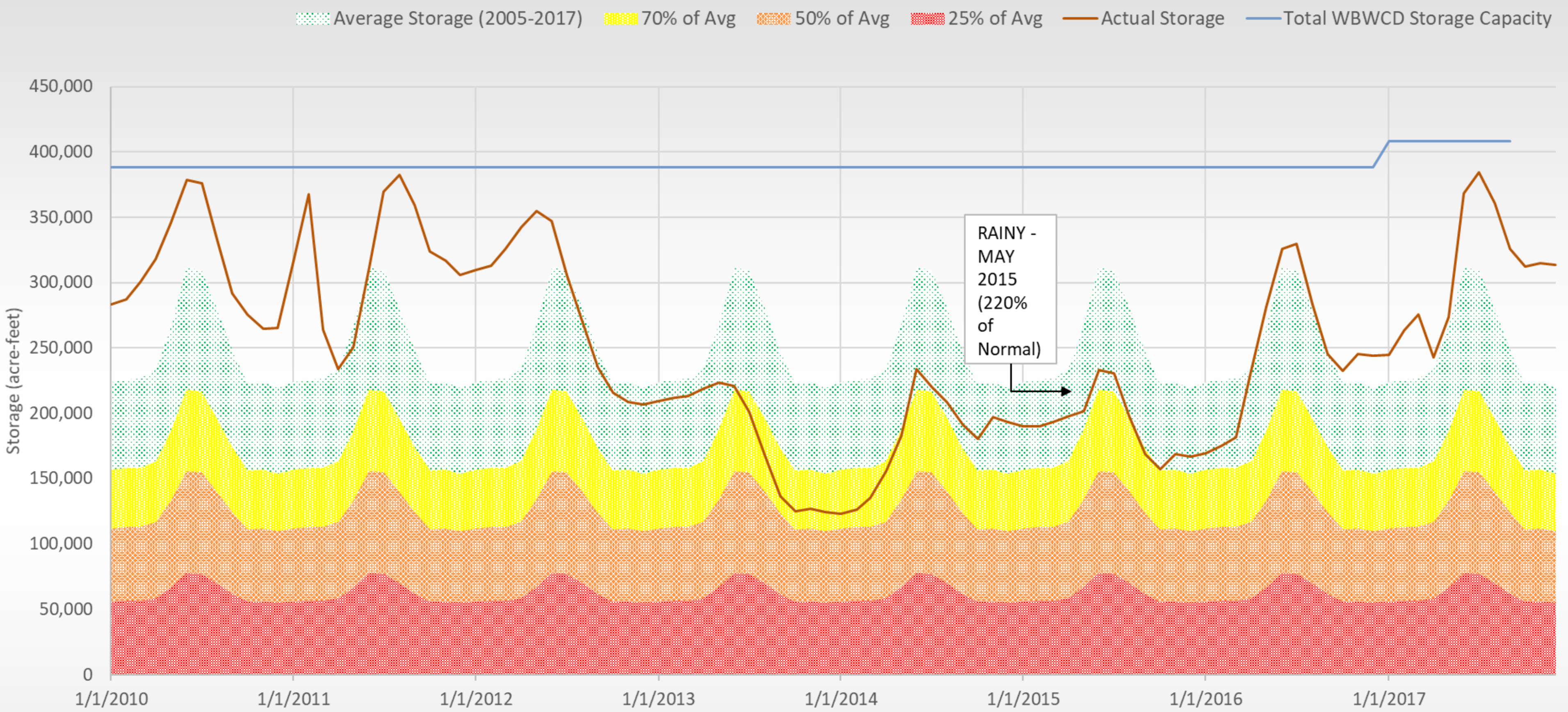
Response Level	Advisory Code	Water Shortage Description
1	**Green**	Normal
2	**Yellow**	Moderate
3	**Orange**	Severe
4	**Red**	Extreme

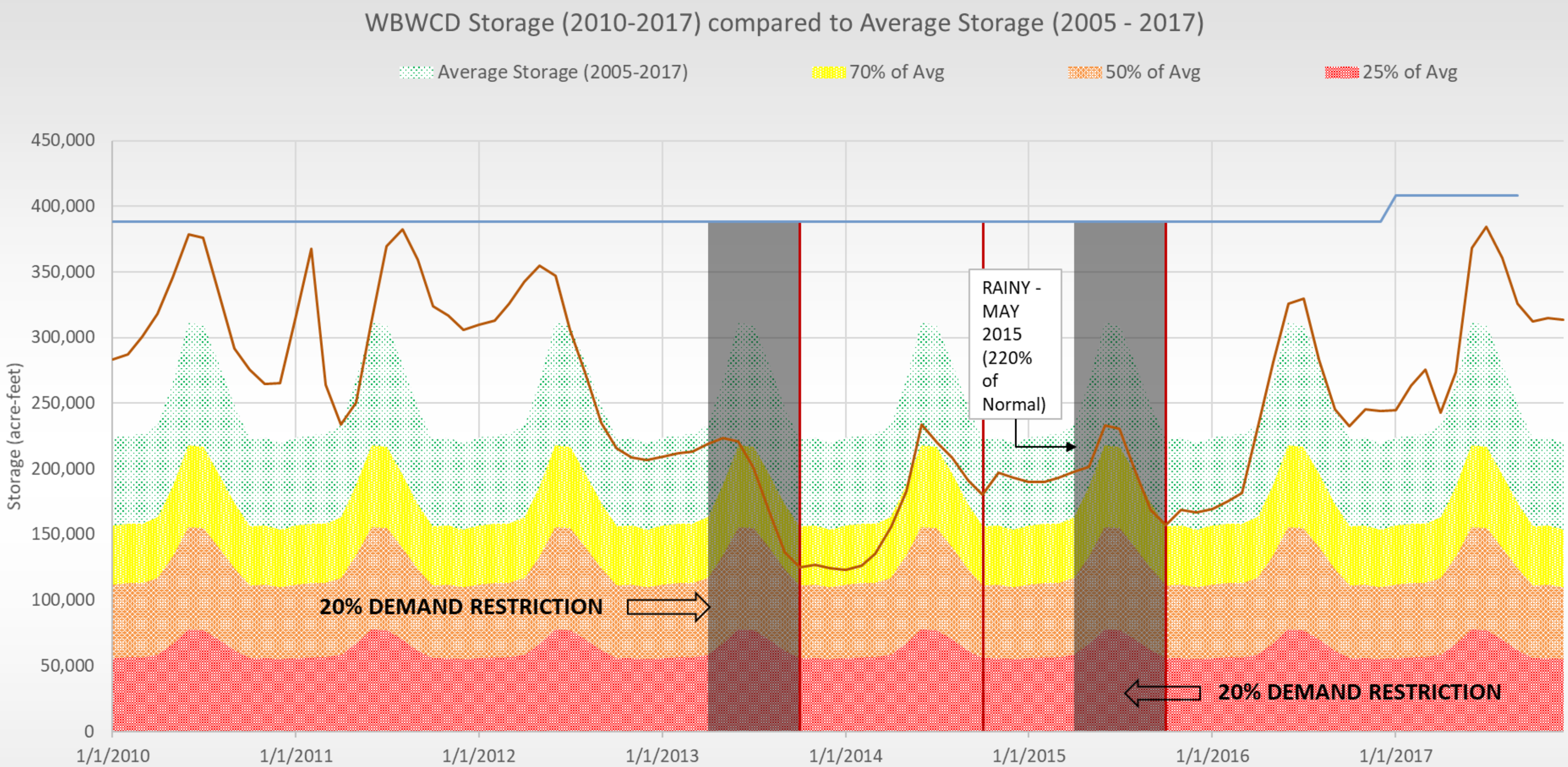
J-U-B ENGINEERS, Inc.



J-U-B ENGINEERS, Inc.

WBWCD Storage (2010-2017) compared to Average Storage (2005 - 2017)




WBWCD Storage (2010-2017) compared to Average Storage (2005 - 2017)
Average Storage (2005-2017)
70% of Avg
50% of Avg
25% of Avg
Storage (acre-feet)
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
20% DEMAND RESTRICTION
RAINY - MAY 2015 (220% of Normal)
20% DEMAND RESTRICTION

Josh King, TLG

- Agenda Item 4:

Summary of Stakeholder Meetings – Demand Reduction Goals for Drought Levels

Demand Reduction Goals
Municipal Meeting

				Demand Reduction (From Municipal Meeting)			
Response Level	**Advisory Code**	**Water Shortage Description**	**Triggering Criteria (percent of average storage recorded since 2005 for a given month of the year)**	**Secondary Water**	**Agricultural Irrigation**	**M&I Culinary Outdoor Water**	**M&I Culinary Indoor Water**
1	**Green**	Normal	Normal variability: storage >= 70%	0	0	0	0
2	**Yellow**	Moderate	Moderately dry conditions: < 70% storage	20%	20%	20%	0%
3	**Orange**	Severe	Severely dry conditions: < 50% storage	65%	40%	65%	20%
4	**Red**	Extreme	Extremely dry conditions: storage < 25%	100%	85%	100%	50%

Demand Reduction Goals
Agriculture Meeting

				Demand Reduction (From Ag Meeting)			
Response Level	**Advisory Code**	**Water Shortage Description**	**Triggering Criteria (percent of average storage recorded since 2005 for a given month of the year)**	**Secondary Water**	**Agricultural Irrigation**	**M&I Culinary Outdoor Water**	**M&I Culinary Indoor Water**
1	**Green**	Normal	Normal variability: storage >= 70%	0	0	0	0
2	**Yellow**	Moderate	Moderately dry conditions: < 70% storage	20%	20%	20%	0%
3	**Orange**	Severe	Severely dry conditions: < 50% storage	55%	40%	55%	5%
4	**Red**	Extreme	Extremely dry conditions: storage < 25%	90%	55%	85%	15%

Demand Reduction Goals
Environmental Meeting

				Demand Reduction (From Environment Meeting)			
Response Level	**Advisory Code**	**Water Shortage Description**	**Triggering Criteria (percent of average storage recorded since 2005 for a given month of the year)**	**Secondary Water**	**Agricultural Irrigation**	**M&I Culinary Outdoor Water**	**M&I Culinary Indoor Water**
1	**Green**	Normal	Normal variability: storage >= 70%	0	0	0	0
2	**Yellow**	Moderate	Moderately dry conditions: < 70% storage	20%	20%	20%	0%
3	**Orange**	Severe	Severely dry conditions: < 50% storage	2nd	2nd	2nd	1st
4	**Red**	Extreme	Extremely dry conditions: storage < 25%	100%	2nd	3rd	1st

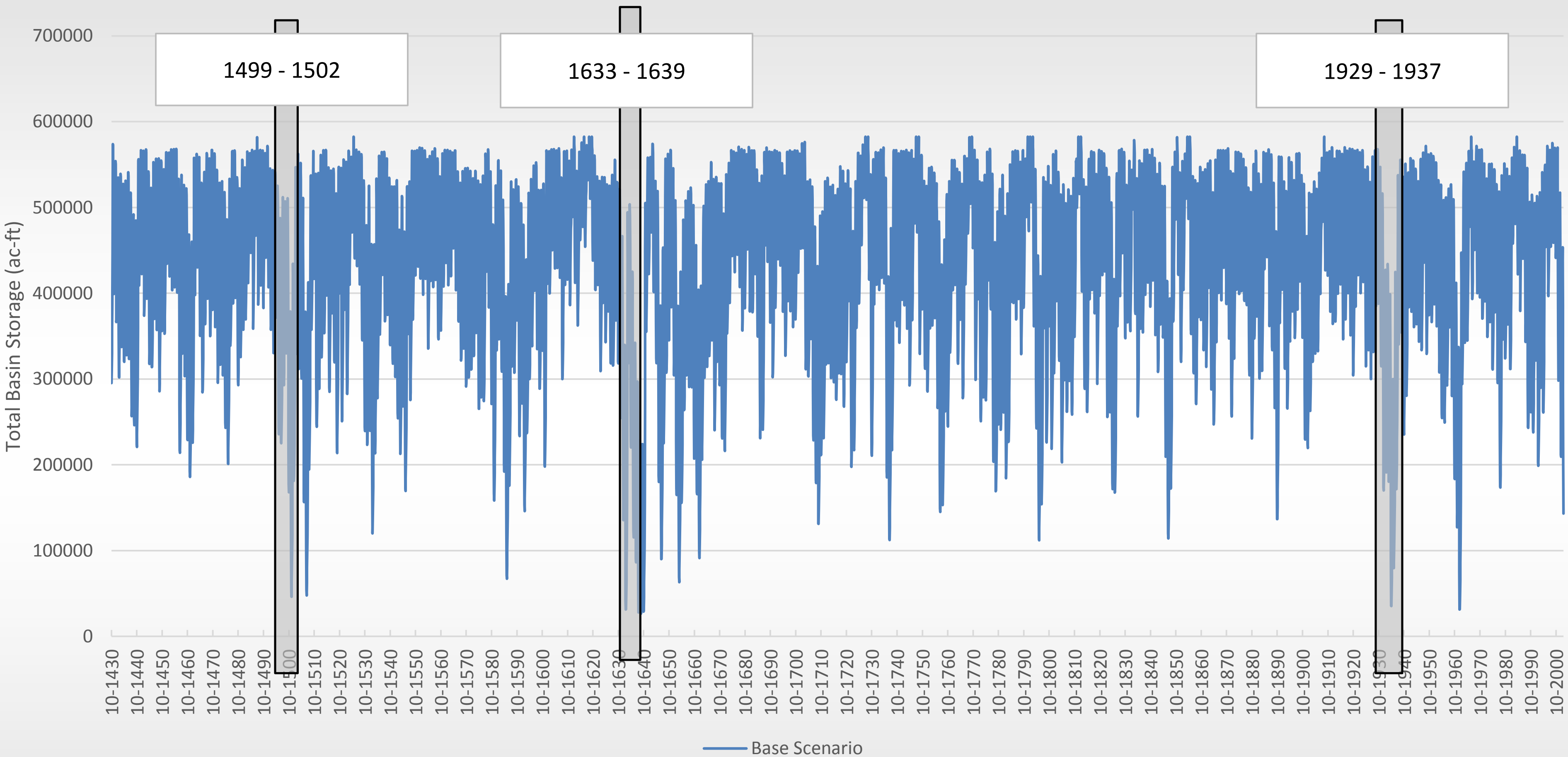
Demand Reduction Averages

				Demand Reduction (Averages)			
Response Level	Advisory Code	Water Shortage Description	Triggering Criteria (percent of average storage recorded since 2005 for a given month of the year)	Secondary Water	Agricultural Irrigation	M&I Culinary Outdoor Water	M&I Culinary Indoor Water
1	Green	Normal	Normal variability: storage >= 70%	0	0	0	0
2	Yellow	Moderate	Moderately dry conditions: < 70% storage	20%	20%	20%	0%
3	Orange	Severe	Severely dry conditions: < 50% storage	60%	40%	60%	13%
4	Red	Extreme	Extremely dry conditions: storage < 25%	95%	70%	93%	33%

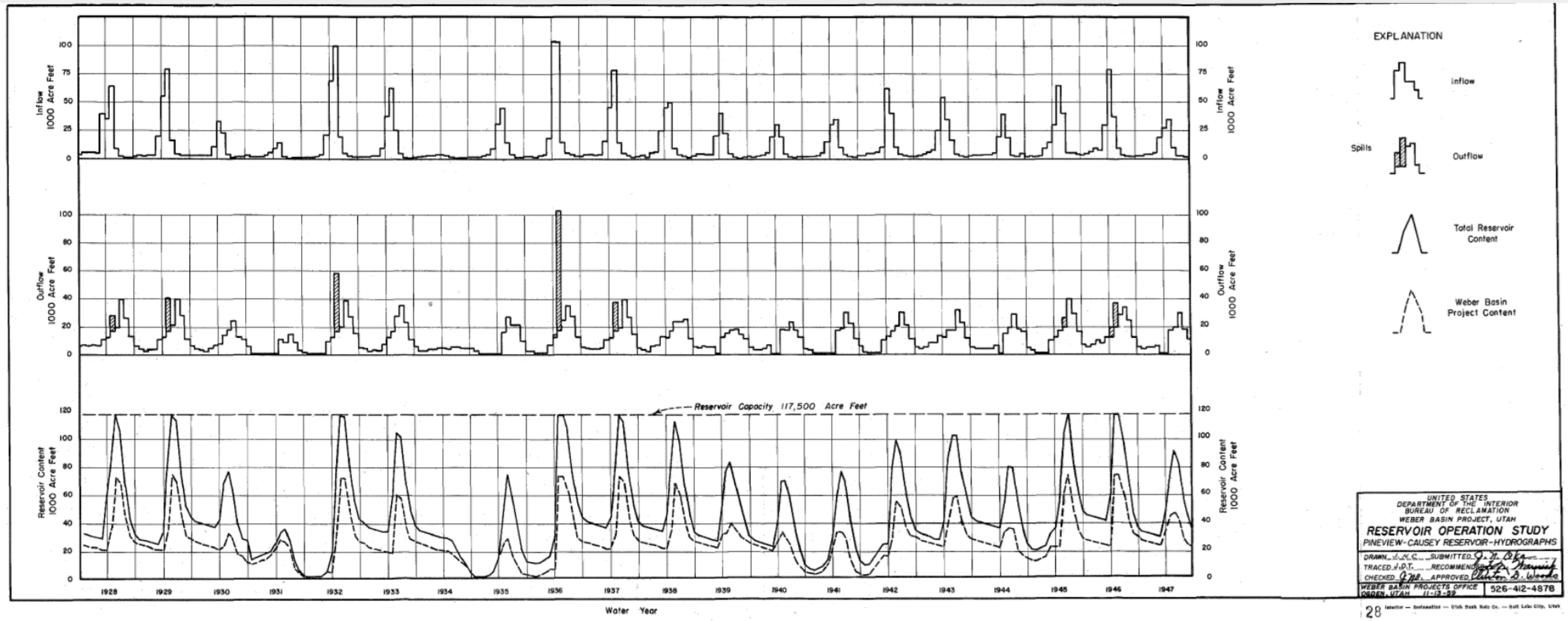
Derek Johnson , WBWCD

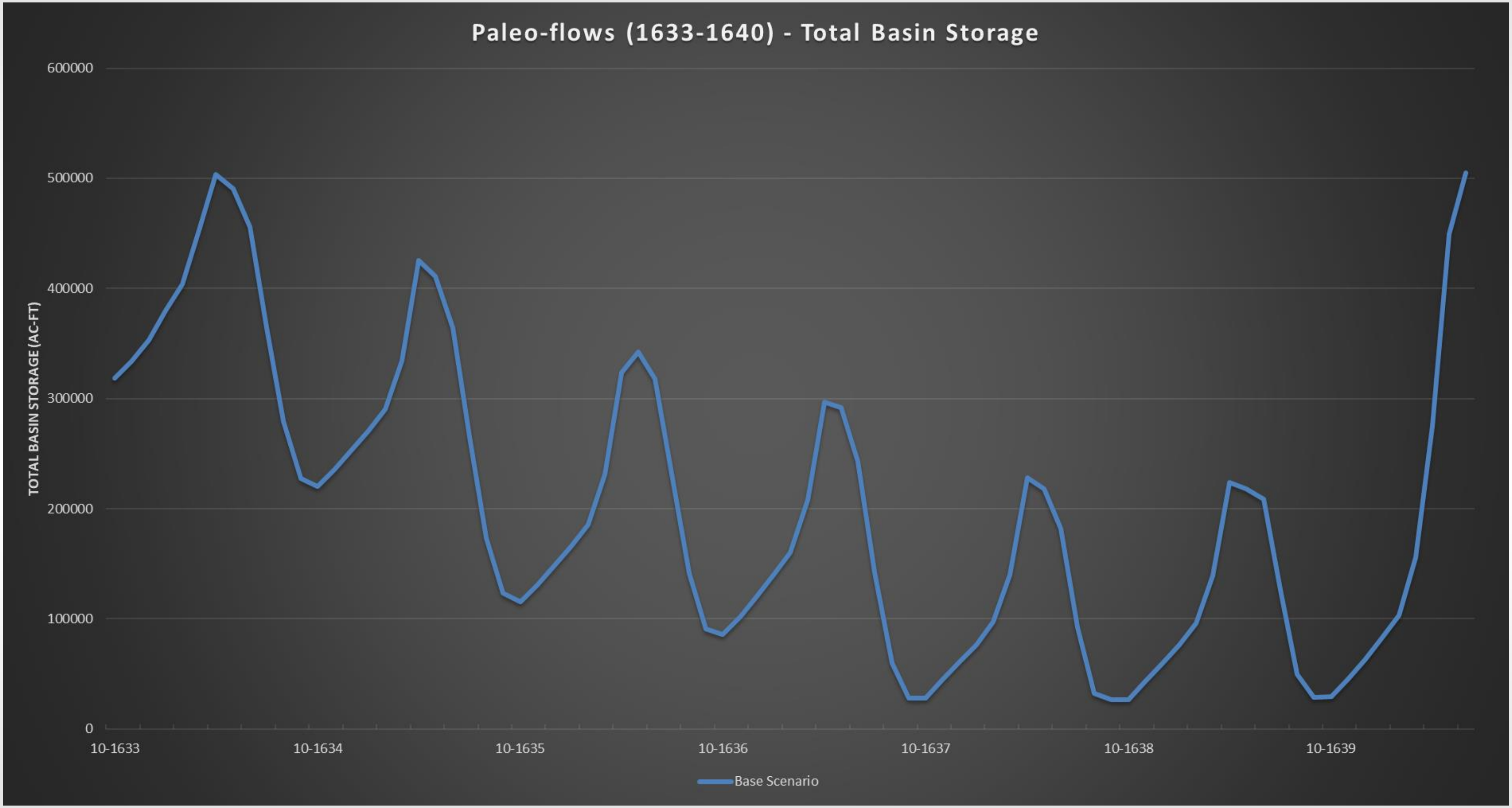
- Agenda Item 5a:
  - a. Weber River Modeling Results

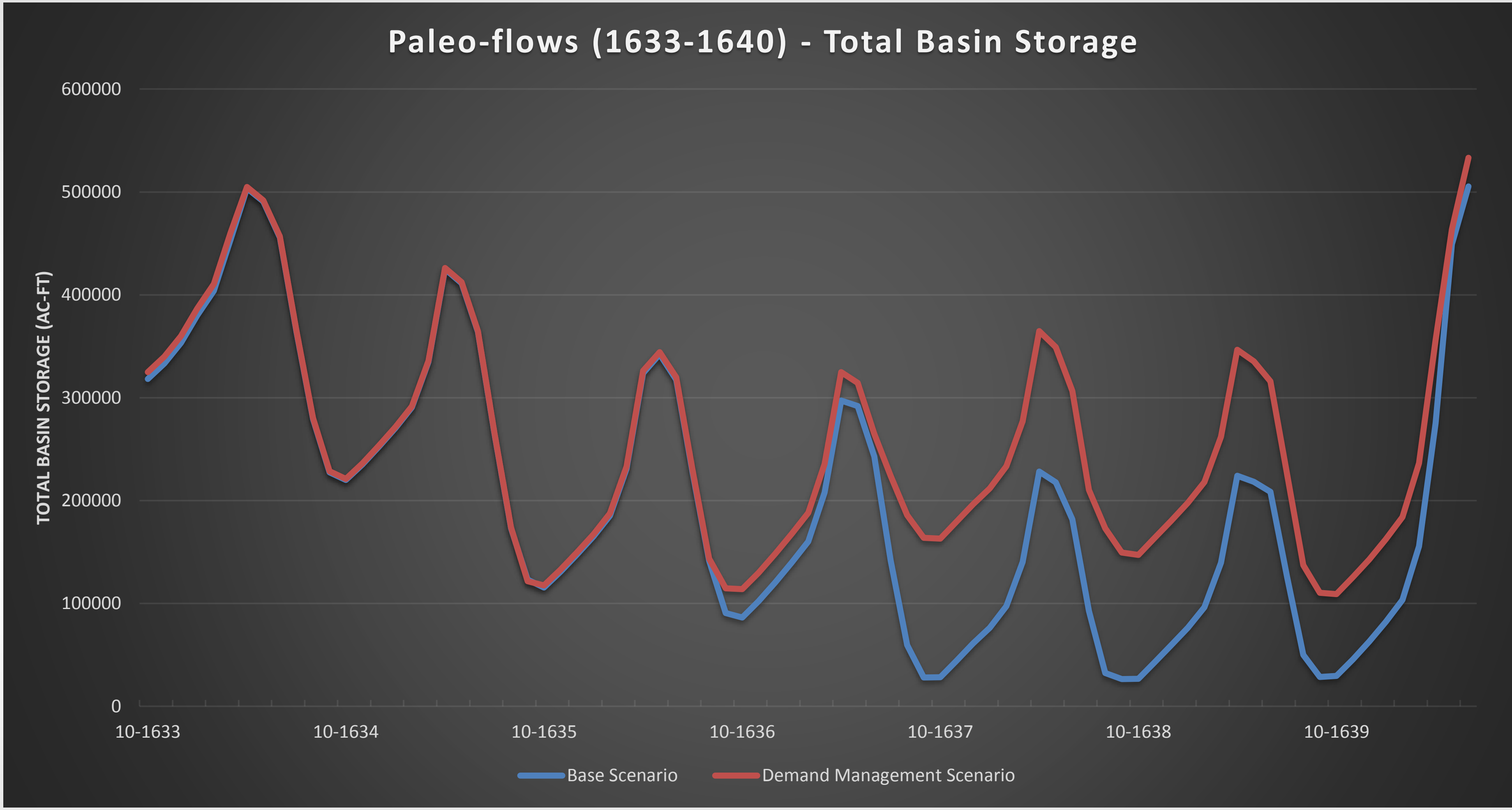
Paleo-flows (1430-2002) - Total Basin Storage



WEBER BASIN PROJECT- RESERVOIR OPERATION STUDY (1959)




Paleo-flows (1633-1640) - Total Basin Storage
TOTAL BASIN STORAGE (AC-FT)
600000
500000
400000
300000
200000
100000
0
10-1633
10-1634
10-1635
10-1636
10-1637
10-1638
10-1639
Base Scenario



J-U-B ENGINEERS, Inc.

Eric Stevens, J-U-B

- Agenda Item 5b:

Benefits of Mitigation – structural vs non-structural

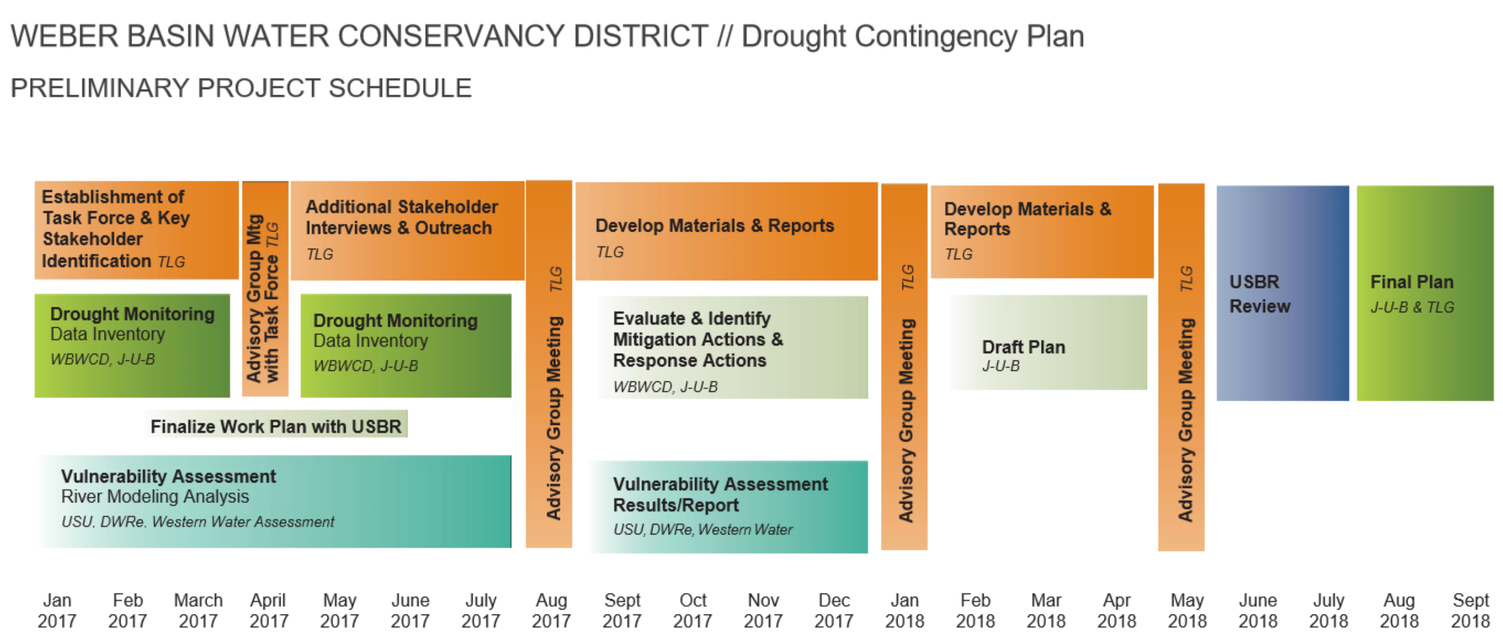
Mitigation Action Definition

Measures that we can take prior to a drought to help lessen the impacts of potential drought within Weber Basin.

Mitigation Actions

- Increase storage
- **Create fallowing agreements**
- Public education about droughts
- Manage flows during wet years
- Store water higher in the basin
- Improve connectivity for better habitat
- Build financial reserves
- Build inter-system relationships
- Improve delivery systems
- **Create inter-agency water sharing agreements**
- **Create re-claimed water re-use agreements**
- Optimize the river system
- **Groundwater recharge (ASR)**
- Increase secondary flow metering
- Improve metering on the river
- Build system redundancies

Project Schedule



Appendix 2-F

Task Force/Advisory Group Meeting Minutes
June 20, 2018

Weber Basin Water Conservancy District Drought Contingency Plan
Advisory Group/Task Force Meeting
6/20/18

<u>Task Force & Advisory Group:</u>
Kenton Moffett *(Ogden City)*
Rick Smith *(D&W; Weber River Water Users)*
Candice Hasenyager *(Division of Water Resources)*
Seth Arens (*Western Water Assessment)*
Grant Cooper (*D+W CCC / LDS Church*)
Connely Baldwin (*Pacificorp*)
Kamilla Schultz (*Clearfield City*)
Rodney Banks (*Roy Water*)
Steve Jackson (*Layton City*)
Holly Lopez (*Park City Public Utilities*)
Clint Brunson (*Utah Division of Wildlife Resources)*
Paul Burnett *(Trout Unlimited)*
Jerry Allen *(Bona Vista Water District)*
Wes Adams (*Layton City*)
Ben Radcliffe (*Bureau of Reclamation*)
Ben Stireman (*Forestry, Fire & State Land/DNR)*
Dwight Slaugh (*USBR*)
Skye Sieber (*National Audubon Society)*
Sam Christiansen (*City of North Salt Lake)*
Bobby Boone (*Trout Unlimited)*
Lily Bosworth (*Trout Unlimited)*

<u>Project Team:</u>
Darren Hess *(Weber Basin)*
Derek Johnson *(Weber Basin)*
Zoe Rogich (The Langdon Group)
Cindy Gooch (J-U-B Engineers)
Brad Nelson *(Weber Basin)*
David Rosenberg *(Utah State University)*
Chris Slater (J-U-B Engineers)
Josh King (The Langdon Group)

<u>Meeting Minutes</u>

Welcome and Introductions
- Darren welcomed group and introduced Poll Anywhere

Meeting Objectives
- Reviewed Draft Drought Contingency Plan
    - This plan will help take the guessing out of drought levels and projections

Drought History Review
- Derek reviewed total storage and Weber Basin's Storage History
    - 1975 – 2017 history
- 1977 – Drought Year
    - 1977 was a bad drought year
    - Supply on the Weber River side was so bad they had to implement a 40% reduction
- Droughts have been a bit more erratic
    - In 2001 – 2004 secondary and irrigation contracts were restricted
- Want to be better prepared for the future with the Drought Contingency Plan
- Paleo Records (come from the tree rings study)
    - 1630's – 1640's was longer and more intense than the 2013 – 2016 drought
        - A long drought like that is possible

Drought Contingency Plan Objectives
- Engage stakeholders

- Understand drought
- Overview of the plan steps for the Drought Contingency Plan

Historic Total Basin Active Storage

- Reviewed Weber Basin's historic total basin storage
- Dot on the graphs shown are for the June 1st storage of every year
  - If reservoirs are full at the beginning of the year, that indicates it will be a good water year
  - Use the dots on the graph to establish drought levels
    - If the dots are in the red that would be an extreme event and reservoirs would be completely dry by the end of the year
- Overview of 1960 – 1962 drought
  - Previous low for Great Salt Lake was 1963, because of those drought years
- Overview of 2013-2015 drought
  - This drought was considered a moderate event
- Climate change scenarios for the future
  - Climate change is showing a peak every year
  - Hot/Dry is the worst case scenario for a drought
    - It's possible to have a future scenario similar to the drought in 1960
  - A severe drought (red) has a return rate of approximately 160 years
  - An extreme drought (orange) has a return rate of approximately 50-60 years
  - A moderate drought (yellow) has a return rate of approximately 7 years

Water Supply Conditions

- Red **(Severe)**, Orange **(Extreme)**, Yellow **(Moderate)**, Gray **(Advisory)**, Blue **(Good)**
  - Gray is an advisory scenario
    - Example: If reservoirs are high because last year was a good water year, but this year has been a poor water year.
    - The gray will give the message that it is dry and we do have storage but if we burn through it and have a bad winter next year we could be in trouble.
- Drought Level Triggers
  - Total Basin projected June 1st storage for the year
  - Projected June 1st upstream basin storage (does not include Willard Bay Storage)
  - Other drought monitors (U.S. Drought Monitor Intensity classification)
- Review of Utah's Drought Monitor and drought indicators
- Overview of the Drought Monitoring Process
  - Project where the water is going to be by June based on water/snow from January to May. Those forecasts are looked at in March.
- Overview of the Drought Dashboard
  - The dashboard will monitor groundwater, runoff, snow pack and projected June 1st storage
- Attendees Were Asked: *What features, data, and capabilities would you like to see on this dashboard**?*** Responses included:
  - Sub Basin Information
  - Reservoir Levels
  - Soil Moisture
  - Snowpack

- Projected Storage
- End User Actions
- Recommended irrigation schedules
- Actual June first storage number
- Drought monitor link
- Link to historical drought levels
- Projected drought level
- Possibility shortages
- Water Use restrictions (if necessary)
- Slider bar to see recent/historical drought levels
- Interactive dashboard (if this… then what)
- An opportunity to comment and ask questions
- List of suggested conservation actions to reduce consumption
- Definitions
- Provide more links on the dashboard:
  - Range of snow pack
- Give information to those you know water
- What don't we have access too?
- Make the dashboard unique with information you can't find on other websites
- Updated probabilities, average projections – some of those concepts that can be transferred to storage
- Don't need to reinvent the wheel – base information, collecting it and making it specific to Weber Basin
- Define, extreme, severe and moderate (definitions) so people don't misinterpret or mix up with different drought levels identified in other drought plans or indices.
- How drought is defined and how it is actually experienced on the ground
- Dashboard product for a routine dialogue to explain those discrepancies

Mitigation Measures

- Overview of Measure Objectives
  - Supply
    - What can we do to have more supply?
  - Financial
  - Implementation & Risk Reduction
    - How quickly can they be done?
    - What can we do with a drought
  - Environment
    - How can we minimize impact to industry?
- Reviewed mitigation evaluation spreadsheet
- Mitigation measures will allow Weber Basin to have something in place before a drought happens
- Types of measures evaluated
  - Storage
  - Agreements
  - Flow measurement
  - Rate structures
  - Water reuse
  - Education

    - Habitat improvements

  Weber Basin's Top 10 mitigation actions

    1. Short Term Transfer Agreements
    2. Internet Water Supply Dashboard
    3. Drought Surcharge Fees
        - WB Working on this project now
    4. WBWCD Secondary Water Metering
        - New connections get a meter
    5. Other Systems secondary Water Metering
    6. Drought Surcharge fees education
    7. Drought Plan Results
    8. Weber Canyon ASR
    9. Continue Meters with Division of Wildlife Resources, Trout Unlimited and other habitat
    10. Create new tiered rate structure and short term transfer water fund
        - Could use extra money for the agreements
- ASR – every water agency future shortages there could be space for greater study on that issue

Response Actions

- Reviewed Demand reduction targets
- Reviewed General Strategies to meet targets and did poll.
    - Extreme (Red) – drought rates exercise fallowing agreements and no watering
- Discussion of metering
    - How much water could be saved from going down the gutter and changing daily practices?
    - Weber Basin has seen, while installing secondary water meters, people use more than 50% than what they need
    - Weber Basin wants residents to water what their estimated need would be
    - Cities also need to implement ordinances
    - Working with irrigation districts to implement water waste patrols
        - Staff and resources
        - Programs like slow the flow where residents can have someone come in and do an audit on their property with how much they are using and how much they should be using
            - Giving them tools to understand (dashboard could help people connect to resources)
            - Meters show how much they should be using and how much they should use
- Coordinate with UDOT and commercial advertisers to spread drought conditions message with variable message boards
- Shorten irrigation season
    - Restricting hours of use instead of days (time)
- Educating people is key
    - Implement an outreach strategy
        - Education is three of the ten mitigation strategies
        - Certain people who care about water conservation will talk to their neighbors
- Implement mandatory water restrictions

    - 20% on agriculture side with level three. Have not done it on secondary water before with meters Weber Basin can start measuring that
    - Time of day restrictions
- Drought water rates would be applied at a level three
- Parks provide community benefits – if they were watered correctly this would be a good opportunity to show people how they can water their property during a drought

Operational and Administrative Framework

- Water supply manager analyses data
- Update general manager
- Monthly water supply report to board of trustees
- Update dashboard monthly
- General manager gives public updates
    - Especially during restrictions

Review of Conclusions and Recommendations

2018

DROUGHT CONTINGENCY PLAN

Weber Basin Water Conservancy District

J-U-B ENGINEERS, INC.

THE LANGDON GROUP a J-U-B Company

GATEWAY MAPPING INC. a J-U-B Company

OTHER J-U-B COMPANIES

UTAH DNR WATER RESOURCES

UTAH STATE UNIVERSITY · 1888 ·

WESTERN WATER ASSESSMENT

A NOAA RISA TEAM

- We'll be asking for your input today via

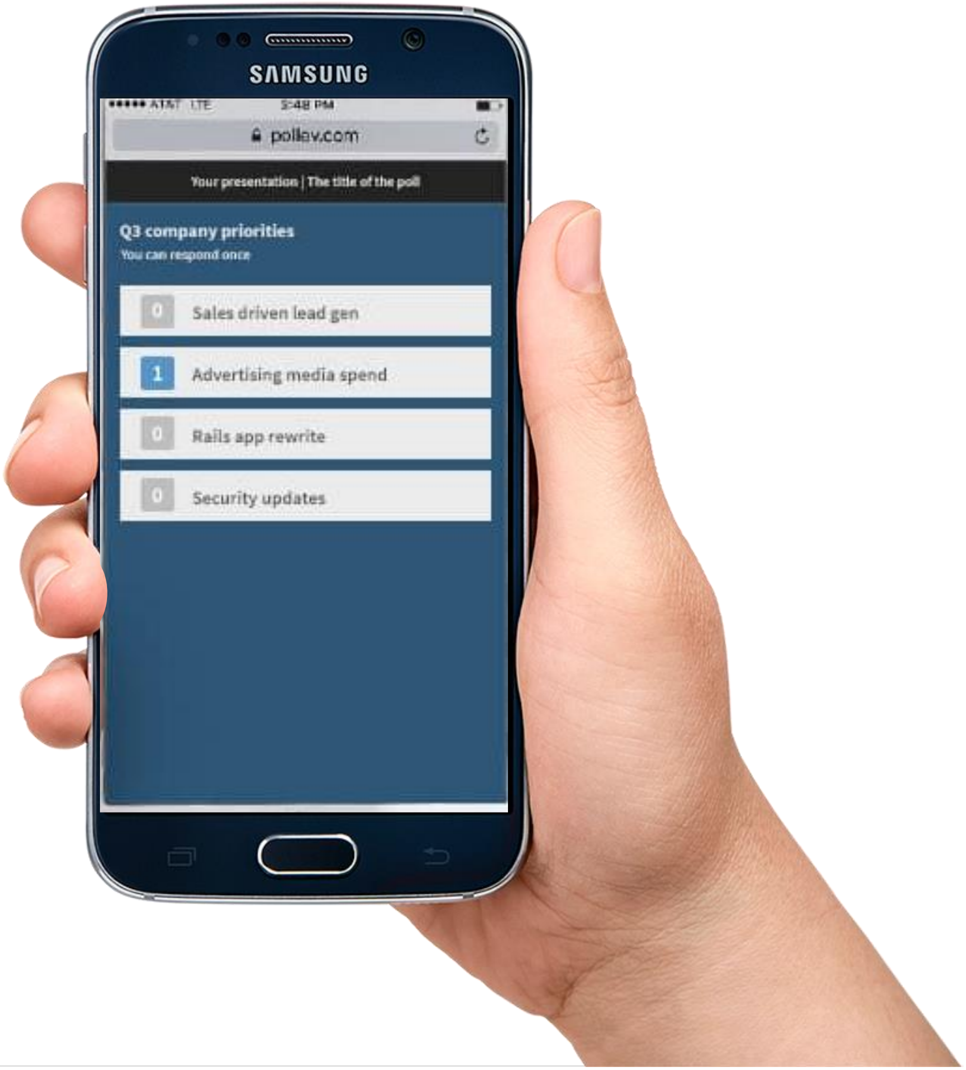
Poll Anywhere

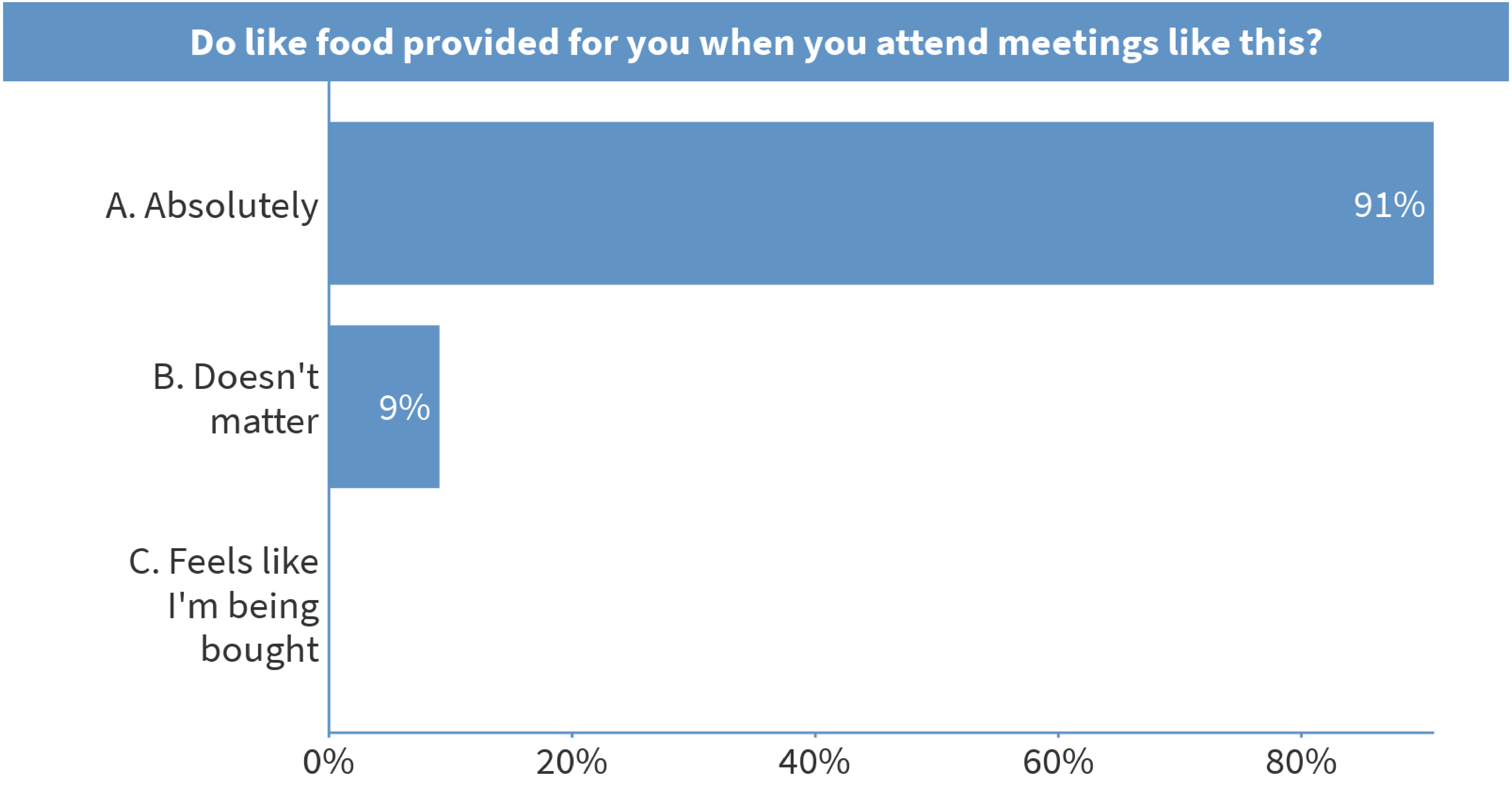
Just use your phone, tablet, or other web-enabled device to respond.

Text weberbasin to 22333

OR

Browser PollEv.com/weberbasin




Do like food provided for you when you attend meetings like this?
A. Absolutely
91%
B. Doesn't matter
9%
C. Feels like I'm being bought
0%
20%
40%
60%
80%

If you could have one type of food at these types of meetings, what would it be?

"Nothing"

"Prime rib"

"Water"

"Cosra vita"

"Any"

"Sauerkraut"

"Water"

"Cafe Rio"

"A"

"Beer"

"Middle Eastern"

Thai

Thai

Sushi

Carrots

Pizza

Café río

Steak

Thai

Chinese

Fresh fruit

Costa Vida

Bbq

Caferio

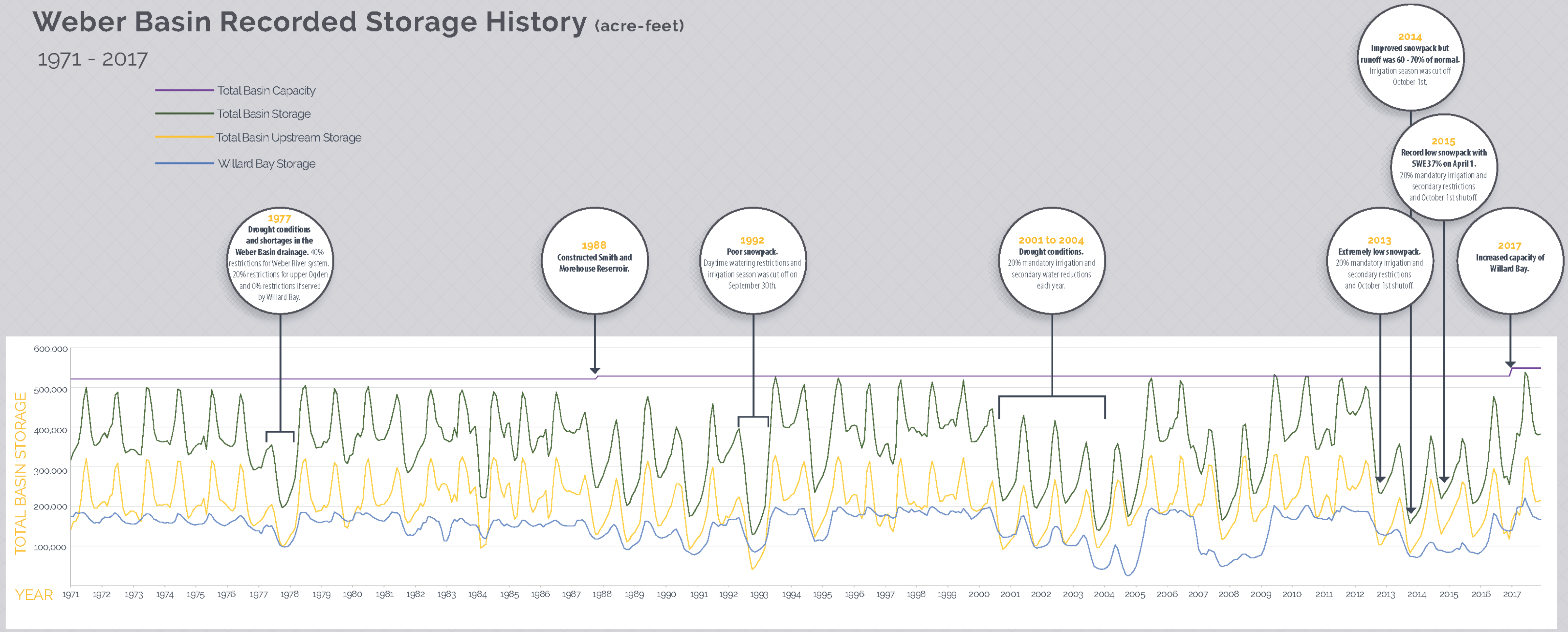
Meeting Objectives

1. Review Draft Drought Contingency Plan
2. Gather Feedback for Specific Response Actions

Agenda

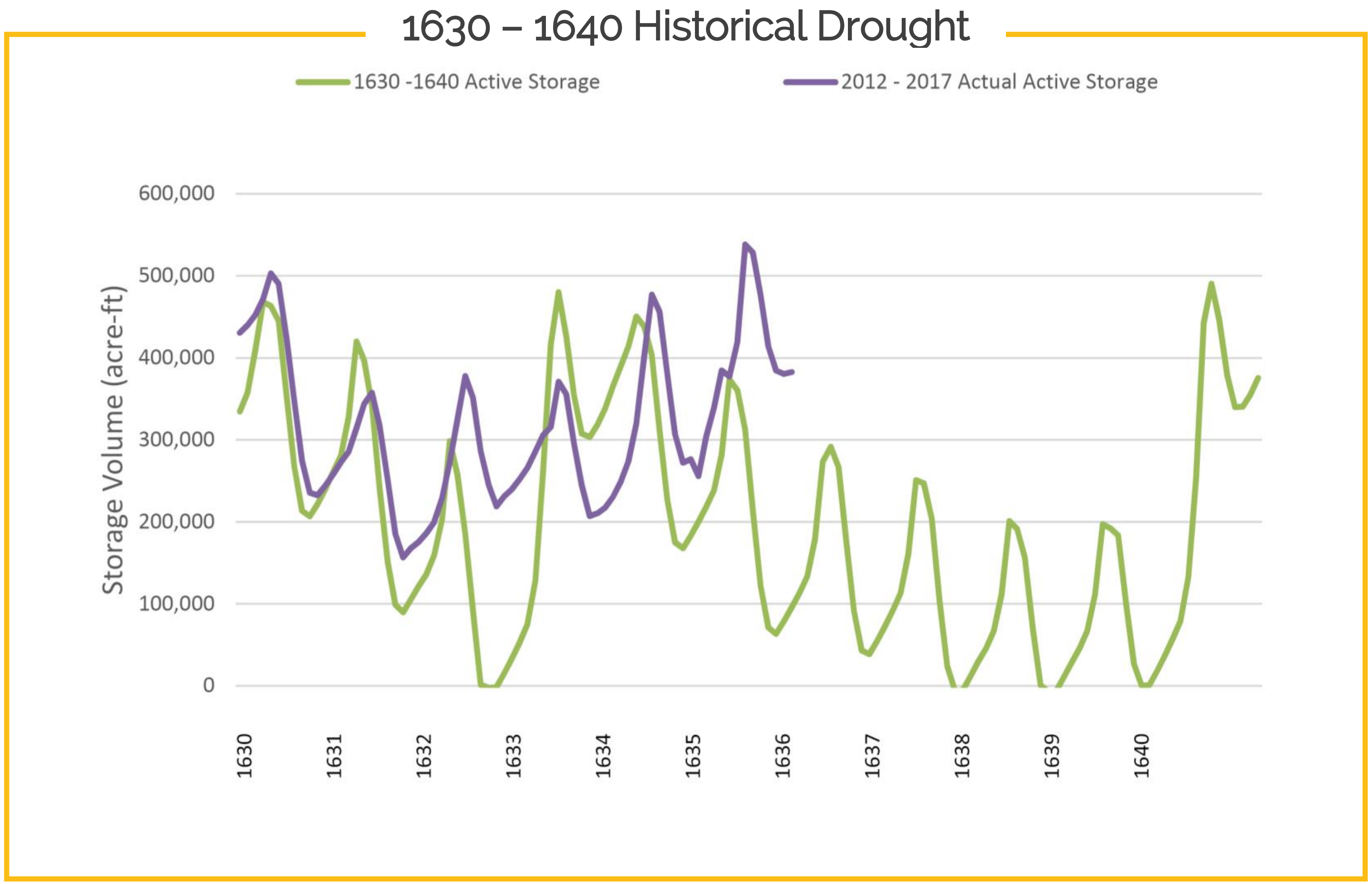
- Drought History
- Drought Levels and Projections
- Drought Monitoring
- Break
- Mitigation Measures
- Response Actions
- Conclusions/ Recommendations

Drought History



1630s Drought

The drought from the 1630s was much longer and more intense than the 2013 – 2016 drought.



Plan Objectives

- Engage stakeholders throughout the process to inform the plan and meet objectives
- Understand past drought history and drought\vulnerabilities
- Evaluate WBWCD drought vulnerabilities and risks
- Establish drought levels and their associated triggers
- Formalize the process used to monitor for drought
- Identify and prioritize drought mitigation measures
- Develop a drought response plan
- Formalize drought administrative framework

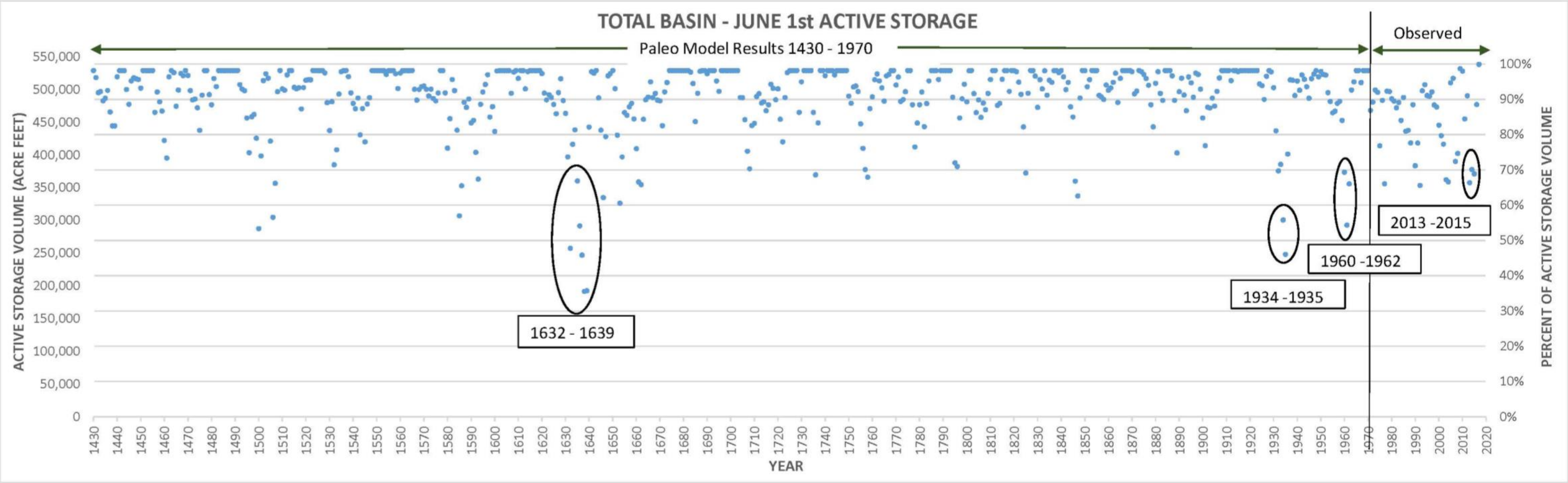
Plan Steps

1. Gather stakeholder input/feedback throughout the plan creation
2. Identify historical drought from paleo records
3. Model historic water supplies based on records
4. Define drought levels
5. Project potential future climate scenarios
6. Model future climate scenarios
7. Assess risks
8. Formalize drought monitoring process
9. Identify mitigation measures
10. Create Drought Response Plan
11. Formalize administration of the plan

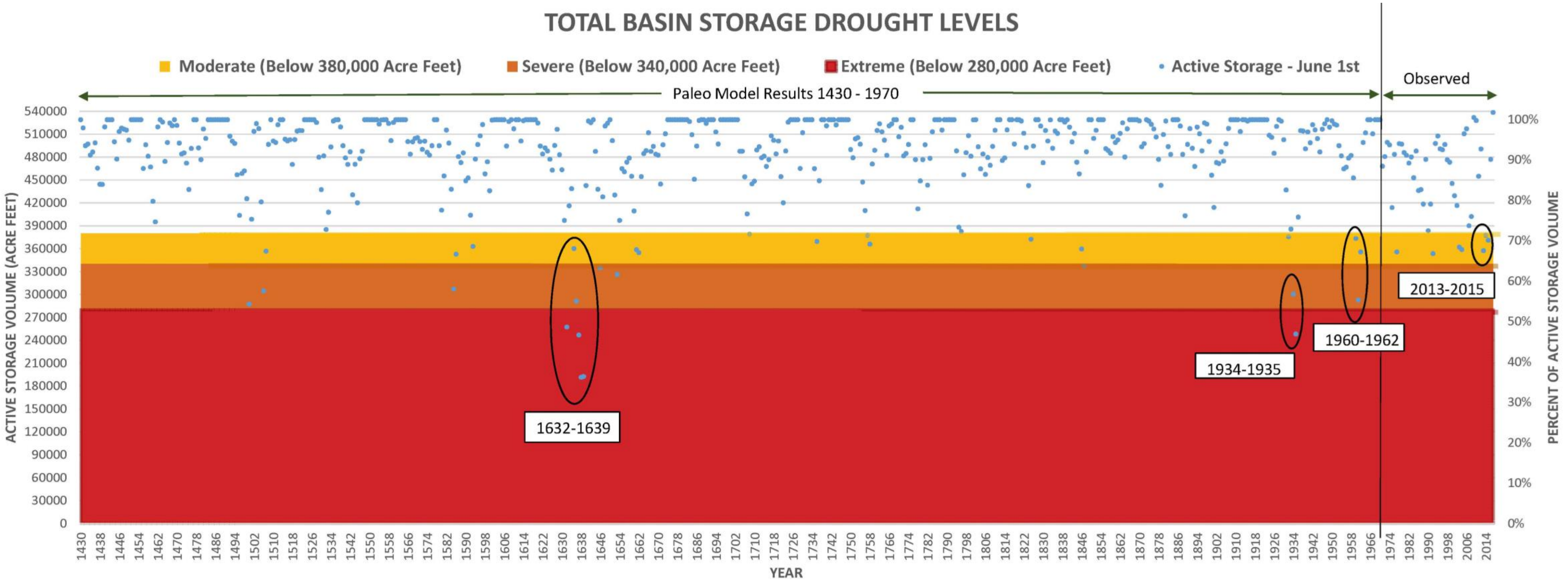
Task Force and Advisory Group

- Ben Quick - Pineview Water Systems
- Blake Carlin - Bona Vista Water District
- Candice Hasenyager - Utah Division of Water Resources
- Cary Southworth - US Bureau of Reclamation
- Clint Brunson - Division of Wildlife Resources
- Clint McAffee - Park City
- Cole Panter - Weber River Commission
- Connely Baldwin - Pacificorp
- Craig Miller - Utah Division of Water Resources
- Derrick Radke - Summit County
- Gary Henrie - US Bureau of Reclamation
- Grant Cooper - Davis & Weber Canal Board
- Holly Lopez - Park City Public Utilities
- Jamie Barnes - Utah Division of Forestry, Fire and State Land/DNR
- Jerry Allen - Bona Vista Water District
- Joe Havasi - Compass Minerals/Great Salt Lake Minerals
- Justin Record - US Bureau of Reclamation
- Kamilla Schultz - Clearfield City
- Kent Kofford - US Bureau of Reclamation
- Kenton Moffett - Ogden City
- Laura Ault -Utah Division of Forestry, Fire and State Lands
- Laura Vernon - Utah Division of Forestry, Fire and State Lands
- Mark Slagowski - Bountiful City
- Matt Peterson - Ogden Bay Produce
- Paul Burnett - Trout Unlimited
- Paul Thompson - Utah Division of Wildlife Resources
- Rick Smith - Davis & Weber Canal Co. and Weber River Water Users
- Rodney Banks - Roy Water Conservancy District
- Scott Hodge - Clearfield City
- Stacy Majewski - Layton City
- Steve Jackson - Layton City
- Theo Cox - Weber River Water Users Assoc.
- Tony Melcher - Division of Water Resources
- Wes Adams - Layton City
- Wess Wight - Bountiful Irrigation District

Historic Total Basin Active Storage



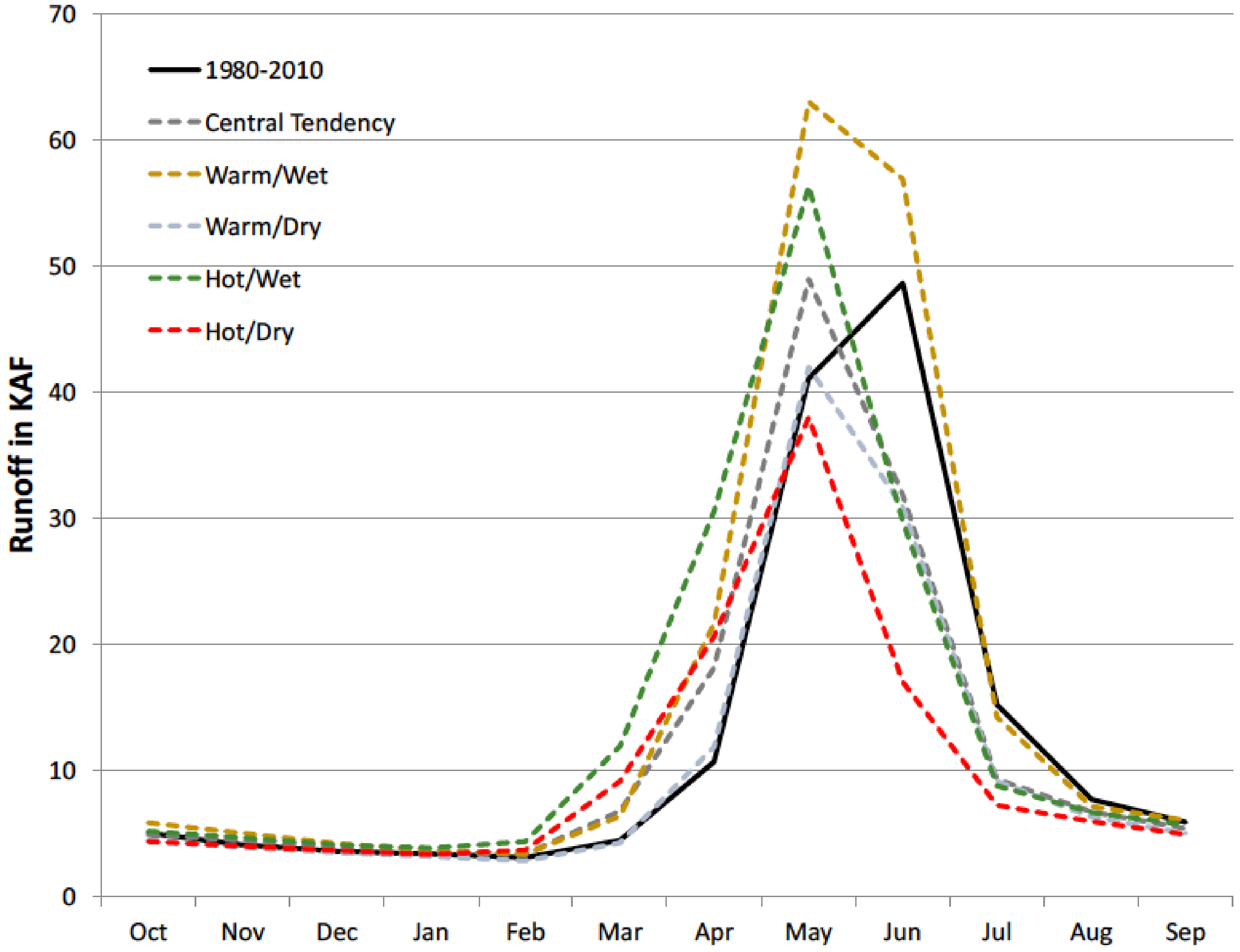
Establishment of Drought Levels



Climate Change Scenarios

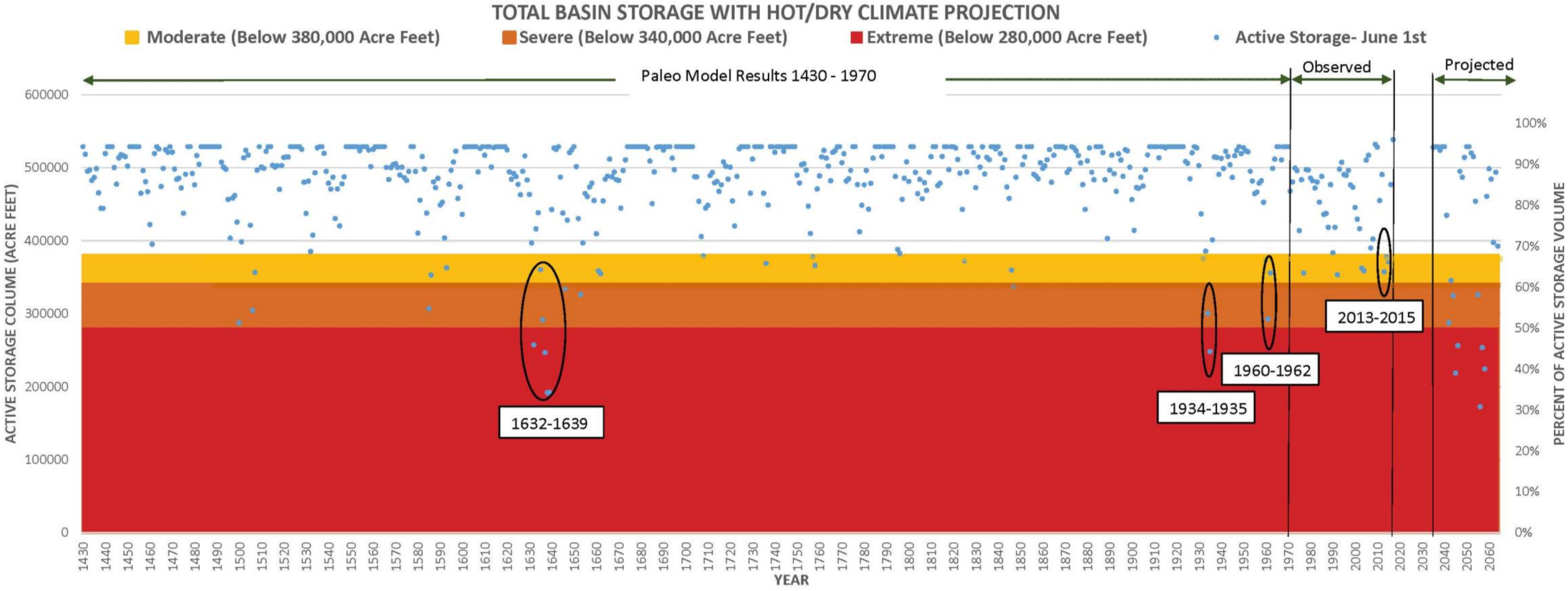
Hot-Dry is the worst future scenario

The peak moves to May from June in all scenarios.



Weber Basin Water Conservancy District

Model Storage Projections



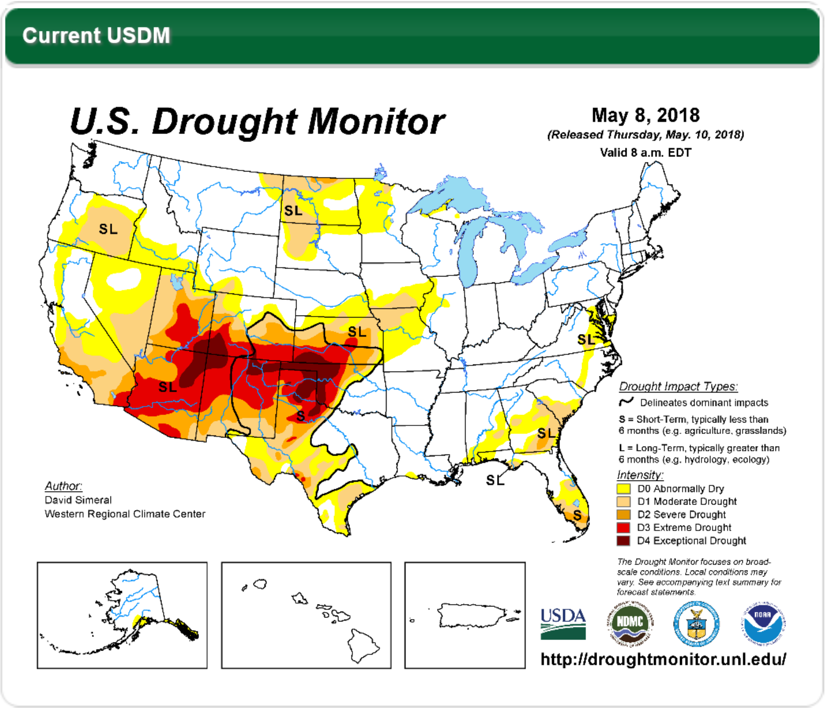
Water Supply Conditions

Drought Levels

RESPONSE LEVEL	ADVISORY CODE	WATER SHORTAGE DESCRIPTION	GENERAL DESCRIPTION
1	Blue	Normal	Projected June 1st storage greater than 72% of total basin storage capacity, normal or better snowpack
2	Gray	Advisory	Projected June 1st storage greater than 72% of total basin storage capacity, low projected snow pack and low CBRFC flows
3	Yellow	Moderate	Projected June 1st storage is 64-72% of total basin storage capacity
4	Orange	Severe	Projected June 1st storage is 53-64% of total basin storage capacity
5	Red	Extreme	Projected June 1st storage is < 53% of total basin storage capacity

Drought Triggers

Drought Levels			Drought Level Triggers		
RESPONSE LEVEL	WATER SHORTAGE DESCRIPTION	GENERAL DESCRIPTION	PROJECTED JUNE 1ST TOTAL BASIN STORAGE [1]	PROJECTED JUNE 1ST TOTAL UPSTREAM BASIN STORAGE (ACRE-FEET)[2]	U.S. DROUGHT MONITOR INTENSITY CLASSIFICATION[3]
1	Normal	Projected June 1st storage greater than 72% of total basin storage capacity, normal or better snowpack	Greater than 380,000	Greater than 245,000	No Drought Intensity Classification to D1 (Moderate Drought)
2	Advisory	Projected June 1st storage greater than 72% of total basin storage capacity, low projected snow pack and low CBRFC flows	Greater than 380,000	Greater than 245,000	D0 (Abnormally Dry) to D3 (Severe Drought)
3	Moderate	Projected June 1st storage is 64-72% of total basin storage capacity	340,000 to 380,000	200,0000 to 245,000	D1 (Moderate Drought) to D4 (Exceptional Drought)
4	Severe	Projected June 1st storage is 53-64% of total basin storage capacity	280,000 to 340,000	160,000 to 200,000	D2 (Severe Drought) to D4 (Exceptional Drought)
5	Extreme	Projected June 1st storage is < 53% of total basin storage capacity	Less than 280,000	Less than 160,000	D3 (Moderate Drought) to D4 (Exceptional Drought)

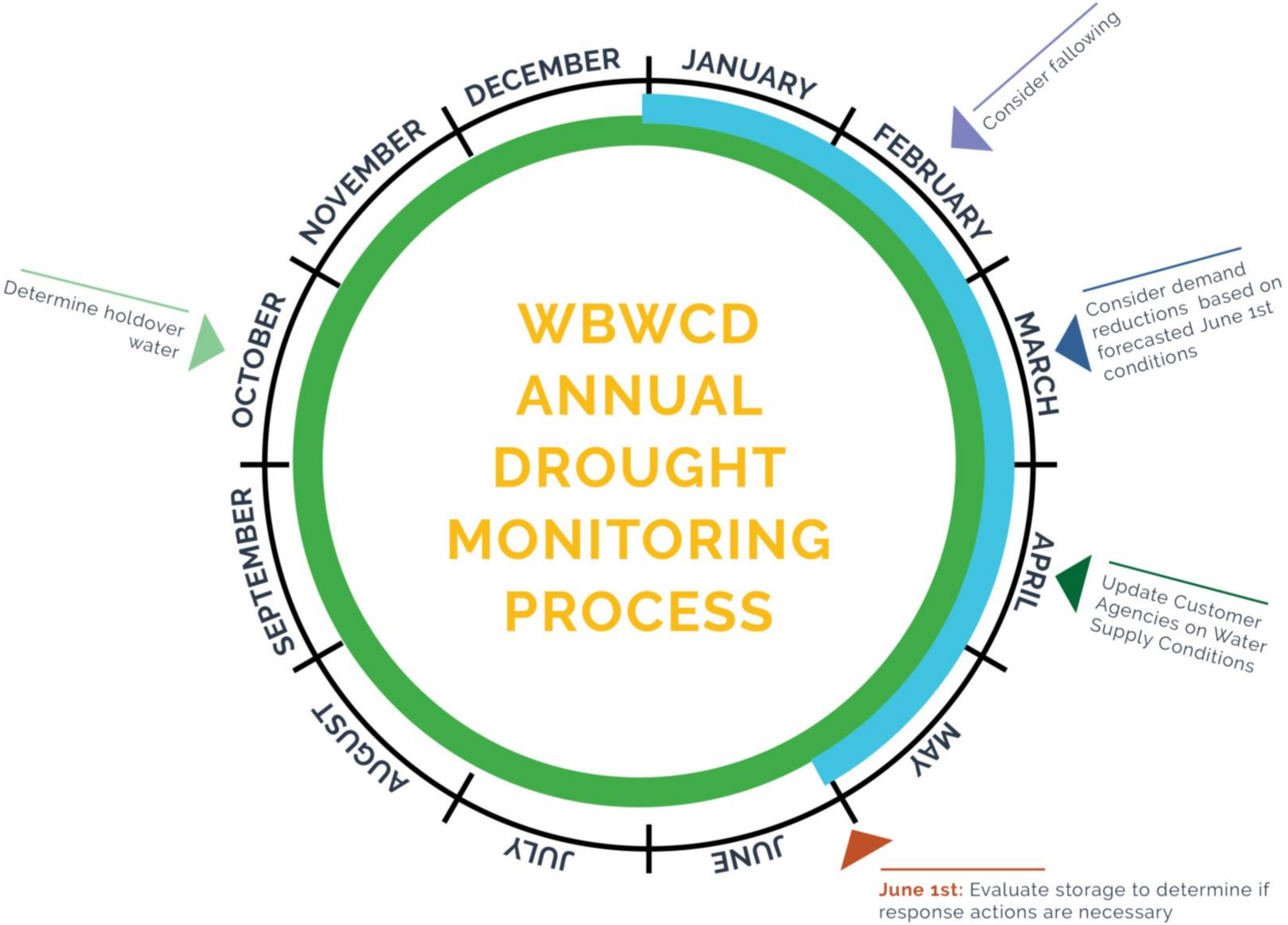


DROUGHT INDICATORS

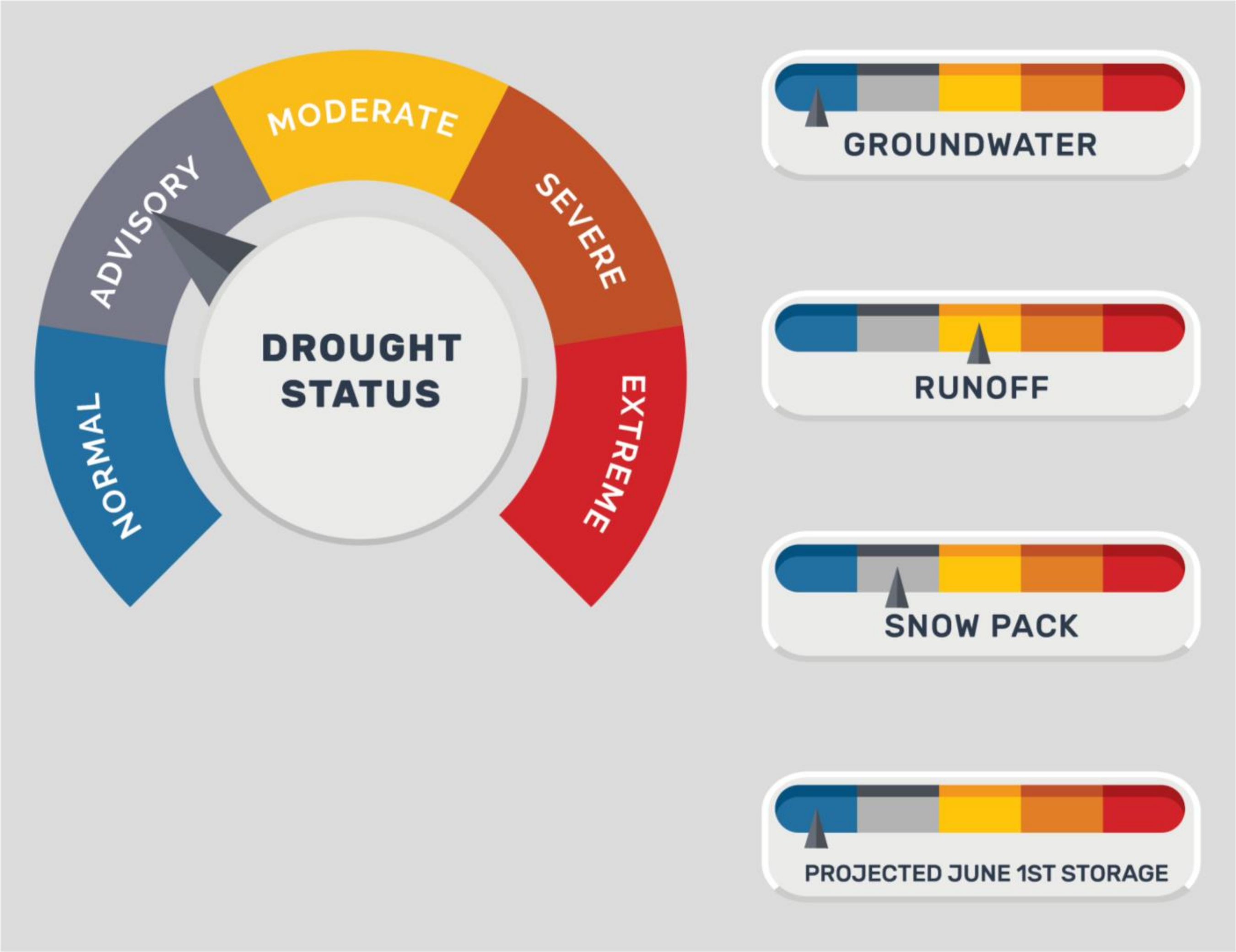
WBWCD uses other tools to actively project June 1st storage reservoir storage levels. These include:

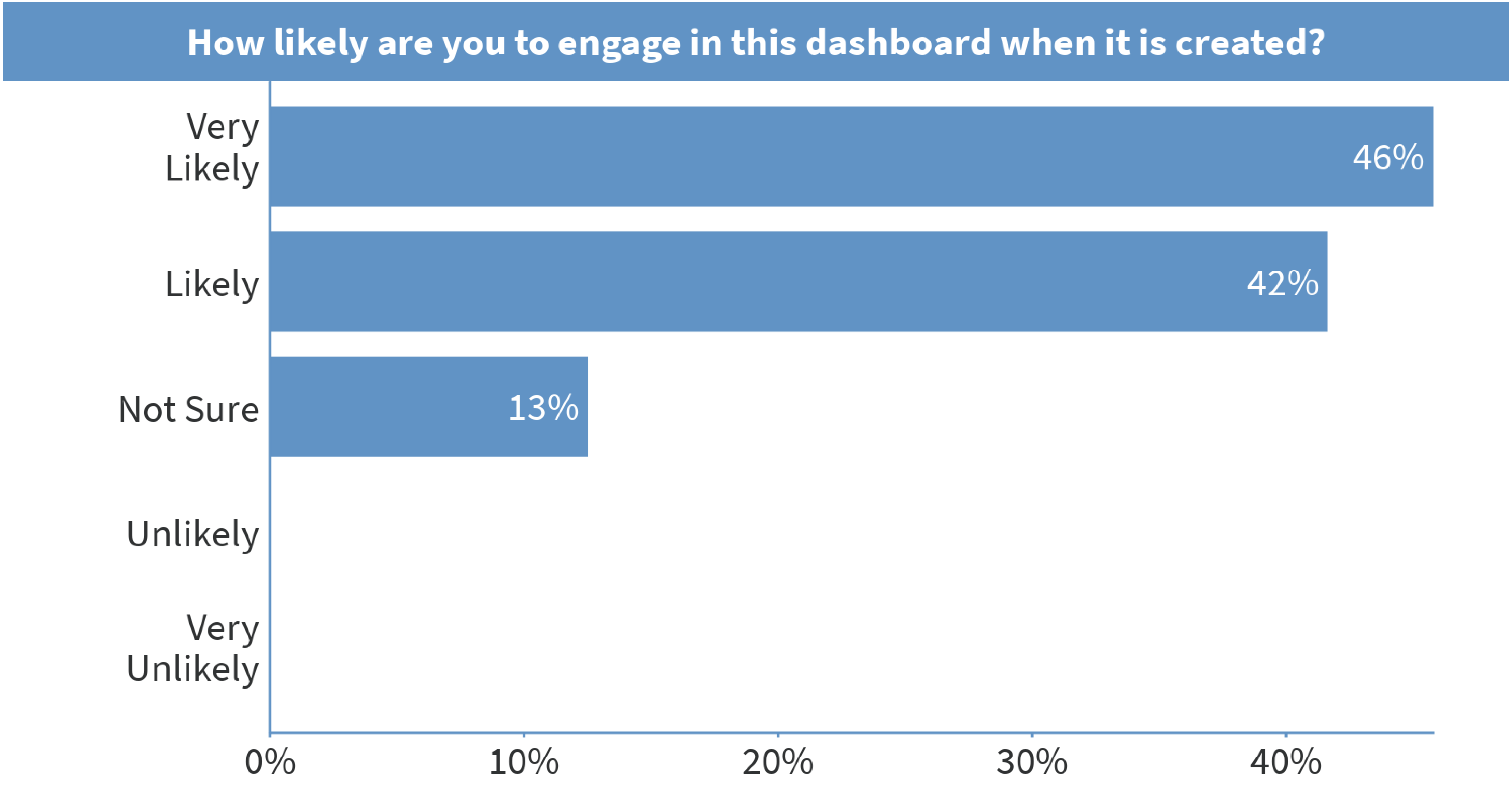
- The U.S. Drought Monitor Intensity Classification. National Drought Mitigation Center
- NRCS Snow Pack Forecasts
- Intermountain West Drought Early Warning System
- Colorado Basin River Forecast Center (CBRFC) Run-off and Snowpack Forecasts which gives outlook projections for:
    - Water supply
    - Reservoir conditions
    - Daily precipitation
    - Monthly precipitation
    - Soil moisture
    - Peak flood probability

Drought Monitoring Process



Drought Dashboard




How likely are you to engage in this dashboard when it is created?
Very Likely
46%
Likely
42%
Not Sure
13%
Unlikely
Very Unlikely
0%
10%
20%
30%
40%

What features, data, capabilities would you like to see in this dashboard?

"Definitions"

"List of suggesed conservation actions to reduce consumption"

"Provide information on website links with more data or national prospective."

"An opportunity to comment and ask questions"

"interactive dashboard. if this then what/"

"Slider bar to see recent/historical drought levels"

"Water use restrictions if necessary"

"Possibility of shortages"

"Projected drought level"

"Link to historical drought levels"

"Drought monitor link"

Soil moisture

Sub basin information

Reservoir levels

Snowpack

Projected storage

End user actions

Recommended irrigation

schedules

Actual June 1 storage number

Mitigation Measures

Mitigation measures are actions taken prior to a drought to help lessen the impacts of drought within Weber Basin.

Drought Mitigation

Measure Objectives

SUPPLY

- Increase annual WBWCD water supply for drought years or reduce usage in drought years
- Improve mobility of water supplies

FINANCIAL

- Minimize costs
- Obtain funding assistance
- Maintain revenue during drought

IMPLEMENTATION & RISK REDUCTIONS

- Reduce drought risk
- Focus on actions that are easier to implement
- Prepare communities to respond quickly to drought
- Improve communication and available information
- Improve coordination with agricultural users

ENVIRONMENT

- Minimize impacts to industry
- Minimize impacts to aquatic ecosystems
- Minimize impacts to recreation

Mitigation Evaluation

MITIGATION MEASURES	OBJECTIVES																	
	Supply			Financial					Implementation / Risk Reduction						Environment			
	Increase Annual WBWCD Water Supply for Drought Years or Reduce Usage in Drought Years		Improve Mobility of Water Supplies	Minimize Costs			Obtain Funding Assistance	Maintain Revenue During Drought	Reduce Drought Risks	[illegible] to Implement		Prepare Communities to Respond Quickly to Drought	Improve Communication / Available Information	Improve Coordination With Agricultural Users	Minimize Impacts to [illegible]	Minimize Impacts to Aquatic Ecosystems		Minimize Impacts to Recreation
	METRICS																	
	WBWCD Supply Added/Reduced Usage (Acre Feet)	Additional Years that Increased Water Will be Available During a Multi-Year Drought (Years)	Mobility Improvement	Capital Cost to Develop Water or Cost to Reduce Usage ($/Acre Foot)	Annual O&M Cost ($/Acre Foot/Year)	Debt Service and Operation and Maintenance Costs for 30 Year Life Cycle ($/Acre Foot/Year)	Grant Availability (Likelihood)	Improved Rate-Value Maintain Revenue During Drought ($)	High Risks from Risk Assessment that are Reduced (Number)	Policy Change / Political Pushback (Magnitude)	Time to Complete (Years)	Communities that are Educated about Drought (Number)	Increase in Drought Level Knowledge of Water Users in the District	Improved Coordination between WBWCD and Agricultural Users	Additional Flows in Weber River Near the Great Salt Lake During Drought (cfs)	Additional Flows in the River at Critical Times (cfs)	Potential Level of Adverse Impacts to Ecosystems	Additional Water Volume in Reservoirs During Drought (Acre Feet)
	Less than 1,000	Less than 2	None	More than $4,000	More than $250	More than $400	None	None	1	High	More than 10	None	None	None	None	None	High	None
	1,000 to 9,999	2-3	Low	$2,001 to $4,000	$101 to $250	$201 to $400	Low	Low	2	Medium	6 to 10	1 to 2	Low	Low	Low	Low	Medium	Low
	10,000 to 20,000	4-5	Medium	$250 to $2,000	$25 to $100	$50 to $200	Medium	Medium	3	Low	1 to 5	3 to 4	Medium	Medium	Medium	Medium	Low	Medium
	More than 20,000	More Than 5	High	Less than $250	Less than $25	Less than $50	High	High	More than 3	None	Less than 1	More than 4	High	High	High	High	None	High
Storage																		
Weber Canyon ASR - Develop ASR near mouth of Weber Canyon. [illegible] during drought.	10,000	2-3	Medium	$ 600	$ 60	$ 90	High	Low	2	Low	1 to 5	1 to 2	Low	None	Low	Low	Low	Low
Larrabee Storage - Develop [illegible] storage [illegible] Wasatch Back (Maple Chalk Creek)	10,000	2-3	Medium	$ 3,000	$ 10	$ 180	None	Medium	4	High	More than 10	1 to 2	Low	None	Low	Medium	Medium	Low
South Davis ASR Feasibility Study - A feasibility study to [illegible] ASR [illegible]	Less than 1,000	2-3	Low	**STUDY COST $161,000 TOTAL (SEE FOOTNOTE #2)	n/a	n/a	High	Medium	2	Medium	6 to 10	1 to 2	Low	None	None	None	None	None
Bear River Storage Allocation - Develop Bear River allocation.	50,000	4-5	Low	$ 7,500.00	$ 30	$ 380	Low	Medium	6	High	More than 10	1 to 2	Low	None	Low	None	High	More than 20,000
Agreements																		
Short-Term Transfer Agreements - Create a program and get contracts in place to compensate large agricultural users to fallow land or allow [illegible]	10,000	More Than 5	High	$ 20	$ 10	$ 110	Low	Medium	3	Medium	1 to 5	None	Medium	High	Low	None	Medium	Medium
Water Sharing Agreements - Create interagency agreements with customer agencies within the District boundaries to [illegible] during drought years.	2,500	More Than 5	High	$ 20	$ 5	$ 190	None	Medium	2	High	1 to 5	None	Low	Low	None	None	None	None
Ogden City Pineview Water Sharing Agreement - Coordinate with Ogden City to determine if 4,500 shares of water in Pineview are available to purchase or lease from Ogden. Ogden owns 10,000 acre feet, but only about 4,500 acre feet are available for use. Ogden typically uses WBWCD water instead of this Pineview water. The Pineview water is a very high priority right. Determine if an agreement can be reached to purchase or lease the water for drought mitigation.	4,500	More Than 5	High	$ 3	n/a	$ 180	None	Medium	4	High	1 to 5	1 to 2	Low	None	None	None	Low	None
Flow Measurement																		
WBWCD Secondary Water Metering - Meter all secondary WBWCD water users and provide usage reports to the users. Save 25% average when going to meters. 11,000 services left to meter at a cost of $1,200 per service.	4,000	More Than 5	Medium	$ 4,600	$ 50	$ 264	High	Medium	3	Medium	6 to 10	More than 4	High	None	Medium	Low	Low	Medium
Other Systems Secondary Water Metering - Start a WBWCD program to provide secondary water metering technical assistance and meter installation assistance for secondary systems in the District boundaries, but not owned by the District. Assume 20,000 meters added.	28,000	More Than 5	None	$ 4,600	$ 50	$ 265	High	Medium	3	Medium	More than 10 (Approx. 25 years)	More than 4	High	None	Medium	Low	Low	Medium
Rate Structures																		
Drought Surcharge Fees - Study and develop a secondary water drought surcharge fee structure for Weber Basin to utilize during drought periods. Fee structures will provide revenue needed for system operation and maintenance and to fund response actions during droughts. (assume all secondary connections are metered)	31,000	More Than 5	None	*STUDY COST $125,000 TOTAL SEE FOOTNOTE #2	n/a	n/a	None	High	3	Medium	1 to 5	None	Medium	None	Low	None	None	Medium
Create New Tiered Rate Structure and Short Term Transfer Water Fund - Create a fund prior to a drought to purchase water through short term transfer agreements during times of drought. Use overage fees from water users that exceed a certain level of water use in any given month.	5,200	More Than 5	None	$ 20	n/a	$ 7	None	Medium	3	Medium	1 to 5	None	Medium	None	Low	None	None	Medium
Water Re-use																		
Water Reuse Project - Create a reclaimed water reuse agreement with one of the treatment facilities located in the District. Build infrastructure needed to utilize reclaimed water for secondary water.	8,000	More Than 5	Medium	$ 4,700.00	$ 340	$ 560.00	Medium	Medium	3	High	6 to 10	None	Low	None	None	None	High	High
Education																		
Drought Surcharge Fees Education - Educate cities and the public about rate structures. Prepare a sample ordinance to provide for cities for drought water rate adjustments. Visit cities to explain the rate structures and the benefits (30 customer agencies).	Less than 1,000	More Than 5	None	$ 19	n/a	$ 0.86	None	High	3	Medium	More than 10	More than 4	High	None	Medium	None	None	Low
Drought Plan Results - Present the drought plan process findings and recommendations to cities and irrigation companies in the District by visiting city council meetings and irrigation meetings. Education about usage reductions that will be needed during different drought stages.	Less than 1,000	Less than 2	None	STUDY COST $87,000 TOTAL SEE FOOTNOTE #1	n/a	n/a	None	Medium	3	None	1 to 5	More than 4	High	High	Low	None	None	Medium
Internet Water Supply Dashboard - Create a web based system that reports current performance of system and drought level and informs people what water conservation actions they should be implementing.	1,000 to 9,999	More Than 5	None	$ 20	$ 0.15	$ 1.00	Med	Medium	4	None	1 to 5	More than 4	High	Low	Low	None	None	Medium
Assistance for Other Secondary Systems - Help secondary distribution system managers (retail systems) manage their systems more efficiently to conserve water.	Less than 1,000	Less than 2	None	$ 120	n/a	$ 0.06	Low	None	1	Medium	More than 10	More than 4	Medium	Less than 500	Low	Low	None	None
Habitat Improvement Collaboration																		
Advisory Group Meetings - Meet regularly with Utah Division of Wildlife Resources, Trout Unlimited, Utah Division of Forestry, Fire, and State Lands, other advisory groups stakeholders and key habitat stakeholders to coordinate drought strategies including river operation strategies that will make the river more drought resilient. Strategies may include river braiding, connectivity improvements for better habitat, improved management of water during wet years for more consistent flows and better GSL inflows, water rushing through the river to clean channels during wet years, etc.	Less than 1,000	Less than 2	None	MEETING COST $5,000 PER YEAR (SEE FOOTNOTE #1)	n/a	n/a	None	None	3	None	Less than 1	None	Low	Low	High	High	None	Medium
Distribution																		
Salt Lake Interconnect Feasibility Study - Do a study to determine the feasibility of making an agreement and a physical connection between the WBWCD system and the Salt Lake City or Jordan Valley Water Conservancy District System. An interconnection would provide some redundancy on the south end of the WBWCD service area.	Less than 1,000	Less than 2	Medium	STUDY COST $71,500 TOTAL SEE FOOTNOTE #1	n/a	n/a	High	Medium	2	Low	1 to 5	None	None	None	Medium	None	None	None
Line and Expand Capacity of Willard Canal - Line the remaining unlined section of Willard Canal (approximately 7 miles) with concrete. Assume 2,000 feet of canal lined each year for 19 years. Increases capacity of canal to 2,000 cfs	5,000	More Than 5	Low	$ 21,100	Medium	$ 980	High	Medium	2	Low	More than 10	None	None	None	Low	Medium	Low	Low

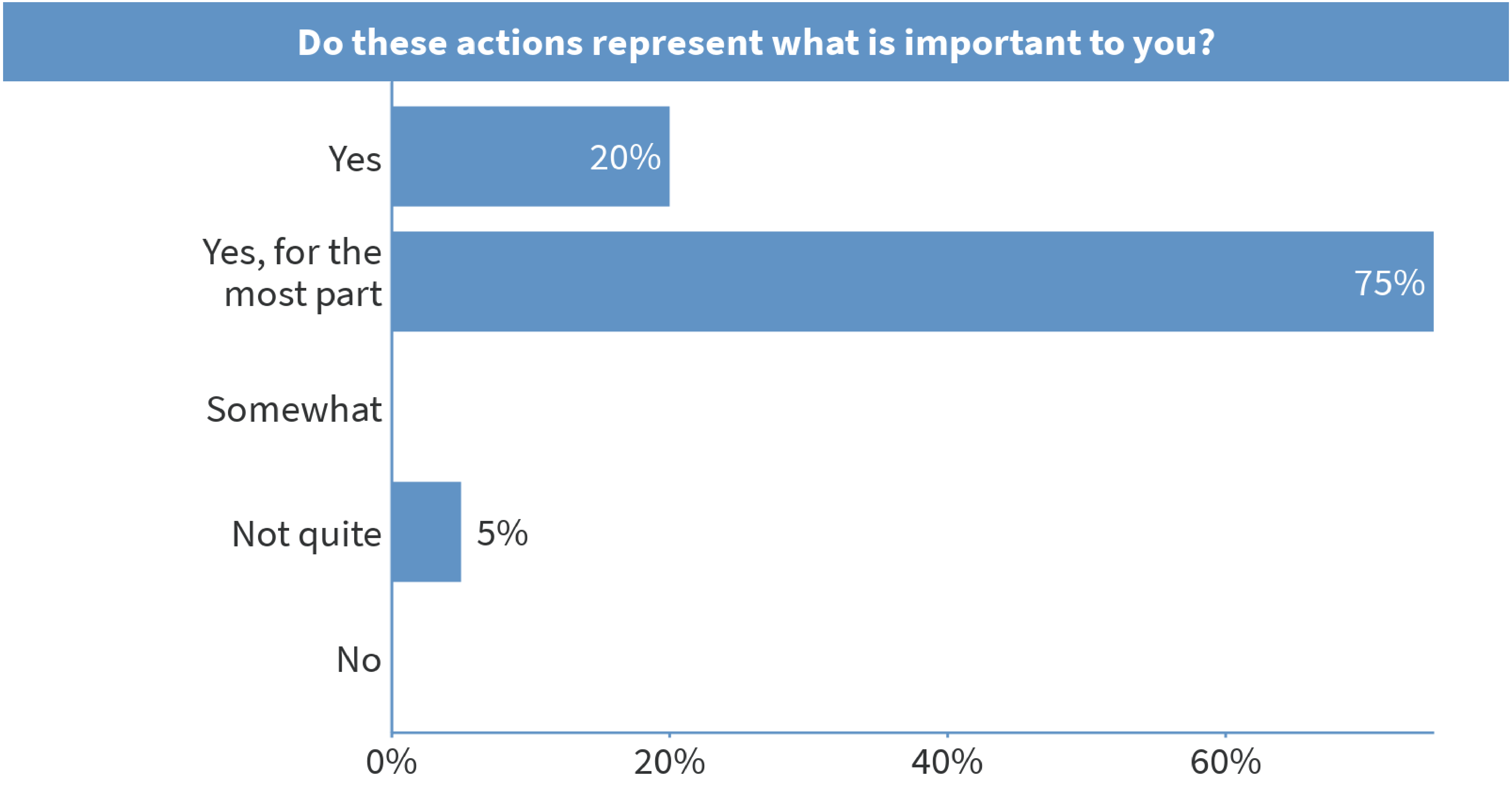
Top 10 Mitigation Actions

TYPES OF MEASURES EVALUATED

- STORAGE
- AGREEMENTS
- FLOW MEASUREMENT
- RATE STRUCTURES
- WATER REUSE
- EDUCATION
- HABITAT IMPROVEMENTS

Top 10 Mitigation Actions

1	**Short-Term Transfer Agreements** - Create a program and get contracts in place to compensate large agricultural users to fallow land or plant drought tolerant crops when asked.
2	**Internet Water Supply Dashboard** - Create a web based system that reports current performance of system and drought levels and informs people what water conservation actions they should be implementing.
3	**Drought Surcharge Fees** - Study and develop a secondary water drought surcharge fee structure for Weber Basin to utilize during drought periods. Fee structures will provide revenue needed for system operation and maintenance and to fund response actions during droughts. (Assume all secondary connections are metered)
4	**WBWCD Secondary Water Metering** - Meter all secondary WBWCD water users and provide usage reports to the users. Save 35% average when going to meters. 11,000 services left to meter at a cost of $1,200 per service.
5	**Other Systems Secondary Water Metering** - Start a WBWCD program to provide secondary water metering technical assistance and meter installation assistance for secondary systems in the district boundaries, but not owned by the District. Assume 80, 000 meters needed.
6	**Drought Surcharge Fees Education** - Educate cities and the public about rate structures. Prepare a sample ordinance to provide for cities for drought water rate adjustments. Visit cities to explain the rate structures and the benefits (50 customer agencies).
7	**Drought Plan Results** - Present the drought plan process findings and recommendations to cities and irrigation companies in the district by visiting city council meetings and irrigation meetings. Education about usage reductions that will be needed during different drought stages.
8	**Weber Canyon ASR** - Develop more ASR near mouth of Weber Canyon. Use purchased Echo or East Canyon water in wet years to be used later during drought.
9	**Continue meetings with Division of Wildlife Resources, Trout Unlimited, and other habitat stakeholders** to better define strategies to make river habitat more drought resilient while still meeting water delivery requirements. Strategies may include stream connectivity improvements and water pulsing through the river to clean channels during wet years.
10	**Create New Tiered Rate Structure and Short Term Transfer Water Fund** - Create a fund prior to a drought to purchase water through short term transfer agreements during times of drought. Use overage fees from water users that exceed a certain level of water use in any given month.


Do these actions represent what is important to you?
Yes
20%
Yes, for the most part
75%
Somewhat
Not quite
5%
No
0%
20%
40%
60%

Response Actions

A planned action taken after a drought level trigger event occurs. The purpose of a response action is to manage the resulting impact of an adverse event.

Demand Reduction Targets

Drought Levels		Demand Reduction Targets				
RESPONSE LEVEL	WATER SHORTAGE DESCRIPTION	SECONDARY WATER[4]	AGRICULTURAL IRRIGATION[5]	M&I CULINARY OUTDOOR WATER[4]	M&I CULINARY INDOOR WATER[4]	TOTAL YEAR 2020 DEMAND REDUCTION (ACRE-FEET)[5]
1	Normal	0%	0%	0%	0%	0
2	Advisory	Reduce demands through messaging and general water conservation				0 to 43,000
3	Moderate	20%	20%	20%	0%	43,000
4	Severe	60%	40%	60%	10%	123,000
5	Extreme	95%	70%	95%	25%	206,000

General Strategies to Meet Targets

Drought Levels		Demand Reduction Targets
RESPONSE LEVEL	WATER SHORTAGE DESCRIPTION	STRATEGIES TO REACH DEMAND REDUCTION TARGETS
1	Normal	Continue current conservation efforts to meet statewide goal to reduce usage by 25% between year 2000 and 2025
2	Advisory	Begin messaging to inform the public that water shortages are possible if drought conditions continue and that additional conservation efforts are needed.
3	Moderate	Increased messaging, implement yellow drought rates and shortened irrigation season
4	Severe	Increased messaging, implement orange drought rates, exercise fallowing agreements, cut watering of lawns in half, reduce agricultural water use, start indoor water reduction strategies.
5	Extreme	Increased messaging, implement red drought rates, exercise fallowing agreements, no residential lawn watering (trees and gardens yes)

Drought Return Periods

1. ## Moderate

Every 7 years since 1971. Assume every 7 years.

2. ## Severe

Every 60 years. Assume every 60 years or so.

3. ## Extreme

Every 135 years. Assume every 100 years or so.

Related to These Drought Return Periods,

Select the EARLIEST LEVEL these actions should be taken

3 Moderate

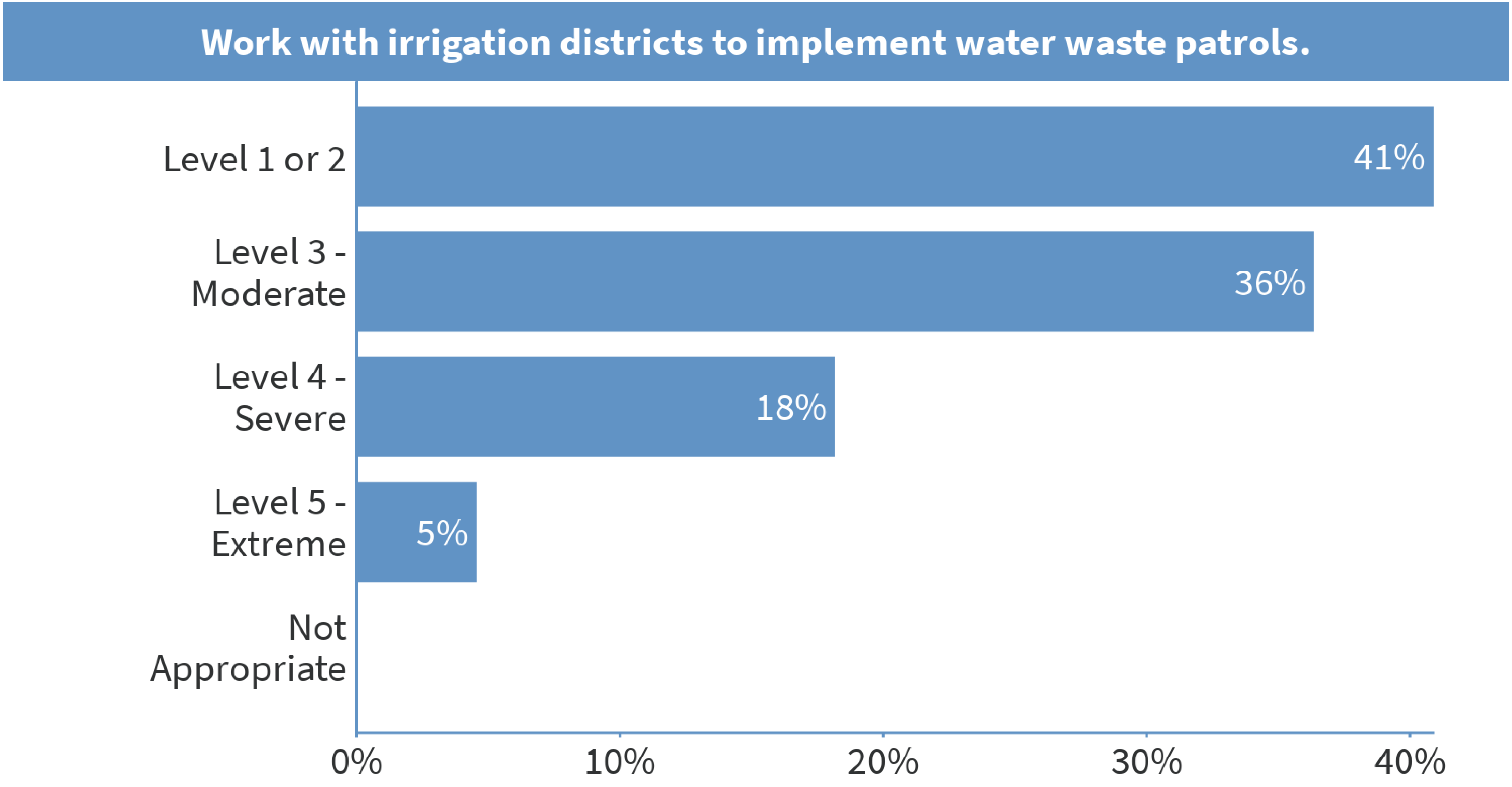
Every 7 years since 1971. Assume every 7 years.

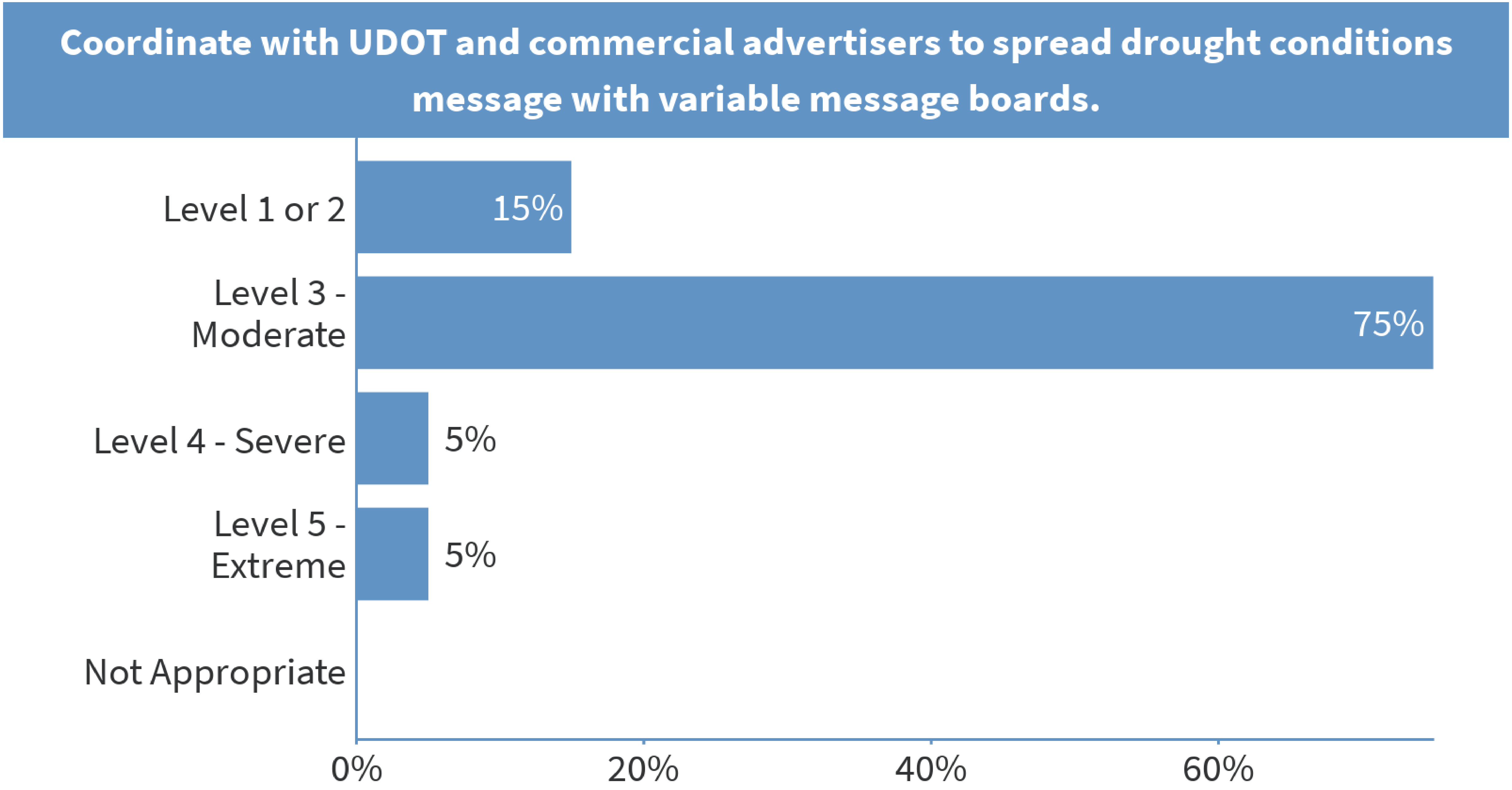
4 Severe

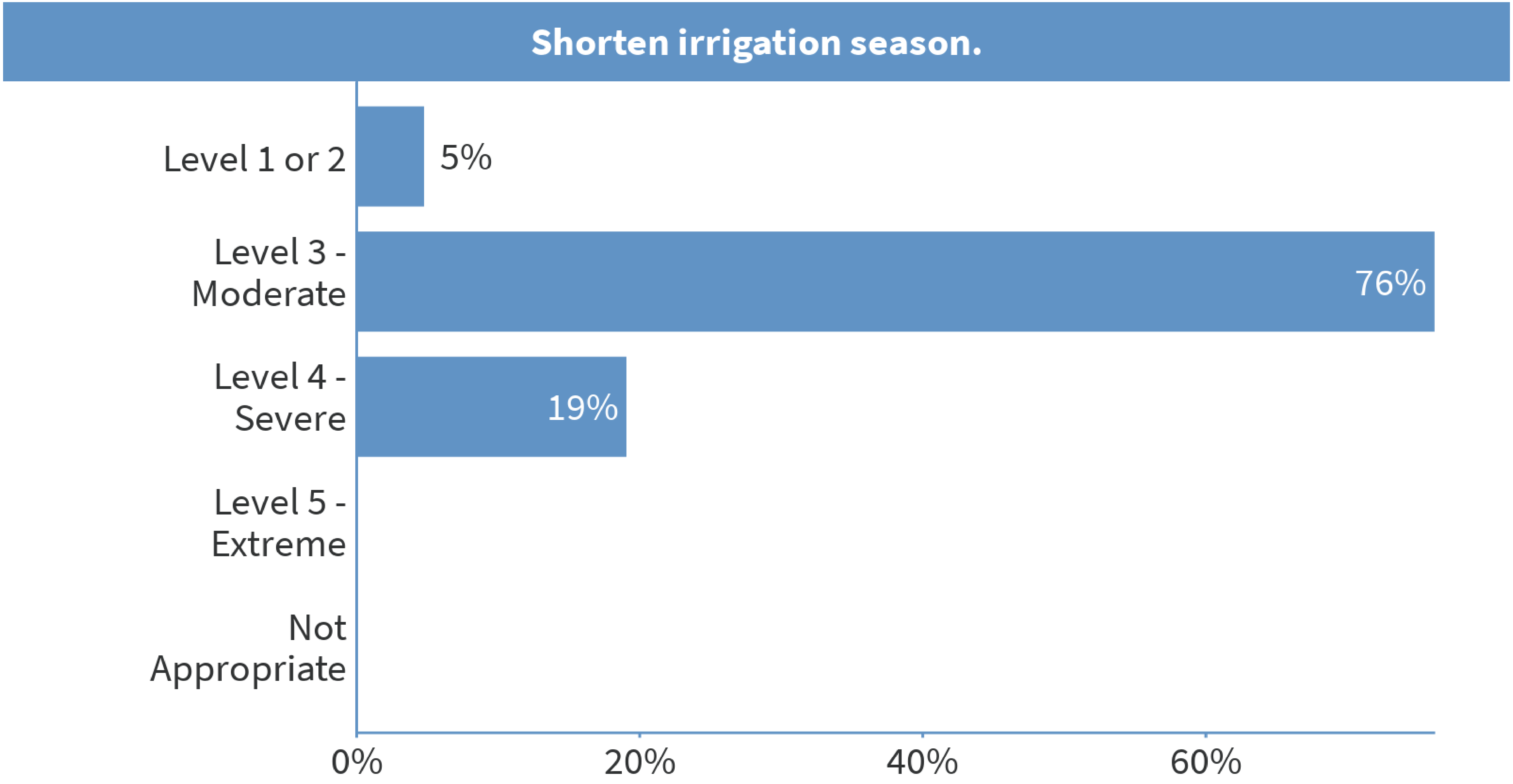
Every 60 years. Assume every 60 years or so.

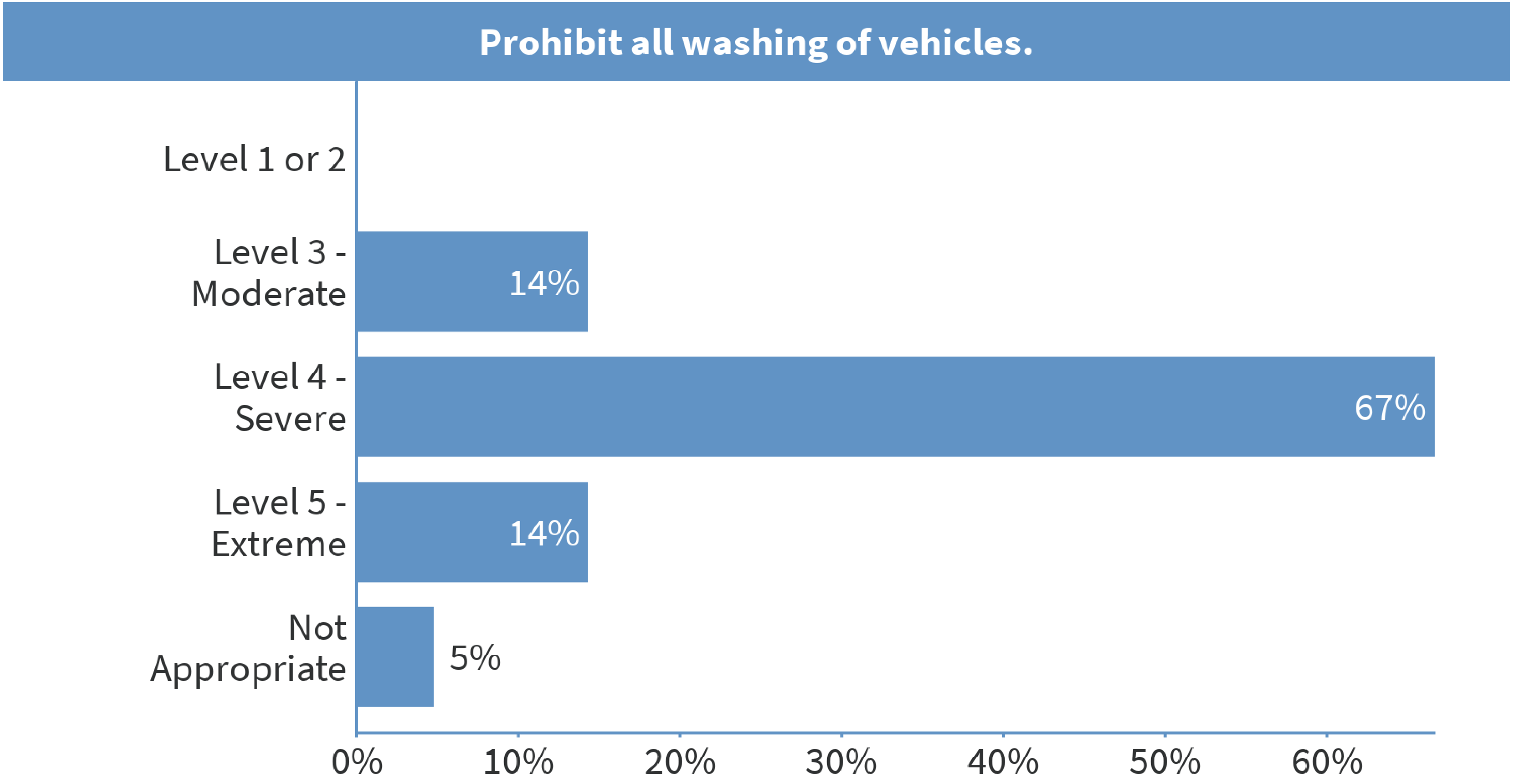
5 Extreme

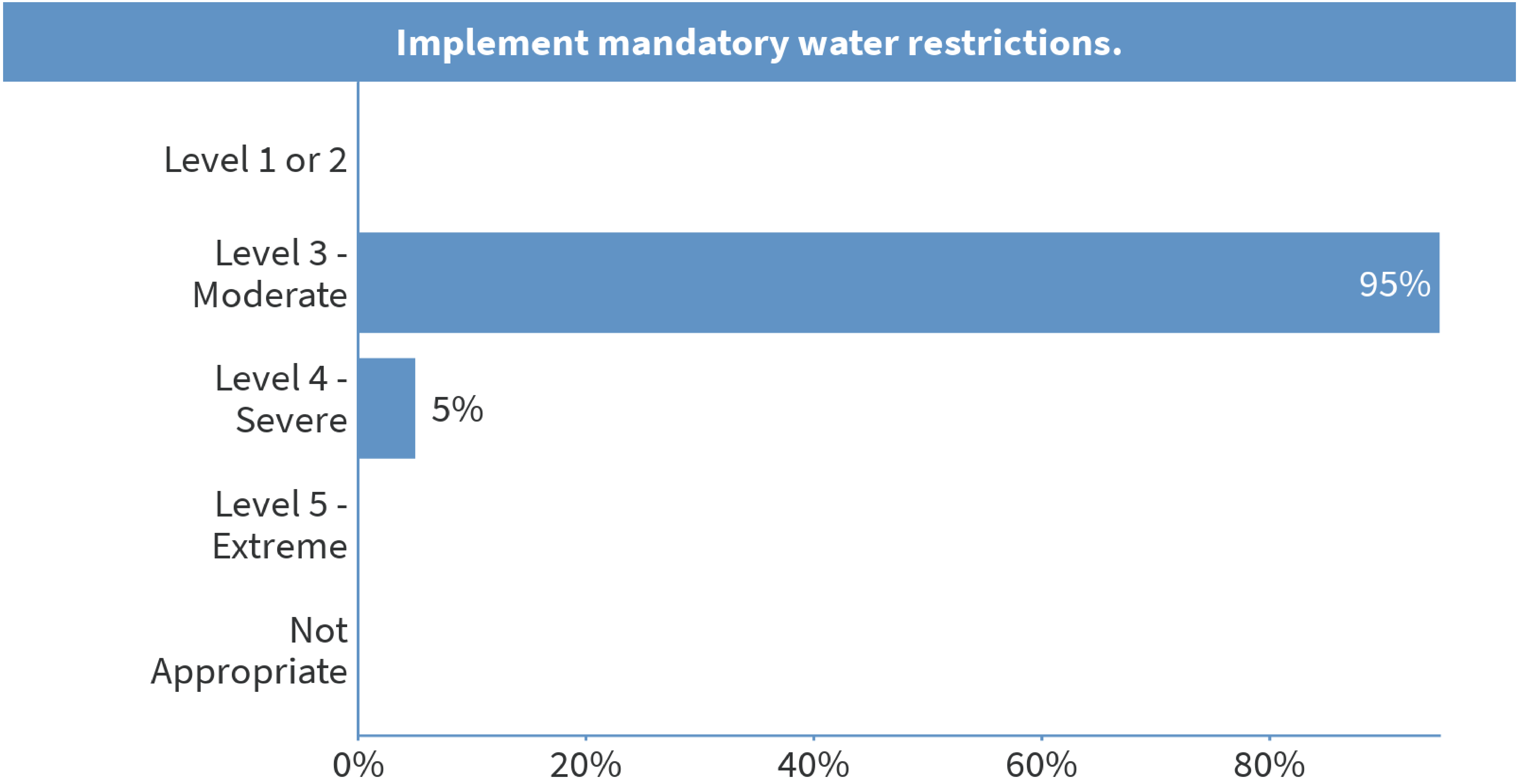
Every 135 years. Assume every 100 years or so.

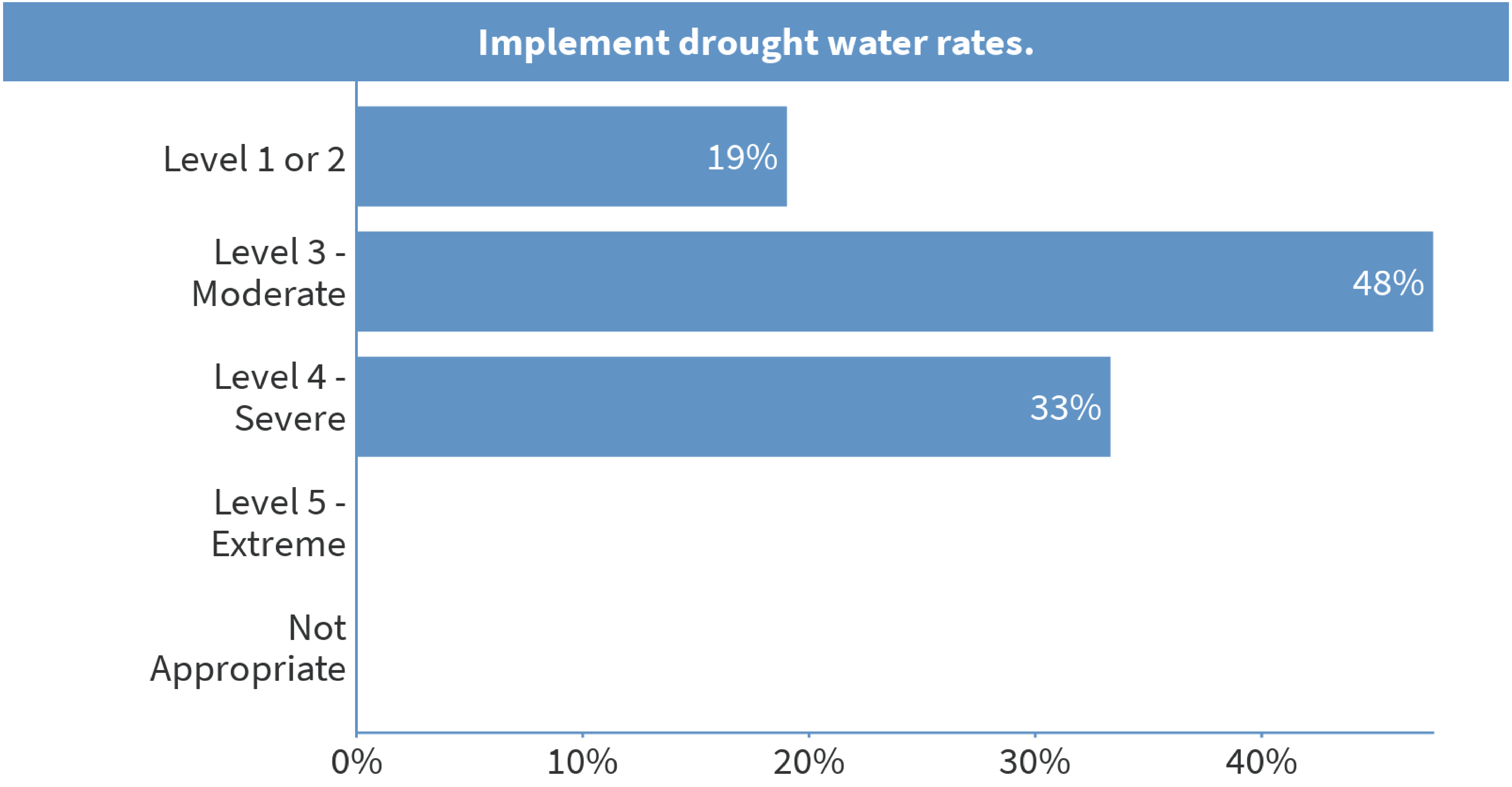

Work with irrigation districts to implement water waste patrols.
Level 1 or 2
41%
Level 3 - Moderate
36%
Level 4 - Severe
18%
Level 5 - Extreme
5%
Not Appropriate
0%
10%
20%
30%
40%

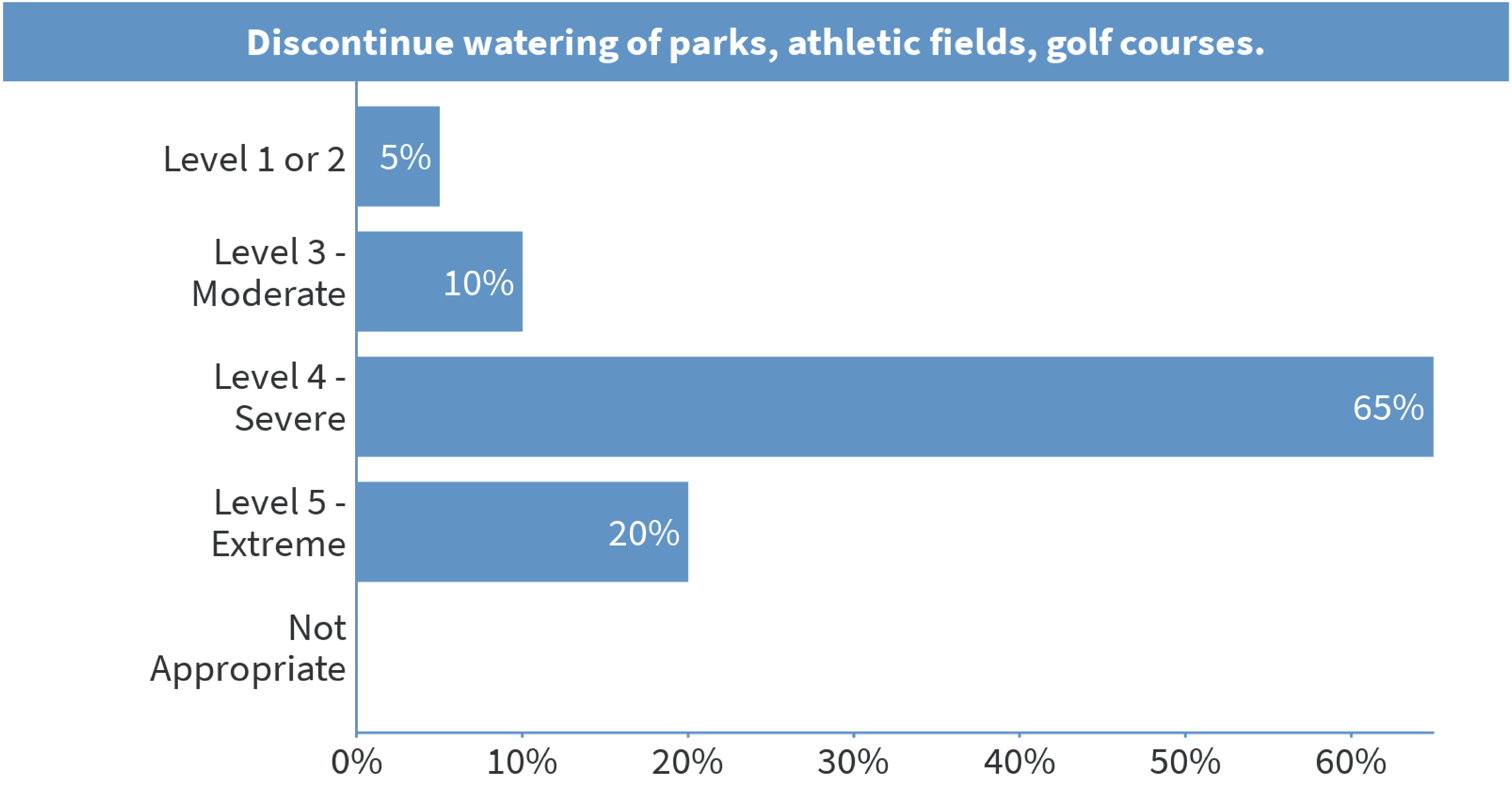

Coordinate with UDOT and commercial advertisers to spread drought conditions message with variable message boards.
Level 1 or 2
15%
Level 3 - Moderate
75%
Level 4 - Severe
5%
Level 5 - Extreme
5%
Not Appropriate
0%
20%
40%
60%

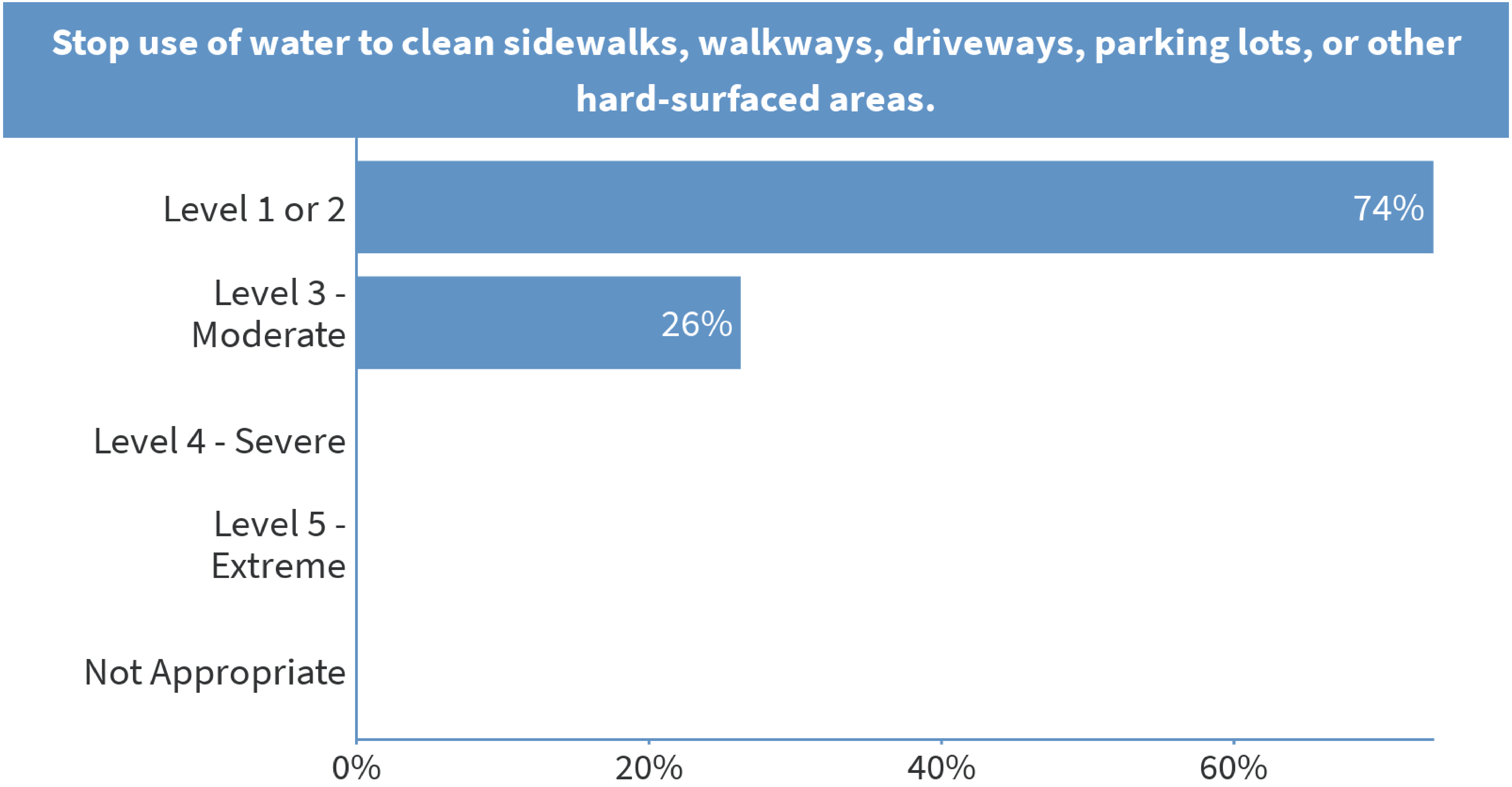

Shorten irrigation season.
Level 1 or 2
5%
Level 3 - Moderate
76%
Level 4 - Severe
19%
Level 5 - Extreme
Not Appropriate
0%
20%
40%
60%


Prohibit all washing of vehicles.
Level 1 or 2
Level 3 - Moderate
14%
Level 4 - Severe
67%
Level 5 - Extreme
14%
Not Appropriate
5%
0%
10%
20%
30%
40%
50%
60%


Implement mandatory water restrictions.
Level 1 or 2
Level 3 - Moderate
95%
Level 4 - Severe
5%
Level 5 - Extreme
Not Appropriate
0%
20%
40%
60%
80%


Implement drought water rates.
Level 1 or 2
19%
Level 3 - Moderate
48%
Level 4 - Severe
33%
Level 5 - Extreme
Not Appropriate
0%
10%
20%
30%
40%


Discontinue watering of parks, athletic fields, golf courses.
Level 1 or 2
5%
Level 3 - Moderate
10%
Level 4 - Severe
65%
Level 5 - Extreme
20%
Not Appropriate
0%
10%
20%
30%
40%
50%
60%


Stop use of water to clean sidewalks, walkways, driveways, parking lots, or other hard-surfaced areas.
Level 1 or 2
74%
Level 3 - Moderate
26%
Level 4 - Severe
Level 5 - Extreme
Not Appropriate
0%
20%
40%
60%

OPERATIONAL AND ADMINISTRATIVE FRAMEWORK

1. WATER SUPPLY MANAGER ANALYZES DATA
2. UPDATE TO GENERAL MANAGER
3. MONTHLY WATER SUPPLY REPORT TO BOARD OF TRUSTEES
4. UPDATE DASHBOARD MONTHLY
5. GENERAL MANAGER GIVES PUBLIC UPDATES

Summary

Manager Fjeldsted stated we have been getting excellent cooperation from the cities and towns with reference to increasing our water supply. The Navy Supply Depot was cooperative, however, we learned we could not use their well because of the difference in pressure. Sunset turned on their well and the water is going into the canal. We met with Ogden City's Manager and the Superintendent of Waterworks, as well as the City Engineer. They seem to be agreeable to our plan that they start pumping and we would pay them $8 per acre-foot for every drop they save… Layton Sugar Company and North Salt Lake are willing to let us run their wells. **We have contacted no one who has not been willing to cooperate with us**.

– WBWCD Board of Trustees Meeting Minutes 5/19/1961

Appendix 2-G

Municipal Sub-committee Meeting Minutes
November 1, 2017

Weber Basin Drought Contingency Plan
Culinary Providers Meeting
November 1, 2017 9 a.m.

*** The slideshow and examples were used for discussion purposes only*

Darren welcomed group and gave brief background on Weber Basin's Drought Contingency Plan

Chris discussed recent drought history, projections, extreme events and Weber Basin's responses

- Drought History
  - 2014 - 20% reduction in irrigation
  - 2013 and 2015 – Shortened irrigation season
- Extreme Events – according to tree rings
  - Longest drought duration in 1705
    - 13.6 years 6.0% minimum
  - Worst Severity in 1930's
    - 7.2 years with 0.9% minimum

Chris discussed risk evaluation (High Risk, Moderate Risk and Low Risk)

Examples of High Risk

- Loss of Weber River holdover water
- Inability to deliver culinary water
- Inability to deliver agricultural water
- Inability to meet environmental flows
- Severe reduction of power generation
- Low storage (less than 50% in March)
- Lack of agreements of MOU's

Examples of Moderate Risk

- Inability to use Larrabee storage right Weber River
- Inability to deliver secondary
- Failure to gain public support

Examples of Low Risk

- Management decision making failure
- Failure to plan for natural disasters

Culinary providers discussed and identified potential risks during a drought

- Inability to provide the culinary water the city has purchased from Weber Basin
- Managing culinary water would be difficult during a drought
- Would the cities wells be able to hold up over a prolonged drought
  - Additional concerns if a well goes out
- Loss of infrastructure, recreation and green space
- Increased development with less water to support it
- Health and sanitation issues
- Financial reserves

    - How will cities revenues do during drought year?
    - Would pushing conservation too much hurt city's finances?
- Hard to tell residents to conserve but still hit them with a high water bill

Chris discussed mitigation actions with the group

- Weber Basin informed the group of the success they have seen with metering (a reduction of 30-40%)
    - Monthly statements help educate the public on how much water they are using
    - Those that are unmetered had more usage
    - Homes that were metered kept use down, even during a good water year (saved 52%)
- Public education
    - Get people in the habit of conserving even during a good year.
    - Droughts and landscape
        - Changing to local scape with more shrubs, landscape rock and drip irrigation
    - Brochures that go to new homes
    - Ogden City gave an example of their Water Conservation Officer. Each month he reviews the water metering and will educate each homeowner.
- Public involvement
- Ogden city informed the group how their website lays out a resident's water bill and shows them exactly what they are paying for
    - This has helped educate the public
    - They are looking into new software that will allow customers to look at their bill on their phones. Implement a fixed based system that will pick up the meter reading and help them keep track of their water usage and will notify them when it is too high.
    - Fixed based system picks up reading on meter and customers can look at their account, usage and keep track of it.
- Discussed Weber Basin wanting to work with a developer to put in local scape in front of a model home

Chris discussed response actions and drought levels with the group

- Weber Basin informed the group that they make the decision on where to make cuts in March of each year
    - Expressed that without meters, it's hard to enforce cutting back
- Each city has a city council – changes from time to time
    - Decision makers and political bodies look to the culinary providers for guidance in this situations
- Culinary Water
    - Group discussed that there needs to be a regional approach where everyone who is culinary gets cut equally
        - Needs to be consistent
        - This would require every city to be on the same page
- Group discussed that secondary water doesn't matter as much as culinary

How does Weber Basin get info to the public during a water shortage?

- Newsletter
- Notice in paper, website, Facebook and on water statements
- Press release

The group participated in an exercise where they identified where they would place water cuts during a moderate (Yellow), severe (Orange) and extreme (Red) drought

- Yellow
  - Secondary - 20% cut (would be the first to get cut)
  - Agriculture – 20% cut
  - M&I Culinary Water Outdoor - 20% cut
  - M&I Culinary Water Indoor – 0% cut
    - Cutting industrial could affect North Salt Lake's oil customer.
- Orange
  - Secondary - 60-70% cut (People will start to voluntarily shut water off)
  - Agriculture – 40% cut
  - M&I Outdoor – 60-70%
  - Indoor – Implement rate structure – 20%
    - Take into account how many people in a home
- Red
  - In the red zone, Weber Basin would be at less than half of what they typically deliver
    - Barely get by with only M&I use
    - Decision gets made in March for how much water will get used that year
    - Would other states help? Would it be considered a natural disaster?
    - Will senior right holders allow Weber Basin to share for agriculture?
  - Secondary – 100% cut
  - Agriculture – 80-90% cut (enough water for animals)
  - M&I Outdoor – 100% cut
  - M&I – Special rate structure 50% cut
  - High fire year – will there be enough water for firefighters?
  - Implement high fines for watering

Mitigation actions during 2013 – 2015 drought

- Most cities didn't get far enough into putting actual restrictions into place
  - Most was residents voluntarily cutting back
- Many cities made fliers and believed it to be effective for the situation
- Kaysville city cut watering to the parks
- Weber Basin cut usage two weeks early
  - Saves between 3,000-5,000 acre feet of water

DROUGHT CONTINGENCY PLANNING

Culinary Providers Meeting

01 Nov 2017

Weber Basin Water Conservancy District

J·U·B ENGINEERS, INC.

THE LANGDON GROUP

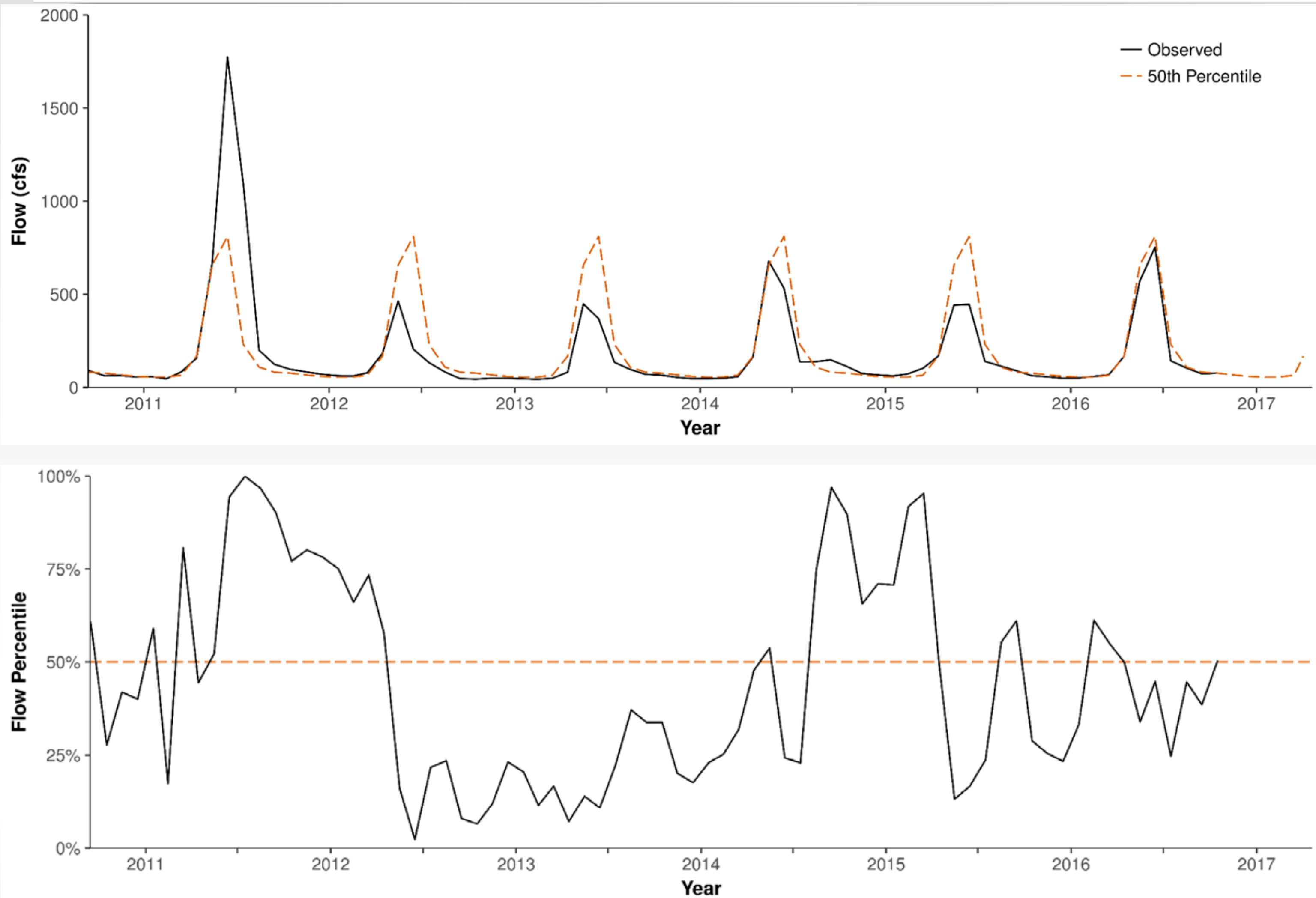
GATEWAY MAPPING INC.

OTHER J-U-B COMPANIES

Meeting Agenda

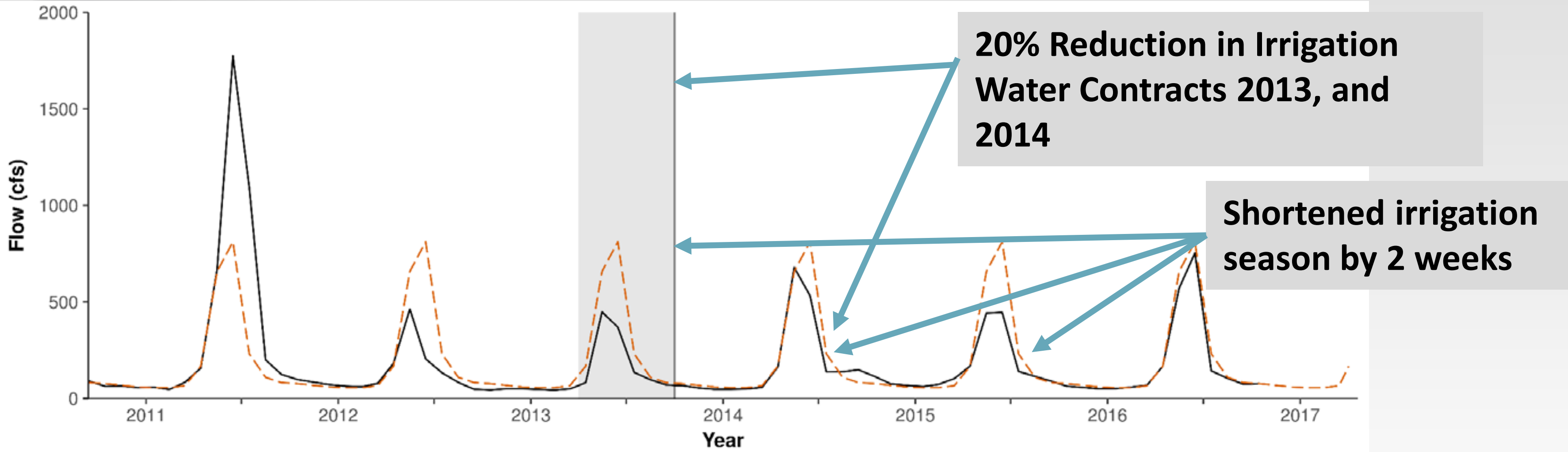
- Welcome/Project Overview (5 min)
- Drought History and Projections (5 min)
- Overview of WBWCD Drought Risks (15 min)
- Mitigation Actions (20 min)
- Break (5 min)
- Response Actions (30 min)
- Next Steps (5 min)

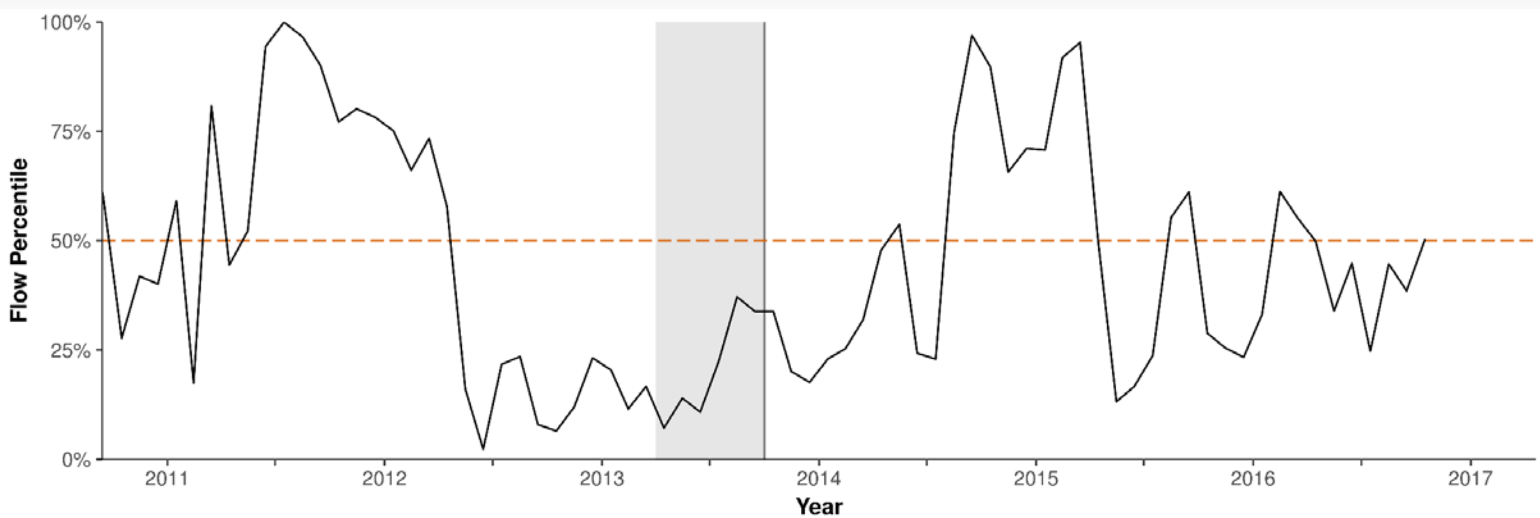
Recent Drought History



Data Provided by USU

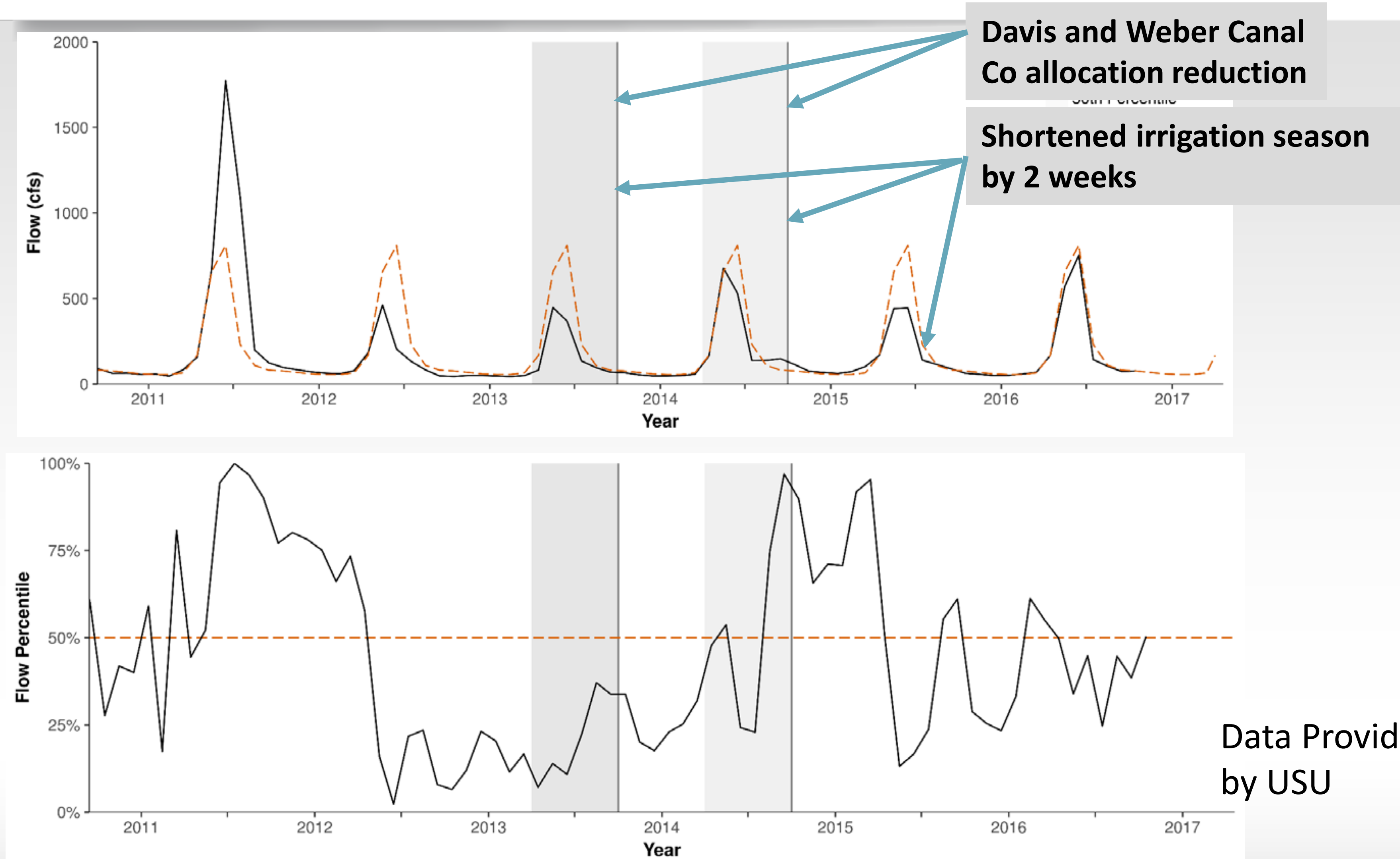
Weber Basin Responses





Data Provided by USU

Davis and Weber Canal Responses



Data Provided by USU

Extreme Events

Longest Duration (1705)

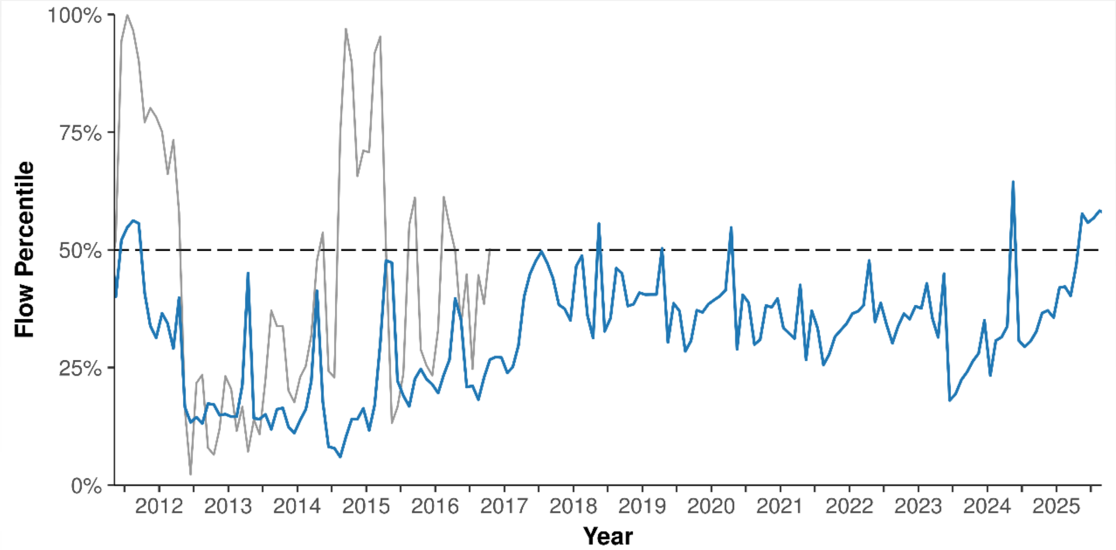
13.6 years

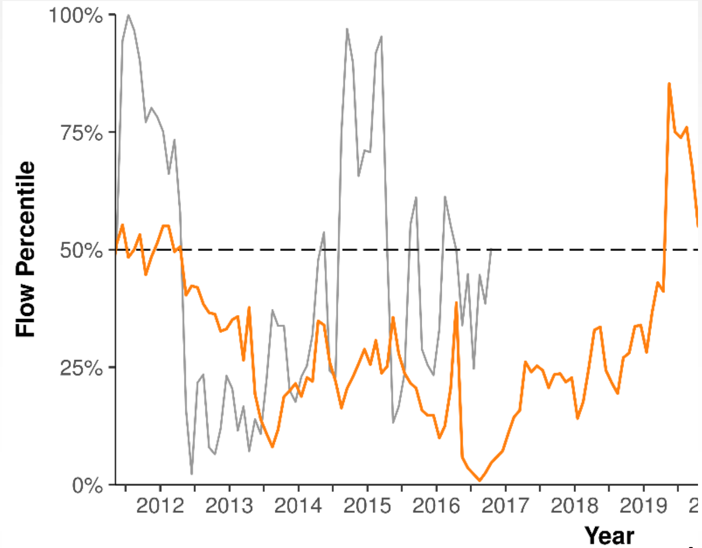
6.0% minimum

Worst Severity (1930)

7.2 years

0.9% minimum





Data Provided by USU

- **View full results at** www.paleoflow.org

High Risks

- Loss of Weber River holdover water
- Inability to deliver culinary water
- Inability to deliver agriculture water
- Inability to meet environmental flows
- Severe reduction of power generation
- Low storage (less than 50% in March)
- Lack of agreements or MOU's

Moderate Risks

- Inability to use Larrabee storage right on Weber River
- Inability to deliver secondary (lawn and garden Water)
- Failure to gain public support
- Failure to maintain infrastructure
- Wasteful watering

Low Risks

- Management decision making failure
- Failure to plan for natural disasters

Mitigation Action Definition

Measures that we can take prior to a drought to help lessen the impacts of potential drought within Weber Basin.

Mitigation Actions

- Increase storage
- Create fallowing agreements
- Public education about droughts
- Manage flows during wet years
- Store water higher in the basin
- Improve connectivity for better habitat
- Build financial reserves
- Build inter-system relationships
- Improve delivery systems
- Create inter-agency water sharing agreements
- Create re-claimed water re-use agreements
- Optimize the river system
- Groundwater recharge
- Increase secondary flow metering
- Improve metering on the river
- Build system redundancies

Response Action Definition

A planned action taken after a system operational trigger event occurs. The purpose of a response action is to manage the resulting impact of an adverse event.

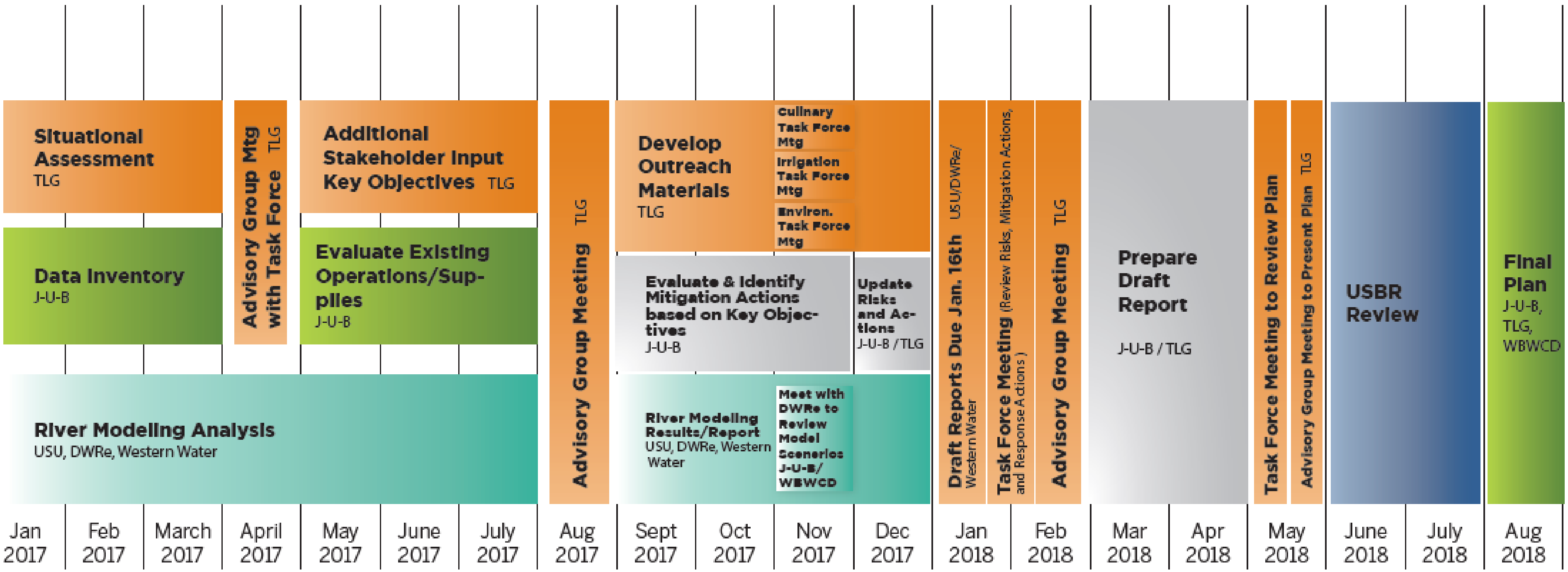
Drought Levels

Response Level	Advisory Code	Water Shortage Description	Triggering Criteria	WBWCD Storage Volume
1	**Green**	Normal	Normal variability: storage > 60%	greater than 329,300
2	**Yellow**	Moderate	Moderately dry conditions: 40-60% storage	219,500 to 329,300
3	**Orange**	Severe	Severely dry conditions: 20-40% storage	219,500 to 110,000
4	**Red**	Extreme	Extremely dry conditions: storage < 20%	less than 65,000

Demand Reduction Goals

				Demand Reduction			
Response Level	**Advisory Code**	**Water Shortage Description**	**Triggering Criteria**	**Secondary Water**	**Agricultural Irrigation**	**M&I Culinary Outdoor Water**	**M&I Culinary Indoor Water**
1	**Green**	Normal	Normal variability: storage > 60%	0	0	0	0
2	**Yellow**	Moderate	Moderately dry conditions: 40-60% storage	20%	20%	20%	0%
3	**Orange**	Severe	Severely dry conditions: 20-40% storage	60-70%	40%	60-70%	20%
4	**Red**	Extreme	Extremely dry conditions: storage < 20%	100%	80-90%	100%	50%

Next Steps



Weber Basin Water Conservancy District

J-U-B ENGINEERS, Inc.

Appendix 2-H

Agricultural Sub-committee Meeting Minutes
November 13, 2017

Weber Basin Drought Contingency Plan
Irrigation Providers Meeting
November 13, 2017 - 1 p.m.

*** The slideshow and examples were used for discussion purposes only*

Darren welcomed group and gave brief background on Weber Basin's Drought Contingency Plan

Chris discussed recent drought history, projections, extreme events and Weber Basin's responses

- <u>Drought History</u>
  - 2014 - 20% reduction in irrigation
  - 2013 and 2015 – Shortened irrigation season
- <u>Extreme Events – according to tree rings</u>
  - Longest drought duration in 1705
    - 13.6 years 6.0% minimum
  - Worst Severity in 1930's
    - 7.2 years with 0.9% minimum

Chris discussed risk evaluation (High Risk, Moderate Risk and Low Risk)

<u>Examples of High Risk</u>

- Loss of Weber River holdover water
- Inability to deliver culinary water
- Inability to deliver agricultural water
- Inability to meet environmental flows
- Severe reduction of power generation
- Low storage (less than 50% in March)
- Lack of agreements of MOU's

<u>Examples of Moderate Risk</u>

- Inability to use Larrabee storage right Weber River
- Inability to deliver secondary
- Failure to gain public support

<u>Examples of Low Risk</u>

- Management decision making failure

The group discussed what drought years would look like

- Suggestion to go back and look at the data (stream flow) from years like 1930, to understand what minimal flow is
  - People survived that drought, and it could help create expectations
    - During a drought everyone should expect to have to "give" a little bit
- Personal hygiene is more important than watering lawns
  - This would be the biggest concern of everyone during a drought

The group discussed water exchange agreements and impacts it would have on agriculture

- Agreements where there are benefits and incentives for the water district and shareholders
  - EX) Ag producer sings up to fallow land for a year or certain period of time, plants a crop that uses less water or growing winter wheat and harvesting in July (No irrigation from August to October)
    - In exchange the agricultural users would be compensated for that crop
      - Agreements would help Weber Basin be more resilient and prepared if there was a drought extended over a significant amount of time.
- How could agreements be attractive to a farmer?
  - It would depend on the farmer
  - Incentives to would need to cover their income (not full 100%)
    - This would also depend on the crops the farmer was growing
    - Agreements would be specific
  - If ag users were only getting 5 acre feet, they may voluntarily only water a small section of property
  - Discuss this scenario with the Farm Bureau

Chris discussed the idea of fallowing

- Some service areas have caps for fallowing (will only let a certain amount go dry)
  - How can it work mutually well? What would be a percent of fallowing that would be ok?
- The group discussed a scenario of another area using fallowing
  - Long term agreement was used
    - 20% acreage was fallowed and they would rotate every 5 years
    - Had an initial amount they agreed upon
      - They knew every five years they would be receiving a check
        - * Note: the price they paid would not be current water values, it would be during a drought water value

Education

- Weber Basin should have discussions with ag users and farmers and have that educational exchange

Group discussed the idea of lease sharing rather than water rights

- Lease shares instead of water rights
  - Water rights have been talked about

Weber Basin discussed what a good year looks like for them

- When Weber Basin is at 100% storage, they are producing 200,000 acre feet
  - 50,000 acre feet is treated water
    - If Weber Basin gets to less than 20% (Red/Extreme), the M&I during a good year would cover that

Chris discussed drought levels and response actions with the group

- Yellow – moderate (Ex: 2013-2015 drought)
- Being proactive instead of reactive so Weber Basin can be better prepared for a drought
- In areas they have rules in places and if someone isn't following them, they get the consequences (Ex: Fine)

- Weber Basin is unable to cut off outdoor culinary
    - Education would be important in that scenario

The group participated in an exercise where they identified where they would place water cuts during a moderate (Yellow), severe (Orange) and extreme (Red) drought

- <u>Yellow (moderately dry – 50-60% Weber Basin storage)</u>
    - Secondary - 20% cut
    - Agriculture – 20% cut
        - Wasn't a huge impact on bottom line when getting feedback (Weber Basin)
    - M&I Culinary Water Outdoor - 20%
        - Can have trouble with political offices supporting cut
        - One neighbor may have culinary and the other has secondary, this could cause conflict
            - EX: West Point City didn't have a reduction and Syracuse did
        - Unless there is a meter, at this point it would really be voluntarily and Weber Basin asking, "Pretty please."
    - M&I Culinary Water Indoor – 0% cut

- <u>Orange (Severe – 30-40% Weber Basin storage)</u>
    - Secondary - 50-60% cut
    - Agriculture – 40% cut (change crops or grow in less area)
        - Weber Basin could create water for ag if it would be possible to get rid of secondary watering
    - M&I Outdoor – 50-60% cut
    - Indoor – Implement rate structure – 5% (More voluntarily)
        - Reality to the scenario if the drought is severe, something needs to happen
- <u>Red (Extremely dry conditions - storage is less than 20%)</u>
    - *In the red zone, Weber Basin would be at less than half of what they typically deliver*
        - At this point minimal flow and public health will be a driving factor
    - Secondary – 100% cut
    - Agriculture – 75% cut (enough water for animals)
        - Fallowing agreements
        - Senior rights gets whatever is left
    - M&I Outdoor – 90-95% cut
        - Residents would be paying the extra rate
        - Trees would still be getting watered
            - EX: During Texas drought, residents were still allowed to water trees once per week to keep them alive
    - M&I Indoor– 10-20 % (rate increases)
        - Hard to regulate
        - Minimal flow and public health will be a driving factor

Chris reviewed the drought contingency plan schedule

DROUGHT CONTINGENCY PLANNING

Irrigation Providers Meeting

13 Nov 2017

Weber Basin Water Conservancy District

J·U·B ENGINEERS, INC.

THE LANGDON GROUP

GATEWAY MAPPING INC.

OTHER J-U-B COMPANIES

Meeting Agenda

- Welcome/Project Overview (5 min)
- Drought History and Projections (5 min)
- Overview of WBWCD Drought Risks (15 min)
- Mitigation Actions (20 min)
- Response Actions (30 min)
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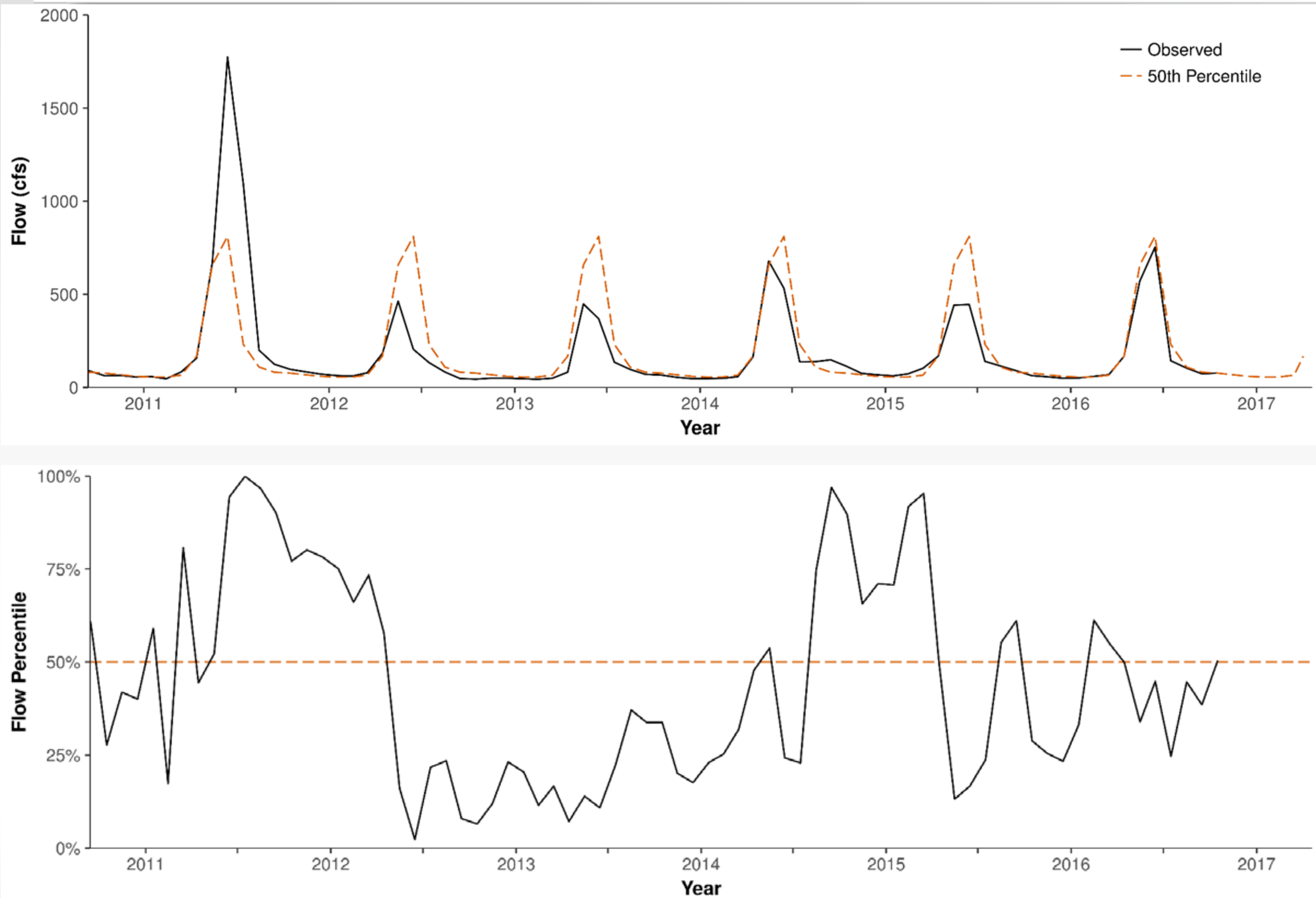
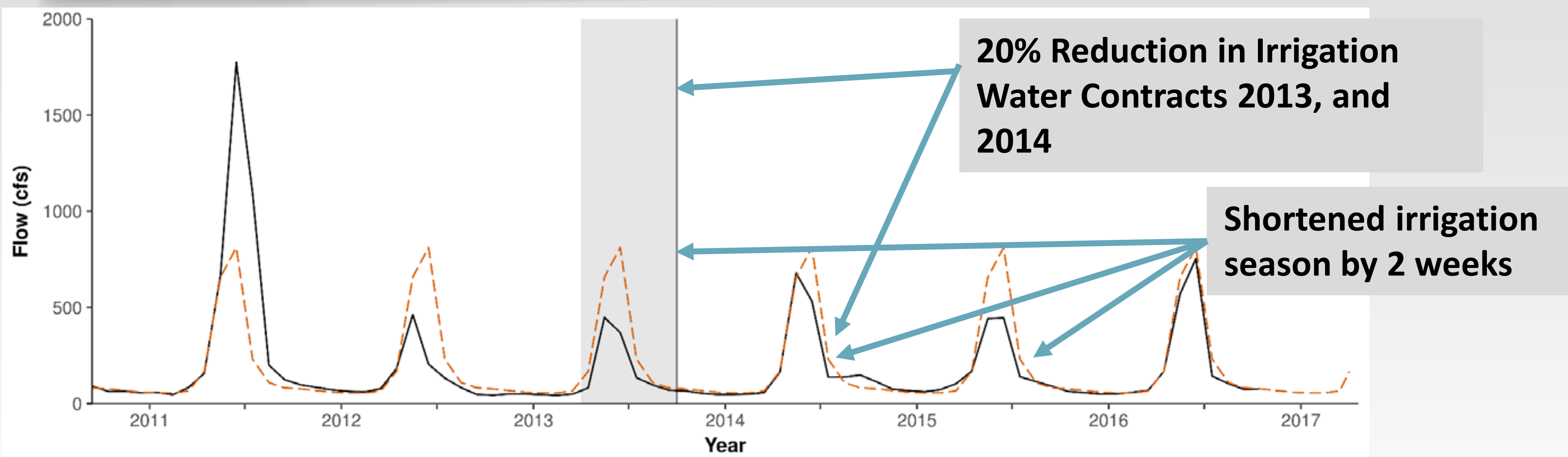
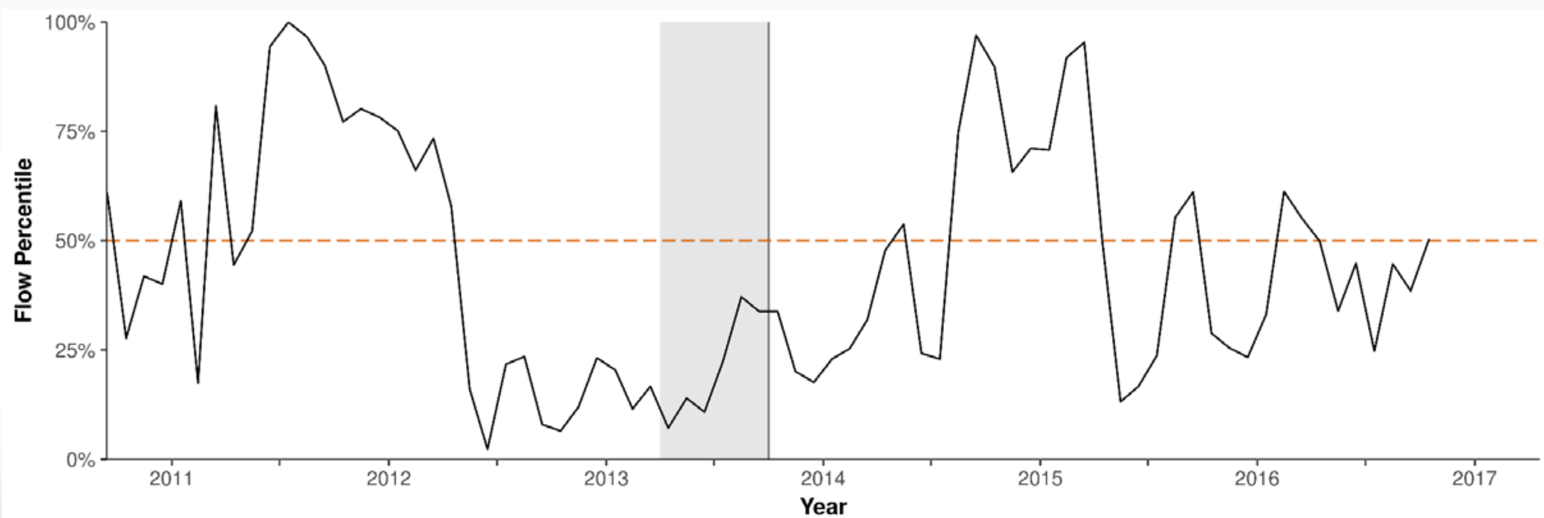
Recent Drought History



Data Provided by USU

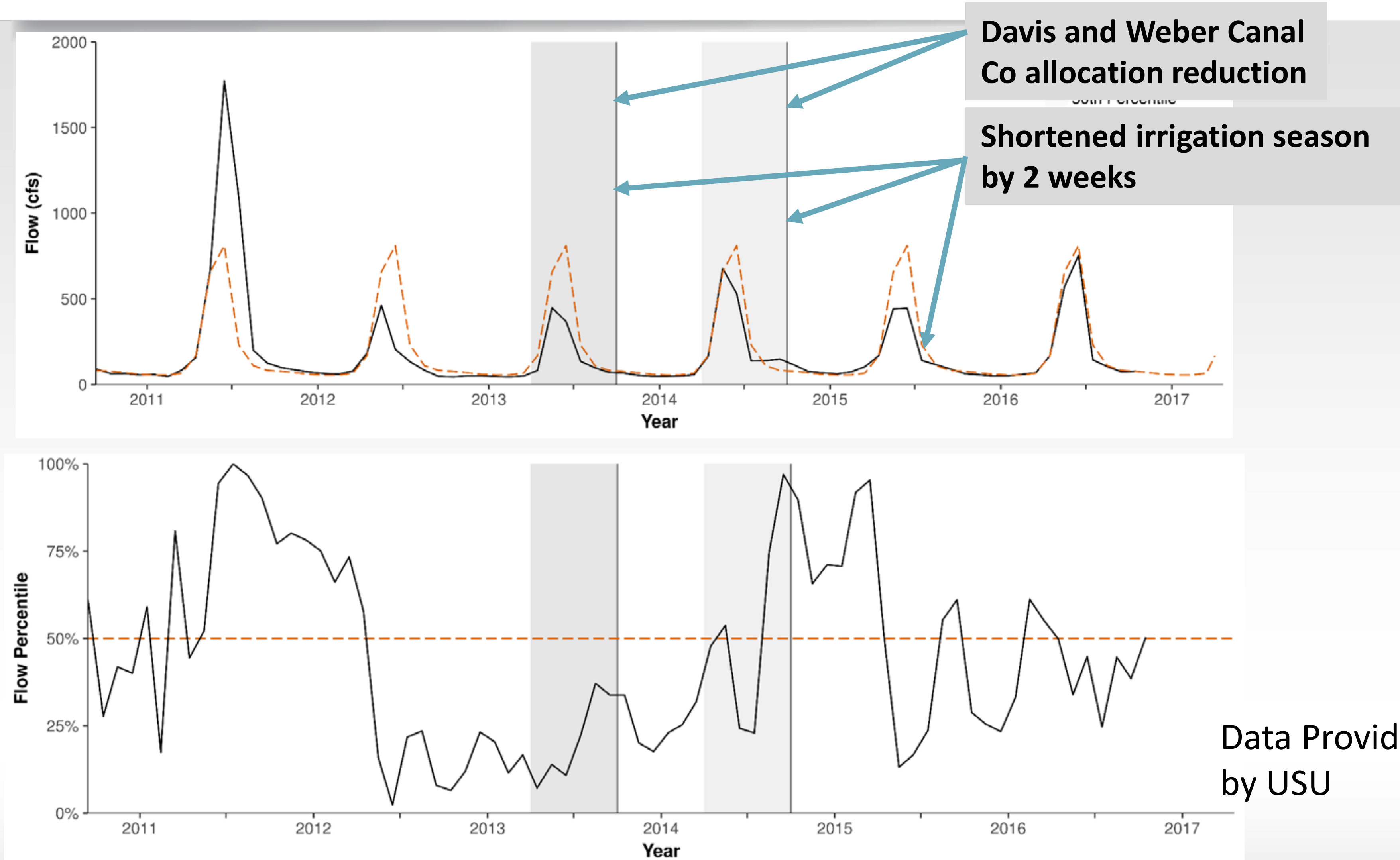
Weber Basin Responses





Data Provided by USU

Davis and Weber Canal Responses



Data Provided by USU

Extreme Events

Longest Duration (1705)

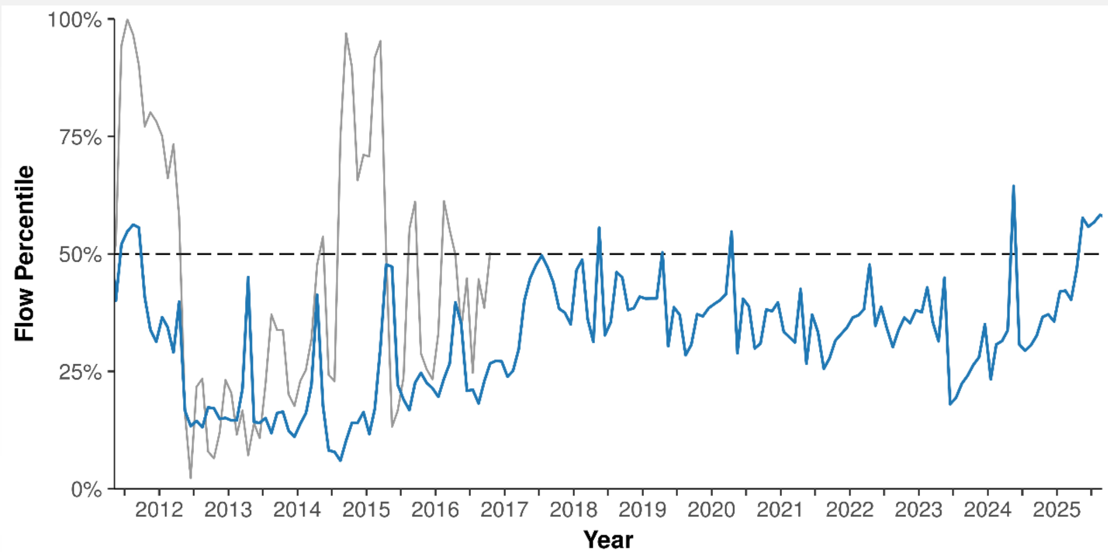
13.6 years

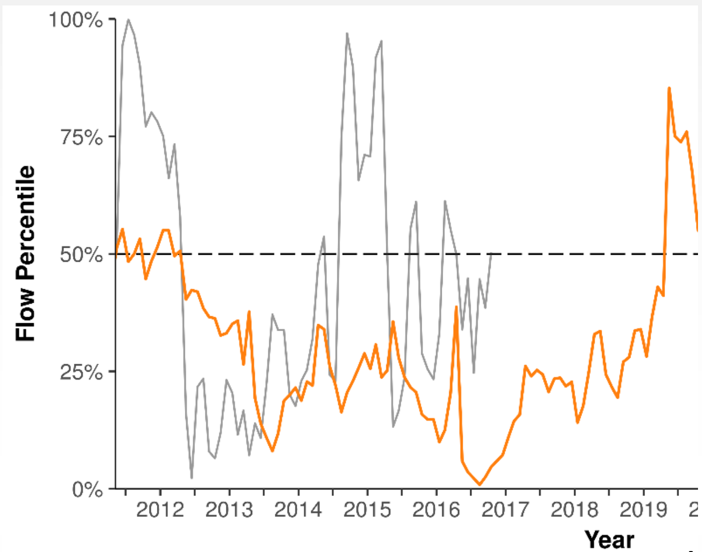
6.0% minimum

Worst Severity (1930)

7.2 years

0.9% minimum





Data Provided by USU

- **View full results at** www.paleoflow.org

High Risks

- Inability to deliver agriculture water
- Inability to deliver culinary water
- Inability to meet environmental flows
- Loss of Weber River holdover water
- Severe reduction of power generation
- Low storage (less than 50% in March)
- Lack of agreements or MOU’s

Moderate Risks

- Inability to use Larrabee right for storage on Weber River
- Inability to deliver secondary (lawn and garden Water)
- Failure to gain public support
- Failure to maintain infrastructure
- Wasteful watering

Low Risks

- Management decision making failure
- Failure to plan for natural disasters

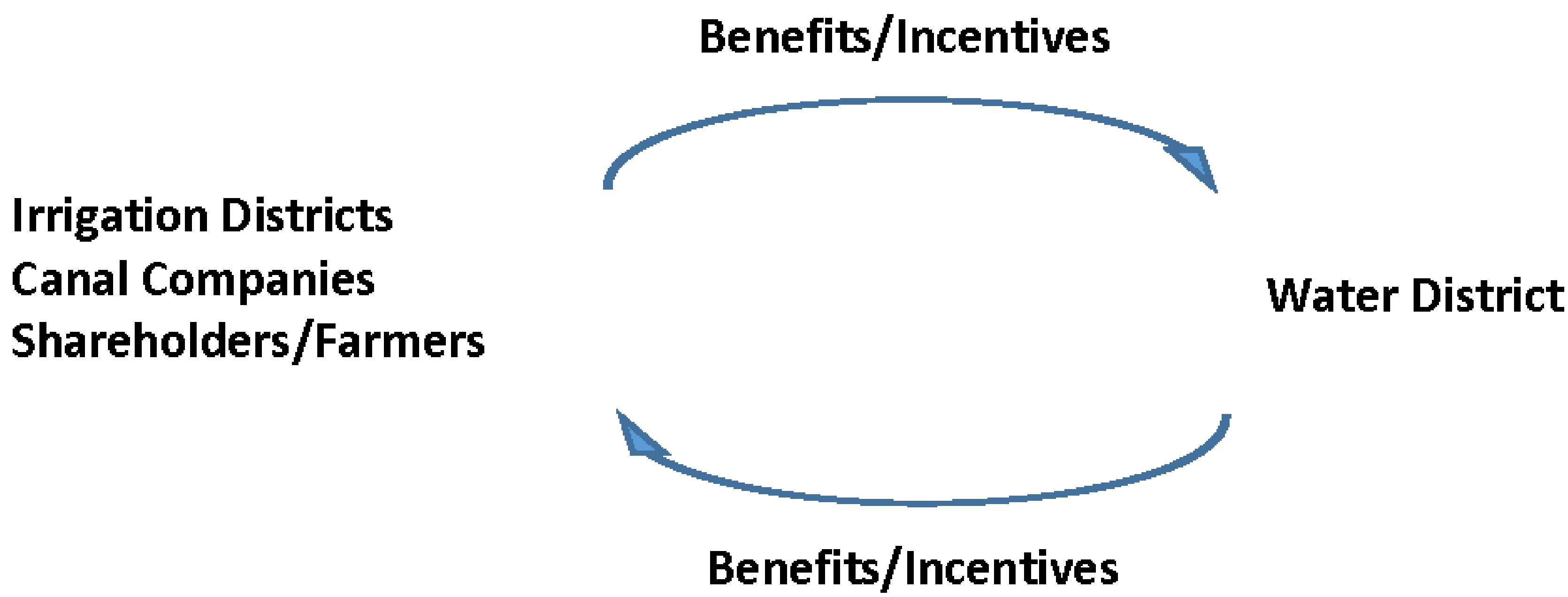
Mitigation Action Definition

Measures that we can take **prior to a drought** to help lessen the impacts of a drought within Weber Basin.

Mitigation Actions

- Increase storage volume
- Create water exchange agreements
- Educate the public about droughts
- Environmental strategy and coordination
- Create reclaimed water re-use agreements
- Increase and improve flow metering

Water Exchange Agreements



Response Action Definition

A **planned action** taken **after** a **trigger event** occurs. The purpose of a response action is to manage the resulting impact of an adverse event.

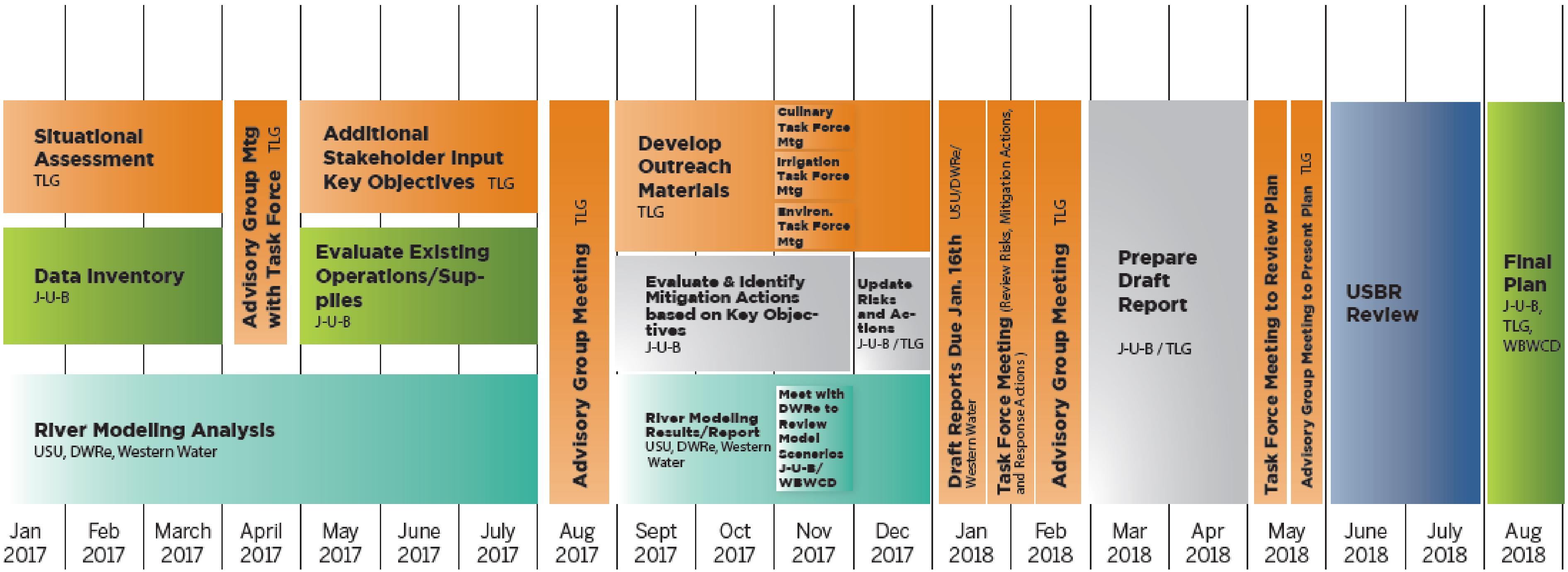
Drought Levels

Response Level	Advisory Code	Water Shortage Description	Triggering Criteria	WBWCD Storage Volume
1	**Green**	Normal	Normal variability: storage > 60%	greater than 329,300
2	**Yellow**	Moderate	Moderately dry conditions: 40-60% storage	219,500 to 329,300
3	**Orange**	Severe	Severely dry conditions: 20-40% storage	219,500 to 110,000
4	**Red**	Extreme	Extremely dry conditions: storage < 20%	less than 65,000

Demand Reduction Goals

				Demand Reduction			
Response Level	**Advisory Code**	**Water Shortage Description**	**Triggering Criteria**	**Secondary Water**	**Agricultural Irrigation**	**M&I Culinary Outdoor Water**	**M&I Culinary Indoor Water**
1	**Green**	Normal	Normal variability: storage > 60%	0	0	0	0
2	**Yellow**	Moderate	Moderately dry conditions: 40-60% storage	20%	20%	20%	0%
3	**Orange**	Severe	Severely dry conditions: 20-40% storage	50-60%	40%	50-60%	5%
4	**Red**	Extreme	Extremely dry conditions: storage < 20%	100%	75%	90-95%	10-20%

Next Steps



Weber Basin Water Conservancy District

J-U-B ENGINEERS, Inc.

Appendix 2-I

Environmental/Industrial Sub-committee Meeting Minutes
November 16, 2017

Weber Basin Meeting
Environmental and Industry Meeting
November 16th, 2017 at 2 p.m.

*** The slideshow and examples were used for discussion purposes only*

Darren welcomed group and gave brief background on Weber Basin's Drought Contingency Plan

Chris discussed recent drought history, projections, extreme events and Weber Basin's responses

- Drought History
    - 2014 - 20% reduction in irrigation
    - 2013 and 2015 – Shortened irrigation season
- Extreme Events – according to tree rings
    - Longest drought duration in 1705
        - 13.6 years 6.0% minimum
    - Worst Severity in 1930's
        - 7.2 years with 0.9% minimum

Chris discussed risk evaluation (High Risk, Moderate Risk and Low Risk)

Examples of High Risk

- Loss of Weber River holdover water
- Inability to deliver culinary water
- Inability to deliver agricultural water
- Inability to meet environmental flows
- Severe reduction of power generation
- Low storage (less than 50% in March)
- Lack of agreements of MOU's

Examples of Moderate Risk

- Inability to use Larrabee storage right Weber River
- Inability to deliver secondary
- Failure to gain public support

Examples of Low Risk

- Management decision making failure
- Failure to plan for natural disasters

Environmental/Industry group discussed and identified potential risks during a drought

- High temperatures and low water in fisheries is a concern (there needs to be CFS)
    - When working with fish those two contributing factors can make it a struggle
    - The oxygen and algae blooms get affected during those times
        - During stressful times like this the fish will find the deepest part of the pools with the most shade. They can survive for a little bit, but if those harsh conditions lasted during July or August the fish would be gone quick

    - It would help if Weber Basin could flush some extra water downstream. This would help increase oxygen and would help the fish go a few more days
        - Understand that fish are in the river and consider their needs. If Weber Basin is doing a delivery they could ask themselves, "Will this help the fish?"
            - The fish do so much better when there is a flush
        - Scheduled minimum flows
        - Creating a communication loop would help during those critical times
            - If critical levels are reached, have the environmental groups and Weber Basin get together and talk about where the stream levels are at. Work to move water and flood certain areas.
- If agriculture wasn't getting their share of water, that's another concern because the their irrigation water helps
- Local economies – fisheries would lose a lot of money
    - Great Salt Lake would be negatively impacted

Chris discussed Mitigation Actions

- Having more homes get metered would help save water in drought years
- In good water years get hydrologists in to see how much water there needs to be and for how long
    - High run-off to feed water off to Willard bay instead of keeping it back and not getting any hydrograph
        - In the middle of a drought Weber Basin should give that flush flow because it will help for a few years, then continue to do it so often
- Get Utah State university involved
- Flushes
    - Two days at 700 CFS is better than two weeks at 1,000 CFS
    - Make an observation of how the flush affected the streams and have a feedback loop for how it worked

Response Actions and Drought Levels Discussed

- Average is taken month by month from 2005
    - Volume is easy to picture
    - Performance
    - Storage capacity for echo – Chart that goes with it

The group participated in an exercise where they identified where they would place water cuts during a moderate (Yellow), severe (Orange) and extreme (Red) drought

- <u>Yellow</u>
    - Secondary - 20% cut (would be the first to get cut)
    - Agriculture – 20% cut
        - Ag needs to be built on a water right
        - Shouldn't surprise agriculture on those years to have a cut
    - M&I Culinary Water Outdoor - 20% cut
    - M&I Culinary Water Indoor – 0% cut
- <u>Orange</u>

  - Secondary - 1st to get cut
  - Agriculture – 3rd to get cut
  - M&I Outdoor – 2nd to get cut
  - Indoor - 4th to get cut
    - Take into account how many people in a home
  - Increase a tax on secondary water – extra went into a bank you could get more ag that would want to. Some people will keep a little water and wouldn't mind a little more
  -
- <u>Red</u>
  - In the red zone, Weber Basin would be at less than half of what they typically deliver
  - Secondary – 4th priority
  - Agriculture – 2nd priority cut
    - Mitigation bank for the ag
    - Pay them for all their crops they would have gotten (dry year expectations)
      - Create an incentive for them
      - Give them an opportunity to water for 10 minutes a week, that way they don't have to completely start over
    - Fallowing
    - Don't want to cut them off completely because if that happens there would be less water in the streams
  - M&I Outdoor – 100% cut
    - Create a rate structure
  - M&I Indoor– Priority
    - Education would become extremely important

Discussion of Fisheries

- Communication would be critical during a drought scenario
  - Develop a scenario where you tell fisheries where triggers are
- Show that Weber Basin is working together to help the fish. Show that the fish is getting recognition and respect by having a plan in place. (Ex: Blue Head Sucker)
  - Plan towards the fisheries being part of the equation and process
  - The last thing anyone would want to happen is lose the fisheries
    - Having flushing be implemented into a "red" plan in addition to meeting demands would help
  - This would be huge for the Fish and Wildlife Services
- Have a discussion for in an instream below Echo

Chris reviewed the drought contingency plan schedule

DROUGHT CONTINGENCY PLANNING

Environment and Industry Stakeholders Meeting
16 Nov 2017

Weber Basin Water Conservancy District

J·U·B ENGINEERS, INC.

THE LANGDON GROUP

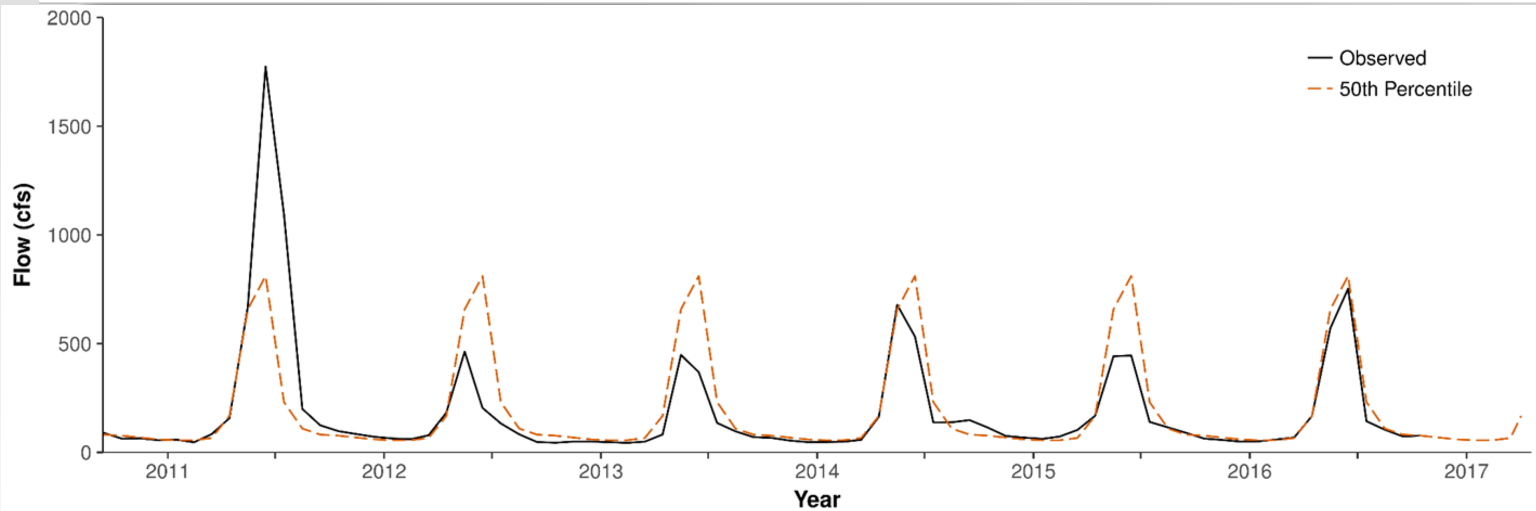
GATEWAY MAPPING INC.

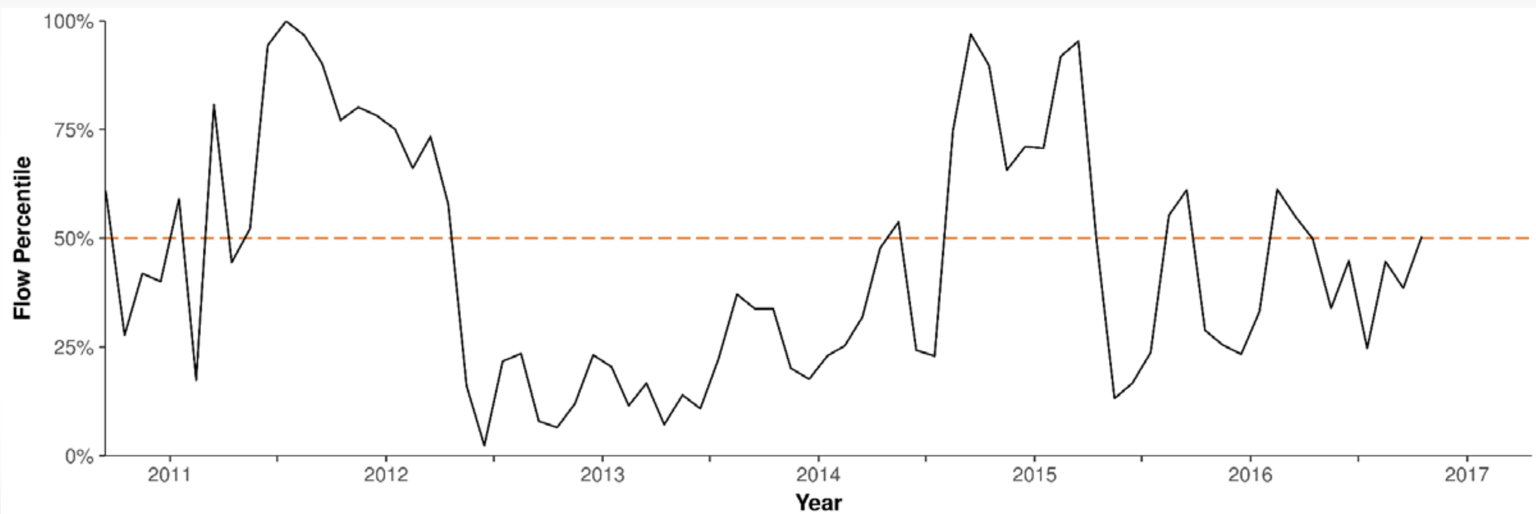
OTHER J-U-B COMPANIES

Meeting Agenda

- Welcome/Project Overview (5 min)
- Drought History and Projections (5 min)
- Overview of WBWCD Drought Risks (15 min)
- Mitigation Actions (20 min)
- Response Actions (30 min)
- Next Steps (5 min)

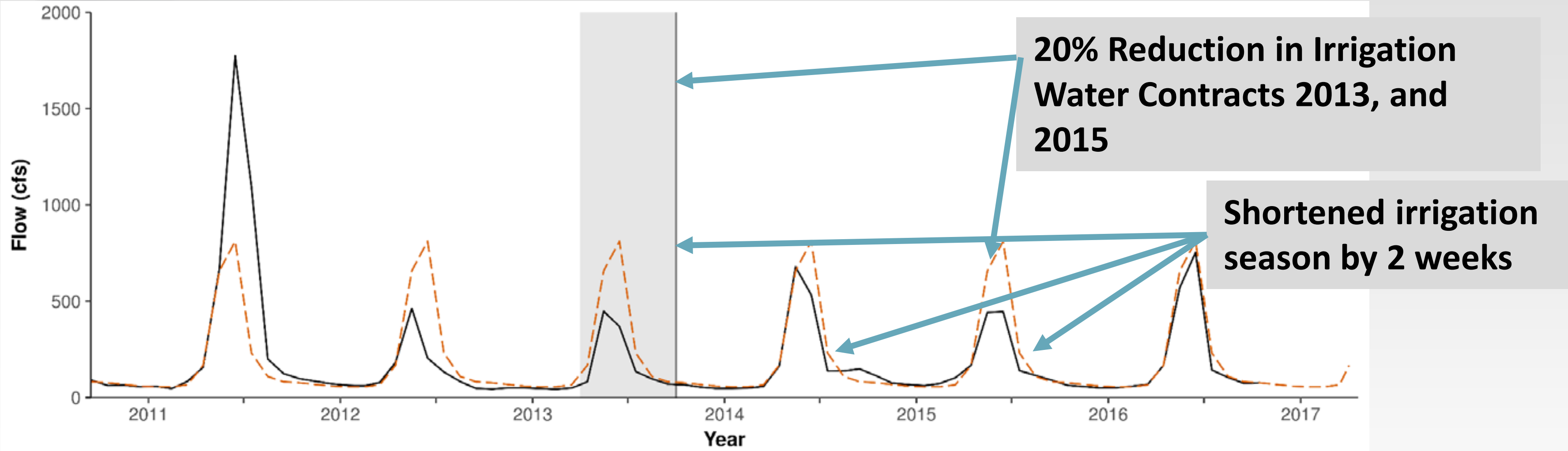
Recent Drought History

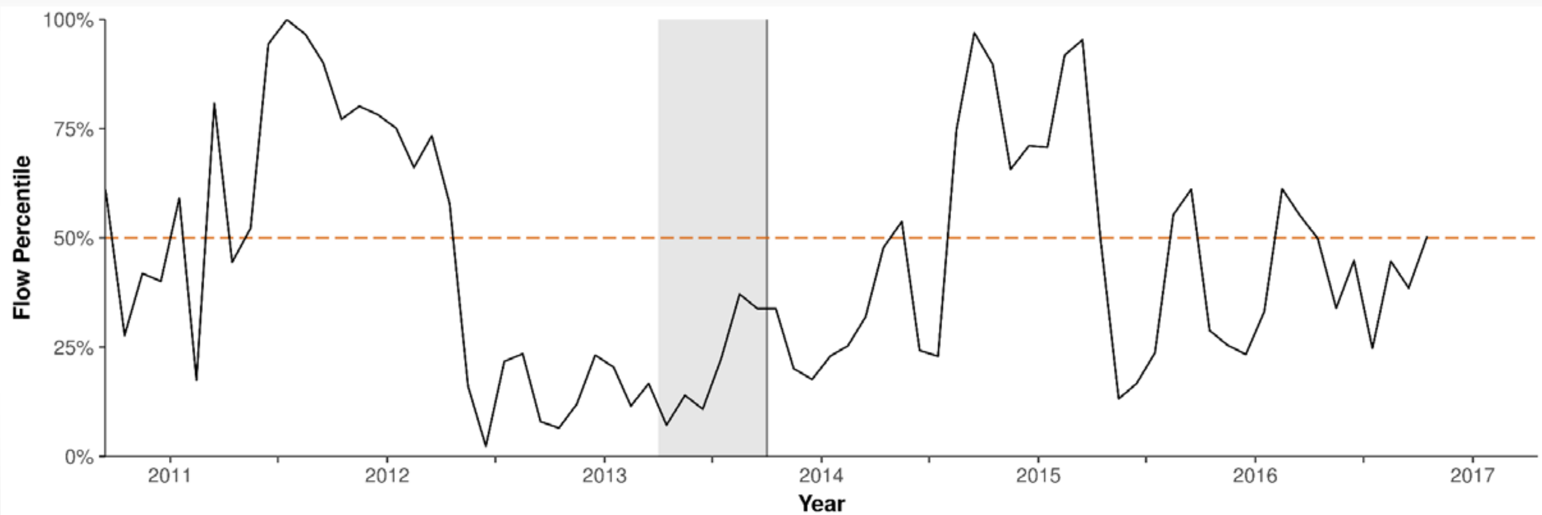




Data Provided by USU

Weber Basin Responses





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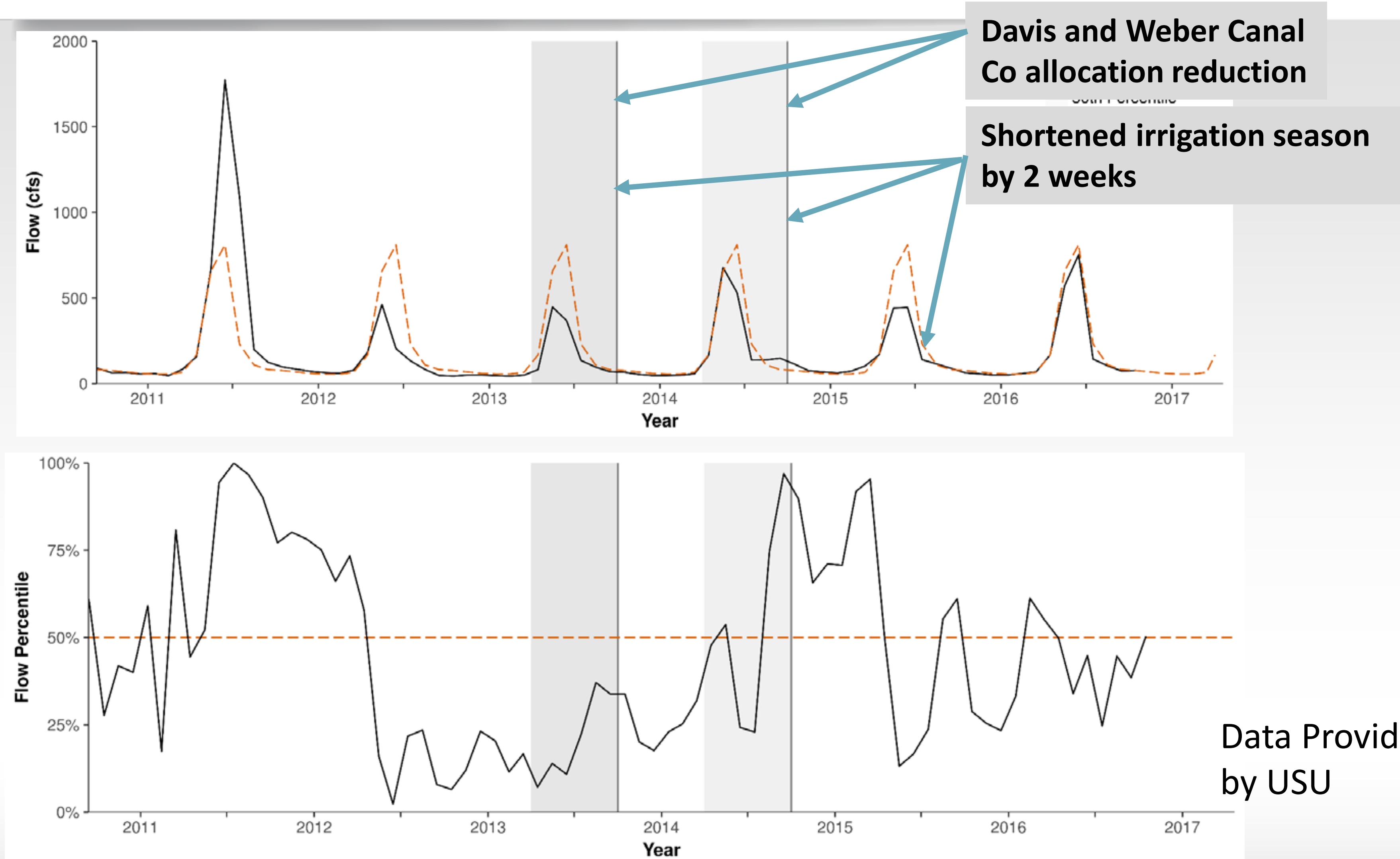

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Extreme Events

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13.6 years	7.2 years
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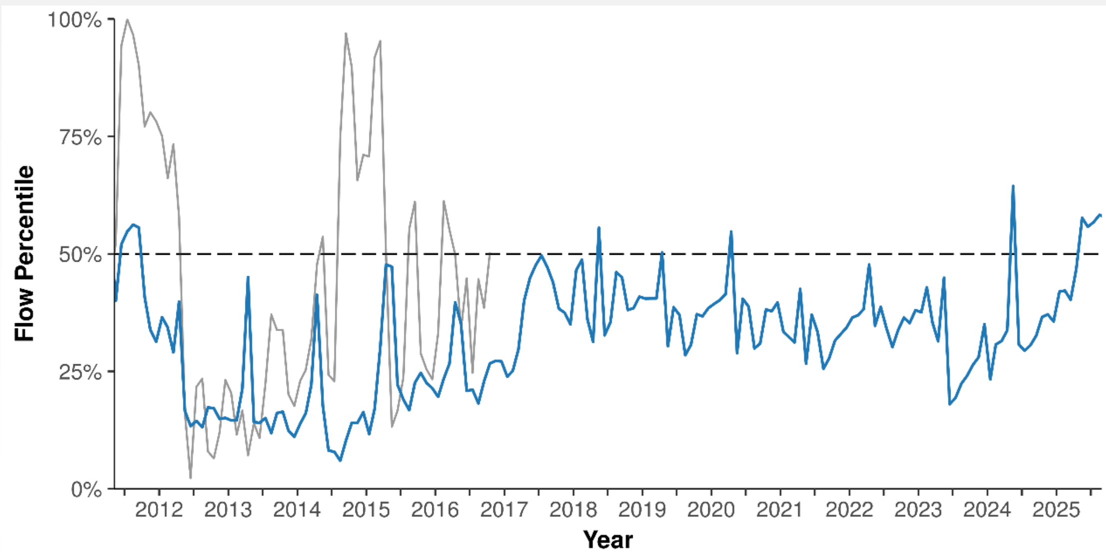

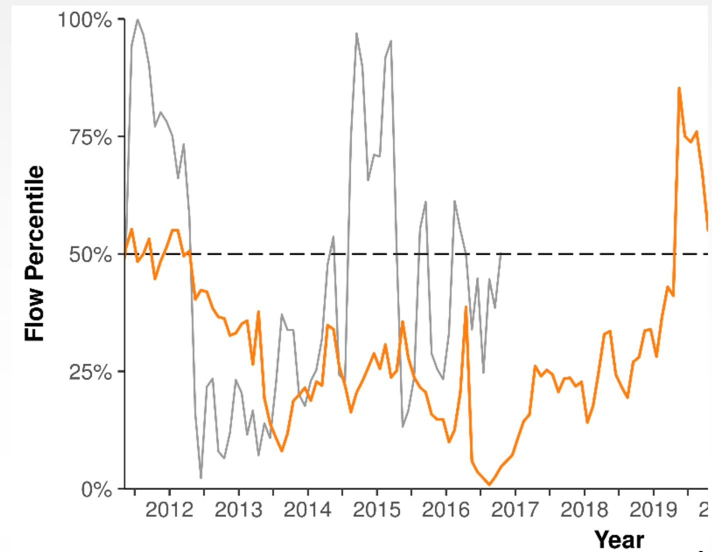

Data Provided by USU

•**View full results at** www.paleoflow.org

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A **planned action** taken **after** a **trigger event** occurs. The purpose of a response action is to manage the resulting impact of an adverse event.

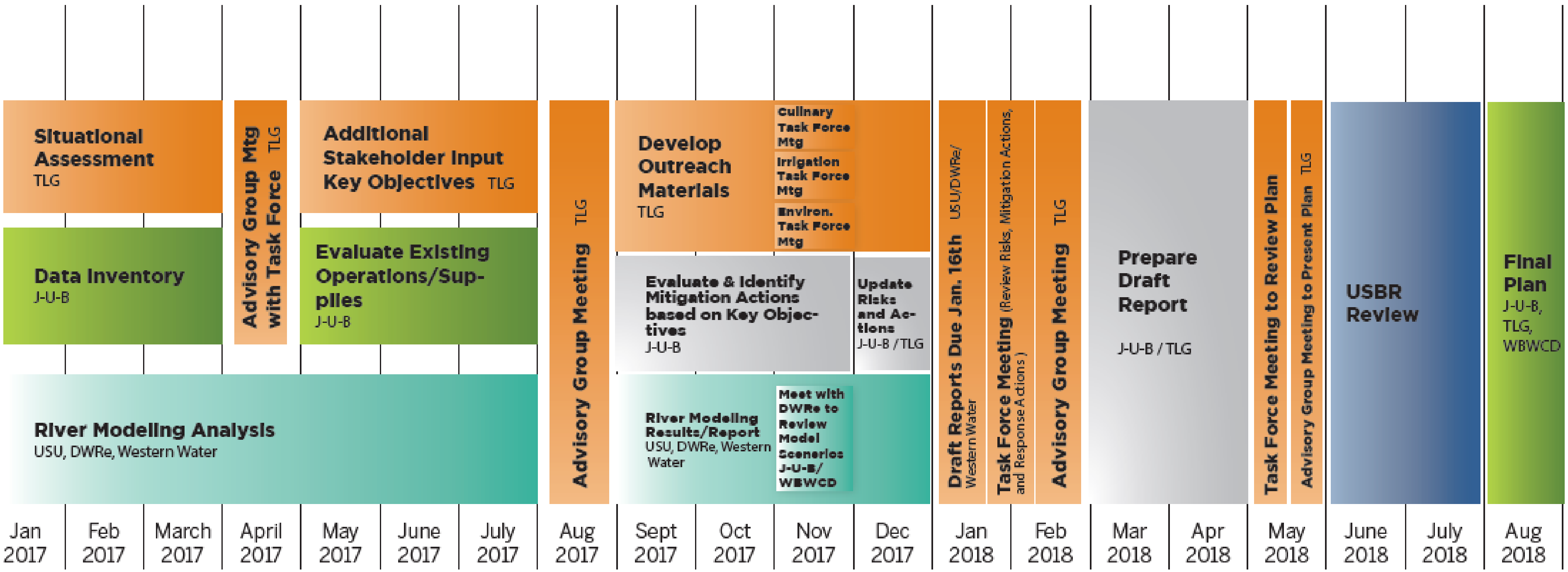
Drought Levels

Response Level	Advisory Code	Water Shortage Description	Triggering Criteria (percent of average storage at the start of each month from 2005 to 2017)
1	**Green**	Normal	Normal variability:
			storage >= 70% of average
2	**Yellow**	Moderate	Moderately dry conditions:
			< 70% of average
3	**Orange**	Severe	Severely dry conditions:
			< 50% of average
4	**Red**	Extreme	Extremely dry conditions:
			storage < 25% of average

Demand Reduction Goals

Response Level	Advisory Code	Water Shortage Description	Triggering Criteria (percent of average storage at the start of each month from 2005 to 2017)	Demand Reduction: Secondary Water	Demand Reduction: Agricultural Irrigation	Demand Reduction: M&I Culinary Outdoor Water	Demand Reduction: M&I Culinary Indoor Water
1	**Green**	Normal	Normal variability: storage >= 70% of average	0	0	0	0
2	**Yellow**	Moderate	Moderately dry conditions: < 70% of average	20%	20%	20%	0%
3	**Orange**	Severe	Severely dry conditions: < 50% of average	2nd Priority	2nd Priority	2nd Priority	1st Priority
4	**Red**	Extreme	Extremely dry conditions: storage < 25% of average	100%	2nd Priority	3rd Priority	1st Priority

Next Steps



Situational Assessment
TLG
Data Inventory
J-U-B
Advisory Group Mtg with Task Force TLG
Additional Stakeholder Input Key Objectives TLG
Evaluate Existing Operations/Supplies
J-U-B
River Modeling Analysis
USU, DWRe, Western Water
Advisory Group Meeting TLG
Develop Outreach Materials
TLG
Culinary Task Force Mtg
Irrigation Task Force Mtg
Environ. Task Force Mtg
Evaluate & Identify Mitigation Actions based on Key Objectives
J-U-B
Update Risks and Actions
J-U-B / TLG
River Modeling Results/Report
USU, DWRe, Western Water
Meet with DWRe to Review Model Scenarios J-U-B/WBWCD
Draft Reports Due Jan. 16th USU/DWRe/Western Water
Task Force Meeting (Review Risks, Mitigation Actions, and Response Actions)
Advisory Group Meeting TLG
Prepare Draft Report
J-U-B / TLG
Task Force Meeting to Review Plan
Advisory Group Meeting to Present Plan TLG
USBR Review
Final Plan
J-U-B, TLG, WBWCD
Jan 2017
Feb 2017
March 2017
April 2017
May 2017
June 2017
July 2017
Aug 2017
Sept 2017
Oct 2017
Nov 2017
Dec 2017
Jan 2018
Feb 2018
Mar 2018
Apr 2018
May 2018
June 2018
July 2018
Aug 2018

Appendix 3-A

Paleohydrology Evaluation – USU

Drought Contingency Plan
Technical Appendices

David E. Rosenberg[1], James Stagge[2]
Utah State University[1] and Ohio State University[2]

December 6, 2018

1. Monthly Streamflow Reconstruction

Stagge et al (2018) developed the PaleoFlow R codebase and web app (http://paleoflow.org) that displays reconstructed monthly streamflow values for individual gauge sites on the Weber, Bear, and Logan rivers dating back, to the 1400s. Monthly reconstructed stream flows are estimated using multiple linear regression with an expanded set of predictors that include annual streamflow reconstructions, inferred El Nino-Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO), and tree-ring chronologies for 7 regional tree species (Allen et al. 2013; Bekker et al. 2014; DeRose et al. 2015; DeRose et al. 2014; Stagge et al. 2018). A new monthly streamflow reconstruction for the Weber River at Oakley was made for October 1429 AD to December 2017 AD, added to the web app, and compared against the observed monthly flow and reconstructed annual flow (Figure 1). See Box 1 for directions to download the monthly reconstructed streamflow from the web app.

Box 1. Download monthly reconstructed stream flows from http://paleoflow.org

1. Go to http://paleoflow.org
2. In the upper left, set **Time Resolution** to *Monthly*
3. Set **Site Location** to *Weber River at Oakley*
4. Set the desired **Flow Units** and keep **Data Subset** at *Full Timeseries*
5. Click **DOWNLOAD Data** button. A comma separated values (csv) file will open.
6. Use the interactive time series plot to click, drag, zoom, or scroll the time series.

A comparison of monthly observed flows to reconstructed flows shows a narrow spread along the 1:1 line of perfect fit (Figure 2). Four common measures of error between monthly observed flows and monthly reconstructed stream flows for the Weber River at Oakley site -- mean error, root mean square error, Nash-Sutcliffe Efficiency, and the coefficient of Determination (R^2) -- were each very similar to two prior monthly stream flow reconstructions for the Bear River at Utah-Wyoming and Logan River at State Dam (Stagge et al. 2018) (Table 1). Close matches between observed and reconstructed flows are indicated by small mean and root mean square errors and Nash-Sutcliffe efficiency and coefficient of determinations approaching 1.0.

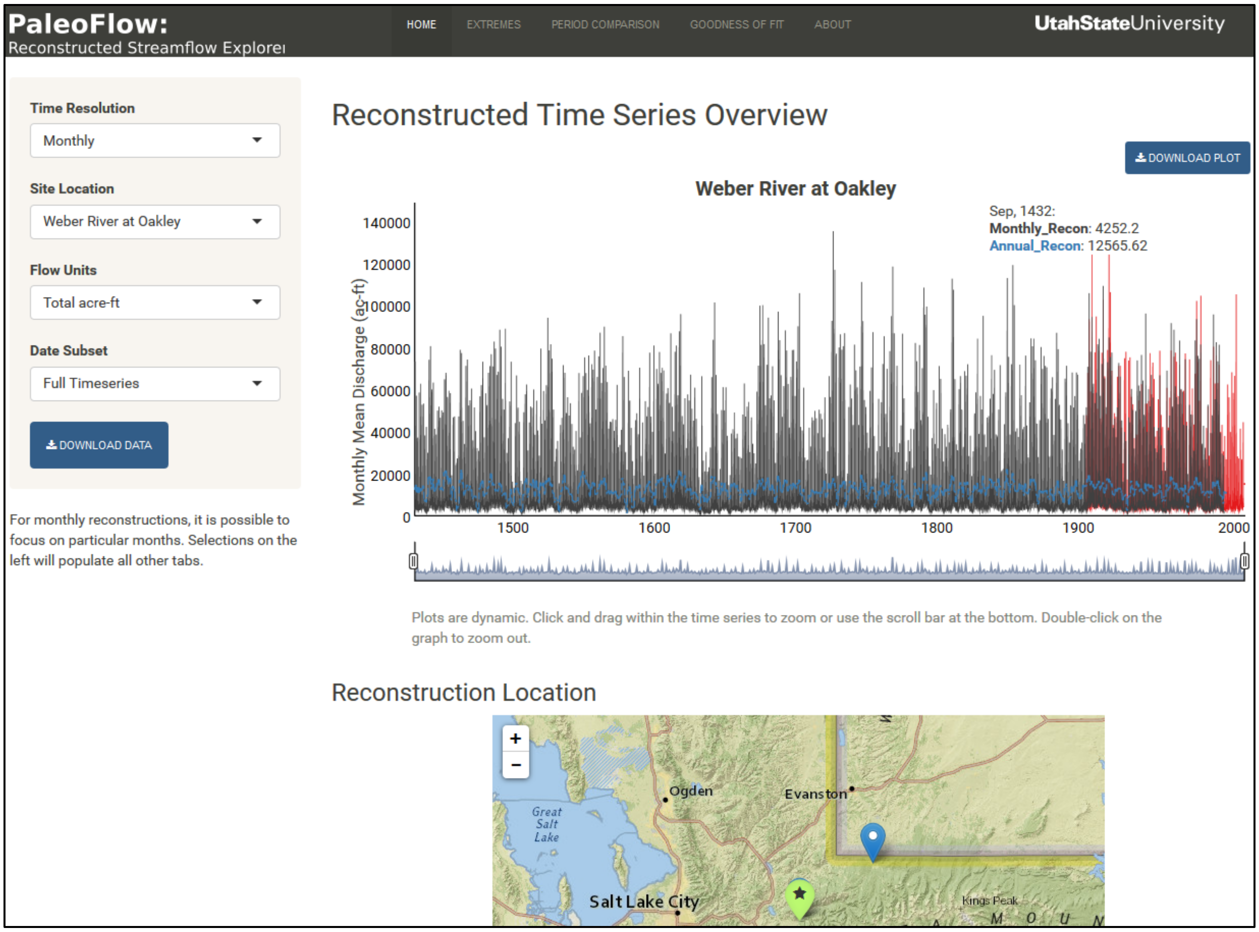


Figure 1. Paleoflow.org showing reconstructed monthly stream flow for the Weber River at Oakley from October 1429 AD to December 2002 AD (black), observed flow from (October 1904 to October 2016; red), and annual reconstructed flow (October 1429 AD to August 2014 AD; blue).

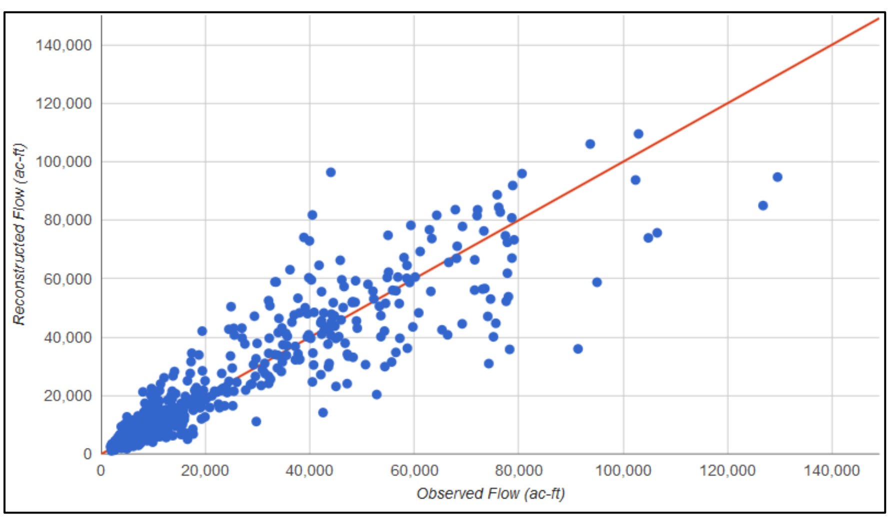


Figure 2. Comparison of monthly observed Weber River at Oakley flow to reconstructed flow. The red 1:1 line indicates a perfect fit.

Table 1. Measure of error between monthly observed and monthly reconstructed streamflow at three northern Utah sites (http://paleoflow.org).

Location	Mean Error (ac-ft)	Root Mean Square Error (ac-ft)	Nash-Sutcliffe Efficiency (-∞ to 1)	Coefficient of Determination (R^2) (0 to 1)
Weber River at Oakley	64.1	6,900	0.86	0.87
Bear River near Utah-Wyoming	833	6,100	0.88	0.89
Logan River at State Dam	-13.1	4,960	0.86	0.87

2. Drought Clustering

We used the monthly stream flow reconstruction for the Weber River at Oakley dating back to October 1429 AD to cluster drought events. Clustering can help organize a large number of droughts that occurred in the paleo record, group similar droughts, develop a taxonomy of drought types based on their occurrence in the paleo record, and identify contingency planning for certain types of drought events.

We defined droughts as occurring when flows remained below that month's 50^{th} percentile flow for at least 3 months. Within this definition, flows above the 50^{th} percentile were allowed for up to 2 months so that a time series of drought flow (D, below the 50^{th} percentile) and no drought flow (N, above the 50^{th} percentile) of D, D, D, N, N, D, D, D, D would be considered a single drought event, lasting 9 months. For each identified drought, we calculated 14 statistics that captured characteristics such as drought duration, start, end, flow, deficit, and mean rate pf change of flow (Table 2).

Table 2. Droughts statistics used in clustering

Statistic	Units
Drought duration	Months
Drought start	Month
Drought end	Month
Minimum flow	cfs
Minimum percentile	0-100
Maximum deficit (50^{th} percentile flow – minimum flow)	cfs
Cumulative deficit (sum of flow below 50^{th} percentile)	cfs
Deficit center of mass (deficit-weighted center of drought mass)	0-1
Percentile center of mass (percentile-weighted center of drought mass)	0-1
Prior year flow	cfs
Mean rate of change in flow prior to peak drought	cfs/month
Mean rate of change in percentile prior to peak drought	percentile/month
Mean rate of recovery in flow following peak drought	cfs/month
Mean rate of recovery in percentile following peak drought	percentile/month

Both hierarchical (branching tree) (Murtagh and Legendre 2014; Wilks 2011) and k-means (centroid search) (Hartigan and Wong 1979; Kaufman and Rousseeuw 2005; Wilks 2011) clustering were used to test sensitivity of the drought event classification scheme to the clustering method. Generally, the results were similar but we found hierarchical clustering preferable because it grouped and separated droughts into a consistent taxonomy, like a family tree (Figure 3). In contrast, k-means clustering lost the internal structuring of mild, medium, and severe droughts because this method generates an entirely new clustering scheme when adding another cluster (the “k” value in the k-means algorithm).

The best cluster scheme showed 11 total drought clusters, which included 7 clusters where events were always less than 1 year in duration (purple in Figures 3 and 4). These events were less than the Weber Basin Water Conservancy District’s 2-year carry-over storage and were thus dropped from further analysis. The four remaining drought clusters (green, red, blue, and orange in Figures 3 and 4) represented progressively longer and more intense (lower minimum percentile flow) drought events with the most severe orange cluster having drought events lasting 2 to 7 years with a minimum flow below the 5th percentile (Figure 4). The red, blue, and orange drought clusters in Figures 3 and 4 are of particular interest to the Weber Basin Water Conservancy District because these drought events persisted longer than the system’s 2-year carryover storage and are drought types that have recurred in the Weber basin over the past 6 centuries.

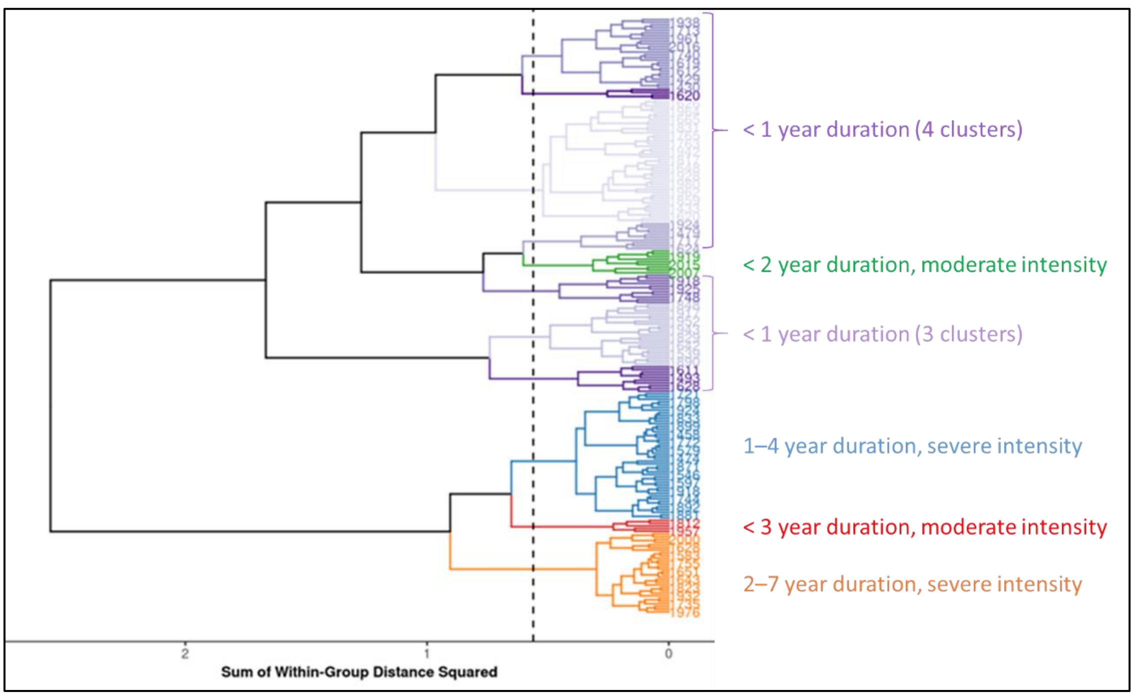


Figure 3. Hierarchy of drought clusters. Clusters with similar drought characteristics are grouped closer together.

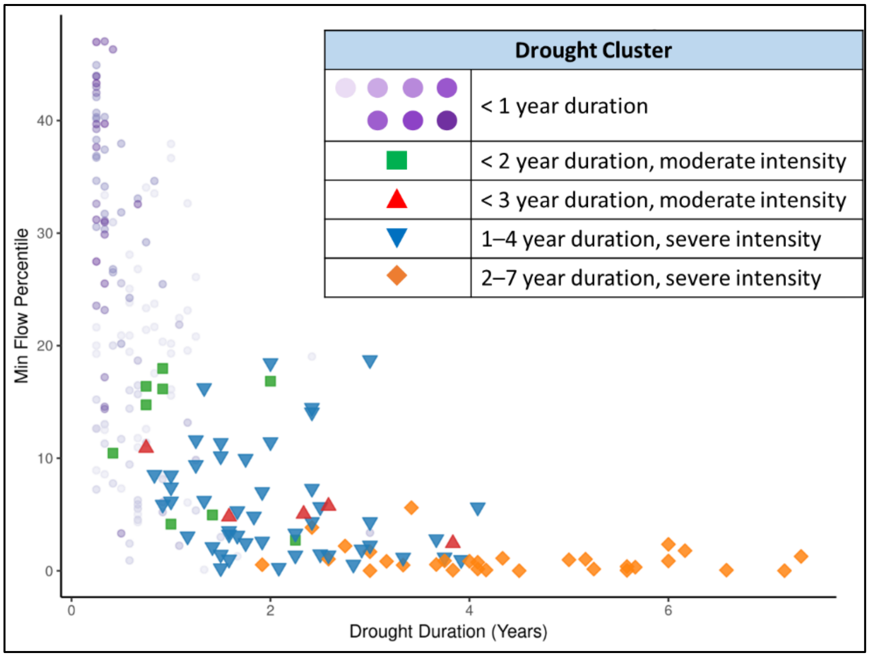


Figure 4. Drought clusters plotted by drought statistics of duration and minimum flow percentile

3. Drought Clustering and Reservoir Storage

We paired the drought clustering results with reservoir storage volumes simulated by feeding the entire reconstructed monthly paleo stream flow record (1429 AD to the present) (Section 1) and Western Water Assessment projected future streamflows for hot-dry, warm-dry, hot-wet, and warm-wet climate scenarios (2034-2064 AD) (see Section 3.6) into the Utah Division of Water Resources' Riverware supply/demand model for the Weber Basin (Section 3.4). The Riverware model simulated reservoir storage for each month of the historical and future climate periods. System reservoir storage was classified as moderate (tan), severe (orange), or extreme (red) when the total June 1 storage volume for all reservoirs fell below, respectively, 380,000, 340,000, or 280,000 acre-feet. These volumes represent 72%, 64%, and 53% of total system storage capacity.

The frequency of monthly reservoir storage triggers was relatively constant across the reconstructed paleo (1429 AD to 1903 AD) and observed (1904 to 2016) periods (Figure 5). If the 30-year 2034 to 2064 AD projected climate conditions represent conditions throughout the 21st century, the warm-wet and hot-wet scenarios will see few storage triggers compared to paleo and observed periods. In contrast, warm-dry and hot-dry scenarios will see a sharp increase in storage triggers. The hot-dry scenario will have a larger number of storage triggers than the warm-dry scenario.

Within the reconstructed paleo period, nearly all the extreme and severe storage triggers occurred during drought events that persisted for three years or longer (Figure 6). These storage triggering drought events match almost entirely with the previously established orange clusters, with 2-7 year duration and severe intensity (Figures 4 and 7). Notably, only a few outlier drought events from the blue cluster (1-4 year duration, severe intensity events) drop system storage into the moderate trigger level. Reservoir storages during all other drought events for all other clusters stay above the moderate reservoir storage trigger.

We also use the reconstructed drought events and clusters to show the effect of potential hot-wet, warm-wet, hot-dry, and warm-dry climate scenarios on drought duration and minimum flow percentile statistics (Figure 8). For example, the recent 1987 to 1991 drought had a 4-year duration and 5% percentile minimum flow and was classified as a 2-7 year duration, severe intensity event (orange diamonds) using the drought clustering scheme. This drought was, however, at the transition zone between several clusters (orange diamonds, blue triangles, red triangles in Figure 4). In a future warm-dry or hot-dry climate scenario, this 1987 to 1991 event would persist longer, last for 5 or 6+ years, have lower flow, and be located more in the center of the orange diamond cluster, rather than on its edge. In contrast, in a future warm-wet or hot-wet climate scenario, the same event would persist for a shorter time and look more like drought events from the blue or red triangles, or green square clusters. Across the four hot-dry, warm-dry, hot-wet, and warm-wet future climate scenarios, storage triggers are more sensitive to reduced precipitation (dry) than temperature (warm or hot). Under some temperature conditions, the minimum flow would increase while in other conditions the minimum flow would decrease relative to the historical value.

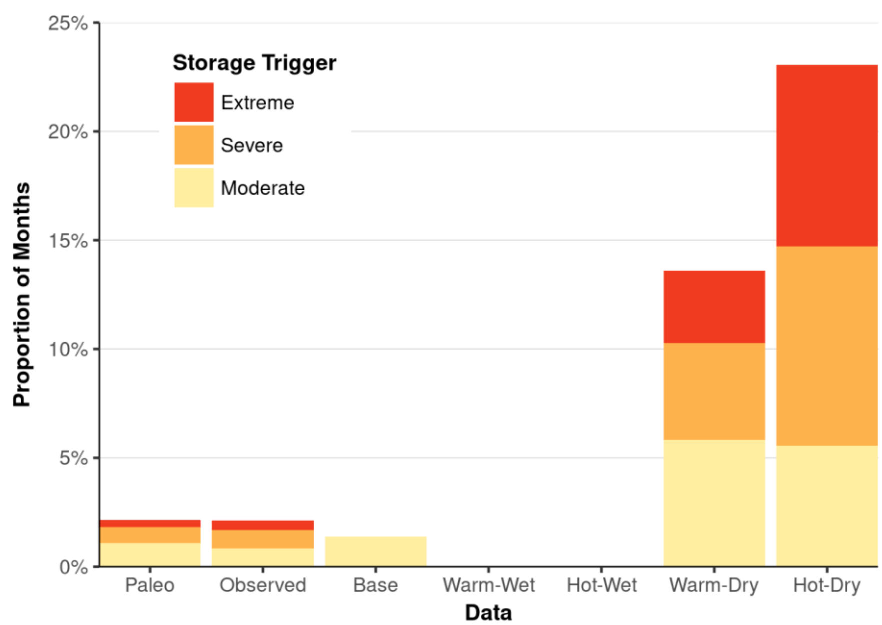


Figure 5. Frequency of reservoir storage triggers (% of months) across the paleo reconstructed (1429 AD to 1903 AD), observed (1904 AD to 2016 AD), and projected future climate change (2034 AD to 2064 AD) periods.

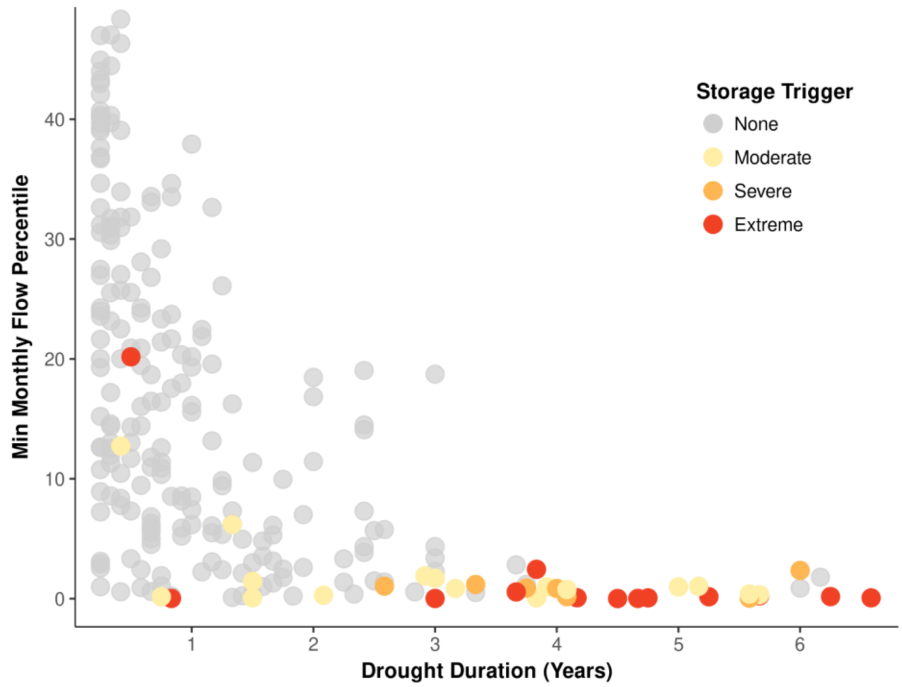


Figure 6. Simulated total system reservoir storage trigger for paleo reconstructed and observed drought events.

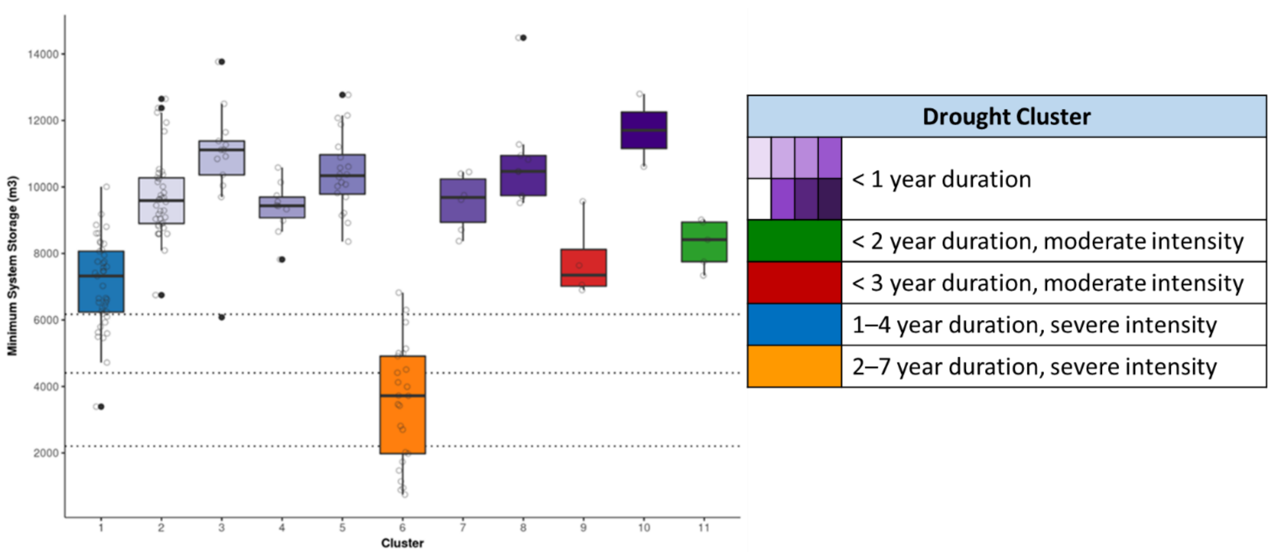


Figure 7. Minimum system storage for paleo and observed drought events. Cluster color indicates the cluster shown in Figure 4.

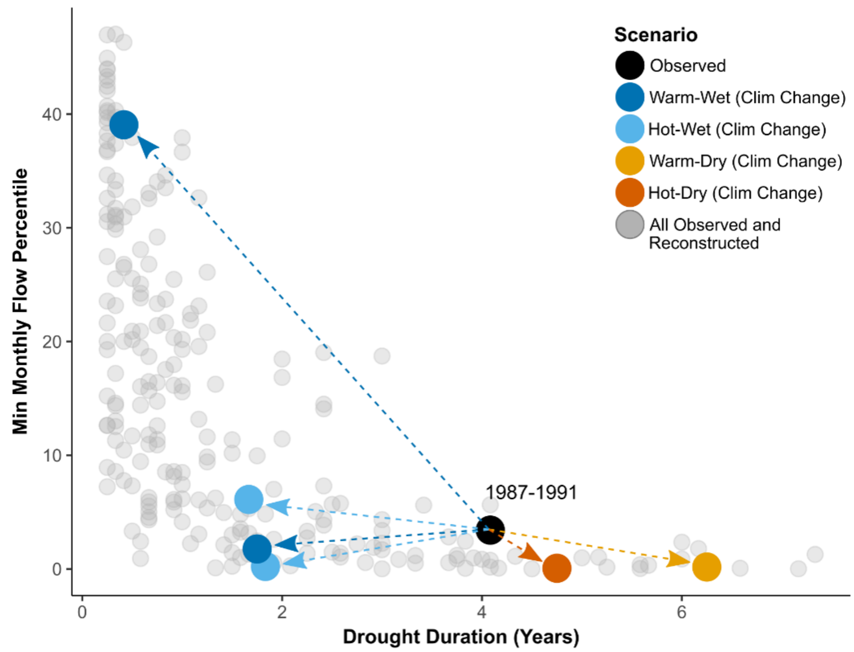


Figure 8. Effect of temperature-precipitation climate perturbations on drought duration and intensity.

We identify six important features for the Weber Basin water system by reconstructing monthly stream flows on the Weber River at Oakley back to 1429 AD, clustering droughts, and using stream flows projected for future climate scenarios with perturbed precipitation and temperature:

1. Recent droughts are not anomalies. These droughts have many analogues in the reconstructed paleo record with similar drought durations and low stream flows.
2. We identified numerous droughts within the paleo and observed records that persisted for four years or longer and saw extreme low flows.
3. These long duration, extreme intensity droughts typically trigger severe or extreme declines in total system storage.
4. Shorter duration droughts persisting up to four years may sometimes trigger moderate declines in total system storage.
5. In future climate scenarios with less precipitation (drier), drought durations will lengthen and minimum flows will decrease. More droughts will belong to the drought cluster with long duration, severe intensity. These droughts will trigger more instances of moderate, severe, and extreme declines in total system storage.
6. In a future climate scenarios that are wetter, drought durations will shorten and may fall below the 2-year threshold of current carryover storage. Shorter duration droughts are unlikely to trigger moderate, severe, or extreme declines in total system storage.

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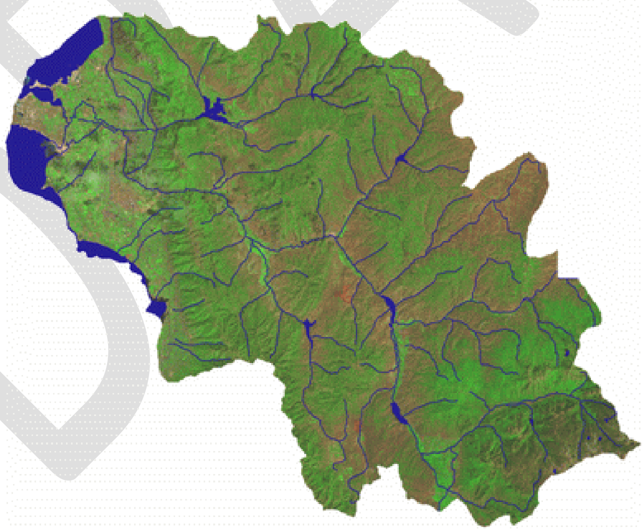
Appendix 3-B

Hydrologic Model Report – Utah DWRe

Utah Division of Water Resources

Weber River RiverWare Model

A Brief Description of the Utah Division of Water Resources Weber River RiverWare Model



By Scott McGettigan P.E. & Tony Melcher
5-23-2018

History of Model

The Utah Division of Water Resources' first version of the Weber River Model was a FORTRAN model that was designed in the 90's. The model was originally created to assist in the Bear River development simulations, and to gain a better understanding of the dynamic between the two basins under potential Bear River project scenarios. The model, however, has since been used for multiple purposes.

Between the time of its initial creation and its most recent update, the Weber River Model was mainly used to make historical runs based on past flow and diversion records. Potential changes to water demand or streamflows weren't thoroughly explored.

Though valuable at the time, it was challenging to modify the FORTRAN model for various modeling alternatives. As a result, the model was converted to its current state, using the RiverWare platform.

Current Model

As mentioned, the Weber River Model has been updated within the last several years to the RiverWare platform. This update has more easily allowed the opportunity to explore alternative scenarios with the model. Making adjustments to rules, reservoirs, inflows, demands, etc. is a much smoother process.

Even though the model has been updated, and how the user interacts with it has altered, much of the core in the model remains the same. The RiverWare version uses much of the same operating policies and settings as the FORTRAN version.

The Weber River Model is mainly a water supply model with the intended purpose being to explore how different scenarios may affect supply. The model is not intended to be an operations model for day-to-day purposes and shouldn't be used as such. The model is best understood and applied to a higher level of evaluation. The model is most valuable when used to explore the long-term dynamics within the basin.

Model Elements and Parameters

Model Layout

The river is modeled from upstream to downstream, and contains representations of major reservoirs, reaches, and water users on the system. Many water users are combined into aggregate groups on sections of the river, especially higher in the system where there is a greater number of individual users. Large canal diversions, most of which are lower in the system, are typically modeled individually. Major tributaries are identified as single inflows while the smaller, ephemeral tributaries are grouped into single reach gains that accumulate downstream between gauges. Figure 1 shows a snippet of the model structure and domain as described.

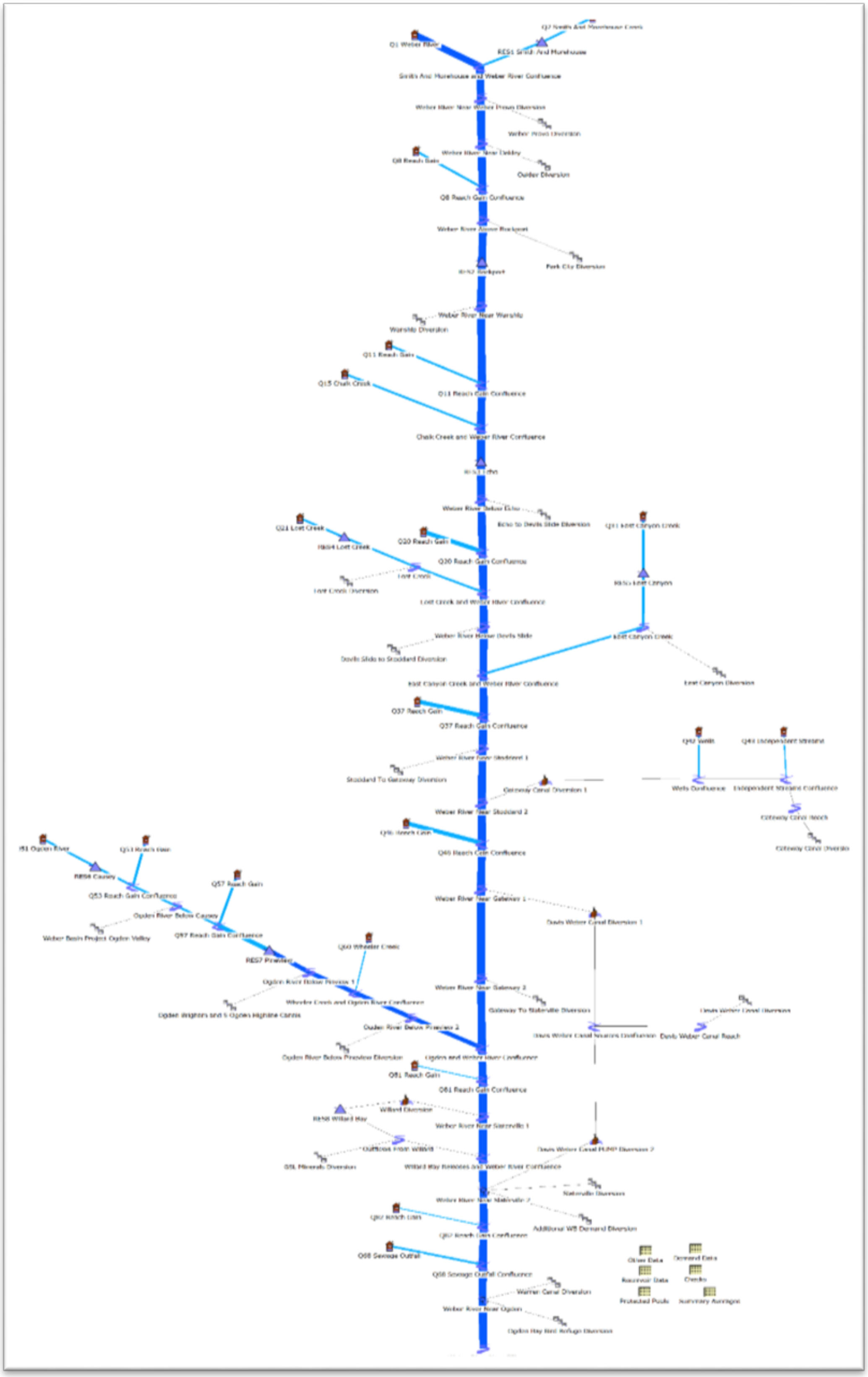


Figure 1 - Weber River Model RiverWare Layout

Reservoir parameters

Much of the reservoir information regarding dead pools, minimum releases, and protected pools was obtained from Weber Basin Water Conservancy District (WBWCD) or verified by them. The stage-area-capacity tables and evaporation rates were, for the most part, transferred from the previous model. The following tables outline some of the essential reservoir parameters. It can also be noted that reservoirs were identified in the FORTRAN model using a nomenclature that has been preserved in the RiverWare model.

Table 1 - Monthly Reservoir Evaporation Rates

Monthly Reservoir Evaporation Rates													
		(ft/mon)											
No.	**Name**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Res 1	Smith and Morehouse	0	0	0	0	0.14	0.32	0.48	0.42	0.2	0.04	0	0
Res 8	Willard Bay	0	0	0.02	0.15	0.33	0.55	0.81	0.7	0.41	0.18	0	0
Res 2 - Res 7	(all others)	0	0	0	0.06	0.2	0.39	0.58	0.51	0.27	0.09	0	0

Table 2-Minimum Reservoir Releases

Minimum Reservoir Releases		
		Flow
No.	**Name**	*(ac-ft/mon)*
Res 1	Smith and Morehouse	450
Res 2	Rockport	3000
Res 3	Echo	0
Res 4	Lost Creek	450
Res 5	East Canyon	300
Res 6	Causey	600
Res 7	Pineview	600
Res 8	Willard Bay	0

Table 3-Reservoir Protected Pools

Non-WBWCD Reservoir Protected Pools			
		Volume	
No.	**Name**	*(ac-ft)*	**Pool Owner**
Res 5	East Canyon	28800	Davis Weber Canal
Res 7	Pineview	44000	Pineview Water Users

Table 4-Minimum and Maximum Reservoir Storages

Minimum and Maximum Reservoir Storages			
No.	Name	Min Volume *(ac-ft)*	Max Volume *(ac-ft)*
Res 1	Smith and Morehouse	751	8350
Res 2	Rockport	2120	61260
Res 3	Echo	0	73940
Res 4	Lost Creek	2500	22510
Res 5	East Canyon	3090	51200
Res 6	Causey	1000	7870
Res 7	Pineview	0	110150
Res 8	Willard Bay	25029	247302

General Model Parameters

Besides the parameters relating to specific objects in the model, there are a handful of other important general settings that should be noted. The model operates on a monthly time-step. The time series range is dependent on what scenario is being run, and is based on an October to September water year. The majority of the units for flow and volume are set to acre-feet, or acre-feet/month or some other form of U.S. customary units (however, RiverWare runs all calculations in SI units).

Service Areas & Demands

Demands for the water users were developed from water rights diversion records. Water user records for every tracked user in the basin were grouped into the aggregate areas, or identified as being part of a major canal and totaled monthly for the period of record collected. These results were then available for use in historical runs, or to identify averages, maximum values, etc. to be used for scenario demands. The service areas used in the model are given in Table 5, with their associated average, maximum, and second highest demands. Maximum demands from this table were used in the model because they are conservative for the purposes of planning. Additionally, the maxima calibrated well with historic storage levels. These service areas are also identified using the naming scheme from the FORTRAN model.

Table 5 - Service Areas and Demands

Service Areas	Historic Annual Demands 2003-2013 (ac-ft)		
	AVG	**MAX**	**2nd**
SA1 Weber Provo Diversion Canal	35500	67700	61000
SA2 Oakley to Wanship	31300	40600	39600
SA3 Wanship to Echo	10800	12700	11900
SA4 Echo to Devils Slide	9000	9800	9700
SA5 Lost Creek	6300	8600	7400
SA6 Devils Slide to Stodard	21700	24900	24300
SA7 Park City	6600	6600	6600
SA8 East Canyon	10800	13000	11500
SA9 Stoddard To Gateway	1500	1800	1800
SA10 Gateway Canal*	88600	101000	95800
SA11 Davis Weber Canal	61900	82500	80300
SA12 Weber Basin Project Ogden Valley	26800	31700	31200
SA13 Ogden Brigham and S Ogden Highline Canals	30700	34400	32400
SA14 Ogden River Below Pineview	23300	26700	24100
SA15 Slaterville	73400	102500	87000
SA16 Warren Canal	19000	23200	20900
SA17 Ogden Bay Bird Refuge	60500	60500	60500
SA18 GSL Minerals	12800	17100	16400
SA19 Gateway To Slaterville	18200	24300	21600
SA20 Additional WB Demand**	0	0	0
TOTALS	**548700**	**689600**	**644000**
** Annual demands come from WBWCD records, not Water Rights*			
** Used for potential growth scenario modeling*			

Model Inflows

Inflow boundary conditions are placed either at reach gains, or at the head waters of major tributaries within the model, and are produced by regression and a back calculation method to eliminate the effects of reservoir operations and diversions. The reach gains essentially represent the difference between two gauges (downstream minus the upstream) that have been corrected back to natural flow. Table 6 shows the inflow calculations specified by QX, which is the naming convention that has been maintained from the previous model.

The back calculation method referred to requires historical reservoir records, which came either from WBWCD or US Bureau of Reclamation (BOR). It also required diversion records, which came from the Utah Division of Water Rights (WRi). These records are essentially the same records used for producing area demands.

Obtaining inflows at gauged sites with incomplete records required a reference station with a more complete record that was used to extend all other gauges. This reference station is the Weber at Oakley Gauge (10128500). This gauge has the longest record on the Weber River and one of the longest in the

State. Every gauge used to develop the model inflows is correlated with the Weber at Oakley gauge as the base station.

Table 6 - Model Inflow Calculations

Weber Model System Inflow Calculations		
QXs	**Calculation**	**Inflow Type**
QX1	= Oakley (10128500) - Smith & Morehouse Outflow	Reservoir Inflow
QX2	= Smith & Morehouse Outflow	Head Waters
QX8	= Rockport Outflow (10129500) - Oakley (10128500)	Reach Gain
QX11	= Echo Outflow (10132000) - Rockport Outflow (10129500) - Chalk Creek (10131000)	Reach Gain
QX15	= Chalk Creek (10131000)	Tributary Stream
QX20	= Devil's Slide (10133500) - Lost Creek (10132500) - Echo Outflow (10132000)	Reach Gain
QX21	= Lost Creek (10132500)	Reservoir Inflow
QX31	= East Canyon (10134500)	Tributary Stream
QX37	= 45% of [Gateway (10136500) - Morgan/Stoddard (10136000) - Devil's Slide (10133500) - East Canyon Outflow (10134500)]	Reach Gain
QX42	= Wells Historical Averages	Well Supply
QX43	= Independent Streams Historical Averages	Multiple Tributaries
QX46	= 55% of [Gateway (10136500) - Morgan/Stoddard (10136000) - Devil's Slide (10133500) - East Canyon Outflow (10134500)]	Reach Gain
QX51	= Causey Outflow	Reservoir Inflow
QX53	= Huntsville (10137500) - Causey Outflow	Reach Gain
QX57	= Pineview Outflow (10140100) - Wheeler Crk (10139300) - Huntsville (10137500)	Reach Gain
QX60	= Wheeler Crk (10139300)	Tributary Stream
QX68	= Sewage Outfall Historical Averages	Return Flows
QX81	= 55% of [10141000 - Pinview Outflow (10140100) - Gateway (10136500)]	Reach Gain
QX82	= 45% of [10141000 - Pinview Outflow (10140100) - Gateway (10136500)]	Reach Gain

Operating Policies/Model Rules

Most of the policy that drives the model forward is based on a service area call structure that was established in the FORTRAN version of the model. This structure represents the early efforts of those who worked on the model in attempting to understand and generalize the way system operators respond to conditions on the river. The structure has been shared with WBWCD operators at various times to verify the approach and, for the most part, has been accepted as a reasonable way to generalize the way the system is operated. The core of the model rules revolves around this call structure and it is presented in Table 7.

Table 7 - Area Reservoir Call Order

Area Reservoir Call Order			
Service Area No.	**Name**	**Model Execution Order**	**Order of Reservoirs Called**
1	Weber Provo Diversion Canal	1	1*
2	Oakley to Wanship	2	1
3	Wanship to Echo	3	2
4	Echo to Devils Slide	4	3,2
5	Lost Creek	5	4
6	Devils Slide to Stoddard	6	3,2
7	Park City	7	1
8	East Canyon Creek	8	5
9	Stoddard to Gateway	9	3,2,4
10	Gateway Canal	10	3,2,4,5,1
11	Davis Weber Canal	14	8***,3,5
12	Weber Basin Project Ogden Valley	11	6
13	Ogden Brigham & S. Ogden Highline canals	12	7
14	Ogden River Below Pineview	13	7
15	Slatterville Diversion	16	7**,8,7,3,2,4,5
16	Warren Canal	18	7,8,3
17	Ogden Bay Bird Refuge	19	8,7,3,2,4,5
18	G.S.L Minerals	20	8
19	Gateway to Slatterville	15	3,2,4,5
20	Additional Weber Basin Demand	17	8,7,3,2,4,5
** Only calls inflows, no storage*			
*** Calls up to %50 of available storage*			
**** Pumped deliveries only under certain criteria*			

Inflow Scenarios

Historic

Any historic scenario that is produced for the Weber River Model is based on a linear-regression of natural flows with the Weber at Oakley gauge as the base station. Every gauge that is used as a tributary or for a reach gain calculation is shown in Table 8 with their associated annual correlation R^2 values. Annual correlation R^2 values are shown, but monthly were actually used. Showing the annual gives an overall perspective on the relationship between the gauges. True historic correlated inflows can only be created for the range covered by the Weber at Oakley gauge which is 1905 – Present.

Table 8 - R^2 Values for Annual Correlations with Weber at Oakley Gauge

Annual Linear Regression with Weber at Oakley Gauge	
Stream Gauge	**Annual R*R**
10129500	0.947
10131000	0.875
10132000	0.968
10132500	0.845
10133500	0.997
10134500	0.791
10136000	0.997
10136500	0.834
10137500	0.873
10139300	0.864
10140100	0.873
10141000	0.917
Causey Res Outflow	0.648
SMRes Outflow	0.956
Weber Independent Streams*	0.155
Note: Monthly, not annual regression was used	
** Small volumes, poor regression likely has no significance*	

Paleo

Through the exceptional efforts made by a number of researchers from universities, including but not limited to USU and BYU, using their expertise in the fields of dendrochronology, statistics, and hydrology, the Weber at Oakley gauge has been extended back to the year 1429. This lengthening of the record is mostly made possible by the study of tree-rings on old-growth trees. The topic is well documented and can be studied more extensively in other publications.

In addition to the work done by these researchers to extend the Oakley gauge, USU has done further work to translate these extended annual flows to monthly flows, making it possible to implement into the Weber Model, and give a more detailed look into how earlier droughts occurred.

One of the major benefits of having the ability to look back so far into the past is the understanding of the level of preparation that be needed should certain hydrologic conditions be encountered. This record gives us a clearer window back into history and the chance evaluate it through modeling former hydrology with current and/or projected demands.

Using the paleo-flows required another set of regression equations be developed for every stream-gauge based on calculated flows for Weber at Oakley through the period which is historically recorded. The alternative correlation coefficients are presented in Table 9.

Table 9 - R^2 Values for Annual Correlations with Reconstructed Weber at Oakley

Annual Linear Regression with Reconstructed Weber at Oakley	
Stream Gauge	**Annual R*R**
10129500	0.661
10131000	0.656
10132000	0.587
10132500	0.646
10133500	0.702
10134500	0.593
10136000	0.666
10136500	0.701
10137500	0.768
10139300	0.732
10140100	0.507
10141000	0.693
Causey Res Outflow	0.529
SMRes Outflow	0.623
Weber Independent Streams*	0.161
Note: Monthly, not annual regression was used	
** Small volumes, poor regression likely has no significance*	

Climate Change

Exploring how potential climate changes could affect streamflow has become increasingly important to water managers in the west. For the Weber River, this is no exception. Western Water Assessment (WWA), a non-profit research program, that provides support to water planning activities, has developed a set of potential hydrologic scenarios that could be encountered based on global climate change models. Using downscaled CMIP5 climate traces, WWA has provided 5 climate pathways of flow on the Weber River. These pathways are: Hot-Dry, Warm-Dry, Hot-Wet, Warm-Wet, and Central-Tendency. Each scenario is a 30 year period of possible future hydrology representing 2030-2060. Plots of how each of these climate conditions might affect Weber at Oakley flow, and any shifts in the hydrograph, are shown in Figure 2. Each of the flow conditions shown in the figure were applied to the model at the main inflows using regression techniques similar to the ones used in applying the paleo-records.

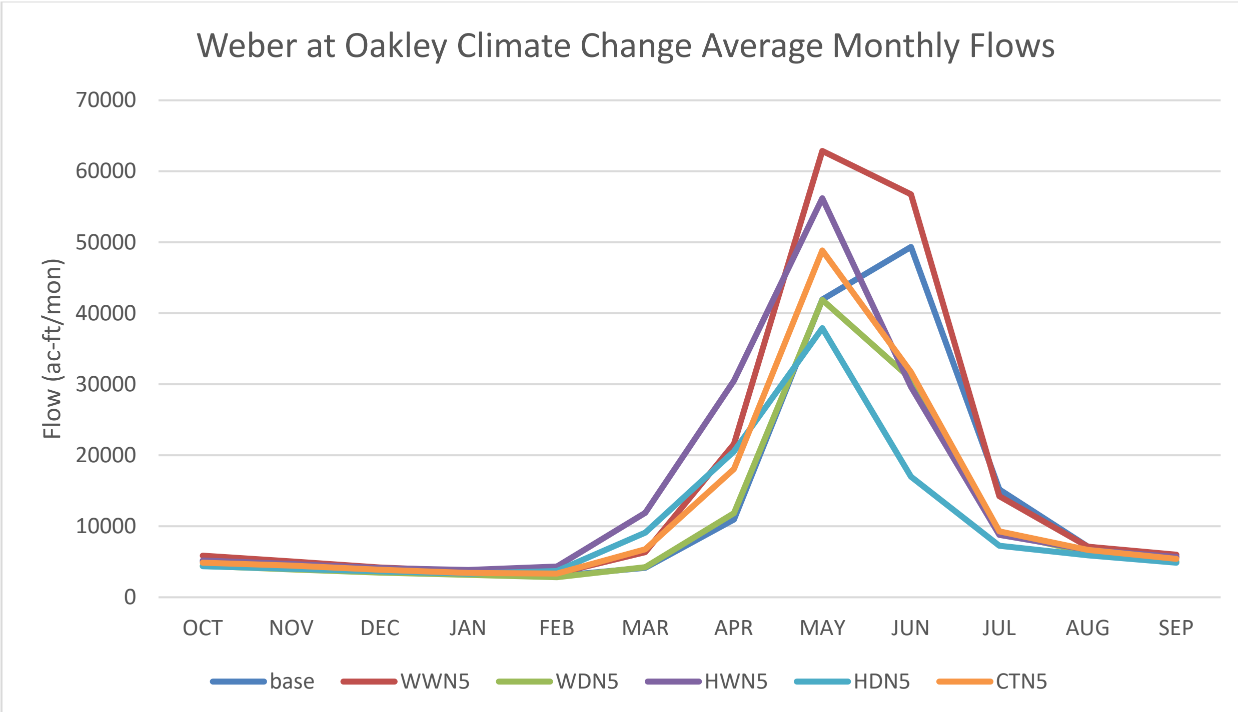


Figure 2 - Weber at Oakley Climate Change Average Monthly Flows

Base Operations/Conditions

Applying either the climate change or paleo inflows to the model produced base set of results for standard operations and current system facilities. The data for each of these 'Base' runs are presented in the following sections. With these base conditions there is a set of data to compare against with hypothetical changes to operations or the system.

Paleo

A plot showing the total basin reservoir storage results for the base paleo scenario run covering the full available period is presented in Figure 3. The years covered are from October 1429 – September 2002. In subsequent sections, plots will be presented showing various drought response and mitigation actions. These actions will be compared to the results of this "base" plot, which will demonstrate the effectiveness of the action.

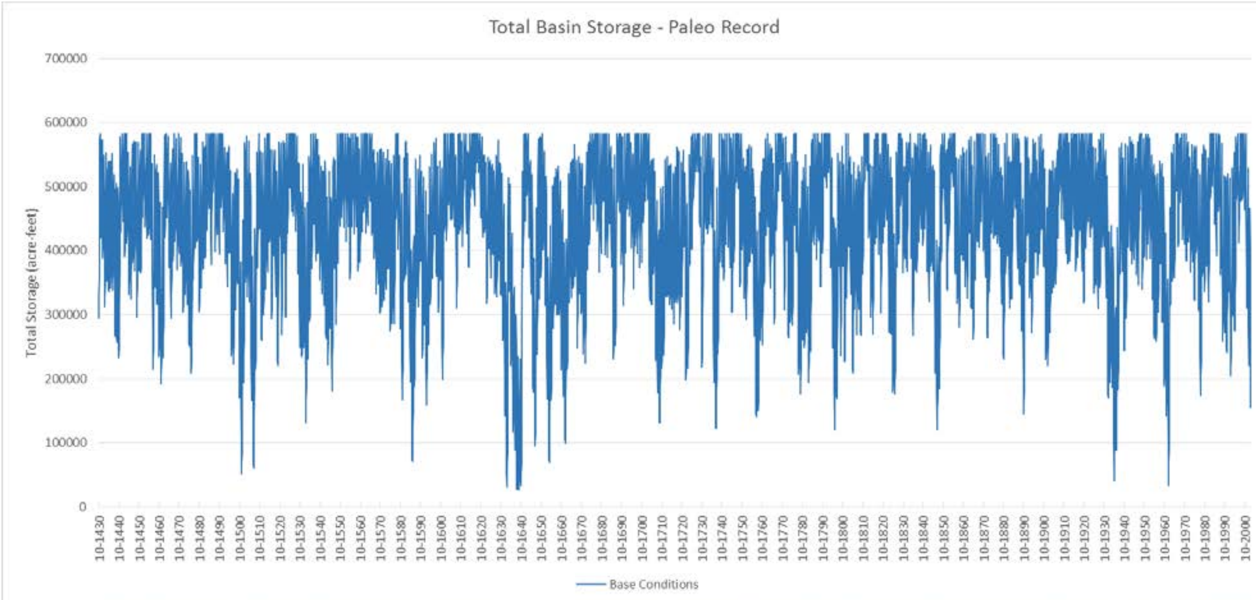


Figure 3 - Total Basin Storage Results for Paleo-flows Under Base Operations

Climate Change

Applying each of the five climate scenario inflows to the model produces five different versions of the effects of climate change to the flow in river. The storage plots for these scenarios are shown in Figure 4. The model period is 30 years, representing the future years of 2030 – 2060. For the purposes of drought contingency planning the two wet scenarios are of less value, but are still presented and may be useful for context. The historical plot is also presented to give context. Historical in this sense refers to historical hydrology. Because the climate trace hydrologic conditions were derived from 1980 – 2010 conditions, adding this plot can shed some light on the implications of the other plots. As with the paleo base scenario, these climate change plots will also be used as a basis for comparison for each drought response and mitigation modeled in subsequent sections.

Figure 4 - Total Basin Storage with the Five Climate Change Pathways under Base Operations

Action Scenarios

Drought Mitigation

Gravel Pit Reservoir

Scenario Description

For this scenario a 16,000 acre-foot off-stream reservoir was placed at the mouth of Weber Canyon where currently a gravel pit is operated. This potential reservoir could be used to address shortages during drought situations, and is modeled in this manner. The reservoir in the model was programed to cover only shortages seen for the Gateway Canal service area.

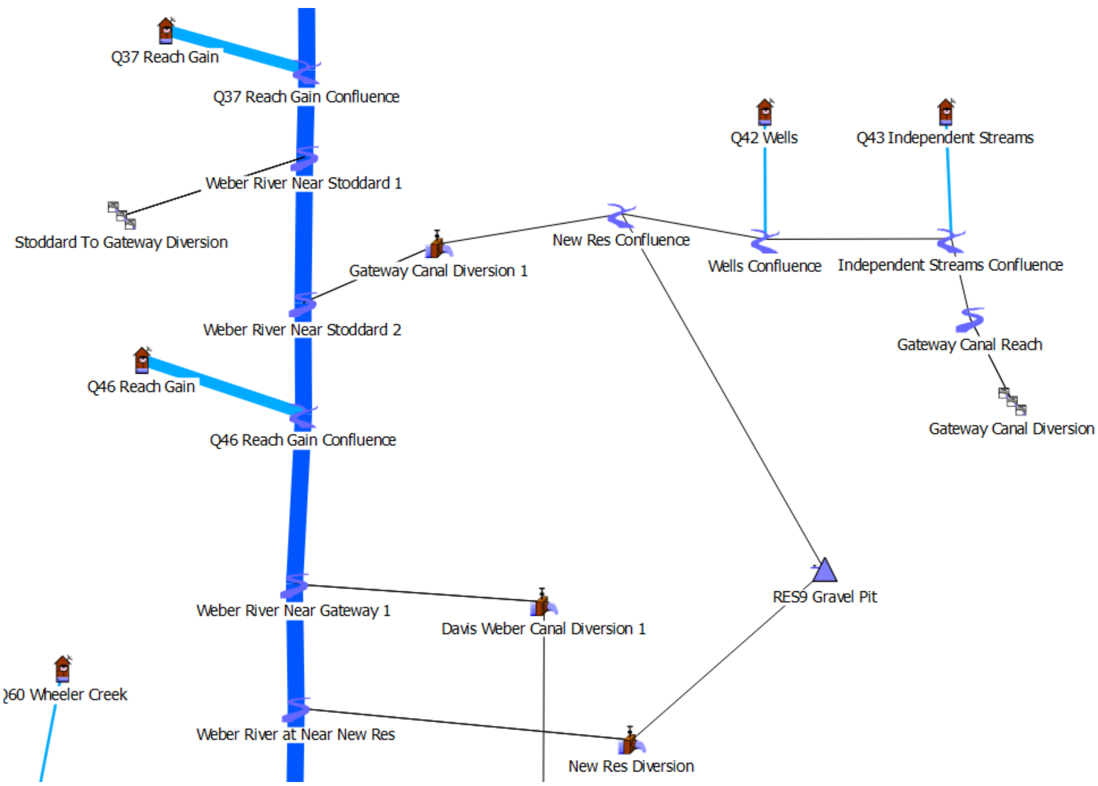


Figure 5 – Screen Capture of Model Containing the Proposed Gravel Pit Reservoir

Scenario Assumptions

The stage-area-capacity table for this hypothetical reservoir is shown in Table 10, which was determined from a feasibility study done by Bowen Collins and Associates on behalf of WBWCD. The diversion capacity established by study was 13 cfs. Evaporation was set to the same rates as the Willard Bay. Calls from this by reservoir by SA10 – Gateway Canal would occur fourth in line, i.e. the alternative reservoir call order for SA10 would be: RES3 – Echo, RES2 – Rockport, RES4 – Lost Creek, *RES9 – Gravel Pit*. Being an off-stream reservoir, any reservoir inflows would need to come by way of diversions. Diversion requests to the reservoir were set to any available water in the river at any time of the year that would bring the reservoir to full.

Table 10 - Potential Gravel Pit Reservoir Stage-Area-Capacity Table

Gravel Pit Reservoir Stage-Area-Capacity		
Elevation	**Capacity**	**Area**
(ft)	*(ac-ft)*	*(acres)*
4366.8	0	78
4370	250	78
4380	1000	84
4390	1900	89
4400	2800	95
4410	3800	101
4420	4900	107
4430	6050	113
4440	7200	120
4450	8500	127
4460	9750	133
4470	11200	141
4480	12600	147
4490	14150	155
4500	15750	163

Chalk Creek Reservoir

Scenario Description

For this scenario a 10,000 acre-foot reservoir was placed on the Chalk Creek tributary. This potential reservoir could be used to address shortages during extreme drought situations, and is modeled in this manner. The reservoir in the model was programed to cover only shortages seen for the Gateway Canal service area.

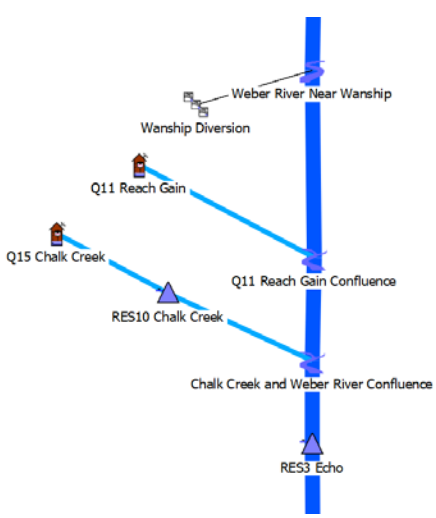


Figure 6 – Screen Capture of Model Containing the Proposed Chalk Creek Reservoir

Scenario Assumptions

The stage-area-capacity table for this hypothetical reservoir is shown in Table 11, which was provided by WBWCD. Evaporation was set to the same rates as the other reservoirs that are at approximately the same elevation. Calls from this by reservoir by SA10 – Gateway Canal would occur fourth in line, i.e. the alternative reservoir call order for SA10 would be: RES3 – Echo, RES2 – Rockport, RES4 – Lost Creek, *RES10 – Chalk Creek*.

Table 11 - Potential Chalk Creek Reservoir Stage-Area-Capacity Table

Chalk Creek Reservoir Stage-Area-Capacity		
Elevation	**Capacity**	**Area**
(ft)	*(ac-ft)*	*(acres)*
5837	0	1
5840	5	2
5850	48	7
5860	146	13
5870	320	21
5880	586	32
5890	976	47
5900	1530	66
5910	2290	89
5920	3290	110
5930	4490	130
5940	5910	154
5950	7550	178
5960	10000	211

Expanded ASR

Scenario Description

For this scenario ground water storage would be expanded to 10,000 acre-feet per year, and withdrawals would occur when needed. Currently the WBWCD ASR project is infiltrated at 2 cfs, and as of current date, no water has ever been recovered from the aquifer. Any water stored in the aquifer would be mandated by DWRi to take a calculated loss. Groundwater pumping from the aquifer was programed in the model to cover only shortages seen for the Gateway Canal service area.

Scenario Assumptions

A storage cap was placed on the aquifer of 30,000 acre-feet. This number was completely arbitrary, but necessary in order to keep the model running for the paleo scenario. The monthly diversions to be infiltrated are 1667 acre-feet over a six month period from March to August. There is no capacity set for pumping from the aquifer, other than the total volume available. The WRi mandated loss is calculated in this manner: the full amount of water is available after the first and second years of storage, every subsequent year any volume not used is assessed a 50% loss.

Wastewater Reuse

Scenario Description

This is a very simple scenario in which wastewater reuse would be implemented at various areas in Davis and Weber counties, which would in turn alleviate the demand on the Gateway Canal for secondary water.

Scenario Assumptions

There are very little assumptions associated with this scenario. To replicate this concept in the model, the annual demand on SA10 – Gateway Canal, was reduced by 10,000 acre-feet, with the same demand pattern in place as in a standard scenario. Everything else was unchanged in the model.

Drought Response

Demand Management

Scenario Description

This is a fairly complicated scenario that involved many adjustments to the model and operating rules in order to function. The intent of this scenario is to respond to droughts with prescribed demand reductions, based on the condition of the system reservoirs. In taking this approach, WBWCD aims to protect its M&I supplies in times of severe shortage.

Scenario Assumptions

Most of the assumptions established for this scenario were derived from a table produced by WBWCD that outlined how and when reductions are to occur. Table 12 shows this this table with three categories of reductions defined by the colors Yellow, Orange and Red.

Table 12 - WBWCD Demand Management Triggers and Reductions

			Water Supply Triggers		**Demand Reduction Targets**			
Response Level	Advisory Code	Water Shortage Description	Total Basin Storage- June 1st	Total Upstream Storage - June 1st	Secondary Water	Agricultural Irrigation	M&I Culinary Outdoor Water	M&I Culinary Indoor Water
1	Green	Normal			0	0	0	0
2	Yellow	Moderate	373,630 AF to 413,630 AF	208,600 AF to 253,600 AF	20%	20%	20%	0%
3	Orange	Severe	313,630 AF to 373,630 AF	168,600 AF to 208,600 AF	60%	40%	60%	10%
4	Red	Extreme	less than 313,630 AF	less than 168,600 AF	95%	70%	95%	33%

In addition to applying reductions at reservoir levels, as described in the previous table, the model attempts to forecast the potential risk of facing a reduction call on June 1st, based on March 1st storage levels and inflow. Two tables were developed by WRe that applied probability risks to ranges of storage and predicted inflows (Tables 13 and 14). The tables were created based on the paleo flow record and use total basin storage and "upstream storage" criteria. The more conservative of the total basin storage and the "upstream storage" criteria was determined during the model simulation and the corresponding reductions were applied. The first two columns of the tables represent all combinations of the 25th, 50th, 75th, and 100th percentiles of total upstream storage on March 1st (column 1) and the total natural runoff volumes between March 1st to June 1st to Pineview reservoir and the Weber River near the Gateway canal diversion (column 2). Probabilities of yellow, orange, and red advisory codes at June 1st are given in columns 3, 4, and 5 respectively.

This scenario implemented the most severe demand reduction given a probability greater than "0." For example, if the March 1st total basin storage for a single year was 350,000 ac-ft and the runoff between March 1st and June 1st was 400,000 ac-ft then this case would correspond with row 2 of the Table 13. The corresponding probabilities are 8 percent for yellow, 0 percent for orange, and 0 percent for red. Similarly, if the March 1st upstream storage was 150,000 ac-ft then this case would correspond with row 2 of Table 14. The corresponding probabilities are 0, 0, and 0 for yellow, orange and red levels respectively. In this case, the yellow reduction would have been implemented, corresponding with Table 13 as it is more severe and the probability is greater than "0." This demand reduction would then be implemented until the next year on March 1st when the reduction status would be updated.

Table 13 –Look-up Table for Total Basin Storage

Demand Management - Total Basin Storage				
March 1st Bins (ac-ft)*	**March 1st - June 1st Runoff Bins (ac-ft)***	**Probability of Yellow Advisory Code**	**Probability of Orange Advisory Code**	**Probability of Red Advisory Code**
378041	322933	13%	11%	9%
378041	427891	8%	0%	0%
378041	556654	0%	0%	0%
378041	1010188	0%	0%	0%
458351	322933	0%	0%	0%
458351	427891	0%	0%	0%
458351	556654	0%	0%	0%
458351	1010188	0%	0%	0%
490562	322933	0%	0%	0%
490562	427891	0%	0%	0%
490562	556654	0%	0%	0%
490562	1010188	0%	0%	0%
553311	322933	0%	0%	0%
553311	427891	0%	0%	0%
553311	556654	0%	0%	0%
553311	1010188	0%	0%	0%
*Values calculated based on the 25, 50, 75, and 100 percentiles and represent the upper end of the binning category.				

Table 14 – Look-up Table for Total Upstream Storage

Demand Management - Upstream Storage				
March 1st Bins (ac-ft)*	March 1st - June 1st Runoff Bins (ac-ft)*	Probability of Yellow Advisory Code	Probability of Orange Advisory Code	Probability of Red Advisory Code
173411	322933	42%	11%	3%
173411	427891	0%	0%	0%
173411	556654	0%	0%	0%
173411	1010188	0%	0%	0%
222415	322933	10%	0%	0%
222415	427891	0%	0%	0%
222415	556654	0%	0%	0%
222415	1010188	0%	0%	0%
243260	322933	0%	0%	0%
243260	427891	0%	0%	0%
243260	556654	0%	0%	0%
243260	1010188	0%	0%	0%
306009	322933	0%	0%	0%
306009	427891	0%	0%	0%
306009	556654	0%	0%	0%
306009	1010188	0%	0%	0%

*Values calculated based on the 25, 50, 75, and 100 percentiles and represent the upper end of the binning category.

Fallowing Program

Scenario Description

The fallowing scenario is similar in function and objectives to the demand management scenario, the main difference being that the reductions would occur through a paid fallowing program administered and funded by WBWCD. The target volume by the program would be 10,000 acre-feet.

Scenario Assumptions

Much of the assumptions and operations for this scenario are identical to the demand management scenario with a few exceptions, the program is modeled to initiate at the Orange reduction level and not have any other stages of response, only the target volume previously mentioned. Also, the service areas modeled with reduced demand are all agricultural. All other details for this scenario are described in the demand management scenario section.

Additional Scenarios

Increased Demand

Scenario Description

This scenario represents a projected increase in demand for various service areas based on a projected increase in population. Projections for this scenario are rough, but give a perspective of how sensitive the system is to non-climate related changes in conditions.

Scenario Assumptions

WBWCD provided the data and information that was compiled to form the demand increases. The following tables (Table 15 and Table 16) show some of the basic overall numbers from WBWCD summarizing demands and expected county ag conversion. All of these increases and conversions were distributed among selected service areas in the model in the manner outlined in Table 17. A base year of 2020 was chosen as to evaluate the increases because the initial demands in the model are already set to a conservatively high estimate.

Table 15 - Total WBWCD Demands for Future Years

Total District-wide M&I Demand No-Conservation & Conservation Scenarios Averaged (acre-ft)			
Year	Wasatch Front	Wasatch Back	Total
2010	181624	35213	216837
2020	198562	41762	240324
2030	213560	48935	262495
2040	230985	55161	286146
2050	244146	58357	302503
2060	262582	61994	324576

Table 16 - Agricultural Conversion Estimates for Counties in Weber Basin

Area	**2060 Conversion Amount (acre-feet)**
Davis County	19586
Weber County (Wasatch Front)	31936
Ogden Valley	4531
Morgan County	2700
Eastern Summit	3411
Snyderville Basin	260
Totals	**62425**

Table 17 - Distributed Service Area Demand Increases

MODEL DEMAND INCREASES EVALUATION (ac-ft/yr)								
	Current Model Demand	M&I Demand Increases					Ag Conversion	M&I Increase w/ Ag Conversion
Year:		2020	2030	2040	2050	2060	2060	2060
Eastern Summit*								
SA2 - Oakley to Wanship	40600	0	706	1382	1648	2001	2195	0
SA3 - Wanship to Echo	12700	0	221	432	515	626	687	0
SA4 - Echo to Devils Slide	9800	0	170	334	398	483	530	0
TOTAL	**63100**	**0**	**1097**	**2148**	**2561**	**3110**	**3411**	**0**
Morgan County								
SA5 - Lost Creek	8600	0	207	350	397	484	481	4
SA6 - Devils Slide to Stodard	24900	0	600	1013	1151	1402	1392	10
SA8 - East Canyon	13000	0	313	529	601	732	727	5
SA9 - Stoddard To Gateway	1800	0	43	73	83	101	101	1
TOTAL	**48300**	**0**	**1164**	**1965**	**2232**	**2720**	**2700**	**20**
Ogden Valley								
SA12 - Ogden Valley	31700	0	882	2038	3560	5759	4531	1228
TOTAL	**31700**	**0**	**882**	**2038**	**3560**	**5759**	**4531**	**1228**
Snyderville Basin								
SA7 - Park City	6600	0	4056	7051	7823	8002	260	7742
TOTAL	**6600**	**0**	**4056**	**7051**	**7823**	**8002**	**260**	**7742**
*Replacement Contracts***	NA	0	222	444	667	889	NA	NA
Wasatch Front								
SA10 - Gateway Canal	101000	0	7444	16092	22624	31774	25571	6203
SA15 - Slaterville	102500	0	7554	16331	22960	32246	25951	6295
TOTAL	**203500**	**0**	**14998**	**32423**	**45584**	**64020**	**51522**	**12498**
BASIN TOTALS	**353200**	**0**	**22197**	**45625**	**61760**	**83611**	**62424**	**21488**
** Negatives rounded-up to zero*								
*** Not applied in calculations*								

Scenario Results - Paleo

Drought Mitigation

Gravel Pit Reservoir

Water is rarely drawn from the proposed Gravel Pit Reservoir during the paleo simulation period. This may be due to the reservoir only being called on as a last resort, and the Gateway Canal service area not being as vulnerable to drought as other areas, due to its lower positioning in the system. Figure 7 is a plot of total storage for this simulation.

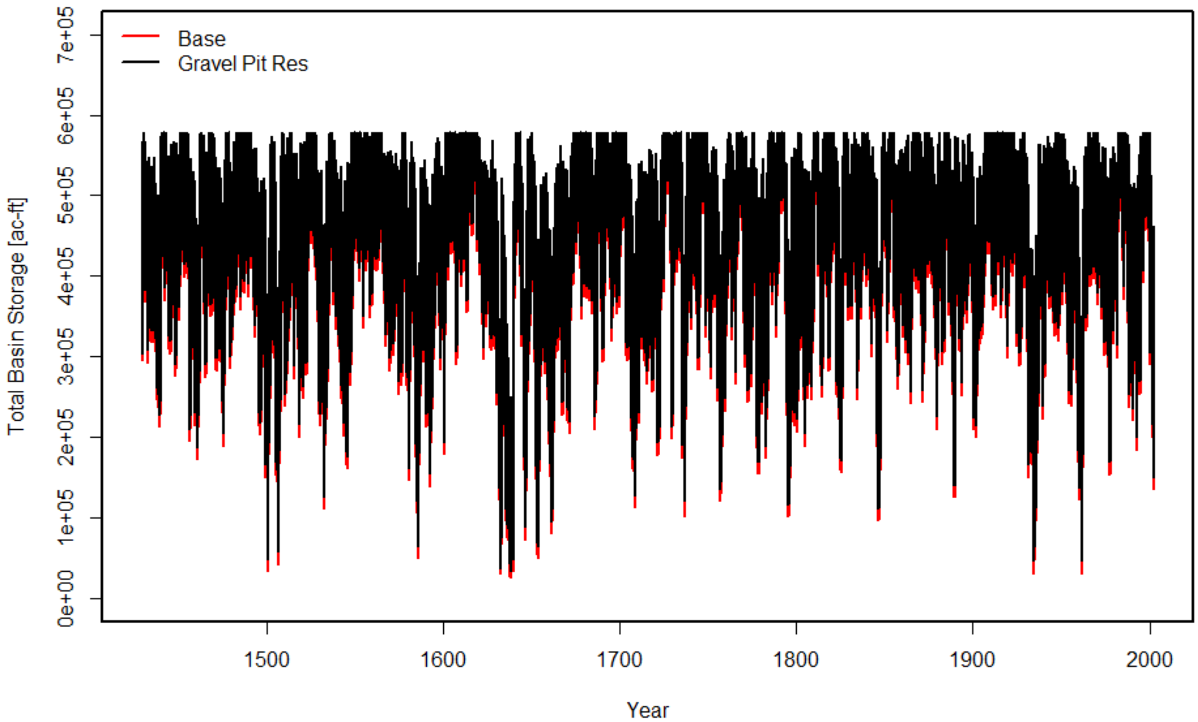


Figure 7 - Estimated Total Basin Storage with Gravel Pit Reservoir Storage

As can be seen in Figure 8, Gravel Pit storage would only be used during the 1630s drought, or during extreme drought conditions. There are however benefits to the additional storage during other drought years. While the reservoir was modeled as a “last resort” reservoir, in actual drought conditions the Gravel Pit storage can be used to lessen the impact of the drought on other reservoirs. This may prevent storages in the district’s reservoirs from reaching dead pool levels.

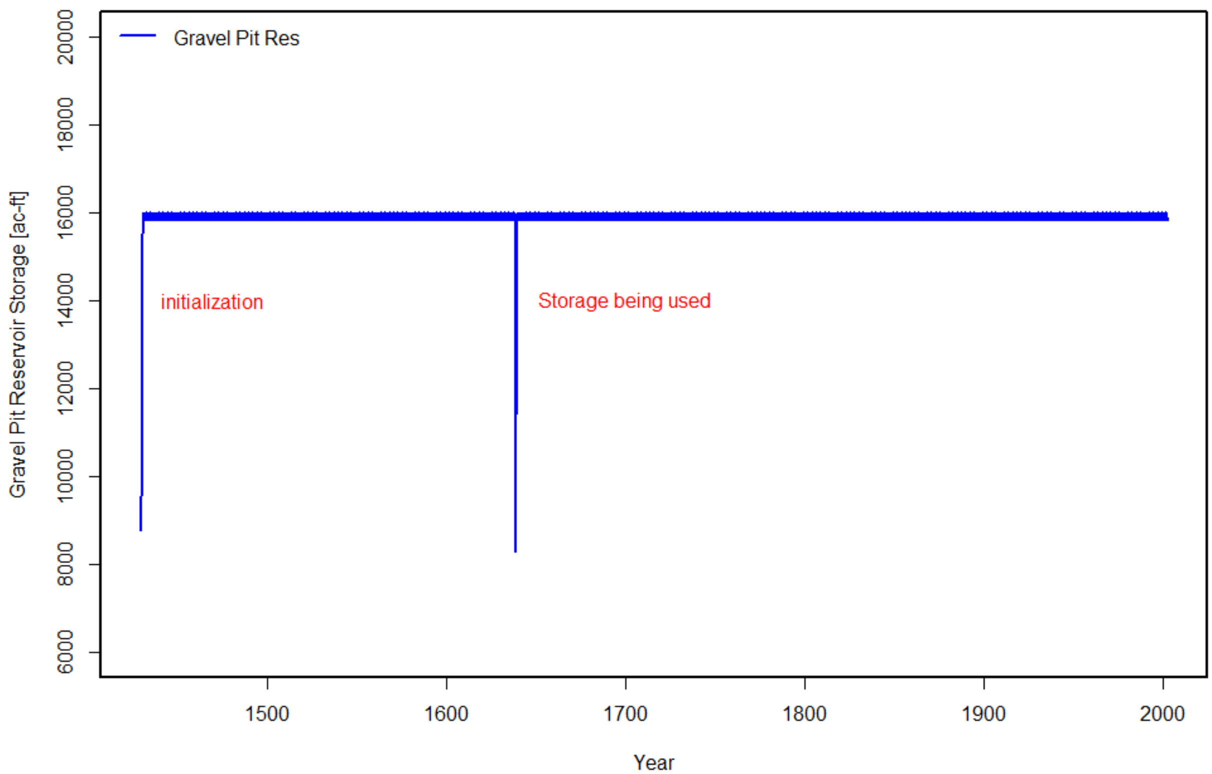


Figure 8 - Gravel Pit Reservoir Storage

Chalk Creek Reservoir

Similar to the Gravel Pit Reservoir, water is rarely drawn from the proposed Chalk Creek Reservoir during the paleo simulation period. Again this may be due to the order in which the reservoir is called in the model and the Gateway Canal service low position in the system. Figure 9 shows a plot of the basin's total storage for the Chalk Creek Reservoir scenario.

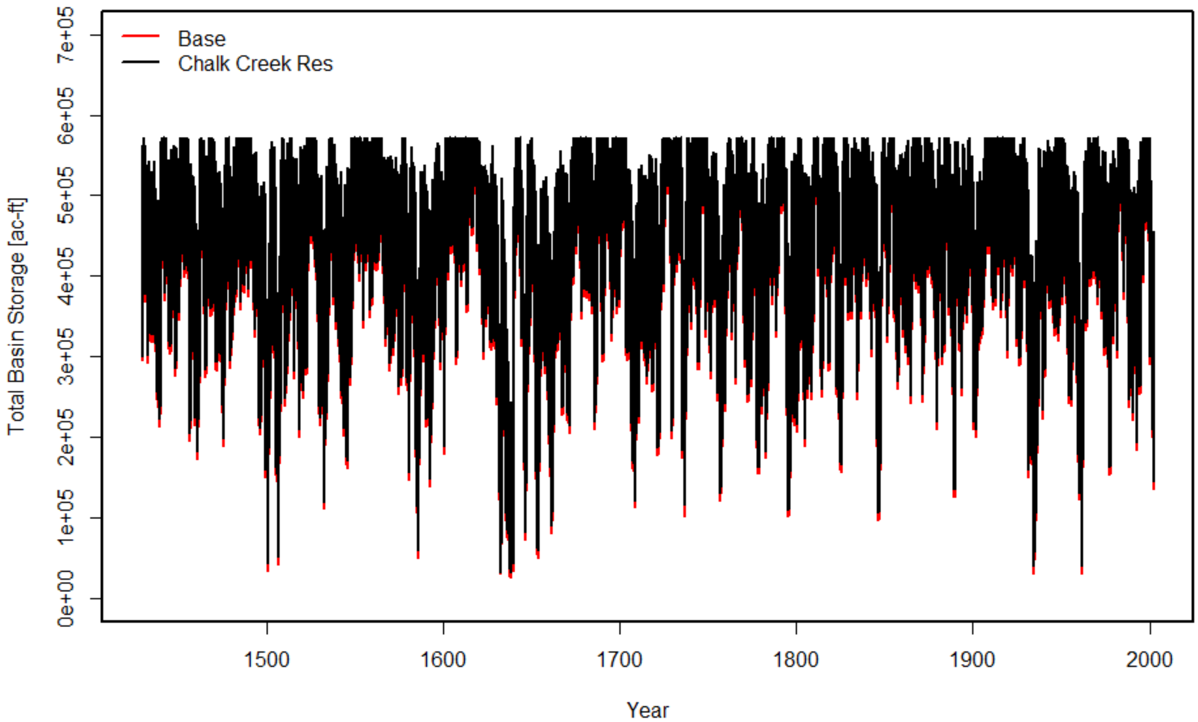


Figure 9 – Estimated Total Basin Storage with Chalk Creek Reservoir Storage

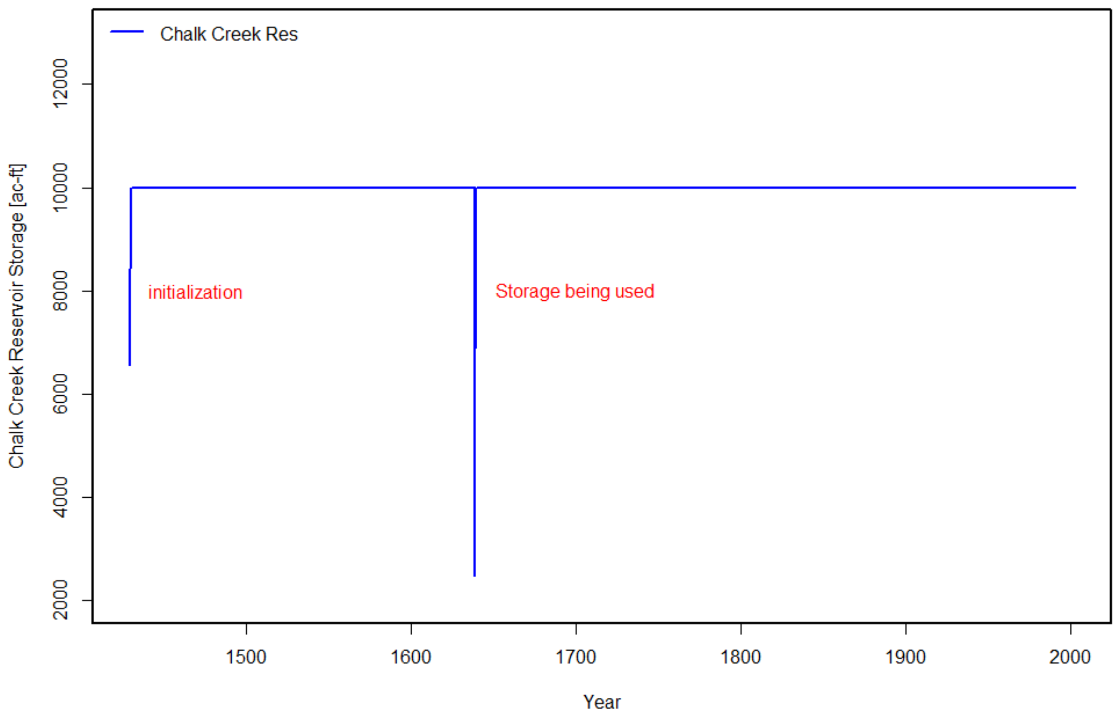


Figure 10 - Chalk Creek Reservoir Storage

Figure 10 shows that Chalk Creek Reservoir is only called during the 1630s drought, similar to Gravel Pit Reservoir. It should be mentioned that, like the Gravel Pit Reservoir, the Chalk Creek Reservoir is modeled as a "last resort" reservoir. These results don't represent the benefit of the additional storage during all drought years. Again, the reservoir can be used to lessen the impact of the drought on other reservoirs. This may prevent storages in the district's reservoirs from reaching dead pool levels.

Expanded ASR

Similar to the Gravel Pit and Chalk Creek scenarios, the implementation of ASR in the Weber Basin model provides an overall increase of storage throughout the record period of about 30,000 acre-feet, as is shown in Figure 11. That available water, however, was only used during the 1630s drought to serve the Gateway Canal service area (Figure 12).

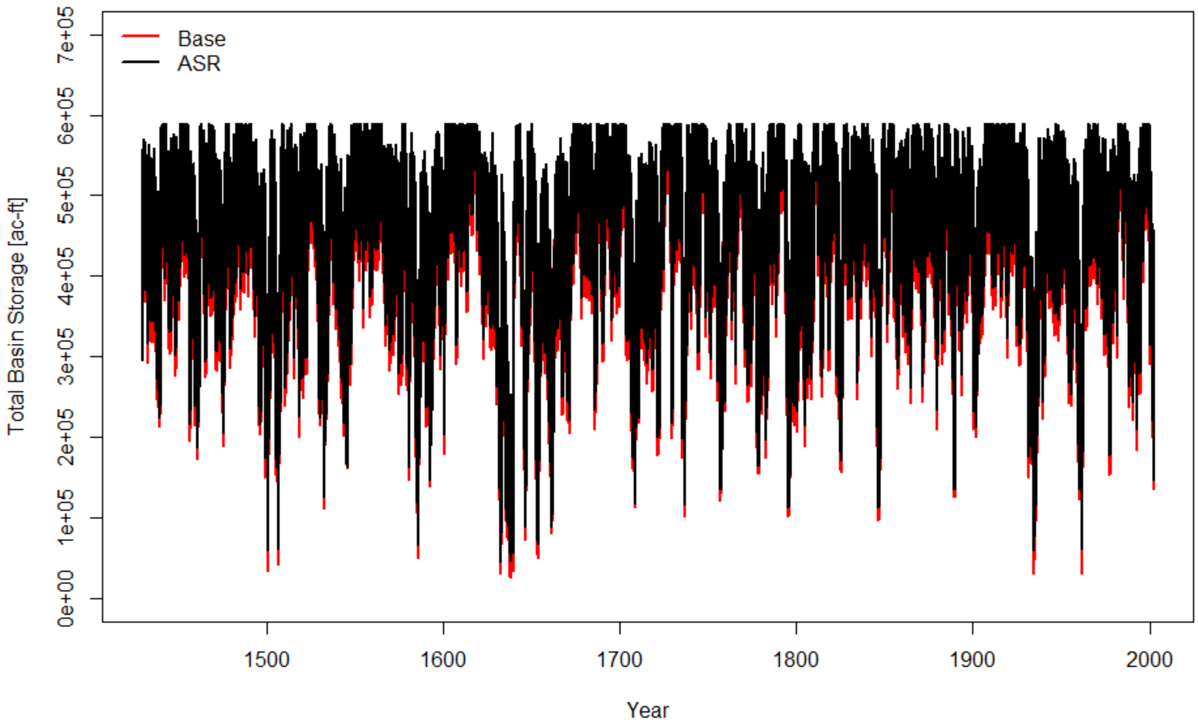


Figure 11 – Estimated Total Basin Storage with Aquifer Storage Recovery

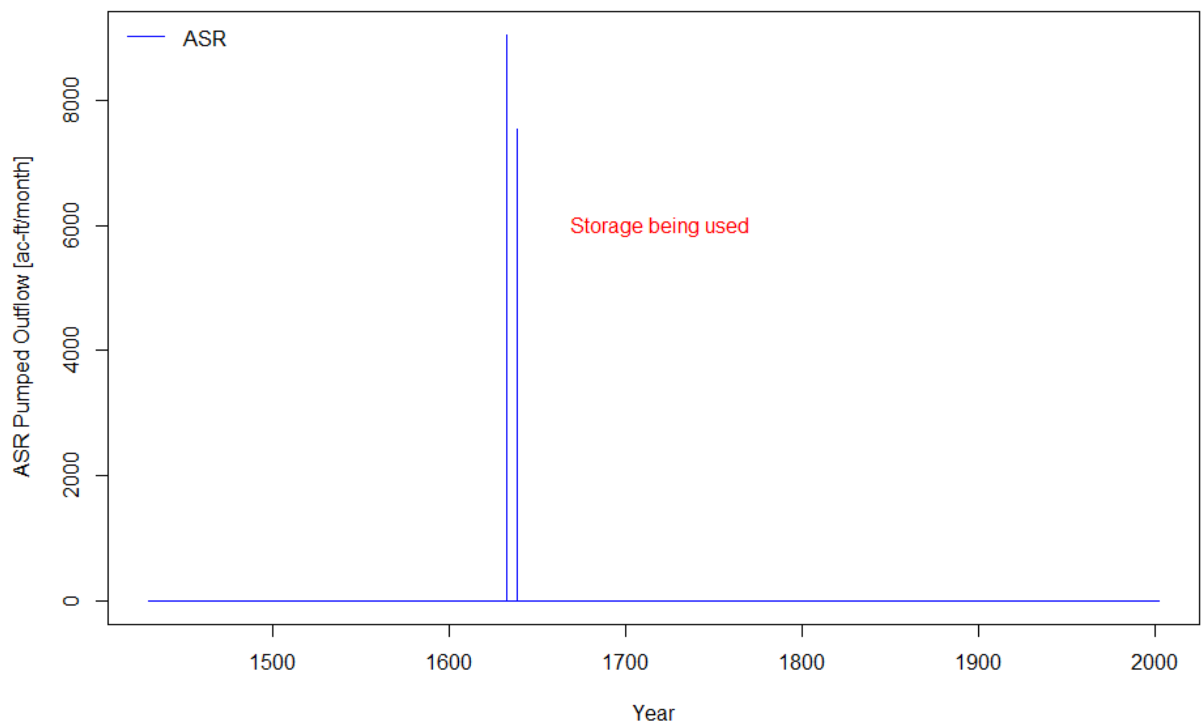


Figure 12 – Aquifer Pumped Outflow

Wastewater Reuse

Implementing waste water reuse into the Gateway Canal service areas will make a measurable and meaningful benefit to the system. Storage can clearly be seen to be improved through-out the whole period, and not just during droughts. Figure 13 shows the plot for this scenario consistently above the base plot.

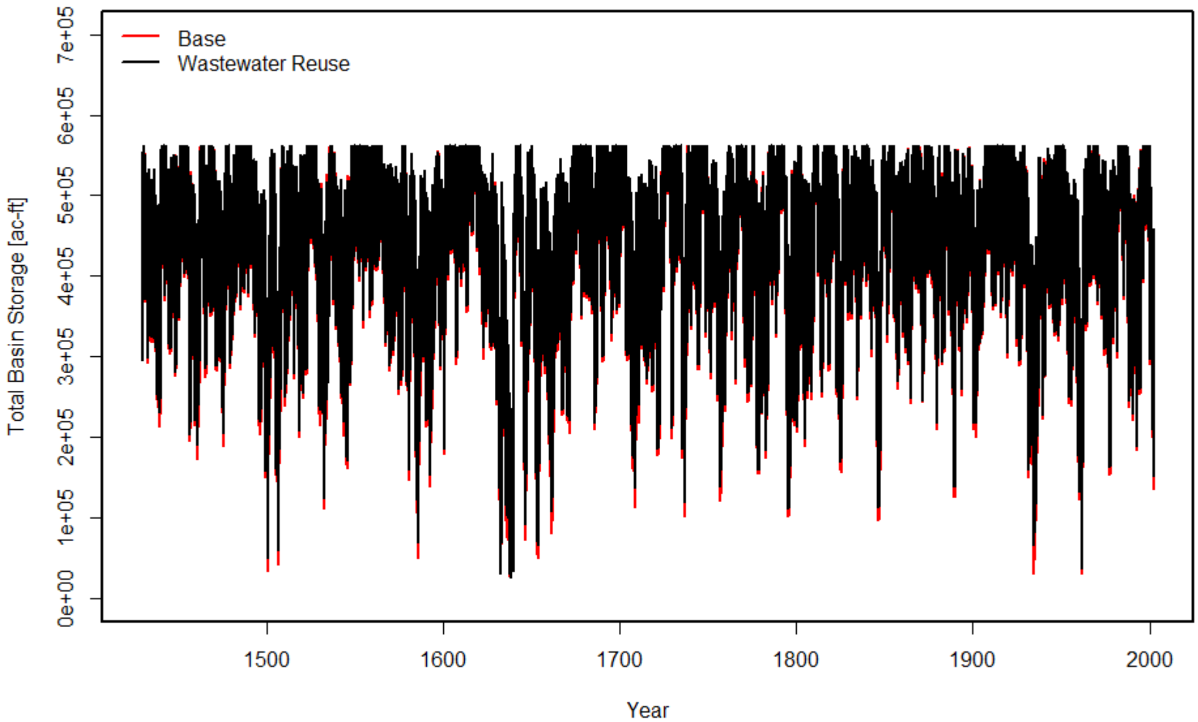


Figure 13 – Estimated Total Basin Storage with Wastewater Reuse

Drought Response

Demand Management

Demand reductions are effective in preserving storage during the times they are implemented. This requires that the storages at which reductions are implemented to be selected with a knowledge of the system's response to historical droughts. At the current stages of response, reservoir storage is increased relative of the base scenario in moderate to extreme drought conditions. Figure 14 shows the benefit of sensibly selected storage thresholds for the paleo simulation period.

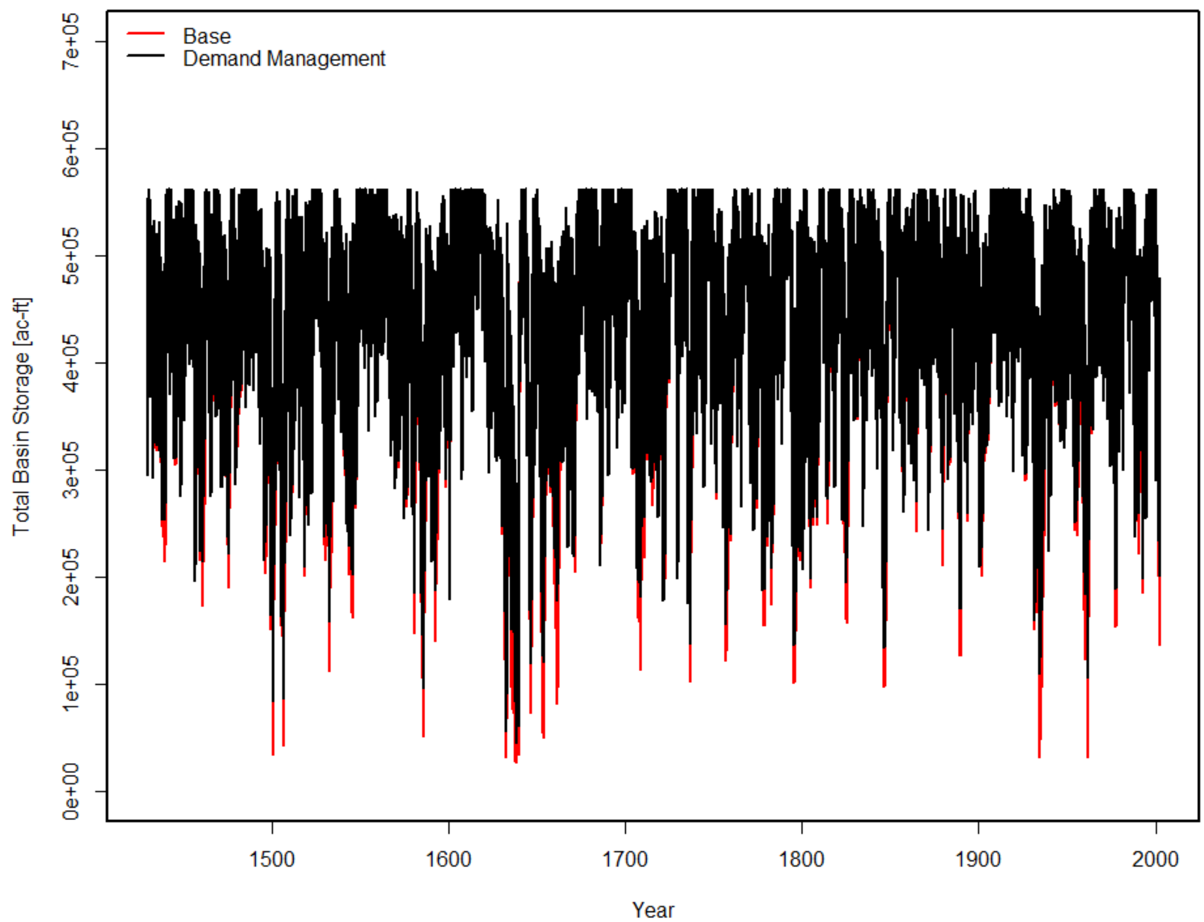


Figure 14 - Estimated Total Basin Storage with the Implementation of Demand Management Scenarios

Fallowing Program

The fallowing program scenario results are similar to the demand management but increase total basin storage to a lesser degree. In the case of a more severe drought (e.g., 1630s), the water saved due to the fallowing program (10,000 acre-feet) is completely depleted. In Figure 15, it can be seen that storage is improved for a number of moderate droughts, but in the case of the 1630s, the fallowing program is not augmented to account for the extreme hydrological conditions.

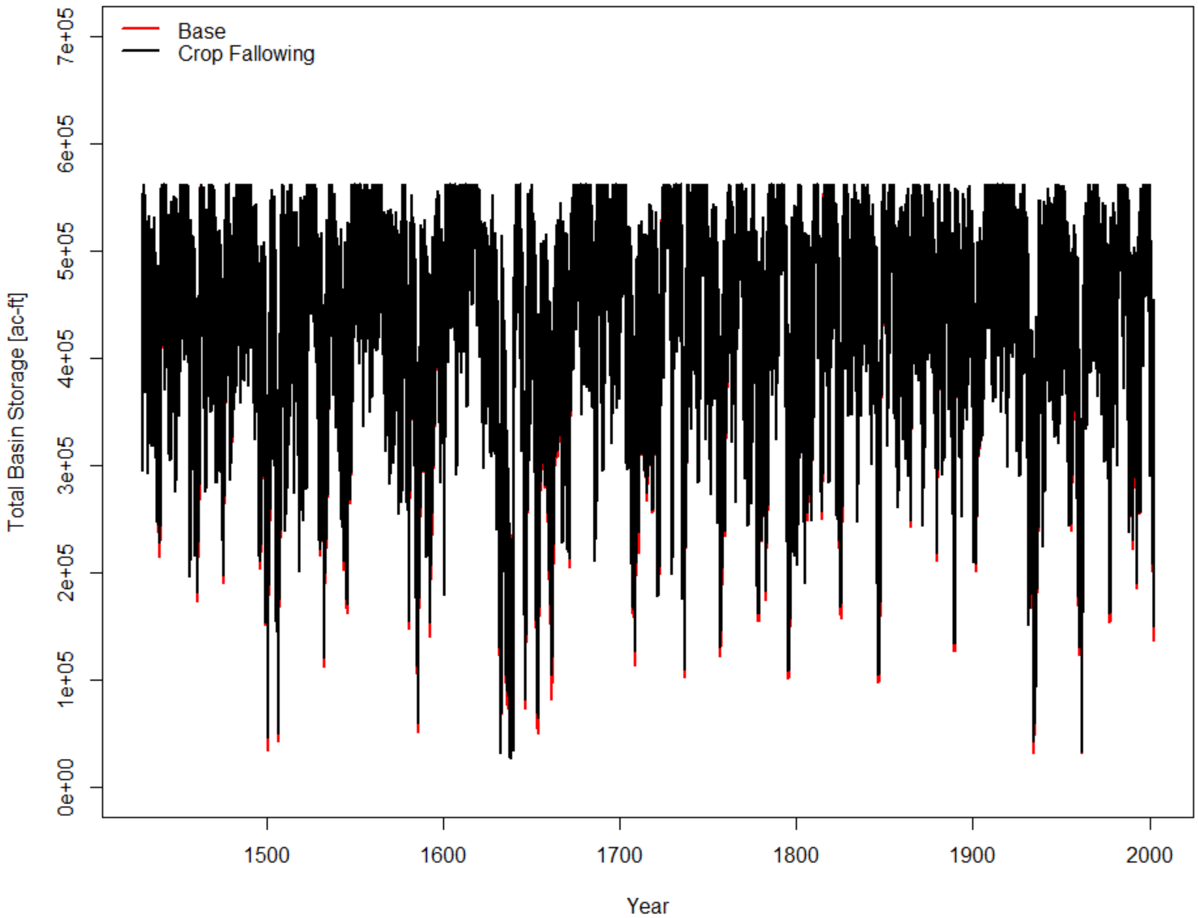


Figure 15 - Estimated Total Basin Storage with Demand Decreases from Crop Fallowing

Additional Scenarios

Increased Demand

As stated previously, results from the increased demand scenario show how responsive the system is to changes that are not climate related. It is clear from Figure 16 that changes that may seem relatively minor in comparison to total flow of the river can have noticeable impacts on the system as a whole. The total increase in volume for the scenario was only 22,500 ac-ft, but the impact is very apparent in the plot, as the dips in storage during droughts are more dramatic.

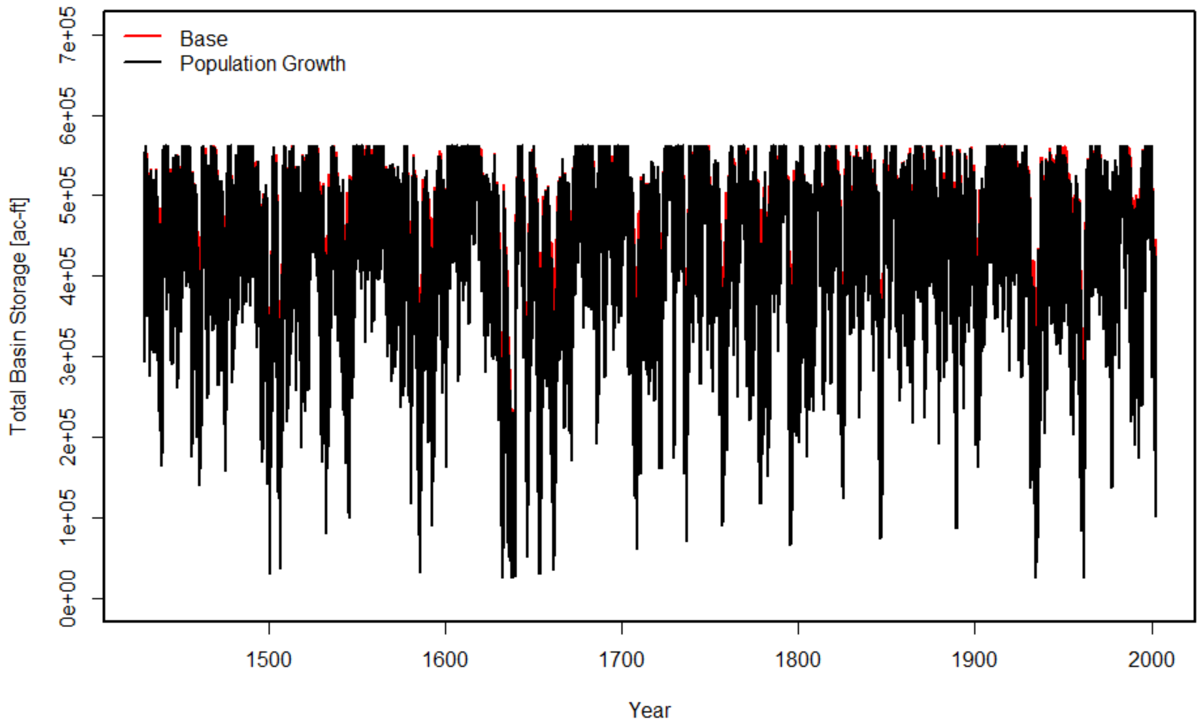


Figure 16 - Estimated Total Basin Storage with Demand Increases Due to Population Growth

Scenario Results - Climate Change

Drought Mitigation

Gravel Pit Reservoir

Figures 17 and 18 show the total basin storage and storage of the Gravel Pit Reservoir subject to historical and the five climate change hydrologic scenarios. Storage from Gravel Pit Reservoir would be used only during warm-dry and hot-dry climate change scenarios. In the warm-dry scenario, the 17,100 acre-feet reservoir was emptied 1 of the 30 simulated years. In the hot-dry scenario, the reservoir was emptied 3 of the 30 simulated years. These results are based on the Gravel Pit Reservoir being operated as a last resort. In actuality, the Gravel Pit storage could be used to curb some of the effects of droughts in other climate scenarios as well. Much is dependent on how the Gravel Pit Reservoir is operated.

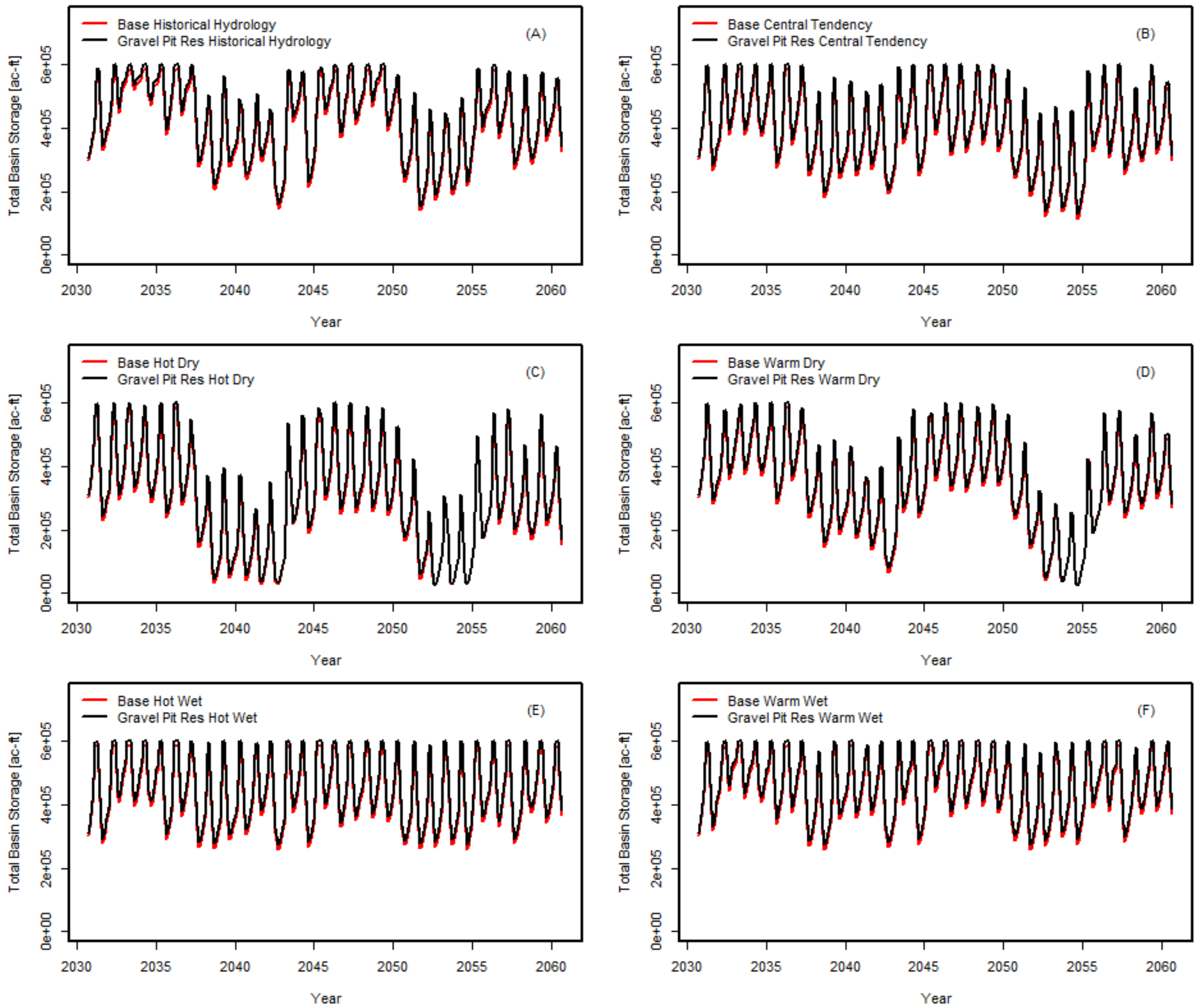


Figure 17 –Total Basin Storage including Gravel Pit Reservoir for the Historical Hydrology and the 5 Climate Change Scenarios

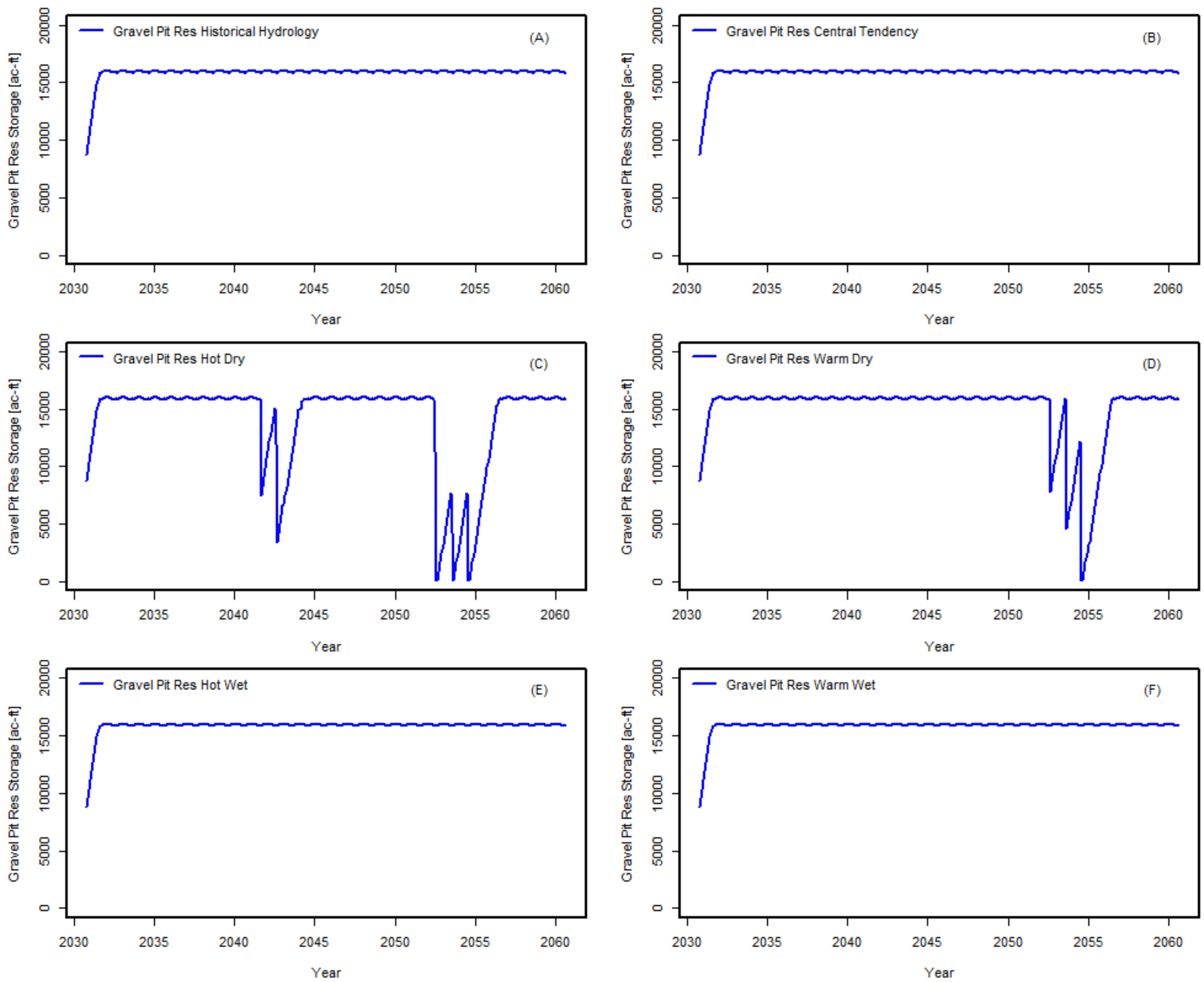


Figure 18 - Gravel Pit Reservoir Storage for the Historical Hydrology and the 5 Climate Change Scenarios

Chalk Creek Reservoir

Figures 19 and 20 show the total basin storage and storage of the Chalk Creek Reservoir subject to historical and the five climate change hydrologic scenarios. Storage from Chalk Creek Reservoir would be used only during warm-dry and hot-dry climate change scenarios. In the warm-dry scenario, the 10,000 acre-feet reservoir was emptied 2 of the 30 simulated years. In the hot-dry scenario, the reservoir was emptied 4 of the 30 simulated years. Again, these results are based on the Chalk Creek Reservoir being called as a last resort. In actuality, the Chalk Creek Reservoir storage could be used to curb some of the effects of droughts in other climate scenarios as well. Much is dependent on how the Chalk Creek Reservoir is operated.

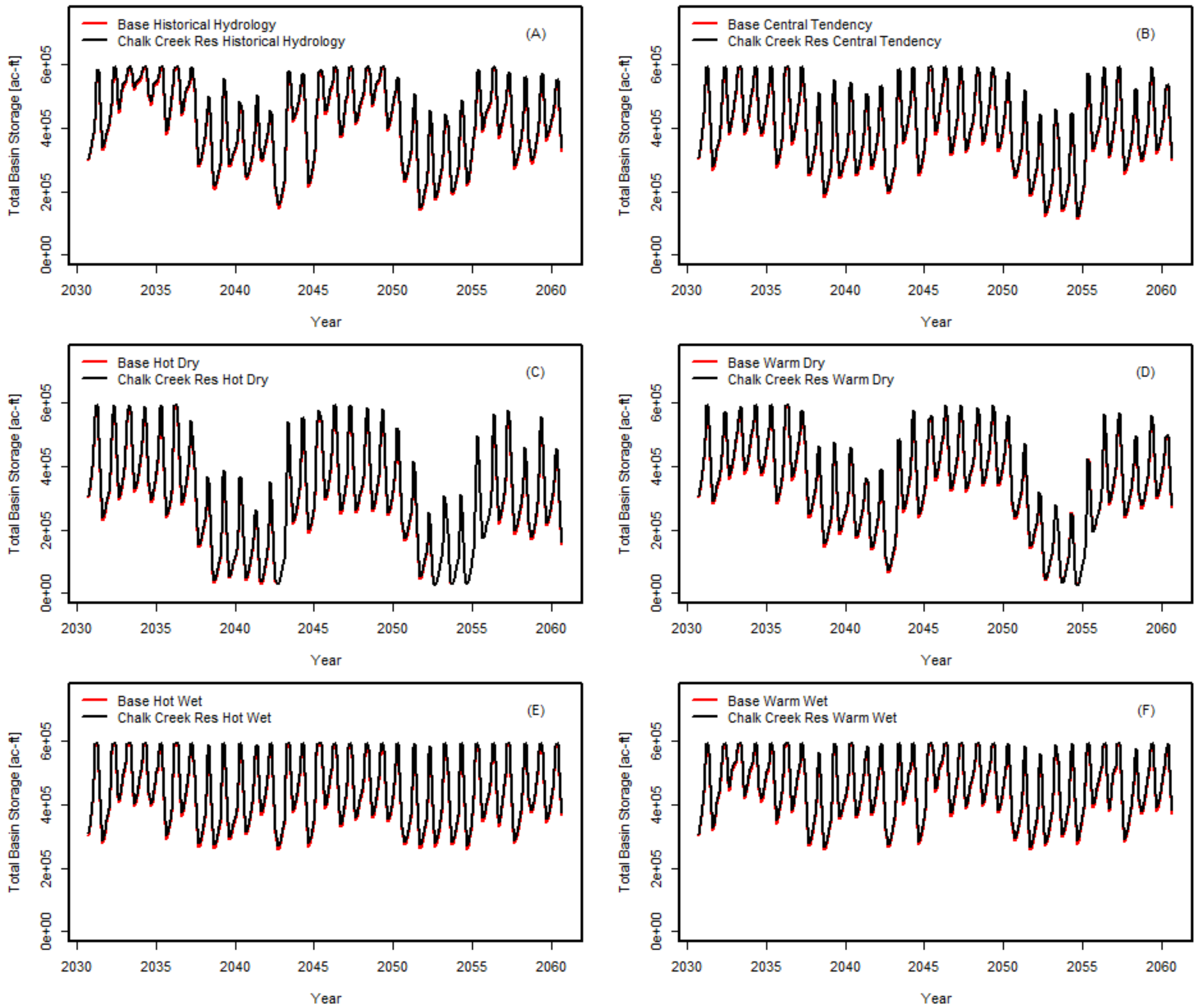


Figure 19 - Total Basin Storage including Chalk Creek Reservoir for the Historical Hydrology and the 5 Climate Change Scenarios

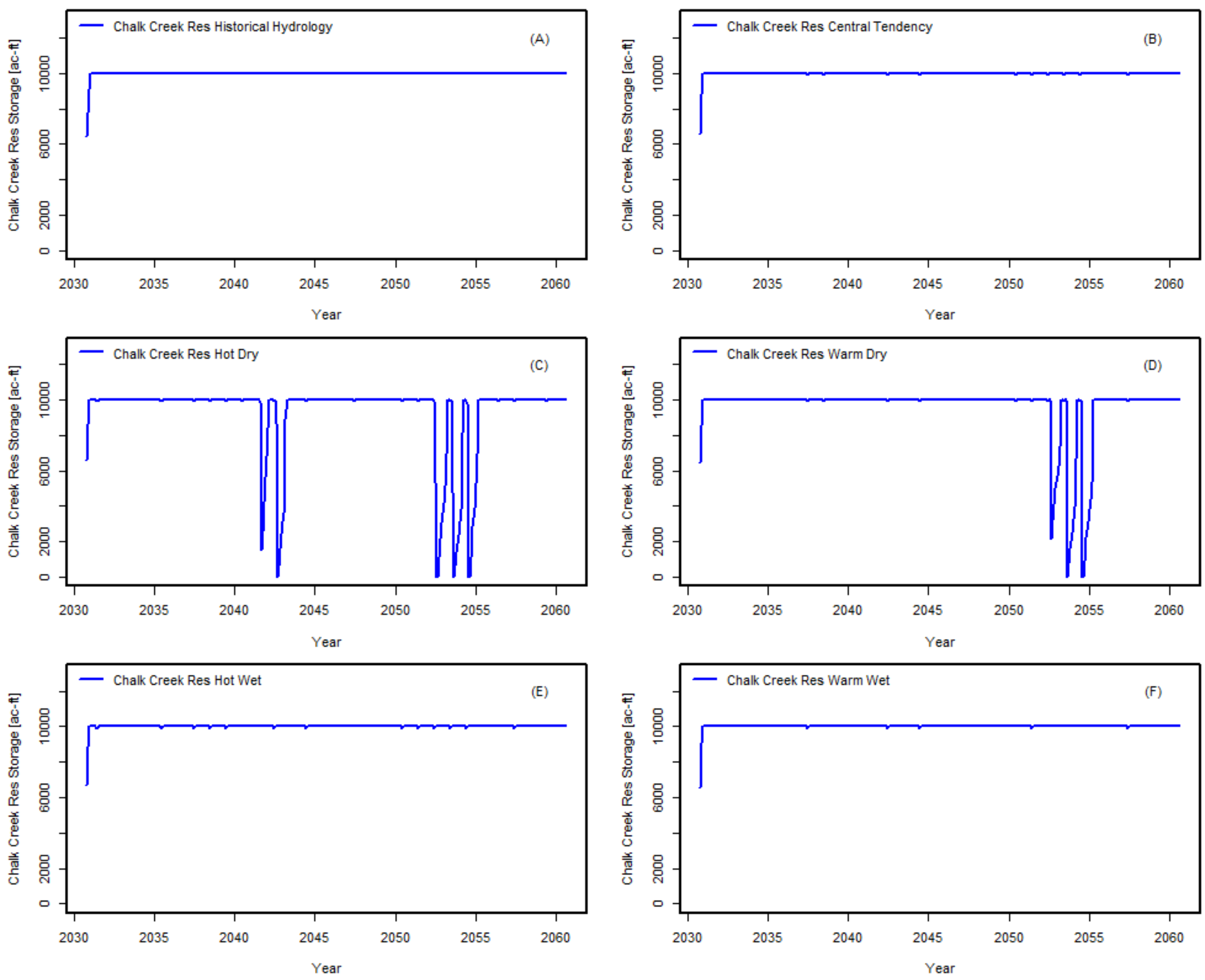


Figure 20 - Gravel Pit Reservoir Storage for the Historical Hydrology and the 5 Climate Change Scenarios

Expanded ASR

Figures 21 and 22 show a total basin storage comparison and average ASR storage for historical hydrologic conditions and 5 climate change scenarios respectively. Figure 21 gives a comparison between the base case and ASR scenario. As one would expect, including ASR increases total basin storage. However, Figure 22 shows that ASR storage is only used during the hot-dry and warm-dry climate change scenarios.

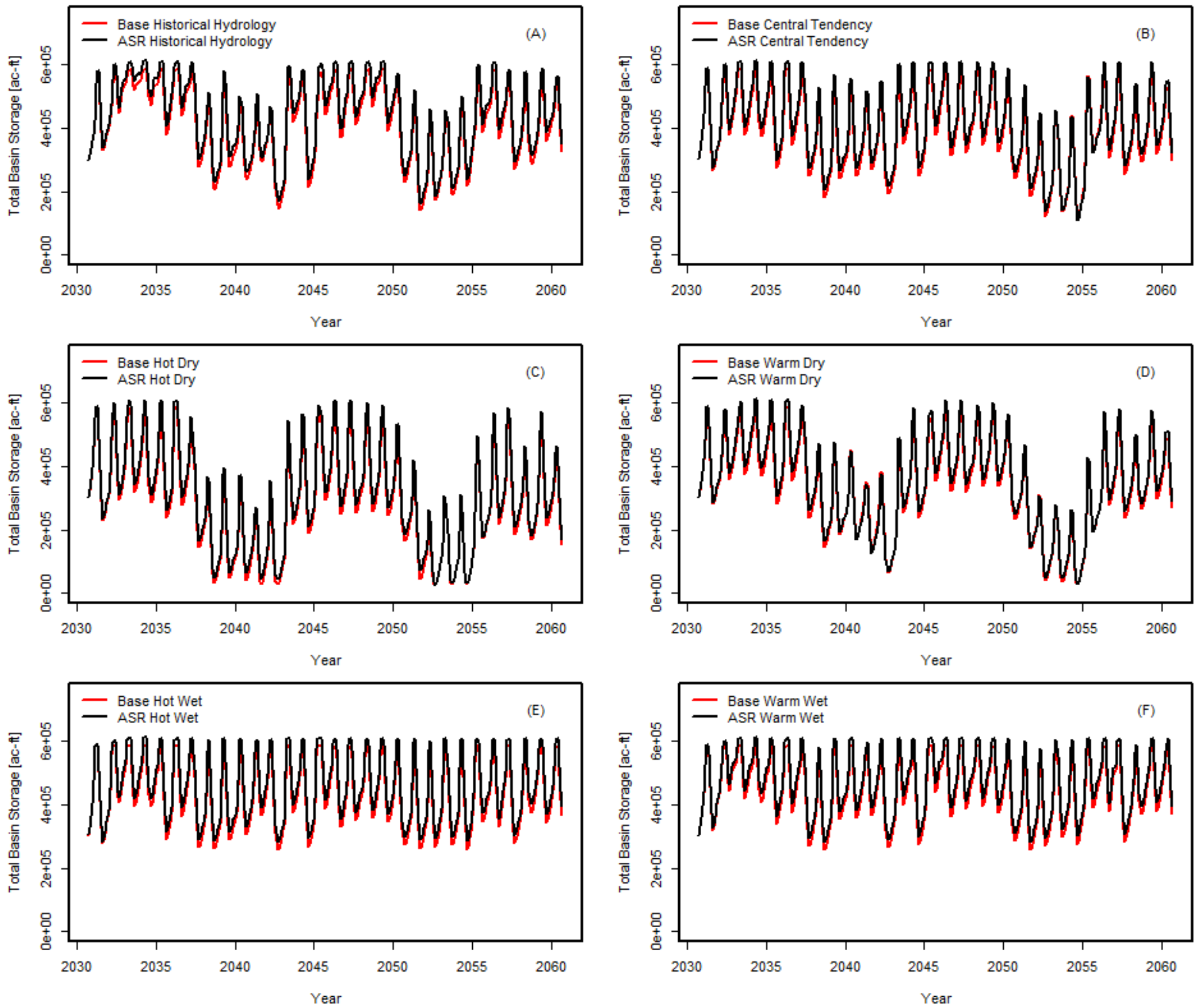


Figure 21 - Total Basin Storage including Aquifer Storage for the Historical Hydrology and the 5 Climate Change Scenarios

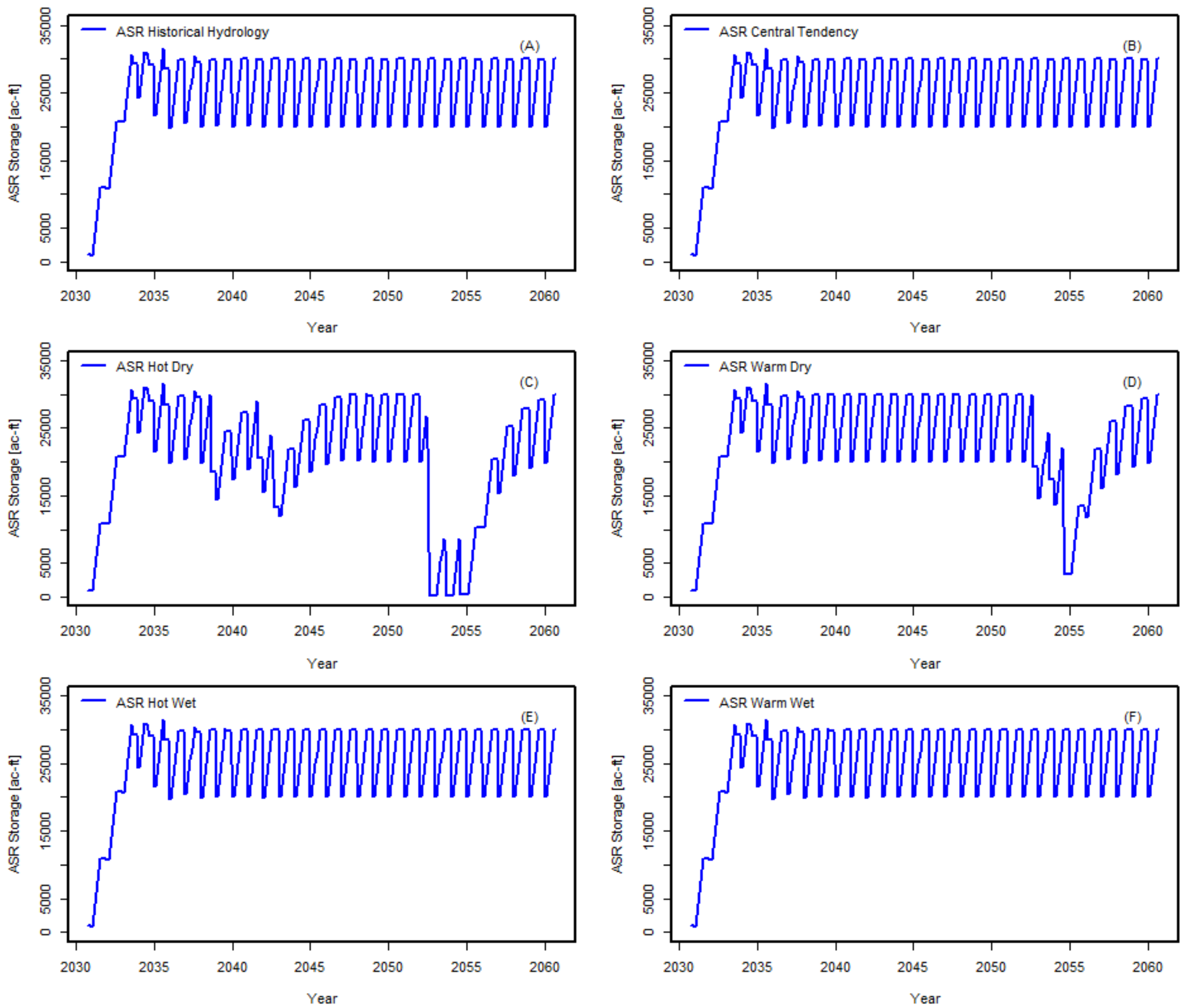


Figure 22 - Average ASR Storage for Historical Hydrogic Conditions and 5 Climate Change Scenarios

Wastewater Reuse

Figure 23 shows a total basin storage comparison between the base case and wastewater reuse for historical hydrologic conditions and 5 climate change scenarios. It is apparent that the greatest benefit from implementing wastewater reuse is obtained during moderate to severe drought conditions. This is likely due to the fact that wastewater reuse is only implemented for the Gateway Canal service area and diversion shortages, even under normal demand conditions, only occur during moderate to severe drought conditions.

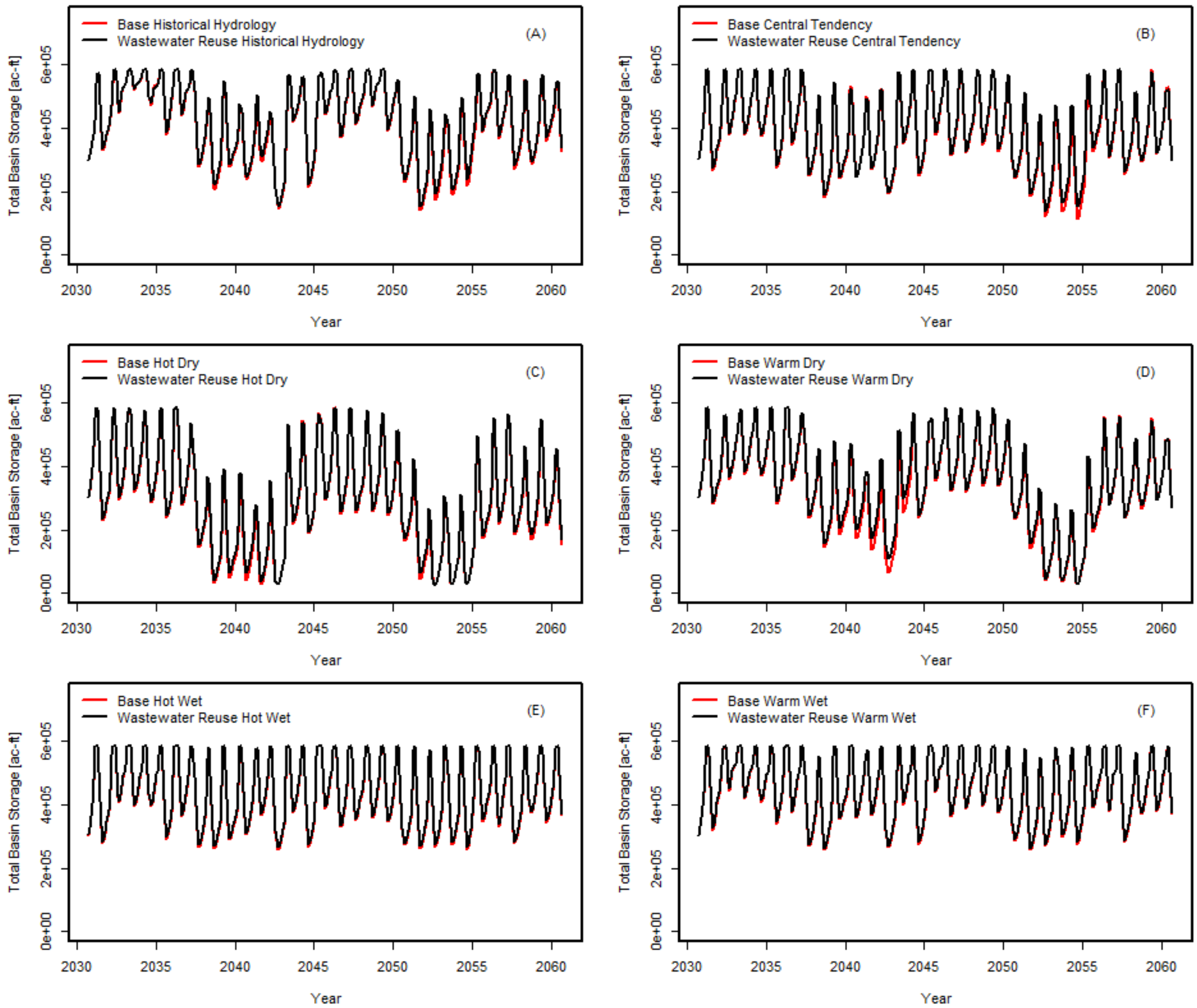


Figure 23 - Total Basin Storage Considering Wastewater Reuse for the Historical Hydrology and the 5 Climate Change Scenarios

Drought Response

Demand Management

Figure 24 shows a total basin storage comparison between the base case and the demand management scenario for historical hydrologic conditions and 5 climate change scenarios. It is apparent from the figure that the greatest benefit from the demand management scenario can be observed during moderate to severe droughts. This is a function of how the demand management scenario is implemented in the model. This scenario used predefined storage and runoff thresholds which triggered demand reductions for moderate and severe droughts.

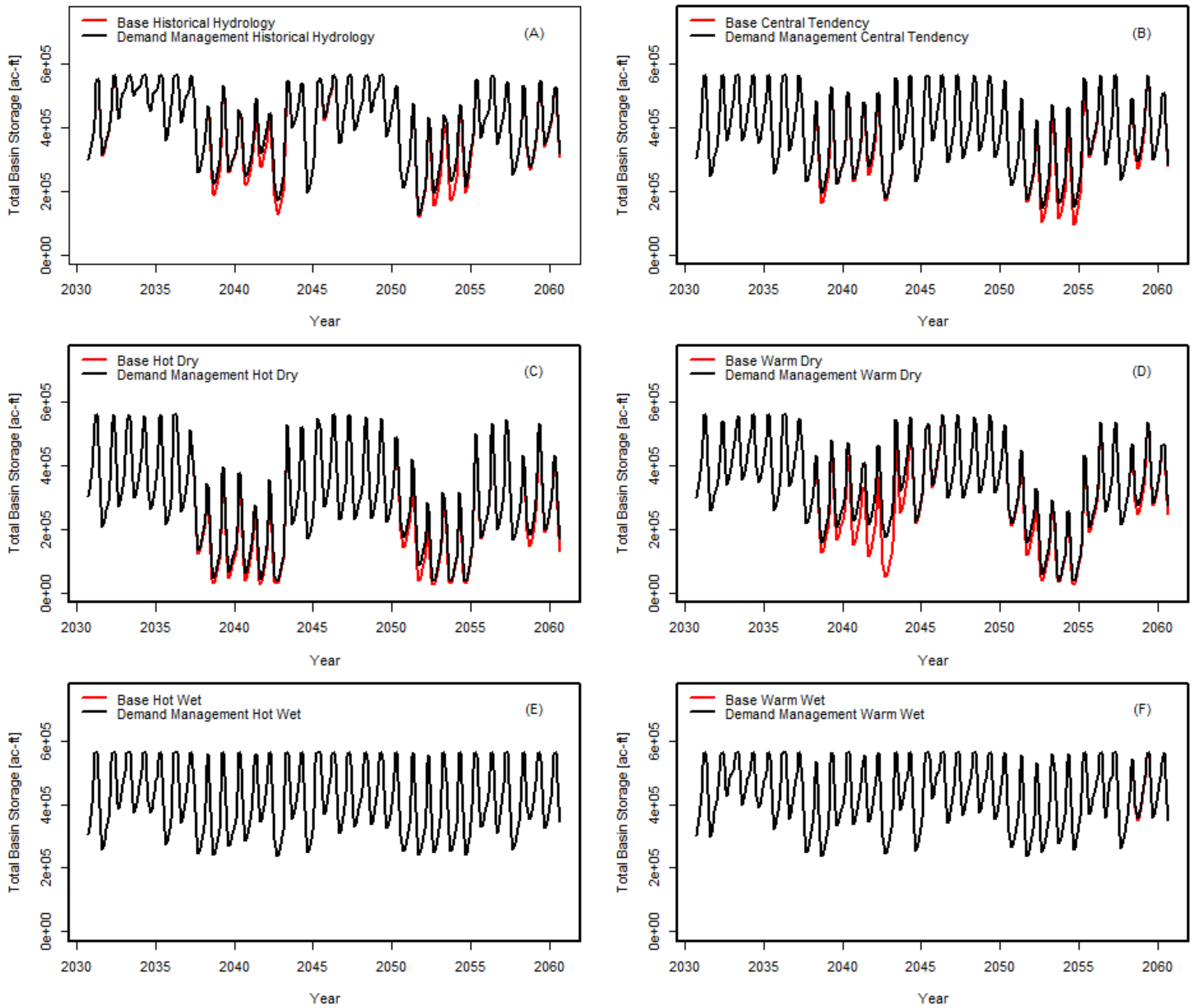


Figure 24 - Total Basin Storage implementing Demand Management Reductions for the Historical Hydrology and the 5 Climate Change Scenarios

Fallowing Program

Figure 25 shows a total basin storage comparison between the base case and the crop fallowing scenario for historical hydrologic conditions and 5 climate change scenarios. This scenario behaved similar to the demand management scenario, with less effect on the moderate droughts. This is due to the fact that the fallowing program was implemented during severe to extreme droughts, according to the demand triggers given in Table 12.

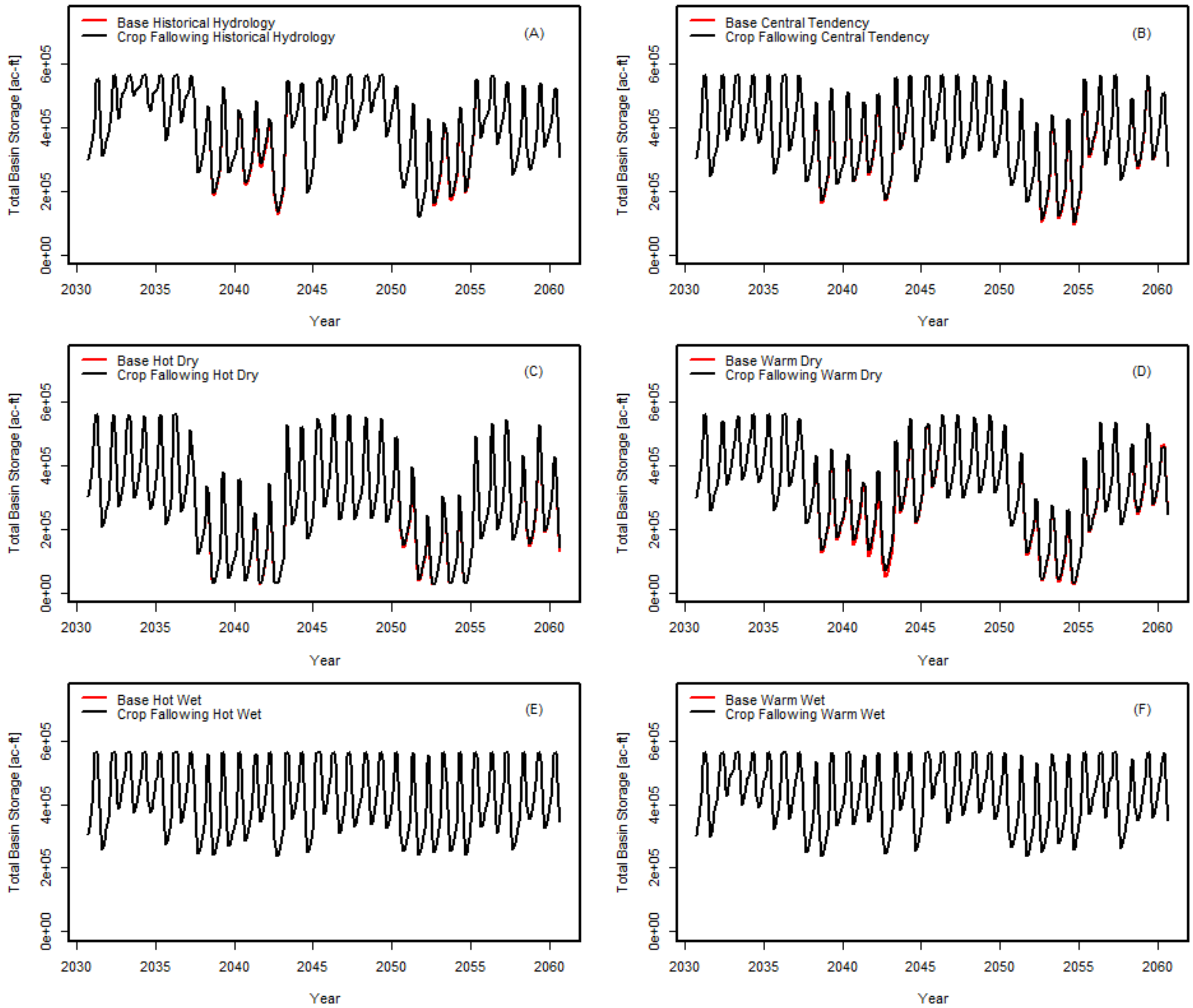


Figure 25 - Total Basin Storage Considering Crop Fallowing Programs for the Historical Hydrology and the 5 Climate Change Scenarios

Additional Scenarios

Increased Demand

Figure 26 shows a total basin storage comparison between the base case and the population growth demand increase scenario for historical hydrologic conditions and 5 climate change scenarios. According to the figure, there are noticeable differences between the base case and the population growth scenarios in each climate change scenario. The most noticeable differences are in the historical hydrology, central tendency, and warm-dry climate change scenarios. Differences would be more noticeable in the hot-dry scenario, but total basin storage appears to approach minimum capacity.

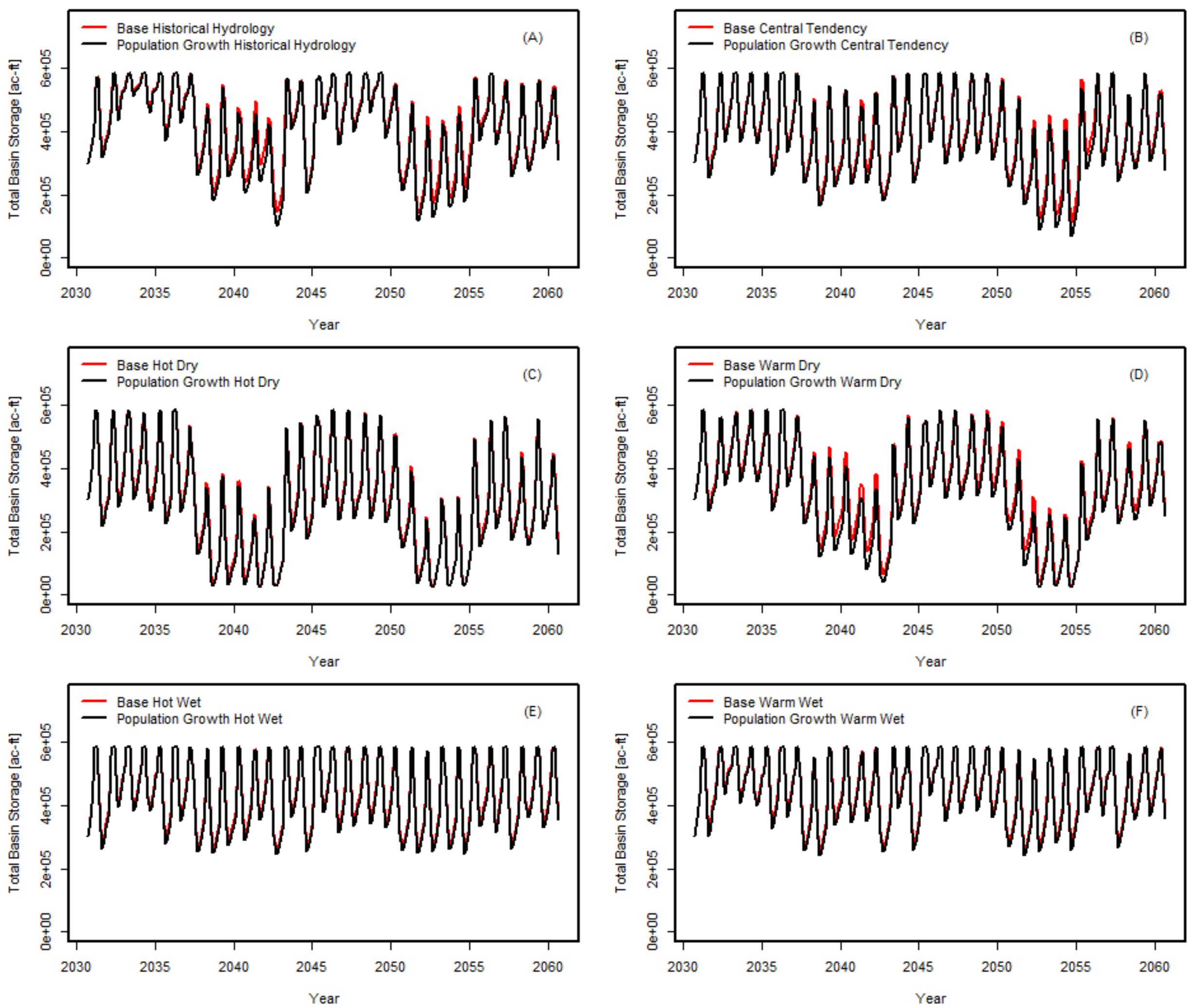


Figure 26 - Total Basin Storage Considering Demand Increases from Population Growth for the Historical Hydrology and the 5 Climate Change Scenarios

Summary

Observations on Inflow Scenarios

The experience of developing and running these scenarios for the model have highlighted a number of points that should be mentioned. The two versions of input data (i.e. climate change, and paleo flows) should be considered different in their value and use.

The paleo records simulated through the model gives stakeholders an extensive window to the past, albeit a hazy one. Nonetheless, these records provide a way to *observe the frequency, severity, and duration of actual droughts from the past*. While the hydrological inputs may give some indication of this, having monthly data modeled in the system gives a clearer understanding of the impacts of inflows.

While some of the drought response actions evaluated through the paleo version of the model are informative, on the whole this approach loses its context when the action is modeled for the entire nearly 600 year period. It may be of greater benefit to evaluate certain sections of the paleo record, however this would present a house keeping challenge with the model that would need to be addressed first.

Climate change scenarios developed from the CMIP5, on the other hand, are at a scale that is simple to comprehend the meaning of response actions. Any change in operation is observable in the results and can be digested easily. There is a great deal of uncertainty, however, with the predictions of the climate change models these inflows were developed from. The consequence being stakeholders have a large range of possibilities to plan for. Ultimately, these inflows provide a way to model potential climate changes which would otherwise not be possible.

Observations on Action Scenarios

Each of the action responses have their benefits and drawbacks. Drought mitigation scenarios such as the Gravel Pit, Chalk Creek, and ASR scenarios increase the district's ability to store water during drought years. These scenarios appear to only supplement water deliveries during extreme drought conditions (e.g., 1630s, hot-dry, and warm-dry scenarios), however there are basin benefits during drought years. These reservoirs are modeled as "last resort" reservoirs that are called on last in line. In actuality, they offer additional storage that WBWCD can use to lessen the impact all drought years.

The wastewater reuse and crop fallowing scenarios appear to increase total basin storage during moderate drought years. However, during extreme drought years, the water saved from implementing these programs is depleted. The demand management scenario offers a demand reduction that accounts for the severity of the drought. This being the case, the demand management scenario appears to be the most adequate scenario for mitigating the effects of extreme drought events.

Model Limitations

Results from model runs are best viewed in terms of total basin storage. Reservoirs are not perfectly modeled, and there are likely variations in how the system would truly be operated given certain conditions. There still may be some benefit in isolating a certain reservoir or groups of reservoirs, but the results should be considered to have higher variability than a total basin storage assessment.

Inflows and demands are skewed by the imperfect approach in accounting for uses in the model. Most of the system uses diversions to calculate inflows without considering return flows, and there are certainly return flows at some of these locations. However, most of the largest diversions are lower in the basin where the return flow is not a factor. There is a possibility that attempting to improve these numbers would not produce very different results from the current flawed process. Reservoir storage, which is the recommended way of inspecting results, would almost certainly not change.

While there is not guarantee that doing any consumptive use analysis for the service areas will dramatically affect the model results, it would be ideal to have this aspect of the model more accurately reflect what is truly happening on the ground. So it is recommended to include in future simulations an improvement to this facet of the model.

Appendix 3-C

Future Climate Evaluation Report
Western Water Assessment

Climate change section

Drought impacts the availability of water in the Weber River Basin and affects Weber Basin Water Conservancy District's (WBWCD) ability to supply water to its customers. Understanding the impact of drought on WBWCD's ability to provide water for its customers requires looking critically at the incidence of drought: both in the past and in the future. Other analyses in this project consider the impact of historical drought on WBWCD water supply. In order to consider the impact of drought on future Weber River Basin water availability, future climate projections were used as an input for a hydrological model of the Weber River.

To project the impact of future drought on WBWCD water supply, two key climate projection tools were used. One, downscaled projections of future temperature and precipitation and two, a hydrological model of the Weber Basin River that is used by the National Oceanic and Atmospheric Administration (NOAA) Colorado Basin River Forecast Center (CBRFC) to forecast streamflows and project seasonal water supply. Temperature and precipitation are key climate inputs to CBRFC's hydrological model. Projections of future Weber River stream flow were obtained by altering the historical record of precipitation and temperature based on downscaled climate projections and then using the altered dataset as the input for the CBRFC hydrological model. The output of the hydrological model (Weber River stream flow) was then used as an input for the Weber River systems model in order to explore the impact of future climate on Weber River water availability, reservoir storage and drought. The climate change analysis conducted using the CBRFC hydrological model of the Weber River was essentially a temperature and precipitation sensitivity analysis of Weber River streamflow. Altering the air temperature or precipitation inputs used in the CBRFC streamflow model, can simulate how a warmer, wetter or drier climate would affect the streamflow and water availability in the Weber River Basin.

METHODS and RESULTS

The climate and hydrological modeling presented in this report were completed by Tim Bardsley in 2014, then employed by Western Water Assessment. The analyses conducted were two-fold. One was the development of downscaled climate projections of temperature and precipitation for the Weber River Basin for 2050. The second was a projection of future Weber River flows using the CBRFC hydrological model and monthly projections of future temperature and precipitation. The results from the CBRFC hydrological model were projections of Weber River flow for 2050 and were then used as an input for the Weber River Basin systems model. This method was used to project future water availability in the Seven Creeks of Salt Lake Valley for Salt Lake Department of Public Utilities (Bardsley et al. 2013).

Projections of future climate for the Weber River Basin were obtained from phase 5 of the World Climate Research Programme Coupled Model Intercomparison Project (CMIP5). Data from 16 global climate models (GCMs) and three emissions scenarios (RCP4.5, RCP6.0 and RCP8.5) were used. Because climate projections from GCMs are at too large of a geographic scale (1-2° grid cells) for the Weber River

Basin, a method of statistically downscaling climate data was used. Downscaled projections of temperature and precipitation were obtained for the Weber River Basin using the bias-correction/spatial disaggregation (BCSD) method (Wood et al. 2004). The BCSD method of downscaling outputs future climate information on a geographic scale of 1/8°. Figure 1 shows the entire geographic area of downscaled climate projections for the Weber River Basin. The watershed's pour point was set at 41.2341° N, 112.0027° W, which is slightly downstream of the confluence of the Weber and Ogden Rivers. Downscaled climate data from the BCSD dataset is available from 2006-2099. Temperature and precipitation projections for this project were made for 2050, averaging 30 years of climate data from 2034-2064. Future climate projections are expressed as an increase in average temperature or a percentage change in precipitation relative to historical modeled climate data from 1981-2010 for the Weber River Basin.

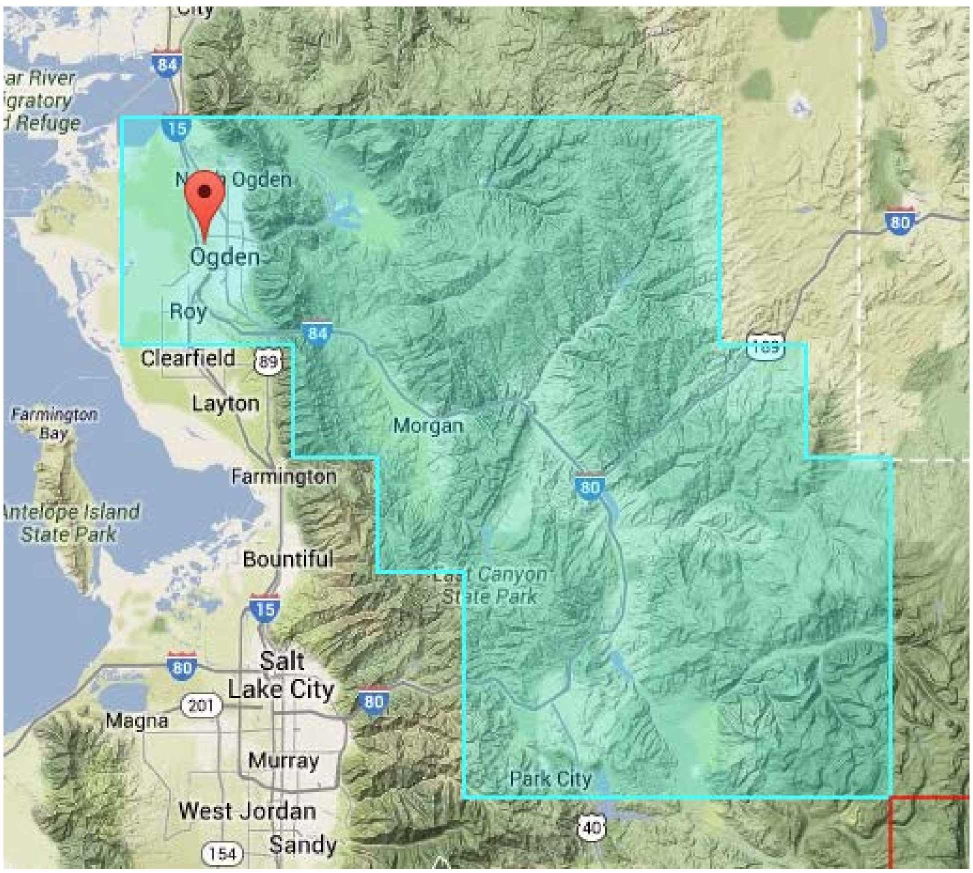


Figure 1. Map of the grid cells used for downscaled projections of Weber River Basin temperature and precipitation.

There is not a single answer to the question of what future climate in the Weber River Basin looks like. Different climate models simulate a range of future climates in the Basin and different future emissions scenarios alter the output from each climate model. In order to convey the range of projected changes in climate and runoff in the Weber River Basin, a scenario planning approach was used. Five scenarios were chosen from 234 monthly runs of downscaled GCMs under three emissions scenarios. In order to choose scenarios, each monthly model run was plotted on as scatterplot as a function of temperature increase and precipitation change (Figure 2). Five scenarios were chosen from 234 monthly model runs that represent the median, or central tendency, of model results and the 10th and 90th percentiles of temperature increase and precipitation change. Five individual monthly model runs that were closest to each of the five scenarios were averaged to obtain an exact temperature increase and precipitation change. These five scenarios were called Central Tendency (median model results), Warm and Wet (10th percentile temperature, 90th percentile precipitation), Warm and Dry (10th percentile temperature, 10th percentile precipitation), Hot and Wet (90th percentile temperature, 90th percentile precipitation) and Hot and Dry (90th percentile temperature, 10th percentile precipitation). Table 1 shows the projected increase in annual average temperature and annual average precipitation for 2050 (2034-2064) compared to 1995 (1981-2010) for each scenario. The values for temperature and precipitation change in Table 1 are the projected annual changes. For each of the five scenarios, projected monthly changes in precipitation and temperature were calculated. Monthly temperature increases and precipitation changes for each scenario were used to project monthly Weber River flows using the CBRFC hydrological model.

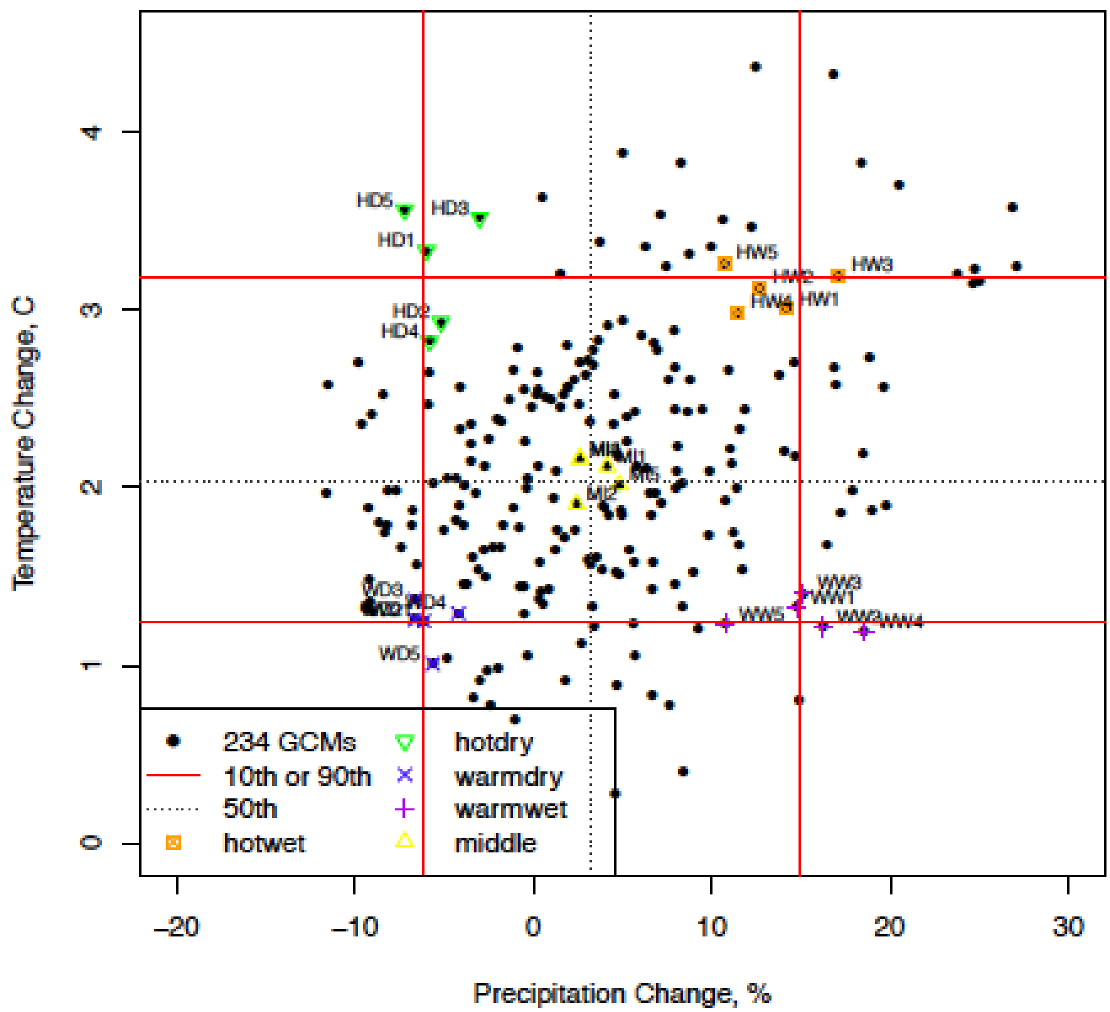


Figure 2. Selection of the five scenarios (central tendency, warm and wet, warm and dry, hot and wet, hot and dry) from 234 monthly GCM runs plotted as a function of temperature increase and precipitation change.

Table 1. Five scenarios of temperature and precipitation change for 2050 compared to 1981-2010. Temperature is in Celsius, precipitation is in percentage change.

Scenario	Temperature	Precipitation
Central Tendency	+2.3°	+4%
Warm and Wet	+1.3°	+12.7%
Warm and Dry	+1.2°	-5.9%
Hot and Wet	+3.1°	+10.2%
Hot and Dry	+3.2°	-6.2%

The hydrological modeling used in this project does not attempt to precisely simulate future hydrological conditions. The hydrological modeling in this project uses Weber River Basin climate from 1981-2010 as a starting point and alters monthly temperature and precipitation inputs to the CBRFC hydrological model in accordance with the future climate projections discussed above and in Table 1. This method of projecting future Weber River hydrology assumes a static climate, meaning that the weather patterns that occurred from 1981-2010 are assumed to occur again in 2035-2064. While weather in the Weber Basin is likely to be different than the weather that occurred in 1981-2010, this method of hydrological modeling will simulate the hydrology of the last 30 years *if* temperatures were warmer and precipitation was altered. Another reason for the use of this modeling technique was the colocation of Western Water Assessment staff with NOAA CBRFC staff.

The CBRFC hydrological model includes the Sacramento Soil Moisture Accounting Model and the Snow-17 temperature index snow model (Burnash 1995; Burnash, Ferral, and McGuire 1973; Anderson 1973). The CBRFC hydrological model was used within the National Weather Service Community Hydrological Prediction System, a modeling environment driven by mean air temperature, precipitation and potential evapotranspiration(Bardsley et al. 2013). The CBRFC forecasts flows at many points along the Weber River. Projections of Weber River flow in 2050 for five future climate scenarios were made for a streamflow gauge on the Weber River in Oakley, UT. The gauge in Oakley was chosen because it is one of the furthest upstream gauges on the Weber River, there are few upstream water diversions and monthly flow data from the Oakley gauge can be used as an input for the Weber River systems model used to simulate reservoir storage and total system water availability. To obtain 2050 projections of Weber River flow at Oakley under the five climate scenarios, monthly climate data from water years 1981-2010 at the Oakley gauge were adjusted to reflect each future climate scenario. The 1981-2010 historical climate record at Oakley was adjusted to create five future climate scenarios; each of the five scenarios were run in the hydrological model and daily stream flows at Oakley were outputted. Daily Weber River stream flows at Oakley for each of the five future climate scenarios were aggregated into monthly flows. Projected monthly flows were for each climate scenario were then used as inputs in the Weber River systems model to assess the impact of future changes in climate on water availability, reservoir storage and the incidence and severity of drought in the Weber River Basin.

While the primary goal of modeling future hydrological conditions at the Oakley streamflow gauge was to help understand future water availability in the entire Weber River Basin, an examination of projected monthly flows in Oakley highlights general changes in the availability and timing of runoff. Figure 3 plots average monthly cumulative stream flows at Oakley for the five future climate scenarios against the historical conditions. Peak annual flows occur earlier in the year (May) for all future climate scenarios compared to historical peak flows (June). Peak Weber River monthly flows are higher in the warm/wet scenario and the hot/wet scenario compared to historical peak monthly flows while peak flows for the hot/dry and warm/dry scenarios are lower than historical peak flows.

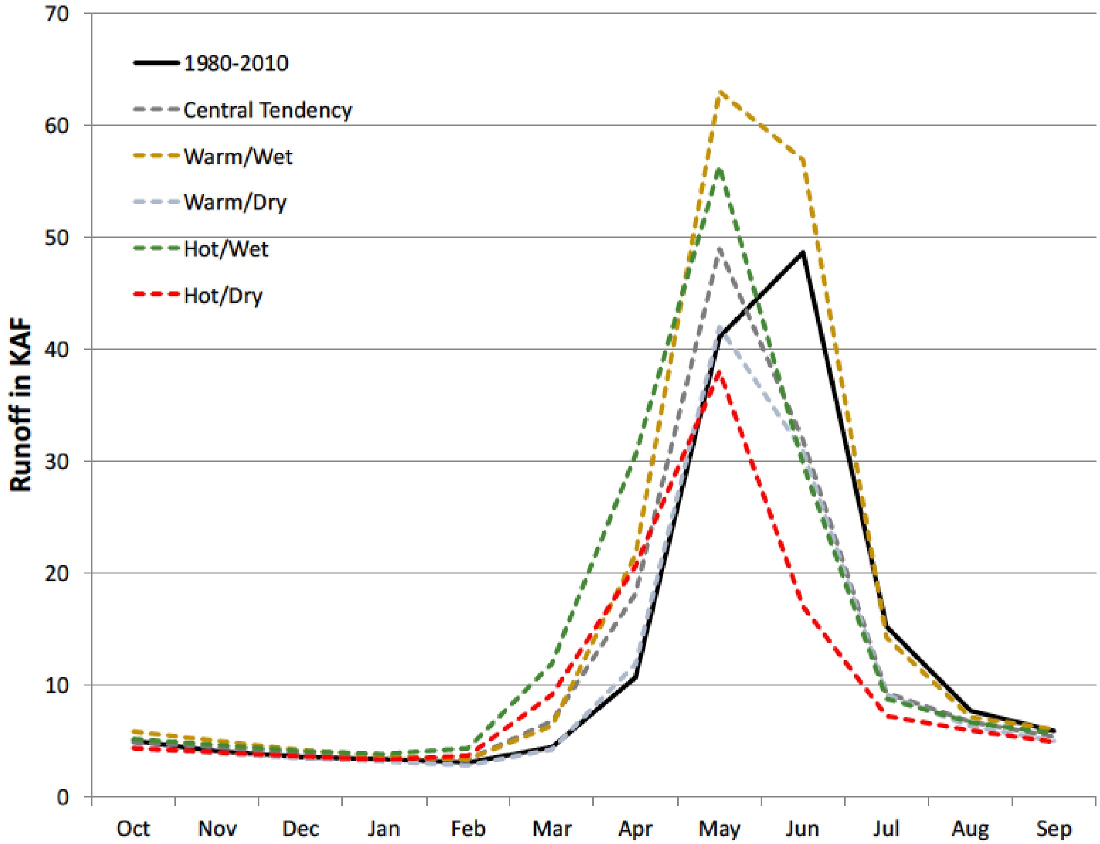


Figure 3. Projections of 2050 (2035-2064) monthly Weber River streamflow at Oakley, UT under five future climate scenarios. Monthly runoff is presented in thousands of acre-feet (KAF). The solid line labeled 1980-2010 is the average historical monthly streamflow at Oakley, UT.(Bardsley et al. 2013)Citations

Literature cited

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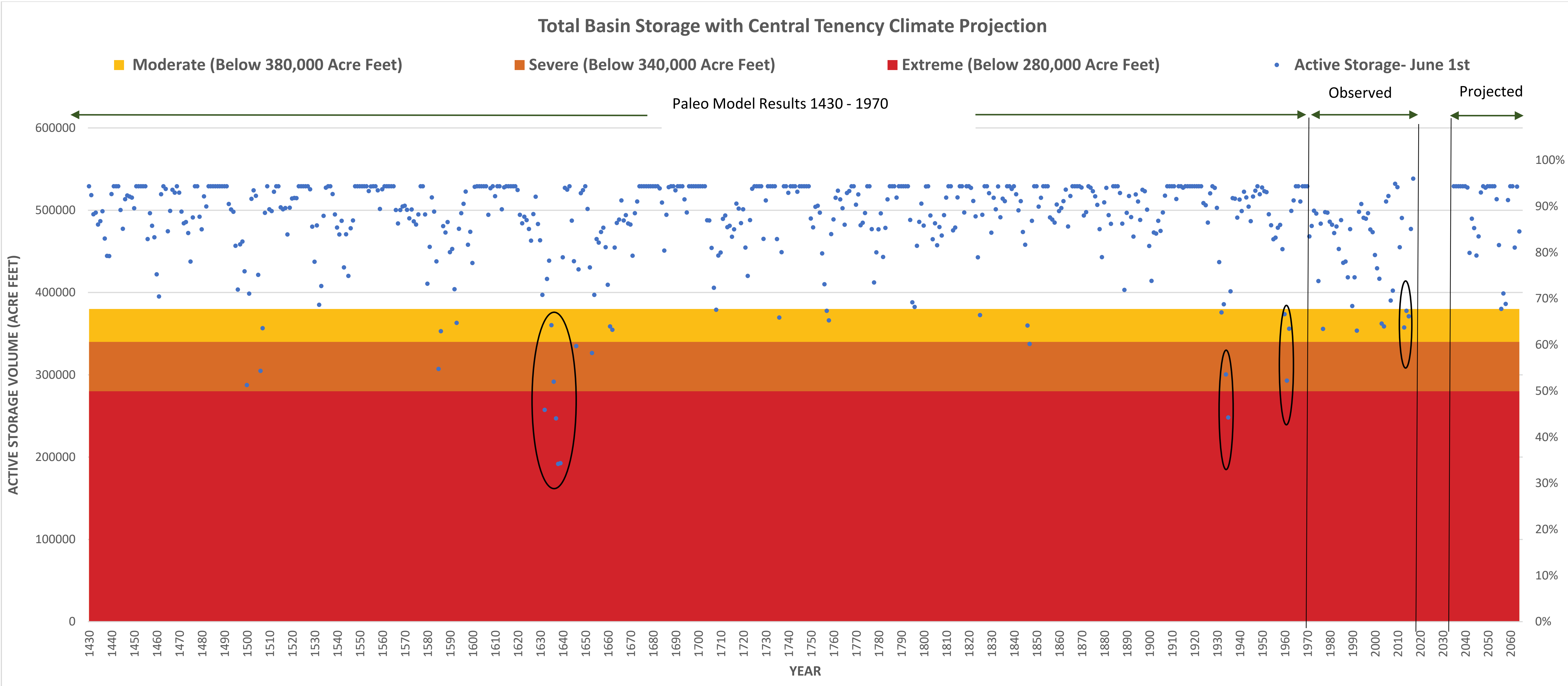
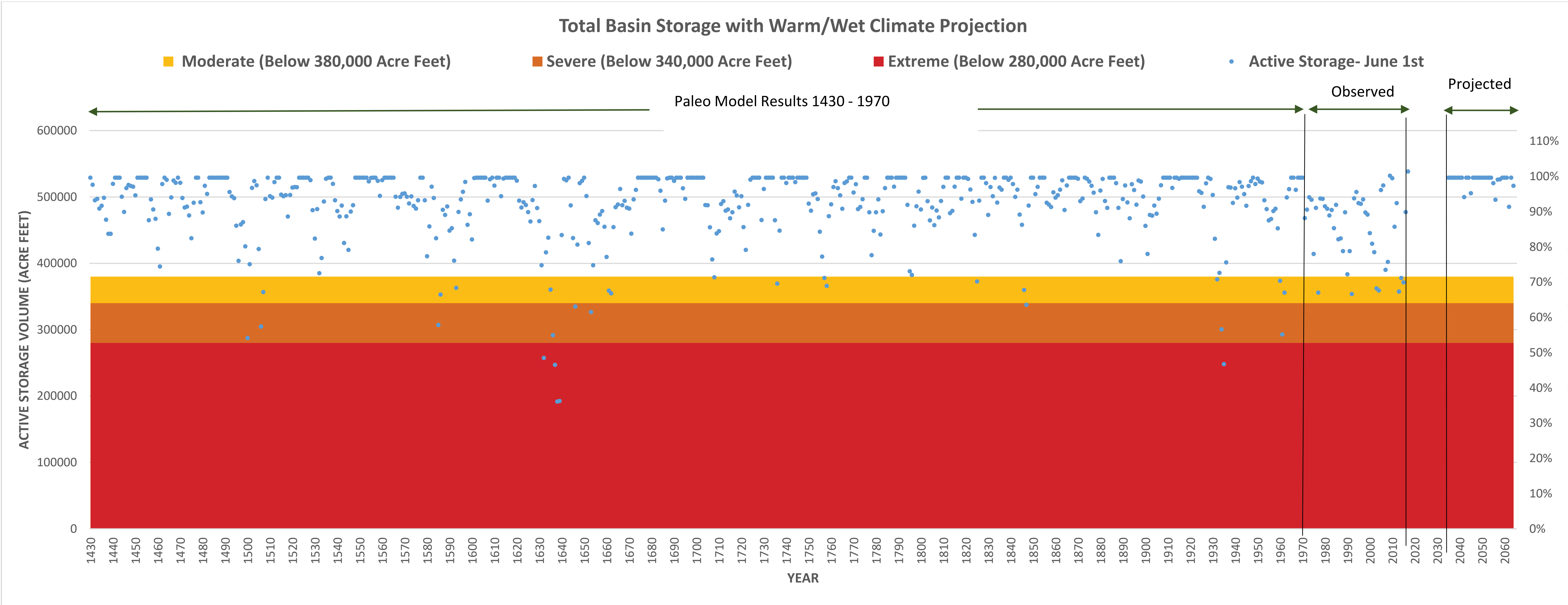
Wood, A. W., L. R. Leung, V. Sridhar, and D. P. Lettenmaier. 2004. "Hydrologic Implications of Dynamical and Statistical Approaches to Downscaling Climate Model Outputs." *Climatic Change* 62 (1–3): 189–216. doi:10.1023/B:CLIM.0000013685.99609.9e.

Appendix 3-D

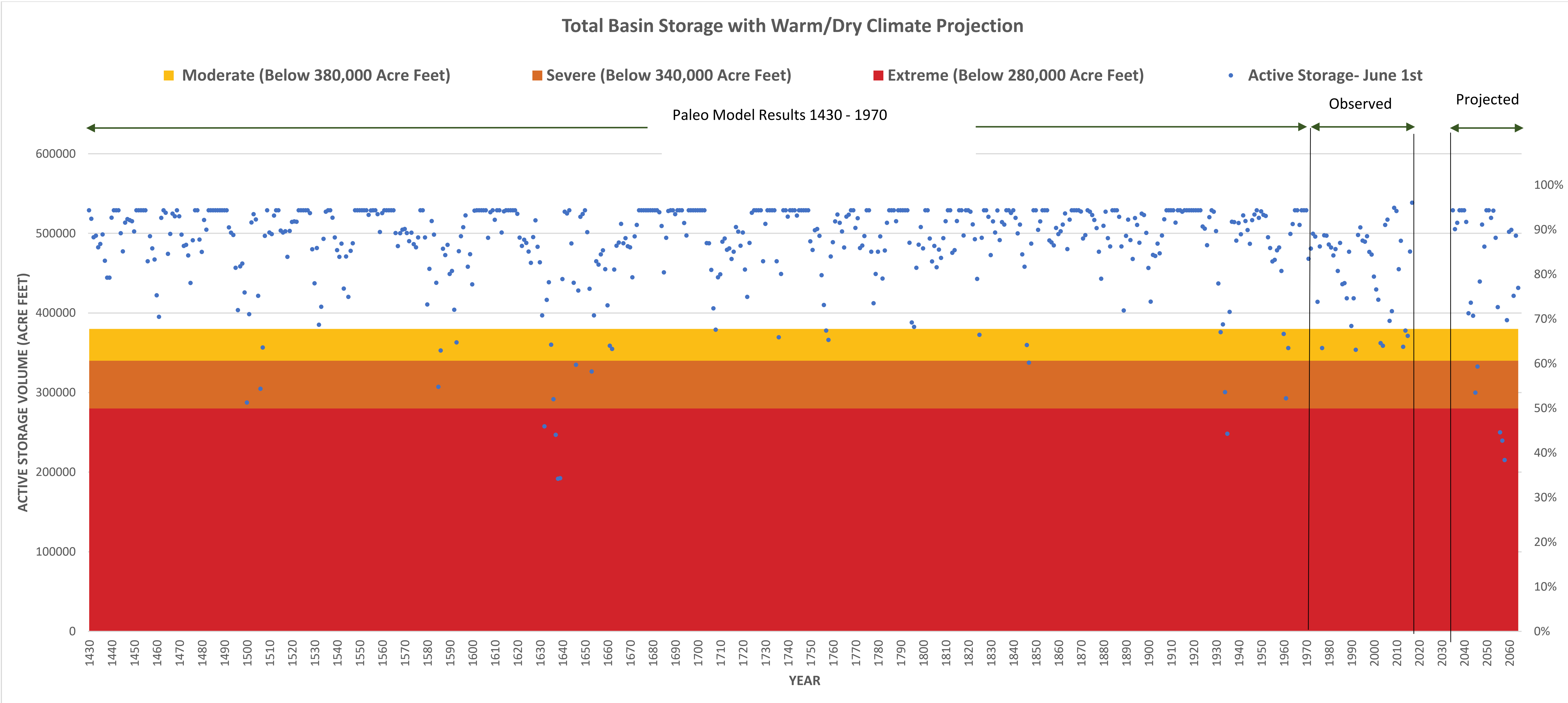
Climate Change Scenarios
Total Storage Graphs



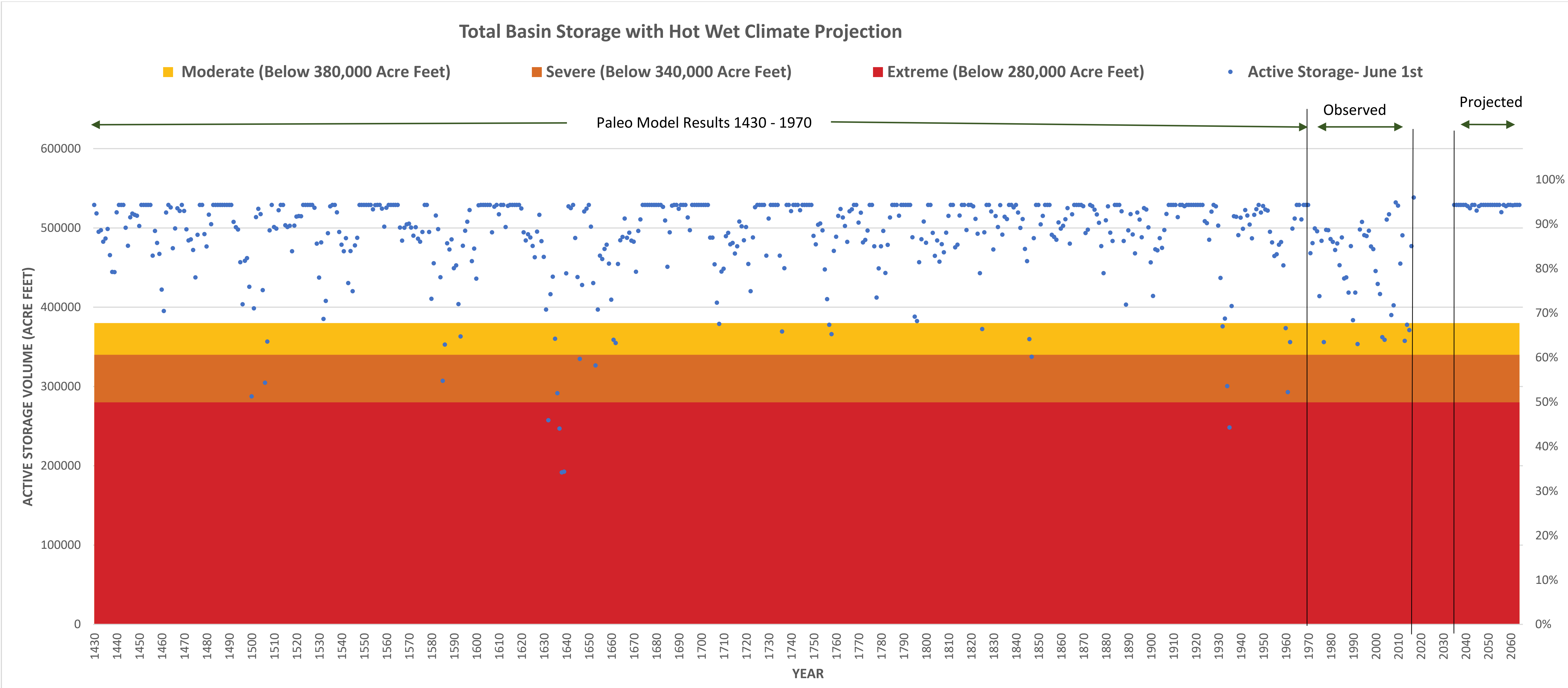
Total Basin Storage with Central Tenency Climate Projection
Moderate (Below 380,000 Acre Feet)
Severe (Below 340,000 Acre Feet)
Extreme (Below 280,000 Acre Feet)
Active Storage- June 1st
Paleo Model Results 1430 - 1970
Observed
Projected
ACTIVE STORAGE VOLUME (ACRE FEET)
PERCENT OF ACTIVE STORAGE VOLUME
YEAR



Total Basin Storage with Warm/Wet Climate Projection
Moderate (Below 380,000 Acre Feet)
Severe (Below 340,000 Acre Feet)
Extreme (Below 280,000 Acre Feet)
Active Storage- June 1st
Paleo Model Results 1430 - 1970
Observed
Projected
ACTIVE STORAGE VOLUME (ACRE FEET)
PERCENT OF ACTIVE STORAGE VOLUME
YEAR



Total Basin Storage with Warm/Dry Climate Projection
Moderate (Below 380,000 Acre Feet)
Severe (Below 340,000 Acre Feet)
Extreme (Below 280,000 Acre Feet)
Active Storage- June 1st
Paleo Model Results 1430 - 1970
Observed
Projected
ACTIVE STORAGE VOLUME (ACRE FEET)
PERCENT OF ACTIVE STORAGE VOLUME
YEAR



Total Basin Storage with Hot Wet Climate Projection
Moderate (Below 380,000 Acre Feet)
Severe (Below 340,000 Acre Feet)
Extreme (Below 280,000 Acre Feet)
Active Storage- June 1st
Paleo Model Results 1430 - 1970
Observed
Projected
ACTIVE STORAGE VOLUME (ACRE FEET)
PERCENT OF ACTIVE STORAGE VOLUME
YEAR
600000
500000
400000
300000
200000
100000
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
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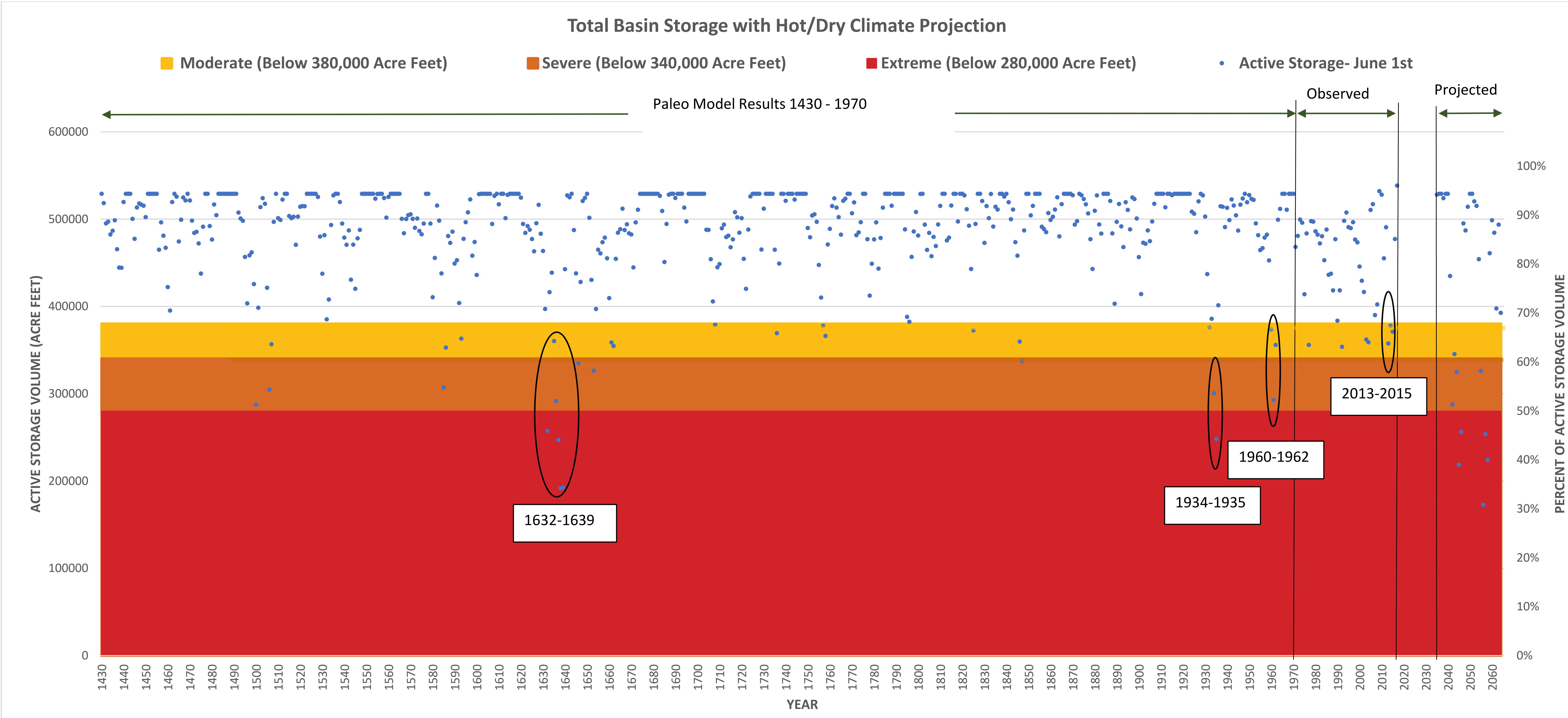

Total Basin Storage with Hot/Dry Climate Projection
Moderate (Below 380,000 Acre Feet)
Severe (Below 340,000 Acre Feet)
Extreme (Below 280,000 Acre Feet)
Active Storage- June 1st
Paleo Model Results 1430 - 1970
Observed
Projected
ACTIVE STORAGE VOLUME (ACRE FEET)
PERCENT OF ACTIVE STORAGE VOLUME
YEAR
1632-1639
1934-1935
1960-1962
2013-2015

Appendix 3-E

Future Drought Projections based on
Climate Scenarios

Average Number of Years Between Drought Events (Past and Projected)

	Projected June 1st Total Basin Storage		Average Number of Years Between Events						
			PAST			PROJECTED (2036-2065)			
Drought Level	Acre-Feet	% of Total Basin Storage Capacity	1430 - 1970	1971 - 2017	Overall Past Return Frequency (1430 through 2017)	Warm-Dry	Warm-Wet	Hot-Dry	Hot-Wet
Moderate	340,000 to 380,000	64% - 72%	36	7	27	*NA	*NA	30	*NA
Severe	280,000 to 340,000	53% - 64%	60	No Events	65	30	*NA	10	*NA
Extreme	Less than 280,000	Less Than 53%	135	No Events	147	10	*NA	6	*NA

* NA = No events were projected in this scenario

Appendix 4-A

Intermountain West Drought Monitoring
Web Addresses

Additional Drought Monitoring Websites

Utah

NIDIS – Utah drought information
Utah drought monitor and resources - https://www.drought.gov/drought/states/utah
Utah Climate Center
Utah climate data - https://climate.usurf.usu.edu/
Utah Snow Survey
Main page and portal - https://www.nrcs.usda.gov/wps/portal/nrcs/main/ut/snow/
Basin products and data -
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ut/snow/products/?cid=nrcseprd1330021
Current Reservoir Levels in Utah (NRCS) -
https://www.wcc.nrcs.usda.gov/ftpref/states/ut/iCharts/dev/RESC/resMapUT.html

Nationwide

NIDIS - Drought.gov
Main Portal - https://www.drought.gov/
Data, Maps & Tools - https://www.drought.gov/drought/data-maps-tools
National Drought Mitigation Center
US Drought Monitor- http://droughtmonitor.unl.edu
Drought Monitoring Tools - http://drought.unl.edu/MonitoringTools.aspx
NRCS National Water and Climate Center
Interactive Map 3.0 Beta - https://www.wcc.nrcs.usda.gov/webmap_beta

Multi-state/basin-wide coverage

NOAA NWS Colorado Basin River Forecast Center (CBRFC)
CBRFC Conditions Map - https://www.cbrfc.noaa.gov/
Water Supply Webinars - http://cbrfc.noaa.gov/present/present.php
Upper Colorado Situational Awareness page - https://www.cbrfc.noaa.gov/dash/lp.php
Western Water Assessment (WWA)
Intermountain West Climate Dashboard- http://wwa.colorado.edu/climate/dashboard.html
Evaporative Demand Drought Index (EDDI) – NOAA ESRL PSD, Desert Research Institute, WWA, NIDIS
Drought prediction tool - https://www.esrl.noaa.gov/psd/eddi/

Appendix 5-A

Potential Mitigation Measures
High, Moderate, Low Risk Levels

The following table lists the preliminary mitigation measures that were listed for the high, medium, and low risks during the risk assessment workshops. These measures were used to help build the list of mitigation measures that were later evaluated based on the mitigation objectives.

RISK: THREAT / LOST OPPORTUNITY	RISK LEVEL	POTENTIAL MITIGATION MEASURES
Loss of Echo Holdover Water Option	High	➢ Increase alternative storage ➢ Renegotiate agreement ➢ Create and negotiate short term transfer (fallowing) agreements
Failure or Inability to Deliver Culinary Water	High	➢ Reduce outside watering ➢ Explore/create agreements to have more available water ➢ Educate about drought possibilities
Failure or Inability to Deliver Agriculture Water (50%)	High	➢ Coordinate with sister agencies/districts ➢ Reduce culinary agreements ➢ Form agreements and collaborate with agriculture ➢ Create programs/incentives to free up water ➢ Prioritize water uses for future drought possibilities (exceptions for food crops)
Failure or Inability to Deliver Agriculture Water (100%)	High	➢ Reduce culinary contracts ➢ Negotiate agreements with others
Failure or Inability to Provide Environmental Flows (Reduced GSL Levels)	High	➢ Improve flow management in wet years (system flushes) ➢ Form agreements for additional sharing ➢ Store water further upstream (Echo, Rockport) ➢ Improve ag water efficiencies ➢ Remove barrier structures to connect habitat
Decrease in Stream Flows and Storage	High	➢ Increase alternative storage ➢ Renegotiate agreements ➢ Create and negotiate short term transfer (fallowing) agreements ➢ Increase flow metering
Failure to Enter into Agreements	High	➢ Negotiate with BOR while working with others ➢ Seek future MOUs with cities ➢ Create and negotiate short term transfer (fallowing) agreements
Increased Wildfires	High	➢ Create 4 wildfire prevention coalitions
Hot-Dry Climate	High	➢ Evaluate climate change on a local level

Failure to Collaborate and Educate	High	➢ Educate users about drought ➢ Provide drought information on district website
Wasteful Water Use	High	➢ Continue education efforts ➢ Continue Slow the Flow ➢ Continue secondary metering ➢ Bill secondary through metering
Inability to Utilize Larrabee Water Right	Moderate	➢ Move water right to facilitate use
Failure or Inability to Deliver Secondary Water (50%)	Moderate	➢ Coordinate with sister agencies/districts/municipalities ➢ Reduce culinary agreements ➢ Educate communities ➢ Create programs/incentives to free up water ➢ Coordinate to reduce drought impact ➢ Prioritize needs for drought conditions (exceptions) ➢ Improve conservation efforts
Failure to Maintain Existing Storage and Delivery Facilities	Moderate	➢ Implement drought rate structures
Power Generation Loss	Moderate	➢ Build financial reserves
Failure or Inability to Deliver Secondary Water (100%)	Low	➢ Increase number of secondary water services that are metered
Management Failure	Low	➢ Update Drought Contingency Plan (DCP) periodically

Appendix 5-B

Mitigation Measures not Evaluated

Make Agreements with Salt Lake Metro to use holdover water. -This is already being done
Complete interference agreement to change the beneficial uses of the Echo water to include M&I use - WBWCD is not doing this because there is plenty of agricultural water demand to use the Echo water on.
Purchase Weber Canyon power plant from PacifiCorp - no interest from RMP and not viable.
Create agreements to purchase emergency supplies from JVWCD or other nearby district. This mitigation measure was changed to an interconnect project with Salt Lake City.
Replace leaking infrastructure (identify large leaks and fix) (hard to quantify water loss) - This is already being done as problem areas become apparent and should continue.
Purchase Millcreek water rights. Construct infrastructure to supply Millcreek from the Willard Canal. WBWCD could then take the surplus water and put it through the river. This could allow WBWCD to have more water rights and allow the river manager to get Millcreek's water delivered. The Weber River Commissioner has a list of water rights holders that indicates if they use their water or not. – This is a better fit for Pineview Water to undertake
Complete climate change evaluation specific to the WBWCD area – This evaluation is already underway.

Appendix 5-C

Mitigation Estimates

Weber Canyon ASR - Develop additonal ASR near mouth of Weber Canyon. Use purchased Echo or East Canyon water in wet years to be used later during drought

ACTION # 1

Construction

Assume volume of 10,000 Acre Feet per year

Description	Unit	Quantity	Unit Cost*	Opinion of Probable Cost
Purchase Property	Acre	1	$ 100,000	$100,000
Purchase echo holdover or east canyon water in wet year	AF	10,000	$ 50.00	$500,000
			Total Construction Cost	$600,000
			Construction Contingency (35%)	$ 210,000
			Engineering (15%)	$ 121,500
			TOTAL	**$ 931,500**
EXTRACTION WELL ESTIMATE			ESTIMATE PROVIDED FOR USE BY WBWCD	$ 5,299,788
			CONSTRUCTION TOTAL	**$ 6,231,288**
			Captial cost per Acre Foot	**$ 623.13**

Financing

Total Loan Amount				$ 6,231,288
Interest Rate				4.00%
Term	Years			50
monthly payment				($24,035)
yearly payment				($288,414)
Operation and Maintenance				
Replace 8 pumps every 10 years	EA	32	$ 200,000	$6,400,000
Pump Replacement cost per Year				$40,000
Power Costs for 50 years of Operation (See power cost calcs below)	years	50	$ 510,792	$25,539,597
annual O&M costs				$638,792
annual O&M costs per acre foot				$ 64
Total cost of 50 year system				**$46,360,305.80**
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED				**$4,636.03**
cost per acre foot of water per year				**$92.72**

Power Costs		**Units**	**Comments**
Elevation Head	1000.00	feet	Discharge to Pump Elevations
Friction Head		feet	
Total Dynamic Head	**1000.00**	**feet**	
Estimated Design Flow	**12000**	**gpm**	**24.55** cfs

Pump Characteristics

Pump Efficiency	0.75	0.65
Motor Efficiency	0.75	0.92

Water Horsepower	3030.30	
Brake Horsepower	4040.40	
Motor Horsepower	**5387.21**	**Hp**
Electrical Power Required	4017.24	kW
Pump Cycles Per Day	1.00	
Pump Run Time	12.00	Hours/day
Electrical Usage Per Day	**48,207**	**kW-hr**
Electrical Usage Per year	**7,231,030**	**kW-hr**
	$ 0.05	**energy charge**
Energy Charge Per Day	$ 2,410.34	
Monthly Power Charge	$ 27,437.74	charged once for every month that the pumps are turned on ($6.83 per kW)
Electrical Cost Per Month	$ 74,720.65	
Number of months used in Year	5	
Electrical Cost Per Year	**$ 510,791.95**	

Engineer's Opinion of Probable Construction Cost

Bowen Collins & Associates, Inc. CONSULTING ENGINEERS

Date: 6/11/2014

Project: Staker Parsons Pit ASR/Recreation Facility *Prepared by: DMS/CDM*

Client: Weber Basin Water Conservancy District

WBWCD Generic Well Development & Equipping [1]

No.	Item	Quantity	Units	Unit Cost	Cost
GENERAL					
1	Mobilization	1	LS		$ 138,000
2	Well Drilling & Development	1	LS		$ 645,920
3	Mechanical Equipment (Vertical Turbine Well Pump, Steel Piping, Valves, Etc.)	1	LS		$ 250,000
4	HVAC Equipment (Louver and Exhaust Fan)	1	LS		$ 15,000
5	Electrical Equipment (Unit Heaters, VFD, PLC, Transformers, Cabinets, Indoor Lighting, etc.)	1	LS		$ 190,000
6	Building Construction (Concrete, etc.)	1	LS		$ 120,000
SUBTOTAL					$ 1,358,920
10% Markup for Engineering, Administration, and Legal		10%			$ 135,892
20% Estimating Contingency		20%			$ 271,784
TOTAL COST					$ 1,766,596

[1]Costs are planning level costs based on recent similar projects. Total cost shown is for a single (1) well at a depth of approximately 1,000 ft. with a capacity of 3,000 gpm, and do not include estimates for property acquisition for the well sites.

Action#3

Larrabee Storage - Develop Larrabee storage right somewhere in the Wasatch Back (Maybe Chalk Creek)

assumptions Similar to Whites Valley Cost   Cost per acre foot $ 1,850   assumptions

	pool elevation (feet)	volume (Acre-feet	firm yield (acre-feet)	cost per acre foot
		34,000	16	,000 $ 3,504.00

Description	Unit	Quantity	Unit Cost	Opinion of Probable Cost	Comments
Storage					
Total Storage	Ac-Ft	10,000			
Reliable Yield	Ac-Ft	7,500	$ 1,850	$ 18,500,000	
Number of reservoirs		1			
TOTAL STORAGE COST				$ 18,500,000	

	TOTAL PROJECT COST FOR IRRIGATION BENEFIT	$ 1 8,500,000
	35% CONTINGENCY	$ 6,475,000
GRAND TOTAL	Engineering (15%)	$ 3,746,250
		$ 28,721,250

Financing   Capital cost per Acre foot $ 3,830

Total Loan Amount	1 $ 5 0,000	$ 28,721,250
Interest Rate		4.00%
Term	Years	50
monthly payment		($110,780)
yearly payment		($1,329,358.47)

O&M

Assume parts and dam tender salary annual $/year O&MEA	$ 50,000
annual O&M costs per acre foot	$ 6.67

Total cost of 50 year system

$66,517,923.50

thirty years of loan payments plus pump replacement costs for 50 years plus 50 years of power costs

COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED

$8,869

total 50 year life cost / acre feet of water developed

Cost per acre foot of water per year

$ 177

Table 10-8 from Bear River Development plan report by Bowen Collens

Table 10-8
Short List of Potential Reservoir Sites

#	Name	Elevation	Volume (AF)		Cost/AF	Characterize	Comparison Cost $M
1	Above Cutler Dam	4,432	51,000	Medium	$927	Difficult environment	$47
2	Cub River	4,465	27,000	Small	$1,586	Cache	$43
3	East Promontory	4,231	238,000	Large	$1,106	Large site	$263
4	Fielding	4,300	70,000	Medium	$280	Least expensive	$20
5	Hyrum Enlargement	4,715	28,000	Small	$660	Cache	$18
6	Temple Fork	6,167	40,000	Small	$1,279	Cache, difficult enviro	$51
7	Washakie	4,406	158,000	Large	$2,278	Most expensive	$360
8	Whites Valley	5,260	170,000	Large	$1,847	Low impact	$314
9	Weber Bay	4,225	124,000	Medium	$1,277	Addl analysis needed	$158

South Davis ASR Feasability Study- Preliminary talks have happened with key players. Continue negotiations and a feasibility study to treat water and do ASR in the winter, pull water out in the summer. Provides more groundwater source for south end of service area and aqueduct redundancy.

Action #4

Note:This mitigation action does not develop water for use. In order to develop more water a project similar to project #1 will need to be done if the study if favorable.

Assumptions

See what millvilel spent and double plust Meet with Woods cross city 3 times, do a feasibility study with USGS Paul inkenbrandt, cost for usgs to study to do feasibility study and identify location, legal 20 hours,

3,000 Acre Feet per year

Description	Unit	Quantity	Unit Cost*	Opinion of Probable Cost	Comments
ASR study from USGS and identification of Locations	LS	1	$ 126,000	$126,000	Millville City's Cost for the project with Paul Inkenbrandt was 42K
Meeting with Woods Cross City	EA	3	$ 400	$1,200	Two Staff Members @ $100/hr. assuming a 2
			Total Cost	$127,200	
			Engineering (15%)	$ 19,080	
			Contingency (35%)	$ 44,520	
			TOTAL	**$ 190,800**	

*All costs give in 2018 dollars

Financing

Total Loan Amount		$ 190,800
Interest Rate		4.00%
Term	Years	50
monthly payment		($736)
yearly payment		($8,831)

Total cost of 50 year system	**$441,557**	$/Acre Foot
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED	**$147.19**	$147.19
cost per acre foot of water per year	**$2.94**	

Bear River Storage Allocation - Develop Bear River allocation

Action #5

APPROX. COST FOR BEAR RIVER DEVELOPMENT	**volume (Acre- feet**	
Bear River Development WBWCD Amount		50,000

Unit Cost	Opinion of Probable Cost
Total Bear River Allocation	220000
WBWCD Allocation	50000
Percentage	23%
Total Price to Build White Valley Res.	$1,219,830,000.00
Price to WBWCD for project	$277,234,090.91

TOTAL PROJECT COST FOR BENEFIT	$	277,234,091
35% CONTINGENCY	$	97,031,932
GRAND TOTAL	**$**	**374,266,023**
Capital cost per Acre foot	$	7,485.32

Financing

Total Loan Amount		$	374,266,023	
Interest Rate			4.00%	
Term	Years		50	
monthly payment			($1,443,570)	monthly payment
yearly payment			($17,322,843.08)	year

Operation and Maintenance

Replace 10 pumps every 10 year	EA	40	$	200,000		$8,000,000
Pump Replacement cost per Year					$	200,000
Power Costs for 50 years of Operation (See power cost	years	50	$	1,352,705		$67,635,239
annual O&M costs						$1,512,705
annual O&M costs per acre foot					$	30

Total cost of 50 year system	**$941,777,392.68**
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED	**$18,835.55**
cost per acre foot of water per year	**$376.71**

Power Costs		**Units**	**Comments**
Elevation Head	1000.00	feet	Discharge to Pump Elevations
Friction Head		feet	
Total Dynamic Head	**1000.00**	**feet**	
Estimated Design Flow	**3000**	**gpm**	**6.14** cfs

Pump Characteristics

Pump Efficiency	0.75		0.65
Motor Efficiency	0.75		0.92
Water Horsepower	757.58		
Brake Horsepower	10700.00		
Motor Horsepower	**14266.67**	**Hp**	
Electrical Power Required	10638.65	kW	
Pump Cycles Per Day	1.00		
Pump Run Time	12.00	Hours/day	
Electrical Usage Per Day	**127,664**	**kW-hr**	
Electrical Usage Per year	**19,149,576**	**kW-hr**	
	$ 0.05	**energy charge**	
Energy Charge Per Day	$ 6,383.19		
Monthly Power Charge	$ 72,662.00	charged once for every month that the pumps are turned on ($6.83 per kW)	
Electrical Cost Per Month	$ 197,878.95		
Number of months used in Year	5		taken from estimate sheet needed horse power for Newton, 8th Ward Canal, Hyrum, and Richmond pump stations
Electrical Cost Per Year	**$ 1,352,704.77**		

Table 12-2 from Bear River Pipeline Concept Report volume 1

20 Cities ENR Index = 8600 - March 2010

Item #	Description	Quantity	UOM	Unit Price	Total Price	Comments/Assumptions
				Bear River Project Grand Total:	**$ 1,219,830,000**	
	Bear River Pipeline Construction Costs				**$367,736,000**	
1	North Box Elder Co. Reach - 150" Diam	94,480	LF	$2,147	$202,849,000	Pipeline costs include pipe materials,
2	South Box Elder Co. Reach - 150" Diam	36,950	LF	$2,147	$79,332,000	coatings/linings, installation, est ROW acquisition,
3	Weber Co. Reach - 90" Diam	79,270	LF	$1,049	$83,155,000	surface restoration, utilities relocation, and general
4	Metering Vaults	3	EA	$800,000	$2,400,000	
	Reservoirs (including pump stations)				**$306,300,000**	
1	Cub River	1	LS	$42,800,000	$42,800,000	
2	Fielding	1	LS	$38,300,000	$38,300,000	
3	Weber Bay	1	LS	$197,000,000	$197,000,000	
4	Collinston Connection	1	LS	$28,200,000	$28,200,000	
	Cache County Project Facilities				**$115,239,000**	See Chapter 7 for details on Cache County Facilities
1	72" Pipeline to Cutler Reservoir	24,728	LF	$704	$17,409,000	From Collinston Diversion (from Washakie Res)
2	30" Pipeline to Newton Reservoir	23,660	LF	$209	$4,945,000	From a Pump Station at Cutler Reservoir
3	Newton Reservoir Pipeline Pump Station	2,600	HP	$3,000	$7,800,000	Cost per HP derived from Cost Memorandum
4	48" Pipeline to 8th Ward Canal	59,747	LF	$473	$28,231,000	From a Pump Station at Cutler Reservoir
5	8th Ward Canal Pipeline Pump Station	2,900	HP	$2,900	$8,410,000	Cost per HP derived from Cost Memorandum
6	42" Pipeline to Hyrum Reservoir	92,570	LF	$325	$30,067,000	From a Pump Station at Cutler Reservoir
7	Hyrum Reservoir Pipeline Pump Station	3,900	HP	$2,700	$10,530,000	Cost per HP derived from Cost Memorandum
8	24" Pipeline to Richmond Irr. Company	13,150	LF	$201	$2,647,000	From a Pump Station at Cutler Reservoir
9	Richmond Pipeline Pump Station	1,300	HP	$4,000	$5,200,000	Cost per HP derived from Cost Memorandum
				Running Subtotal:	**$789,275,000**	
	Mobilization/Field Oversight Expenses				**$78,928,000**	
1	Contractor General Conditions (Prime)	1	LS	10%	$78,928,000	
				Running Subtotal:	**$868,210,000**	
	Project Administration & Management				**$351,620,000**	
1	Legal & Admin	1	ls	10%	$86,820,000	
2	Engineering	1	ls	5%	$47,750,000	
4	Scope Contingency/Market Conditions	1	ls	25%	$217,050,000	
				Bear River Project Grand Total:	**$1,219,830,000**	Total Estimated Constr Costs w/ Contingency

AACE International CLASS 4 Cost Estimate. This estimate is prepared based on information where the preliminary engineering is from 1 to 5 percent complete. Examples of estimating methods used would include equipment and system process factors, scale-up factors, and parametric and modeling techniques. This estimate requires more time expended in its development. The typical expected accuracy range for this class estimate is -15 to -30 percent on the low side and +20 to +50 percent on the high side.

Action #6

Short-Term Transfer Agreements - Create a program and get contracts in place to pay large agricultural users to be on a list to fallow land or plant drought tolerant crops when asked. Pay user for lost income Assume 1,250 acres of fallow land.

Assumptions:
Assume we will only do agreements with owners of 50 or more irrigated acres assume the district will do 25 agreements. Assume 8 hours attorney upfront plus 1 hour for each agreement, 2 weber basin people for 4 hours, for each agreement. Assume each irrigator wants some compensation for each year that they are under the agreement, Assume 1% of the response action price ($1000 per acre). 10,000 AF of water to be available so 3,333 Acres of Land to be fallowed.

Assume that this will only be implemented for orange or red drought stage and that those drought stages will only bee reached every 10th year

IMPLEMENTATION	$	200.00			
Attorney Unit Cost/HR		8			
Attorney Hours/Upfront		1			
Attorney Hours/Agreement					
	$	200.00			
Weber Basin Meeting Cost/HR		4			
Meeting Time/Agreement					
		67	Assumed that each agreement is aprox. 50 Acres		
Agreements					
Total Costs to Implement	$	15,000		3333	66.66
Attorney Cost	$	53,600		1250	.
Weber Basin Cost					
	$	68,600			
TOTAL COST	$	18.29			
Cost per/AF					
FARM USE TO HOME USE CONVERSION					
Average Residential Indoor Water Use		86	gallons	80,000	70
Average indoor use per capita per day		3	ppdu		
Average people per dwelling unit		258	gallons per day		
Average indoor use per dwelling unit					
Average Agricultural Water Use		3	feet ***(This could be significanlty less than 3 feet during a drought year)		
Feet of water per year		130,680	cubic feet		
Cubic feet per acre per Irrigation season		6	months		
Assume 6 month irrigation season		726	cubic feet per day per acre		
Volume per day per acre		5,430	gallons per day per acre		
Gallons per day per acre					
		21.0	**homes**		
# of homes that could be served per acre of agricultural land not irrigated (indoor use only)					
Number of ERU's in WBWCD service area		336,043	people		
Davis County population (US Census Bureau 2015)		243,645	people		
Weber County population (US Census Bureau 2015)		579,688	people		
combined total people		193,229			
homes		**9,180**	acres		
Ag acres needed to take out of service to serve existing homes in davis and weber county (indoor use only)					
		399,891,722			
area in square feet		19,997	approx 4 miles by 4 miles		
length on each side of square area				3.787366073	
Cost for Fallow Program					
		10,000	acre feet of water to be used for indoor use		
Assume 10,000 AF to be available through this program		3,333	approximately acres of ag land taken out of production		
Benefit		70,161	homes could be served with indoor water		
		10000	AF		
Acre/Feet available from program					
			per acre per full fallow year (may need to pay $50 or something a year to get people		
FALLOW COST DROUGHT YEAR	$	1,000.00	to sign on to the program before a drought)		
Cost to fallow one acre of land		3,333		3	
Acres fallowed	**$**	**3,333,333**		330000	
total fallow cost in the drought year					
FALLOW COST NON-DROUGHT YEAR	$	10.00	per acre		
Cost to Maintain Farmer on Fallow List		3,333	acres		
Acres in the program	**$**	**33,333**			
Total cost in Non-Drought Year					
TOTAL COST	$	68,600			
Implementation	$	16,666,667			
Assume **5** Drought years	$	1,500,000			
Assume **45** Non-Drought Years	$	18,235,267			
Sub-Total					
	$	6,382,343			
Contingency (35%)	**$**	**24,617,610**			
TOTAL					

*All costs give in 2018 dollars

Financing		$ 24,617,610
Total Loan Amount		4.00%
Interest Rate	Years	50
Term		($94,952)
monthly payment		($1,139,422)
yearly payment		
		$56,971,107
Total cost of 50 year system		**$5,697.11**
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED		**$113.94**
cost per acre foot of water per year		

Water Sharing Agreements - Create inter-agency agreement with Layton City or Roy City to purchase some water during drought years.

Action #7

Assumptions:
Assume that this will only be implemented for orange or red drought stage and that those drought stages will only be reached every 10th year

IMPLEMNTATION			
Attorney Fee/hr	$	200.00	
Attorney Hours		20	Hours
Attorney Total	$	4,000.00	
Weber Basin Hr Rate	$	100.00	
Weber Basin Total	$	4,000.00	40 Hours assumed for Weber Basin Staff
Sub-Total	**$**	**8,000.00**	
$/AF CAPITOL COST	$	16.00	

COST OF WATER			
Price per Acre Foot Water	$	575.00	Price from Derek for NEW TREATED WATER
Acre Feet to Purchase		2500	acre Feet
Total Price for Water	**$**	**1,437,500.00**	

TOTAL COST			
Implementation	$	8,000.00	
Assume **5** Drought years	$	7,187,500.00	
Assume **45** Non-Drought Years	$	562,500.00	assume $5 /AF admin Fee
Sub-Total Cost	$	7,758,000.00	
Contingency (35%)	$	2,715,300.00	
TOTAL COST	$	10,473,300.00	
Acre/Feet available from program		2500	acre/feet

*All costs give in 2018 dollars

Financing		.	
Total Loan Amount		$	10,473,300
Interest Rate			4.00%
Term	Years		50
monthly payment			($40,396)
yearly payment			($484,755)
Total cost of 50 year system			**$24,237,751**
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED			**$9,695.10**
cost per acre foot of water per year			**$193.90**

Action #8

Ogden City Pineview Water Sharing Agreement - Coordinate with Ogden City to determine if 4,500 shares of water in Pineview are available to purchase or lease from Odgen. Ogden owns 10,000 acre feet, but only about 4,500 acre feet are available for use. Ogden typically uses WBWCD water instead of this Pineview water. The Pineview water is a very high priority right. Determine if an agreement can be reached to purshase or lease the water for drought mitigation.

Assumptions:

Assume that this will only be implemented for orange or red drought stage and th

IMPLEMNTATION

Attorney Fee/hr	$	200.00	
Attorney Hours		20	Hours
Attorney Total	$	4,000.00	
Weber Basin Hr Rate	$	100.00	
Weber Basin Total	$	8,000.00	40 Hours assumed for Weber Basin Staff
Sub-Total	**$**	**12,000.00**	
$/AF CAPITOL COST	$	2.67	

COST OF WATER

Price per Acre Foot Water	$	575.00	Price from Derek for NEW TREATED WATER
Acre Feet to Purchase		4500	acre Feet
Total Price for Water	**$**	**2,587,500.00**	

TOTAL COST

Implementation	$	12,000.00	
Assume **5** Drought years	$	12,937,500.00	
Assume **45** Non-Drought Years	$	-	
Sub-Total Cost	$	12,949,500.00	
Contingency (35%)	$	4,532,325.00	
Total Cost	$	17,481,825.00	
Acre/Feet available from program		4500	acre/feet

*All costs give in 2018 dollars

Financing

Total Loan Amount		$ 17,481,825
Interest Rate		4.00%
Term	Years	50
monthly payment		($67,429)
yearly payment		($809,143)
Total cost of 50 year system		**$40,457,174**
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED		**$8,990.48**
cost per acre foot of water per year		**$179.81**

Action #10

WBWCD Secondary Water Metering - Meter all secondary WBWCD water users and provide usage reports to the users. Save 35% average when going to meters. 11,000 services left to meter at a cost of $1,200 per service. Ask suppliers for discounted meter prices for large volume meter orders.

Assumptions

Save 35% average when going to meters. 11,000 services left to meter at a cost of $1,200 per service.

assume that currently each home is using an acre foot of water per year and will reduce that usage by 35% with a meter

COST OF SECONDARY WATER METER INSTALLED				
Installed Price per Meter		$ 1,200.00		
Meters Needed		11,000	Meters	
	Sub-Total	$ 13,200,000		
	Contingency (15%)	$ 4,620,000		
Total		**$ 17,820,000**		
$/AF Capitol Cost		$ 4,628.57		3428.571429
Water Use per Connection		1	AF	
Water Saved per Meter Install		0.35	AF (ASSUME 35% SAVINGS PER METER)	
TOTAL WATER SAVED		3,850	AF	

*All costs give in 2018 dollars

Financing			
Total Loan Amount		$	17,820,000
Interest Rate			4.00%
Term	Years		50
monthly payment			($68,733)
yearly payment			($824,796)
Total cost of 50 year system			**$41,239,793**
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED			**$10,711.63**
cost per acre foot of water per year			**$264.23**

O&M			
Human Capital	$	156,000.00	$ -
Infrastructure costs	$	25,200.00	
Mailing costs	$	19,000.00	
annual O&M costs	$	200,200.00	#DIV/0!
assuming 1AF per connection			
annual O&M costs per acre foot	$	50	

$0.00	thirty years of loan payments plus pump replacement costs for 50 years plus 50 years of power costs
#DIV/0!	total 50 year life cost / acre feet of water developed
#DIV/0!	

Other Systems Secondary Water Metering - Start a WBWCD program to provide secondary water metering techincal assistance and meter installation assistance for secondary systems in the district boundaries, but not owned by the district.

Actiont #11

Assumptions:
2 weber basin employees do 6 meetings (1) hour a meeting, plus 16 hours of prep time
Assume this would be done every year

Assume that over 50 years, 80,000 meters total are added, or on average 10 meters a year are added.
Assume this is a yearly meeting
Assume that other companies are paying for the actual meters and meter installation, but the cost is included in this evaluation

Weber Basin Hr Rate	$	100	per person per hour	
Weber Basin Total		12	Hours (6 - 1 hour meetings for 2 employees)	
Weber Basin Prep Time		16	Hours (8 hours for 2 employees)	
Sub-Total Meter Cost/year	$	2,800		
50 year cost	$	140,000		
Meters to be installed over the 50 year period		80000	Meters	20
Cost per meter	$	1,200	Meters would be purchased by others	80,000
Sub-Total meter Cost	$	96,000,000		50
				1600
Sub-Total	$	96,140,000.00		
Contingency (15%)	$	33,649,000.00		
Total Yearly Price for District	**$**	**129,789,000.00**		
$/AF Capitol Cost	$	4,635.32		
Water Use per Connection		1	AF	
Water Saved per Meter Install		0.35	AF (ASSUME 35% SAVINGS PER METER)	
TOTAL WATER SAVED		28,000	AF	

*All costs give in 2018 dollars

Financing

Total Loan Amount		$	129,789,000
Interest Rate			4.00%
Term	Years		50
monthly payment			($500,605)
yearly payment			($6,007,263)
Total cost of 50 year system			**$300,363,157**
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED			**$10,727.26**
cost per acre foot of water per year			**$264.55**

O&M

assume 50 per year per connection	$	50.00
total O&M		

Action #12

Drought Surcharge Fee Study - Study and develop a water drought surcharge fee structure for Weber Basin to utilize during drought periods. Fee structures will provide revenue needed for system operation and maintenance and to fund response actions during droughts. (assume all secondary connections are metered)

Assumptions
Hire consultant to do the study for $100,000 and education, and implementation
Assumes that we are going to do the rate structure for all types of water use ASK Derek if we are going to do the rates for all uses

Assume we have a Orange drought every 10 years

Assume that we will have a reduction in water consumption every 10 years that is equal to 50% of the target reduction goal for secondary water for an orange drought based on year 2020 usage projections

Drought surcharge Fee Study

Consultant fee		$	100,000.00
	Contingency (35%)		35,000
	Total	**$**	**135,000**
	$/AF Capitol Cost	$	4.34

WATER SAVINGS from this program

5 years with Orange Drought Condition	31131.73813	AF	drought every 10 years
45 years without Orange Drought Condiditon	0		
Period of Time	50	years	
Average water savings per year	622.6347626		

*All costs give in 2018 dollars

Financing

Total Loan Amount		$	135,000
Interest Rate			4.00%
Term	Years		50
monthly payment			($521)
yearly payment			($6,248)
Total cost of 50 year system			**$312,423**
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED			**$10.04**
cost per acre foot of water per year			**$0.20**

Create New Tiered Rate Stucture and Short Term Transfer Water Fund - Create a fund prior to a drought to purchase water through short term transfer agreements during times of drought. Use overage fees from water users that exceed a certain level of water use in any given month.	Action#13			
Assumptions				
$5,000 to set up account, $50,000 Consultant Fee				
assume this is only done for secondary water rates.	$ 50,000.00			
	5,000			
Assumes that all secondary water meters are in place and that WBWCD is charging based on metered use.	**$ 55,000**			
Assumes that all secondary water meters are in place and that WBWCD is charging based on metered use.				
Assume projected 2040 secondary water demand of 117,000 acre feet per year and that 5% of that demand will be in the overage fee.				
Assume that everyone currently pays $20 per month for 12 months to get 6 months of water. Assume that $40 per motn is charged to the 5% that over use lot of water.				
5850				
Assume that each house uses 1 ac/ft per year	5188.6	AF		
Assume that each house pays $240 per year = cost of $240/acre foot	0			
Assume with new rate structure 5850 acre feet will be charged $20 extra per acre foot	50	years		
Assume this reduces secondary water use by 5% (5% of 2020 useage of secondary water 103,772 af)				
Per year in savings account				
Cost to purchase water fromirrigatiors	#REF!	per acre foot		
	#REF!	acre feet of water per year		
amount of water available in a drought year	#REF!	acre feet of water purchased every 10 years		
Consultant fee				
WBWCD Admin. Fee				
Total			$	55,000
				4.00%
	Years			50
WATER SAVINGS from this program				($212)
5 years with Orange Drought Condition (Drought every 10 years)				($2,546)
45 years without Orange Drought Condiditon				
Period of Time				**$127,283**
				$24.53
				$0.49

*All costs give in 2018 dollars

Financing

Total Loan Amount

Interest Rate

Term

monthly payment

yearly payment

Total cost of 50 year system

COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED

cost per acre foot of water per year

Water Reuse Project - Create re-claimed water reuse agreement with one of the treatment faciliities located in the district. Build infrastructure needed to utilize reclaimed water for secondary water.

Assumptions:
Attorney for agreement 40 hours, 40hours weber basin, purchase water right,
assume 2000 acre feet of reuse, purchase re-use water right
It is assumed that WBWCD already has the rights to the water they they intend to reuse.
Assume the reuse project will be with North Davis sewer in Syracuse $2.5M dollars of capital cost per MGD of re-use
Currently studying this through a reuse project for $320,000

Action#14

IMPLEMENTATION

Attorney Fee/hr	$	200.00		
Attorney Hours		40	Hours	
Attorney Total	$	8,000.00		
Weber Basin Hr Rate	$	100.00		
Weber Basin Total	$	4,000.00	40 Hours assumed for Weber Basin Staff	150,549.00
ENGINEERING FEASIBILITY STUDY	$	320,000.00		
				754,350.00
Sub-Total	**$**	**332,000.00**		

Resources from past projects
Syracuse

West Jordan

Capital Cost

MGD desired	$	5.00		
$M/MGD		7.5	25% Contingency built in 3 times Syracuse cost of 2.5	
Water Received from Improvements		8,000.00	AF	
Total Capital Cost	**$**	**37,500,000.00**		AF
			7.5	AF/Day (153 irrigation days)
TOTAL	**$**	**37,832,000**		CF/day
Capitoal Cost per AF	$	4,729	$/AF	gal/day
				MGD

*All costs give in 2018 dollars

Financing

Total Loan Amount		$	37,832,000
Interest Rate			4.00%
Term	Years		50
monthly payment			($145,921)
yearly payment			($1,751,048)

RESOURCES
1. Syracuse: \\Kays\public\Projects\JUB\Syracuse\55-16-018_SW Master Plan\Text\Reports\Secondary IFFP Final Submission to CIty \Syracuse Secondary
2. West Jordan: \\slcfiles\public\Projects\jub\West Jordan\83-16-033 Water Reuse Study\Text

Operation and Maintenance

Annual O&M Costs	$2,700,000	3 times cost From Syracuse report and comparable to
O&M Cost/AF	$338	West Jordan numbers

Total cost of 50 year system	**$222,552,403.86**
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED	**$27,819.05**
cost per acre foot of water per year	**$556.38**

Action #15

Drought Surcharge Fees - Educate cities and the public about rate structures, Prepare a sample ordinance to provide for cities for drought water rate adjustments. Visit cities to explain the rate structures and the benefits (50 customer agencies).

Assumptions:
16 hours of preperation for weber basin plus 50 (3) hour meetings with 2 WBWCD Employees, compile results/follow up, 16 hours.
Assume this is done every 10 years

Assume 2 water systems adopt similar rate structures every 10 years. Assume over 50 years 10 adopt so 1/5 of the 2040 projected water reduction
Assume that it will take 50 years to get 10 communitites to adopt drought surcharge fees on culinary outdoor water use. By doing so users m&I and secondary water users will meet the demand reduction goal for 2040. 2040 is used because it is in the middle of the 50 year period. the culinary water savings would be

total water savings =	12040.54532	
Weber Basin Hr Rate	$ 100.00	
Prep. Time	16	Hours
Meetings	50	Meetings
Meeting Time	3	Hours
WBCD Employees	2	Employees
Compile info after meeting/follow up on questions	16	hours
Total Time	332	Hours
Sub-Total	$ 33,200.00	
Contingency (35%)	$ 11,620.00	
TOTAL	$ 44,820.00	
Capitol $/AF	#DIV/0!	

WATER SAVINGS

Water Demands for 2040 (Approx. middle of 50 Year Pe	-	acre feet

*All costs give in 2018 dollars

Financing

Total Loan Amount		$ 44,820
Interest Rate		4.00%
Term	Years	50
monthly payment		($173)
yearly payment		($2,074)
Total cost of 50 year system		**$103,724**
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED		**$43.07**
cost per acre foot of water per year		**$0.86**

Drought Plan Results - Present the drought plan process findings and recommendations to cities and irrigation companies in the district by visiting city council meetings and irrigation meetings. Education about cuts that will be needed during different drought stages.

Assumptions:
16 hours of preperation for WBWCD Employees plus 50 (3) hour meetings with 2 WBWCD Employees attending

Assume you do this every 10 years.

Action #16

NOTE: This mitigation action does not develop water for use, but sets up other oportunities to do so. See individual cost spread sheet for costing information

Weber Basin Hr Rate	$	100.00	
Prep. Time		16	Hours
Meetings		50	Meetings
Meeting Time		3	Hours
WBCD Employees		2	Employees
Total Time		316	Hours
Subtotal	$	31,600.00	
Perform Action every 10 years (5 times)	$	158,000.00	
Contingency (35%)	$	55,300.00	
TOTAL	$	86,900.00	

Internet Water Situation Dashboard - Create a web based system that reports current performance of system and drought levels and informs people what water conservation actions they should be implementing.

Action#17

Assumptions:
hire consultant for $200,000, assume this saves 5% of current water use

IMPLEMENTATION COSTS

Weber Basin Hr Rate		
Prep. Time		Hours
Weber Basin Staff Price		
Consultant Fee		
	Sub-Total	

WATER SAVINGS

Water Demands for 2040 (Approx. middle of 50 Year Period)	acre feet
Percent water saved due to exposure to website	
Quantity of water Conserved	acre feet

TOTAL COST

Contingency (35%)
Project Cost
Capitol $/AF

*All costs give in 2018 dollars

Financing

Total Loan Amount	$ 275,400
Interest Rate	4.00%
Term	50
monthly payment	($1,062)
yearly payment	($12,747)

O&M

Yearly Tech/Web upkeep fee	$2,500
O&M $/AF	$0.15

Total cost of 50 year system	**$762,342.25**
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED	**$46.74**
cost per acre foot of water per year	**$0.93**

Yearly Habitat Coordination Meeting- Meet yearly with Utah Division of Wildlife Resources, Trout Unlimited, Utah Division of Forestry, Fire, and State Lands, and other key habitat stakeholders to coordinate river operation stratagies that will make the river more drought resilient. Strategies may include river braiding, connectivity improvements for better habitat, Improved management of water during wet years for more consistent flows and better GSL industry, water pulsing through the river to clean channels during wet years, etc.

Assumptions

One 3 hour meeting for 4 employees, WBWCD prep for meeting 20 hours, Post meeting actiona dn follow up 4 hours

Action #19:

Note **This mitigation action does not develop water for use, but sets up other oportunities to do so. See individual cost spread sheet for costing information**

YEARLY MEETING COSTS			
Weber Basin Hr Rate	$	100.00	
Prep. Time and follow up		24	Hours
Meetings		1	Meetings
Meeting Time		3	Hours
WBWCD Employees		4	Employees
Total Employee Hours		36	Hours
Sub-Total	$	3,600.00	
Contingency (35%)	$	1,260.00	
YEARLY MEETING TOTAL	$	4,860.00	
Yearly Meetings for 50 years	$	243,000.00	
Total	$	243,000	

*All costs give in 2018 dollars

Financing

Total Loan Amount	
Interest Rate	
Term	Years
monthly payment	
yearly payment	

Total cost of 50 year system

Note:

Action#20

Salt Lake Interconnect Feasibility Study - Do a study to determine the feasability of making an agreement and a physical connection between the WBWCD system and the Salt Lake City or Jordan Valley Water Conservancy District System. An interconnection would provide some redundancy on the south end of the WBWCD service area.

This mitigation action does not develop water for use, but sets up other oportunities to do so. See individual cost spread sheet for costing information

Drought surcharge Fee Study

Consultant fee	$	50,000.00	
Weber Basin Total	$	4,000.00	40 Hours assumed for Weber Basin Staff
Subtotal	$	54,000.00	
Contingency (35%)		17,500	
Total	**$**	**71,500**	

*All costs give in 2018 dollars

Financing

Total Loan Amount		$ 71,500
Interest Rate		4.00%
Term	Years	50
monthly payment		($276)
yearly payment		($3,309)
Total cost of 50 year system		**$165,468**
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED		**#REF!**
cost per acre foot of water per year		**#REF!**

Assistance for Other Secondary Systems - Help secondary distribution system managers (retail systems) manage their systems more efficiently to conserve water.

Action#22

Assumptions:
Assume 5 (2) hour training sessions with 2 WBWCD Employees. Also assume 20 hours of preparation. 20 hours for WBWCD follow up on actions.

Weber Basin Hr Rate	$ 100.00	
Prep. Time and follow up	40	Hours
Meetings	5	Meetings
Meeting Time	2	Hours
WBWCD Employees	2	Employees
Total Employee Hours	60	Hours
Sub-Total	$ 6,000.00	
Perform yearly over 50 years	$ 300,000.00	
Sub-Total	$ 300,000.00	
Contingency (35%)	$ 105,000	
Total	**$ 405,000**	
Capitol $/AF	**$ 124.14**	

WATER SAVINGS

Water Demands for 2040 (Approx. middle of 50 Year Pe	326,237	acre feet
Percent water saved due to exposure to website	1.00%	
Quantity of water Conserved	3,262	acre feet
*All costs give in 2018 dollars		

Financing

Total Loan Amount		$ 405,000
Interest Rate		4.00%
Term	Years	50
monthly payment		($1,562)
yearly payment		($18,745)
Total cost of 50 year system		**$937,268**
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED		**$2.87**
cost per acre foot of water per year		**$0.06**

Improve Open Channels - Line canals with concrete. The Ogden Valley and Willard canals are currently being lined. Assume 2,000 feet of canal lined each year.

Action#21

Assumptions

One 3 hour meeting for 4 employees, WBWCD prep for meeting 20 hours, Post meeting actiona dn follow up 4 hours

Capital costs						
Canal Lining Price/LF	$ 2,000.00	canal is 2000 cfs				
Lineal Feet to line /Year	2000					
SubTotal Price per year	$ 4,000,000.00	18.93939394				
Contingency (35%)	$ 1,400,000.00					
TOTAL YEARLY CAPITAL COST	$ 5,400,000.00					
Total over 19 years to reach willard Bay	**$ 102,600,000.00**					
Total Capital Cost/AF	$ 21,113.27					
Water Conserved						
Total length of lined canal	36,960	ft				
Total Miles	7	Miles				
Extra water stored					assume that canal only	
extra storm flow captured	350	CFS	2.64	18.48	carries 1000 cfs	
number of days with extra flow	7	days				
Total Water Saved (AF)	**4,859.50**	**AF**			36960	total lineal
					18.48	feet

*All costs give in 2018 dollars

Financing					
Total Loan Amount		$	102,600,000		
Interest Rate		4.00%			
Term	Years	50			
monthly payment		($395,735)			
yearly payment		($4,748,825)			
				1000	cfs
Total cost of 50 year system		**$237,441,231**		86400000	cubic feet per day
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED		**$48,861.21**		1983.471074	acre feet per day
cost per acre foot of water saved per year		**$977.22**			

Assistance for Other Secondary Systems - Help secondary distribution system managers (retail systems) manage their systems more efficiently to conserve water.

Action#22

Assumptions:
Assume 5 (2) hour training sessions with 2 WBWCD Employees. Also assume 20 hours of preparation. 20 hours for WBWCD follow up on actions.

Weber Basin Hr Rate	$ 100.00	
Prep. Time and follow up	40	Hours
Meetings	5	Meetings
Meeting Time	2	Hours
WBWCD Employees	2	Employees
Total Employee Hours	60	Hours
Sub-Total	$ 6,000.00	
Perform yearly over 50 years	$ 300,000.00	
Sub-Total	$ 300,000.00	
Contingency (35%)	$ 105,000	
Total	**$ 405,000**	
Capitol $/AF	**$ 124.14**	

WATER SAVINGS

Water Demands for 2040 (Approx. middle of 50 Year Pe	326,237	acre feet
Percent water saved due to exposure to website	1.00%	
Quantity of water Conserved	3,262	acre feet

*All costs give in 2018 dollars

Financing

Total Loan Amount		$ 405,000
Interest Rate		4.00%
Term	Years	50
monthly payment		($1,562)
yearly payment		($18,745)
Total cost of 50 year system		**$937,268**
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED		**$2.87**
cost per acre foot of water per year		**$0.06**

Connect Farmington Wells to Culinary System - Install transmission line to connect existing wells in Farmington to WBWCD culinary water transmission system

Action #24

Pump rate is approx. 9 cfs (2 wells)		9 cfs			4039.2 gpm
18" Transmission Line		5000 Feet			
24" Transmission Line		7900 Feet			
Intermediate Pump Station		1 Each			
Estimated annual water volume from WBWCD		3,260 acre feet			
9 cfs for 180 days		9.131018519 cfs for 180 days			
hours per year pumping		4320 hours			
aprroximate volume per year		3213.22314			
*All costs give in 2018 dollars					
Financing					
Total Loan Amount			$ 5,000,000	Estimate provided by Weber Basin via email on 3/12/19	
Interest Rate			4.00%		
Term	Years		50		
monthly payment			($19,285)		
yearly payment			($231,424)		
Capital cost per acre foot			**$ 1,533.74**		
Operation and Maintenance					
Replace 3 pumps every 10 years	EA	12	$ 200,000	$2,400,000	
Pump Replacement cost per Year				$40,000	
Power Costs for 50 years of Operation (See power cost calcs be	years	50	$ 285,837	$14,291,826	
annual O&M costs				$333,837	
annual O&M costs per acre foot				$ 102	
Total cost of 50 year system				**$28,263,036.15**	
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED				**$8,669.64**	
cost per acre foot of water per year				**$173.39**	12000 gpm
					26.73797 cfs
					12 hours per day
					26.51699 acre feet per day
					0 Days

Power Costs		**Units**	**Comments**
Elevation Head	800.00	feet	Discharge to Pump Elevations
Friction Head		feet	
Total Dynamic Head	**800.00**	**feet**	
Estimated Design Flow	**4040**	**gpm**	**9.00** cfs
Pump Characteristics			
Pump Efficiency	0.75		0.65
Motor Efficiency	0.75		0.92

Water Horsepower	816.16	
Brake Horsepower	1088.22	
Motor Horsepower	**1450.95**	**Hp**
Electrical Power Required	1081.98	kW
Pump Cycles Per Day	1.00	
Pump Run Time	24.00	Hours/day
Electrical Usage Per Day	**25,967**	**kW-hr**
Electrical Usage Per year	**4,674,138**	**kW-hr** assumed 6 months useage per year
	$ 0.05	**energy charge**
Energy Charge Per Day	$ 1,298.37	
Monthly Power Charge	$ 7,389.90	charged once for every month that the pumps are turned on ($6.83 per kW)
Electrical Cost Per Month	$ 40,249.52	
Number of months used in Year	6	
Electrical Cost Per Year	**$ 285,836.52**	

Improve Willard Bay Siphon - Improve the existing siphon to allow reliable delivery of 25 cfs and enable WBWCD to access an additional 15,000 annual acre feet of storage

Action #25

Alt 2 from JUB study

WEBER BASIN WATER CONSERVANCY DISTRICT — **J-U-B Project No. 57-18-021**

AV WATKINS DAM SIPHON UPGRADES — **14-Mar-19**

Engineers Opinion of Probable Cost (Planning Level) - Alternative 2 (Lower siphon intake to 4200' and add a pump at outlet)

	Item	Description	Unit	Total Quantity	Engineer's Opinion of Probable Cost: *Unit Price	Engineer's Opinion of Probable Cost: Amount	*Notes
	Construction and Engineering						
	1	Mobilization/Demobilization (5%)	LS	1	$64,000.00	$64,000.00	
	2	Existing Siphon Repair (reposition intake screens, reattach holding brackets with corrosion resistant bolts)	LS	1	$60,000.00	$60,000.00	Cost provided by Cross Marine, estimate dated August 20, 2018
	3	24" HDPE Extension of Siphon Intake Line (piping, installation)	LF	400	$215.00	$86,000.00	Material cost provided by High Country Fusion
	4	15" HDPE Extension of Siphon Intake Line (piping, installation)	LF	400	$135.00	$54,000.00	Labor cost provided by Cross Marine, estimate dated September 24, 2018
	5	Install Filter/Drain around Siphon Pipes	LS	1	$25,000.00	$25,000.00	Engineer's Opinion (Bruce Barrett)
	6	Vortex Mitigation and Intake Structure	LS	1	$20,000.00	$20,000.00	Engineer's Opinion (Darek and Dr. Tullis)
	**7	New Pump Station on Discharge Side of Siphon	EA	1	$455,000.00	$455,000.00	See detailed cost estimate
	8	Bring Power to Site (approx. 2.7 miles of overhead power, including transformer)	LS	1	$580,000.00	$580,000.00	Cost provided by Heath Engineering
		35% Contingency				$470,000.00	
		Engineering (15%)	LS	1	$272,000.00	$272,000.00	
		Subtotal A				$2,086,000.00	
	Operation & Maintenance (over 40 years)			**2033333**	**0.09**	$183,000.00	40 years
o&M for 50 years	9	Power (running pump every third year for 5 months, general site power), converted to 2019 dollars with i = 3%	kWh	2,541,666	$0.09	$229,000.00	Annual O&M costs
	10	Pump Station Maintenance (Replace impellers, service pumps, etc.), converted to 2019 dollars with i = 3%	LS	1	$58,000.00	$58,000.00	
		Subtotal B				$287,000.00	
		Proposed Total				**$2,373,000.00**	

* 2019 Dollars

** Including structure, pumps (for siphon, South Drain, and vacuum priming pump), piping, appurtenances, electrical, SCADA. Does not include generator and transfer switch. Assumes WBWCD will mobililze portable generator if needed. See detailed pump station cost estimate also included in Appendix E.

Acre feet of water	15000	
$	3,177,082.50	
maintenance cost per year		$5,740.00
cost per year per acre foot		$0.38

Financing

Total Loan Amount	$ 2,086,000
Interest Rate	4.00%
Term Years	50
monthly payment	($8,046)
yearly payment	($96,550)
Total cost of 50 year system	**$4,827,509**
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED	**$321.83**
cost per acre foot of water per year	**$6.44**

Appendix 5-D

Scoring of Mitigation Measures

		OBJECTIVES																			
		Supply			Financial					Implementation / Risk Reduction						Environment					
		Increase Annual WBWCD Water Supply for Drought Years or Reduce Usage in Drought Years		Improve Mobility of Water Supplies	Minimize Costs			Obtain Funding Assistance	Maintain Revenue During Drought	Reduce Drought Risks	Focus on Actions that are Easier to Implement		Prepare Communities to Respond Quickly to Drought	Improve Communication / Available Information	Improve Coordination With Agricultural Users	Minimize Impacts to Industry/Great Salt Lake (GSL)	Minimize Impacts to Aquatic Ecosystems		Minimize Impacts to Recreation		
		METRICS																			
		WBWCD Supply Added/Reduced Usage (Acre Feet)	Additional Years that Increased Water Will be Available During a Multi-Year Drought (Years)	Mobility Improvement	*Capital Cost to Develop Water, or Cost to Reduce Usage ($/Acre Foot)	*Annual O&M Cost ($/Acre Foot/Year)	*Debt Service and Operation and Maintenance Costs for 50 Year Life Cycle ($/Acre Foot/Year)	Grant Availability (Likelihood)	Improved Potential to Maintain Revenue During Drought ($)	High Risks from Risk Assessment that are Reduced (Number)	*Policy Change/ Political Pushback (Magnitude)	*Time to Complete (Years)	Communities that are Educated about Drought (Number)	Increase in Drought Level Knowledge of Water Users in the District	Level of Improved Coordination Between WBWCD and Agricultural Users	Additional Flows in Weber River Near the GSL During Drought (cfs)	Additional Flow in the River at Critical Times (cfs)	*Potential Level of Adverse Impacts to Ecosystems	Additional Water Volume in Reservoirs During Drought (Acre Feet)	Scoring	Mitigation Measure Rank
		Less than 1,000	Less than 2	None	More than $4000	More than $250	More than $400	None	None	1	High	More than 10	None	None	None	None	None	High	None	0	
		1,000 to 9,999	2 -3	Low	$2,001 to $4,000	$101 to $250	$201 to $400	Low	Low	2	Medium	6 to 10	1 to 2	Low	Low	Low	Low	Medium	Low	1	
		10,000 to 30,000	4 - 5	Medium	$250 to $2,000	$25 to $100	$50 to $200	Medium	Medium	3	Low	1 to 5	3 to 4	Medium	Medium	Medium	Medium	Low	Medium	2	
	MITIGATION MEASURES	More than 30,000	More Than 5	High	Less than $250	less than $25	Less than $50	High	High	More than 3	None	Less than 1	More than 4	High	High	High	High	None	High	3	
ID	**Storage/Source**																				
1	**Weber Canyon ASR** - Develop additonal ASR near mouth of Weber Canyon. Use purchased Echo or East Canyon water in wet years to be used later during drought	10,000	2 -3	Medium	$ 600	$ 60	$ 90	High	Low	2	Low	1 to 5	1 to 2	Low	None	Low	Low	Low	Low	6.08	9
3	**Larrabee Storage** - Develop Larrabee storage right somewhere in the Wasatch Back (Maybe Chalk Creek)	10,000	2 -3	Medium	$ 3,800	$ 10	$ 180	None	Medium	4	High	More than 10	1 to 2	Low	None	Low	Medium	Medium	Low	5.55	14
4	**South Davis ASR Feasibility Study**- A feasibility study to treat water and do ASR in the winter, pull water out in the summer. Provides more groundwater source for south end of service area and aqueduct redundancy.	Less than 1,000	2 -3	Low	**STUDY COST $191,000 TOTAL (SEE FOOTNOTE #2)	n/a	n/a	High	Medium	2	Medium	6 to 10	1 to 2	Low	None	None	None	None	None	5.05	18
5	**Bear River Storage Allocation** - Develop Bear River allocation.	50,000	4 - 5	Low	$ 374,266,000.00	$ 1,512,700	$ 18,840	Low	Medium	6	High	More than 10	1 to 2	Low	None	Low	None	High	More than 20,000	5.05	19
24	**Connect Farmington Wells to Culinary System** - Install transmission line to connect existing wells in Farmington to WBWCD culinary water transmission system	3,260	4 - 5	High	$ 1,500	$ 102	$ 170	High	Medium	3	Low	1 to 5	1 to 2	Low	Low	None	None	Low	Low	6.25	7
	Agreements																				
6	**Short-Term Transfer Agreements** - Create a program and get contracts in place to compensate large agricultural users to fallow land or plant drought tolerant crops when asked.	1,000 to 9,999	More Than 5	High	$ 20	$ 10	$ 110	Low	Medium	3	High	More than 10	None	Medium	High	Low	None	Medium	Medium	6.70	4
7	**Water Sharing Agreements** - Create inter-agency agreement with customer agencies within the district boundaries to purchase some water during drought years.	2,500	More Than 5	High	$ 20	$ 5	$ 190	None	Medium	2	High	1 to 5	None	Low	Low	None	None	None	None	5.92	12
8	**Ogden City Pineview Water Sharing Agreement** - Coordinate with Ogden City to determine if 4,500 shares of water in Pineview are available to purchase or lease from Ogden. Ogden owns 10,000 acre feet, but only about 4,500 acre feet are available for use. Ogden typically uses WBWCD water instead of this Pineview water. The Pineview water is a very high priority right. Determine if an agreement can be reached to purchase or lease the water for drought mitigation.	4,500	More Than 5	High	$ 3	n/a	$ 180	None	Medium	4	High	1 to 5	1 to 2	Low	None	None	None	Medium	None	5.75	13
	Flow Measurement																				
10	**WBWCD Secondary Water Metering** - Meter all secondary WBWCD water users and provide usage reports to the users. Save 35% average when going to meters. 11,000 services left to meter at a cost of $1,200 per service.	4,000	More Than 5	Medium	$ 4,600	$ 50	$ 264	High	Medium	3	Medium	6 to 10	More than 4	High	None	Medium	None	Low	Medium	6.97	3
11	**Other Systems Secondary Water Metering** - Start a WBWCD program to provide secondary water metering technical assistance and meter installation assistance for secondary systems in the district boundaries, but not owned by the District. Assume 80, 000 meters added.	28,000	More Than 5	None	$ 4,600	$ 50	$ 265	High	Medium	3	Medium	More than 10 (Approx. 25 years)	More than 4	High	None	Medium	None	Low	Medium	6.47	5
	Rate Structures																				
12	**Drought Surcharge Fees** - Study and develop a secondary water drought surcharge fee structure for Weber Basin to utilize during drought periods. Fee structures will provide revenue needed for system operation and maintenance and to fund response actions during droughts. (assume all secondary connections are metered)	31,000	More Than 5	None	*STUDY COST $135,000 TOTAL SEE FOOTNOTE #2	n/a	n/a	None	High	3	Medium	1 to 5	None	Medium	None	Low	None	None	Medium	7.07	2
13	**Create New Tiered Rate Structure and Short Term Transfer Water Fund** - Create a fund prior to a drought to purchase water through short term transfer agreements during times of drought. Use overage fees from water users that exceed a certain level of water use in any given month.	5,200	More Than 5	None	$ 20	n/a	$ 7	None	Medium	3	Medium	1 to 5	None	Medium	None	Low	None	None	Medium	6.00	10
	Water Re-use																				
14	**Water Reuse Project** - Create a re-claimed water reuse agreement with one of the treatment facilities located in the district. Build infrastructure needed to utilize reclaimed water for secondary water.	8,000	More Than 5	Medium	$ 4,700.00	$ 340	$ 560.00	Medium	Medium	3	High	6 to 10	None	Low	None	None	None	High	High	4.22	21
	Education																				
15	**Drought Surcharge Fees Education** - Educate cities and the public about rate structures, Prepare a sample ordinance to provide for cities for drought water rate adjustments. Visit cities to explain the rate structures and the benefits (50 customer agencies).	Less than 1,000	More Than 5	None	$ 19	n/a	$ 0.86	None	High	3	Medium	More than 10	More than 4	High	None	Medium	None	None	Low	6.40	6
16	**Drought Plan Results** - Present the drought plan process findings and recommendations to cities and irrigation companies in the district by visiting city council meetings and irrigation meetings. Education about useage reductions that will be needed during different drought stages.	Less than 1,000	Less than 2	None	STUDY COST $87,000 TOAL SEE FOOTNOTE #1	n/a	n/a	Low	Medium	3	None	Less than 1	More than 4	High	High	None	None	None	None	5.98	11
17	**Internet Water Supply Dashboard** - Create a web based system that reports current performance of system and drought levels and informs people what water conservation actions they should be implementing.	1,000 to 9,999	More Than 5	None	$ 20	$ 0.15	$ 1.00	Med	Low	4	None	1 to 5	More than 4	High	Low	Low	None	None	Medium	7.73	1
22	**Assistance for Other Secondary Systems -** Help secondary distribution system managers (retail systems) manage their systems more efficiently to conserve water.	Less than 1,000	Less than 2	None	$ 120	n/a	$ 0.06	Low	None	1	Medium	More than 10	More than 4	Medium	None	Low	Low	None	None	4.25	20
	Habitat Improvement Collaboration																				
19	**Advisory Group Meetings** - Meet regularly with Utah Division of Wildlife Resources, Trout Unlimited, Utah Division of Forestry, Fire, and State Lands, other advisory group stakeholders and key habitat stakeholders to coordinate drought strategies including river operation strategies that will make the river more drought resilient. Strategies may include river braiding, connectivity improvements for better habitat, Improved management of water during wet years for more consistent flows and better GSL industry, water pulsing through the river to clean channels during wet years, etc.	Less than 1,000	Less than 2	None	MEETING COST $5,000 PER YEAR (SEE FOOTNOTE #1)	n/a	n/a	None	None	3	None	Less than 1	None	Low	Low	High	High	None	Medium	6.22	8
23	**Wildfire Prevention Coaltion** - Coordinate with the other water conservancy districts, municipalities, and counies along the Wasatch Front to develop a coalition to help prevent wild fires.	Less than 1,000	Less than 2	None	MEETING COST $5,000 PER YEAR (SEE FOOTNOTE #1)	n/a	n/a	None	None	2	None	Less than 1	None	None	None	None	None	None	None	3.72	22
	Distribution																				
20	**Salt Lake Interconnect Feasibility Study** - Do a study to determine the feasibility of making an agreement and a physical connection between the WBWCD system and the Salt Lake City or Jordan Valley Water Conservancy District System. An interconnection would provide some redundancy on the south end of the WBWCD service area.	Less than 1,000	Less than 2	Medium	STUDY COST $71,500 TOAL SEE FOOTNOTE #1	n/a	n/a	High	Low	2	Low	1 to 5	None	None	None	Medium	None	None	None	5.35	17
21	**Line and Expand Capacity of Willard Canal** - Line the remaining unlined portion of Willard Canal (approximatley 7 miles) with concrete. Assume 2,000 feet of canal lined each year for 19 years. Increases capacity of canal to 2,000 cfs	5,000	More Than 5	Low	$ 21,100	Medium	$ 980	High	Low	2	Low	More than 10	None	None	None	Low	Medium	Low	Low	5.35	16
25	**Improve Willard Bay Siphon** - Improve the existing siphon to allow reliable delivery of 25 cfs and enable WBWCD to access an additional 15,000 annual acre feet of storage	15,000	2 -3	Low	$ 139	$ 0.4	$ 10	High	Medium	1	Low	1 to 5	None	None	Low	Low	None	Low	None	5.38	15

Footnote #1 - *Low values are preferred for this metric. Footnote #2 - **This mitigation action does not develop water for use, but sets up other opportunities to do so. See individual cost spread sheet for costing information

Appendix 5-E

Drought Surcharge Rates –
Chapter V2 AWWA Manual M1

Chapter V.3

Drought and Surcharge Rates

A rate surcharge is a separate charge added to existing rate structures to collect either a targeted amount of revenue or to assess an appropriate charge for particular usage characteristics outside of those covered in the basic charge for service. Surcharges are often presented separately from the existing rates and labeled for the specific purpose for which the funds will be used or the events that caused the need for the surcharge. Drought rates are a specific form of a surcharge rate.

Water utility rate surcharges are used relatively infrequently, but in certain circumstances can be an effective tool for meeting the utility's short-term and possibly long-term financial requirements. Surcharges are usually placed into effect for limited periods of time and may have a specific revenue target, often directed toward emergency purposes, to fund specific, one-time requirements, or to establish/replenish a reserve fund. They may be subject to legal constraints.

The term *surcharge* may be used to describe a variety of different rates that are in addition to a basic rate structure. For purposes of this chapter, the term *surcharge* will apply to a temporary rate for the utility that wants to highlight the separate recovery of specific costs. Examples include situations where a utility is responding to a natural disaster, managing demand in times of drought, building up reserves in anticipation of large capital project financing or for rate stabilization funds, or paying for one-time upgrade requirements, such as water system security or compliance with new water quality regulations.

GENERAL CONSIDERATIONS

Surcharges are, by definition, an atypical charge designed to recover revenues for a specific purpose. Accordingly, the basis or need for the surcharge should be readily understood and considered valid from the utility's governing body and the utility's customers. For utilities regulated by a public service commission, the ability to implement rate surcharges is subject to regulatory approval. Public utilities generally have more flexibility in the policy decision to establish a surcharge rate.

Some common reasons for implementing rate surcharges include the following:

- Response to disaster—A surcharge is an appropriate fee for supplying funds needed to financially assist a utility in recovering from a one-time natural or infrastructure disaster. In these cases, the cost to recover from a natural disaster (e.g., forest fire in a watershed, earthquake, hurricane) or an infrastructure failure (e.g., major transmission main break) are not normal ongoing costs (i.e., included within the utility's revenue requirement). Normal ongoing costs would typically be recovered from the rate structure or could have been fully anticipated when establishing rates. From a customer's perspective, the need for the surcharge, if labeled appropriately, is clear, and when the funds are fully collected, the surcharge can be removed. In these cases, a surcharge provides a method for recovering the costs needed without disturbing the integrity of the existing rate design. The acceptability of surcharges as a response to natural disaster is, in part, a function of the severity of the disaster and the effective inability of typical measures, such as insurance or emergency reserve funds, to manage risks to cover the extent of the utilities' damages.

- Rate stabilization—Surcharges are often used to accumulate designated reserves for a rate stabilization fund. Once established, a rate stabilization fund can be drawn on to mitigate large impacts of prospective rate adjustments. The rate stabilization fund is used to meet a portion of the utility's revenue requirements. Rate stabilization may also help the utility manage through unexpected low-revenue periods. Once rate stabilization fund levels are established, the maintenance of the appropriate fund level is often managed by adjusting the necessary future increases in general rate revenue to recognize any variations in annual water sales rather than maintaining the fund level through subsequent surcharges.

- Elevation surcharges—For some systems, the cost of pumping due to differences in elevation and terrain within their service area can be significant. Elevation (zone) surcharges are a method to fairly reflect the additional or incremental costs associated with pumping from one elevation zone to a higher elevation zone. Elevation surcharges are well accepted within the industry but have very limited applications. At a minimum, these surcharges typically include the incremental power costs associated with pumping from the lower zone to the higher elevation zone. The cost of infrastructure related to elevation zone pumping may also be included in the elevation zone surcharges, but some utilities may exclude this particular cost given the impact to the overall surcharge. Administratively, elevation zone surcharges may be challenging in that a utility may have multiple elevation zones.

- Capital financing—Surcharges may also be an effective means of accumulating funds for major capital project financing. For example, a surcharge may be put in place to prefund a major water treatment plant upgrade to address new regulatory requirements. By prefunding the capital project, the utility will help minimize the amount of their long-term borrowing and potentially minimize customer rates over the long-term. It should be understood that prefunding typically does not cover 100 percent of the capital construction cost of the improvement. This approach typically funds only a portion of total project costs to avoid a significant one-time overall increase in general rates to provide the funding for the project.

- Drought surcharges—Drought surcharges are often used on an emergency and temporary basis to pay for costs associated with purchasing emergency water supplies during a severe drought or to support drought restrictions. When drought conditions result in the need to purchase emergency supplies, a surcharge is a logical and simple way to pass along the additional temporary cost of acquiring these high-cost water resources to the current users who require the water supply. Often, surcharges used during drought conditions are also intended to provide a price incentive for customers to reduce water demand. In both of these cases, the surcharge can be in place while the drought exists and can be removed once the drought has ended.

HISTORICAL PERSPECTIVES

Rate surcharges have been used when specific situations dictated the financial need for such charges. In the late 1980s and early 1990s during a severe drought, surcharges were used in California to cover the additional costs associated with obtaining emergency water supplies. In Pennsylvania, surcharges have been used to help investor-owned water systems accelerate the pace of needed improvements to the water delivery system. With the approval of state legislators and utility regulators, water investor-owned utilities in Pennsylvania have previously implemented a distribution system improvement charge (DSIC). By allowing utilities to make incremental rate adjustments to pay for improvements, this mechanism enhances rate and revenue stability, reduces regulatory lag, and lengthens the time between formal rate cases. Less frequent rate cases reduce rate case expenses for all parties. The Rhode Island Public Utility Commission has approved surcharges to repay one-time loans caused by revenue shortfalls. In addition, some utilities that historically attempted to pay for growth-related debt service via system development charge revenues discovered, as a result of slowed growth, the need to implement rate surcharges to cover the revenue shortfall between the growth-related debt-service payments and the reduced system development charge revenue.

ADVANTAGES AND DISADVANTAGES

The relative advantages and disadvantages of rate surcharges may be assessed in terms of simplicity, equity, revenue stability, conservation, effect on customers, and implementation including legal considerations.

Simplicity

For the most part, surcharges are simple to calculate, understand, implement, and administer. Surcharges can be applied and collected in different ways, but utilities typically strive to implement a surcharge that is easy to administer, given the typical short-term nature of this type of charge. Drought surcharges may be more complex if they follow the various stages of drought specified within a drought management plan (Stage 1, Stage 2, etc.).

Equity

The issue of equity can often be addressed by considering the specific circumstances that create the need for the surcharge and the way in which the surcharge is assessed and collected. For equity to prevail, there should be a reasonable relationship between the amount of surcharge revenue collected from each customer class and the benefits that accrue when the surcharge revenues are used. Properly designed drought surcharges should be equitable if discretionary usage is primarily targeted.

Revenue Adequacy and Stability

By definition, a surcharge is a temporary rate assessed to collect revenues above that generated from existing rate levels. Accordingly, surcharges generally enhance revenue adequacy by increasing the total amount of revenue generated. Surcharges may provide additional revenue, but in the case of drought surcharges, the surcharge may off-set the decline in revenue and consumption. It is also important to realize that demand for water may decrease due to the increased water bills caused by surcharges, which also affects revenue stability.

Conservation

Surcharges are generally not considered a long-term conservation pricing tool because they are typically temporary in nature. The distinction between conservation pricing and surcharge pricing is that conservation pricing is usually a long-term pricing approach intended to permanently alter demand while surcharge pricing is temporary and is intended to support the identified need. However, drought surcharges can be effective in reducing short-term demands especially when designed to help manage short-term, severe drought restrictions.

Effect on Customers

The effects of surcharges on customers vary in relation to the level of the surcharge and the length of time the surcharge is in effect. It also varies depending on how it is assessed. In most cases, the relative effect on individual customers is minimal and limited in duration.

Implementation

Implementing rate surcharges should be relatively straightforward but may be limited by specific billing systems. In the planning process, the utility should strive to communicate the need for the charge to its customers and to calculate a fee that is equitable, easy to implement, and easy to administer. Generally, the perception and acceptance of surcharges by customers may vary based on the need for, or reasoning behind, the surcharge. Some level of customer resistance will likely be encountered.

DETERMINING RATE SURCHARGES

Determining rate surcharges is a fairly simple matter, but the method of collection can take many forms.

Fixed Surcharge

A fixed amount surcharge is a fixed or flat rate generally applicable to all customers, i.e., each customer's bill includes a fixed dollar amount surcharge. For example, each customer may be charged a $5.00 surcharge on their bill regardless of the volume of usage or the type of customer. Variations of fixed surcharges include surcharges that increase with meter or connection sizes or that vary by customer class. This may be an appropriate and equitable approach to assessing surcharges and is one that has a low-cost recovery risk.

Volumetric Surcharge

The volumetric surcharge approach is often used when the surcharge revenues are used to benefit customers in proportion to how they use water or when there is a need to reduce the amount of water used via price (i.e., drought surcharges). In this approach, only the volumetric portion of the rate has a surcharge applied to it. Depending on how the volumetric surcharge is applied, it potentially allows a utility to be more specific in the customers that the surcharge targets and in the impact on demands of different user groups. Volumetric surcharges have greater revenue risk and variability than fixed fee surcharges.

Percentage Bill

This approach simply places a fixed percentage surcharge on the total bill of the customer. The percentage bill approach is simple and straightforward and can be accomplished in two different ways. First, each of the rate components of the entire rate structure may be increased equally to produce the incremental amount of revenues. This approach does not explicitly separate the surcharge from the rates. Alternatively, the bill can be computed at current rates, and then a percentage surcharge assessed in addition to that amount. This approach is more explicit in that the surcharge is clearly identified.

DETERMINING DROUGHT SURCHARGES

Drought surcharges are a specific form of a rate surcharge used during a drought. A water utility typically has two overriding objectives during a drought. The first is to reduce the volume of water used by its customers to reflect the utility's potentially reduced and constrained water supply resources. This reduction is usually accomplished by a combination of actions, such as appealing to customers to voluntarily reduce water demands, placing mandatory restrictions on discretionary water uses (often outdoor uses such as irrigation and car washing), and increasing rates or adding surcharges as incentives to reduce water demands. The goal is to immediately reduce demands on water supplies made scarce by the drought. The second objective during a drought is to maintain adequate revenues to meet system revenue requirements. To the extent that the first objective (i.e., water-use reduction) is met, it is often correspondingly more difficult to meet the second objective. To deal with this situation, many utilities draw on financial reserves, reduce budgeted expenditures (although during a drought, a utility will often incur unbudgeted costs), and implement drought surcharges.

DROUGHT SURCHARGE CONSIDERATIONS

Revenue forecasting for post-drought pricing periods should anticipate the potential for long-term effects on demand patterns arising from the temporary drought conditions. Drought surcharges are intended to reduce demand immediately as a precautionary or emergency response to a temporary and severe limitation in water supplies. Once the drought or emergency has passed, drought surcharges may be removed or revised to align with longer-term pricing objectives, which may be achieved through normal rate setting. In contrast, conservation pricing is designed to permanently reduce or modify total annual demand or alter demand patterns and often is an institutionalized characteristic of a utility's rate structure. Notably, however, depending on the duration and severity of a drought and the effectiveness of the drought surcharges, permanent reductions in water usage may be induced, although this may not be the intended consequence of the drought surcharge strategy.

The approach used for drought surcharges may blend the drought surcharge with existing rates or the drought surcharges may be a separately identified surcharge on a customer's bill. A utility's ability to select between these two approaches may be limited by its billing system and either approach can be effective, although a separately identified drought surcharge provides a clearer price signal to customers.

Types of Drought Surcharges

Drought financing and demand management. Surcharges are often used as an emergency and temporary fee to pay for costs associated with purchasing emergency water supplies during a severe drought or to support drought restrictions. When drought conditions result in the need to purchase emergency supplies, a surcharge is a logical and simple way to pass along the additional temporary cost of acquiring these high-cost water resources to the current users who require the water supply. Often, surcharges used during drought conditions are also intended to provide a price incentive for customers to reduce water demand. In both of these cases the surcharge can be in place while the drought exists and can be removed once the drought has ended. Excess funds are generated from surcharges imposed solely to encourage conservation, above those needed to meet potentially increased costs, and should be set aside in a reserve fund to be used for future drought-related mitigation purposes, such as development of additional sources for supply.

The following is a discussion of different approaches to drought surcharges.

General rate adjustment. One method of rate setting during a drought is to implement a drought surcharge on all commodity rates. For example, all volume rates (regardless of the rate structure) could be increased by a specific percentage estimated to yield an acceptable level of demand reduction, while still generating the required revenue requirement from the decreased consumption. While this is a relatively simple and unsophisticated method of developing drought surcharges, customers may better accept this approach because it may be perceived as treating all customers "equally." This method of establishing rate surcharges is also relatively easy to explain to customers and implement for billing purposes. However, this method does not target those users or end uses most able to reduce water demands or most likely to respond to price changes. Finally, the drought surcharge component is not explicitly identified under this approach and may not clearly communicate the drought issue to the customer. Thus, while this approach is simple and appears to treat customers equally, its lack of specificity and transparency may ultimately make it less acceptable.

General volumetric surcharge. To better communicate the price impact to customers of using water during a drought, many utilities implement separate drought surcharges that are distinct from their established water rates. A general volumetric surcharge provides incentive for customers to reduce demand and specifically identifies on their bills the cost impacts of using water during periods of drought. Volumetric surcharges may take many forms including ones that uniformly apply the surcharge over all consumption blocks, apply the surcharge to consumption beyond a stated level (e.g., a surcharge applied to consumption over 10,000 gallons per month), or graduated increases in the surcharge as consumption increases (i.e., an increasing block surcharge). While this form of drought surcharges may be effective in communicating cost impacts, it is also a relatively blunt pricing technique that does not target specific individualized customer uses (i.e., residential vs. commercial) or consider whether or not specific customers have the ability to reduce their consumption (discretionary versus nondiscretionary use).

Class-based volumetric surcharges. A variation of the general volumetric surcharge approach is to establish quantity limits per customer for different classes of users and to apply a surcharge to any user exceeding the limit for that class. In essence, this is a volumetric surcharge by customer class of service. This approach requires establishing reasonable consumption targets based on the consumption characteristics for each class. Often, the target setting can be performed in a reasonable and relatively equitable manner for single-family and multiple-family residential customers, with the latter group set on a per-dwelling unit basis. It is more difficult to set uniformly applied quantity limits for commercial and industrial customers than residential customers because of diversity in the number, types, and sizes of commercial and industrial customers. This diversity limits the extent to which volumetric surcharges may be equitably applied to commercial and industrial customers. As a result, this approach may be less effective in achieving the desired consumption reduction targets for commercial and industrial customers than those applicable to relatively homogeneous residential consumption.

Individualized volumetric surcharge. Another approach is to apply drought surcharges to users whose water demands exceed a specified percentage of their base-period water use. For example, the utility might apply a 25 percent surcharge to any customer with water use greater than 80 percent of that customer's average demand during a previous base period. This approach sets a clear water reduction target for each individual user and provides reduction incentives to all customers. An individualized approach can also recognize variations within a class, such as household size and lot size that may be important in setting target consumption levels. Agricultural and irrigation limits might be based on the type of crop or plant being watered and the acreage. While this approach places a similar reduction requirement on all customers, there remains a disadvantage of using historical usage characteristics to establish targeted levels of reduction. In those instances where a customer is already using water efficiently, the customer has less of an ability to reduce their demand and thus avoid a surcharge while a customer whose water use has been the least efficient has the greatest opportunity for avoiding the surcharges. Individualized approaches are limited to utilities that have billing systems that can set individualized consumption goals or consumption thresholds.

Targeted volumetric surcharge levels. A utility could target certain customer classes for larger surcharges than others. Such classes would include those that have more discretionary use and should be able to more easily reduce water use. This approach avoids affecting customers whose water demands are extremely inelastic or are desirable from a public health or other policy perspective. For example, a utility might place a high surcharge on residential outdoor usage and might not apply the same level of surcharges to hospitals or public schools. A major concern with this approach is that the utility may be criticized for targeting some customer groups and exempting others. There are also certain legal implications and considerations to this targeted approach. Implicit in this approach is the ability of a utility to evaluate and make conclusions about the relative merit of one use of water over another.

Drought Surcharge Policy Issues

Drought management plan. In a drought, policymakers are faced with many decisions requiring them to balance water supply management imperatives, customer and community needs, and the potential financial consequences of drought response. When prepared in advance, a drought management plan can provide well-thought-out and comprehensive guidance in times of drought. A well-prepared drought management plan should provide clear policy direction as it relates to declaring a drought. The drought management plan will also discuss the various specific "stages" of drought and the target reductions of water use for each stage. The drought management plan provides the planning basis for the drought surcharges and the targeted savings from the drought surcharges. These plans should include drought pricing and financial management strategies as well as water resource strategies.

Timing for implementation of drought surcharges. With the development of a drought management plan, the utility has a clear understanding of the various stages of drought, the actions to be taken, and the needed consumption savings. The drought management plan frequently establishes clear criteria for declaring when a utility is in a drought. Drought management plans typically classify droughts as to their severity (e.g., Stage 1 through Stage 5). Given the key information contained within the drought management plan, a utility can develop drought surcharges well in advance of a drought. The drought surcharges can be adopted and in place, ready to be implemented when a drought stage is declared by the governing body of the utility. Once the drought stage is declared, the associated drought surcharges become effective until the drought stage changes or the drought is declared to be over. By developing the drought surcharges in advance of an actual drought, and using the information contained in the drought management plan, the utility can carefully consider the various options available to them for establishing equitable drought surcharges and any billing system limitations.

Revenue sufficiency. While drought pricing can help a utility manage the revenue reductions that result from reduced water sales, it is likely that the utility will need to also use its financial reserves as well as reduce and defer planned expenditures. Because the duration of a drought is not known (i.e., 1-year events vs. 10-year events), utilities cannot be certain about how long their reserves will last and thus should draw on them cautiously, especially insofar as the ability to replenish them is limited during the drought.

Ideally, a well-designed drought surcharge should hold customers harmless if they comply with the desired and targeted savings levels. In other words, a customer that has a targeted Stage 1 reduction of 10 percent and reduces their consumption accordingly may pay roughly the same bill as before the drought and produce the same level of revenue because the pricing of the surcharge has been structured to recover the same level of revenue, assuming a 10 percent reduction in consumption. The difficult and challenging part of establishing drought surcharges is the uncertainty of how customers will respond and what reductions in consumption will be realized. When reductions in consumption are greater than the targeted level, the utility may have a budget shortfall. If the reductions in consumption do not occur, the utility should collect more than their revenue requirement.

Additional and/or deferred expenses. A drought response often requires additional expenses beyond the anticipated revenue requirement and may at the same time require the deferral of other anticipated expenses within the utility's revenue requirement. The additional expenses may be a function of the need to obtain additional and costly water supply, additional pumping costs, and so forth. In addition, expenses may be incurred to impose water-use restrictions in the event that the utility elects active enforcement of its rules. The utility will also likely incur additional costs associated with public outreach and communication. The drought management plan may have estimates of the unplanned expenditures for each drought stage. At the same time, capital projects may be postponed or deferred during a drought to help preserve cash flow and reserves.

Equity. Cost-of-service rate-making considerations are a recommended practice when establishing the utility's overall general rate structure. However, variance from the traditional cost-of-service principles may become necessary when implementing emergency drought surcharges, which include controlling demand and recovering total system costs. In designing drought surcharges, a utility should consider the price and demand response of various types of water uses and target those that are the most discretionary and responsive to price. This may or may not strictly relate to cost-of-service considerations.

Bill presentation and accounting issues. If the drought surcharges are intended to integrate with the other drought-related programs, it should ideally be clearly communicated to customers on their bill. This means that the drought surcharge should be presented as a separate line item on the bill. Utilities should also have a method for tracking the amount of drought surcharge revenue they receive from each customer class. This is important for accountability and transparency reasons during the drought. After the drought, this will provide valuable information for analysis purposes.

Customer acceptance. Customer acceptance and ease of implementation are important considerations in selecting a drought surcharge approach. Customers naturally expect their water reduction efforts during a drought to be recognized and perhaps rewarded, not penalized. In designing the surcharge rates, and as previously discussed, if all customers respond appropriately, consumption will decrease. The surcharge rate should, if properly designed, make the utility financially whole (i.e., lower use × higher surcharge rate should produce revenue = revenue requirement). For the customers that respond appropriately (e.g., save the reduced level of usage suggested in the drought plan), their bill should be roughly equal to what they pay under normal water conditions. Those customers that do not choose to conserve will appropriately end up with increased bills. Accordingly, to achieve the expected results of the surcharge, a vigorous educational campaign is important in explaining the drought pricing rationale and gaining its acceptance by its customers.

Media relations. Working with the media during a drought is critical to providing information to customers about the severity of the drought, desired customer responses, and the need, purpose, and implications of drought pricing strategies. As it relates to drought surcharges, the utility should provide background on when the drought surcharges might go into effect, the potential magnitude of the drought surcharges, and its purpose. It should also explain that drought surcharges are one tool in a set of measures that the utility is using to engage the community in effective water resource management.

Removal of drought pricing. Just as it is complicated to know when to implement drought surcharges, it is just as complicated to know when the drought is over and to remove drought surcharges. Caution is needed to avoid removing the drought pricing prematurely and then having to reimplement the drought surcharges. Formal action declaring the end of the drought should be the basis for the removal of the drought surcharges.

DROUGHT SURCHARGE EXAMPLE

In this example, the drought surcharges are triggered by the severity of the drought (Stage 1, Stage 2, etc.). For increasing levels of severity, more aggressive pricing policies are implemented as part of a comprehensive drought management plan to change customer behavior and reduce water demand. These drought surcharges are instituted when a declaration is made that a drought emergency exists. The basis around which the drought surcharges are established is related to the estimated price responsiveness and price elasticity. Assuming an average price elasticity response of –0.1 to –0.2 for a relatively large change in price, a 25 percent increase in the commodity charge would yield a demand reduction of about 2.5 percent to 5 percent, all other factors remaining constant. It is presumed that other drought responses (i.e., restrictions and public education) will compliment and add to this reduction.

During a moderate Stage 1 drought, the following actions would be taken:

- Single-family rates are assessed a surcharge of 25 percent that is applied to the two upper blocks (i.e., more discretionary use). The initial block is assumed to be more "essential needs."
- The multifamily, commercial, and industrial rates under normal water conditions are converted from uniform block rates to increasing two-block rates. Block 1 remains at its current level, and block 2 is indexed to the block 2 rates for the single-family class.
- Irrigation rates are also converted to a two-block rate and block 1 increases by 25 percent (because all outdoor irrigation use is considered discretionary) and block 2 is indexed to the block 3 rates for the single-family class.

If the drought situation worsens to a Stage 2 severe drought, a greater emphasis is given to targeting outdoor usage with higher prices:

- Block 1 rates for all customers are adjusted, but at moderate levels, particularly for single-family and multifamily customers, because their block 1 use is considered to be nondiscretionary or essential and is less sensitive to price.
- Blocks 2 and 3 rates are increased creating a steeper pricing curve to the customers as they use more water. The single-family residential blocks 2 and 3 increased by 50 percent of their normal water condition level. Multifamily and commercial/industrial block 2 rates are indexed to the single-family residential rate and irrigation consumption. Irrigation class usage, which is deemed the most discretionary, in block 2 is priced at the block 3 single-family residential level.

Finally, if the drought situation became critical (Stage 3), the utility would need to increase the price incentive to reduce demand. In this case, the utility might implement the following:

- Block 1 for all customers, except irrigation, would increase by 50 percent over its normal level.
- Single-family residential blocks 2 and 3 would increase by 100 percent over their normal level, increasing the price curve to these customers for outdoor usage.
- Multifamily and commercial/industrial blocks 2 would be indexed to the midpoint between blocks 2 and 3 for the single-family residential.
- Irrigation block 2 rates would be indexed to the block 3 single-family rates.

This example for drought rate adjustments is summarized in Table V.3-1. A utility should carefully plan the details for implementation. This phased-in approach to rate setting in a drought is designed to reduce water demand and yet maintain as much of the revenue stream for the utility as possible under various levels of water shortage.

The example, while greatly simplified, provides an overview of the basic approach and considerations that may be used in the pricing and development of drought surcharges. As the drought surcharges are analyzed and developed, consideration must be given to the overall reductions in use needed under the particular drought stage and the overall revenue impacts.

The characteristics of the utility's customer base, water supply, and constraints on resources should be evaluated in tailoring a drought surcharge approach that will best meet the utility's needs. Careful planning and effective customer communication

Table V.3-1 Drought surcharge pricing example ($ per thousand gallons)

Customer Class	Non-Drought Normal Water	Stage 1 Moderate Drought	Stage 2 Severe Drought	Stage 3 Critical Drought
Single-Family Residential				
Block 1	$1.00	$1.00	$1.10	$1.50
Block 2	$1.50	$1.87	$2.25	$3.00
Block 3	$2.00	$2.50	$3.00	$4.00
Multiple-Family Residential				
Block 1	$1.25	$1.25	$1.38	$1.87
Block 2	$1.25	$1.87	$2.25	$3.50
Commercial/Industrial				
Block 1	$1.30	$1.63	$1.79	$1.95
Block 2	$1.30	$1.87	$2.25	$3.50
Irrigation				
Block 1	$1.75	$2.19	$2.63	$2.89
Block 2	$1.75	$2.50	$3.00	$4.00

NOTE: For example only and based on specific assumptions.

will enhance the likelihood that drought surcharges will help secure required changes in water demand patterns and gain general community acceptance.

SUMMARY

Rate surcharges can be an effective means of financially protecting the utility during periods of severe drought, or other natural disasters. Surcharges may also provide an effective means to fund specific improvements or build necessary reserves for future requirements. While rate surcharges have limited application and may be politically sensitive to implement, and subject to legal constraints, they can help stabilize rates over the long term and provide other nonfinancial benefits, such as achieving needed reductions in consumption during drought periods.

Appendix 5-F

Fallow Land Calculation

Short-Term Transfer Agreements - Create a program and get contracts in place to pay large agricultural users to be on a list to fallow land or plant drought tolerant crops when asked. Pay user for lost income Assume 1,250 acres of fallow land.

Assumptions:
Assume we will only do agreements with owners of 50 or more irrigated acres assume the district will do 25 agreeme
attorney upfront plus 1 hour for each agreement, 2 weber basin people for 4 hours, for each agreement. Assume eac
compensation for each year that they are under the agreement, Assume 1% of the response action price ($1000 per a
water to be available so 3,333 Acres of Land to be fallowed.

Assume that this will only be implemented for orange or red drought stage and that those drought stages will only be

IMPLEMENTATION				
Attorney Unit Cost/HR	$ 200.00			
Attorney Hours/Upfront	8			
Attorney Hours/Agreement	1			
Weber Basin Meeting Cost/HR	$ 200.00			
Meeting Time/Agreement	4			
Agreements	67	Assumed that each agreement is aprox. 50 Acres		
Total Costs to Implement				
Attorney Cost	$ 15,000		3333	66.66
Weber Basin Cost	$ 53,600		1250 .	
TOTAL COST	$ 68,600			
Cost per/AF	$ 18.29			

FARM USE TO HOME USE CONVERSION				
Average Residential Indoor Water Use			ogden pop	gpcpd
Average indoor use per capita per day	86	gallons	80,000	70
Average people per dwelling unit	3	ppdu		
Average indoor use per dwelling unit	258	gallons per day		
Average Agricultural Water Use				
Feet of water per year	3	feet ***(This could be significanlty less than 3 feet during a drought year)		
Cubic feet per acre per Irrigation season	130,680	cubic feet		
Assume 6 month irrigation season	6	months		
Volume per day per acre	726	cubic feet per day per acre		
Gallons per day per acre	5,430	gallons per day per acre		
# of homes that could be served per acre of agricutural land not irrigated (indoor use only)	**21.0**	**homes**		
Number of ERU's in WBWCD service area				
Davis County population (US Census Bureau 2015)	336,043	people		
Weber County population (US Census Bureau 2015)	243,645	people		
combined total people	579,688	people		
homes	193,229			
Ag acres needed to take out of service to serve existing homes in davis and weber county (indoor use only)	**9,180**	acres		
area in square feet	399,891,722			
length on each side of square area	19,997	approx 4 miles by 4 miles		
		3.787366073		
Cost for Fallow Program				
Assume 10,000 AF to be available through this program	**10,000**	acre feet of water to be used for indoor use		
Benefit	3,333	approximately acres of ag land taken out of production		
	70,161	homes could be served with indoor water		
Acre/Feet available from program	10000	AF		

FALLOW COST DROUGHT YEAR			
Cost to fallow one acre of land	$ 1,000.00	per acre per full fallow year (may need to pay $50 or something a year to get people to sign on to the program before a drought)	
Acres fallowed	3,333	acres	3
total fallow cost in the drought year	**$ 3,333,333**		3300000

FALLOW COST NON-DROUGHT YEAR		
Cost to Maintain Farmer on Fallow List	$ 10.00	per acre
Acres in the program	3,333	acres
Total cost in Non-Drought Year	**$ 33,333**	

TOTAL COST	
Implementation	$ 68,600
Assume **5** Drought years	$ 16,666,667
Assume **45** Non-Drought Years	$ 1,500,000
Sub-Total	$ 18,235,267
Contingency (35%)	$ 6,382,343
TOTAL	**$ 24,617,610**

*All costs give in 2018 dollars

Financing		
Total Loan Amount		$ 24,617,610
Interest Rate		4.00%
Term	Years	50
monthly payment		($94,952)
yearly payment		($1,139,422)
Total cost of 50 year system		**$56,971,107**
COST PER ACRE FOOT OF WATER DEVELOPED AND DELIVERED		**$5,697.11**
cost per acre foot of water per year		**$113.94**

Appendix 5-G

Colorado Sample Fallow Agreement

CONTRACT FOR PARTICIPATION IN
[redacted] ASSOCIATION
2018 CONSERVED CONSUMPTIVE USE PILOT PROGRAM

THIS CONTRACT (the "Contract") is entered into by and between [redacted] ("Association") and COOPERATOR NAME ("Cooperator"). The parties may hereafter be referred to individually as a "Party" or collectively as the "Parties." The effective date of this Contract is DATE, 2017 ("Effective Date").

RECITALS

A. The Association operates the [redacted], a federal reclamation project, pursuant to contracts with the United States Department of the Interior, Bureau of Reclamation.

B. The Association has developed a pilot program (the "Pilot Program") to assist it in determining the feasibility of voluntarily reducing the consumptive use of [redacted] irrigation water in exchange for compensation and making the conserved consumptive use ("CCU") available to supplement flows and increase the amount of stored water in the Colorado River system.

C. Cooperator owns and/or leases land ("Cooperator's Property") within the area served by the [redacted]. Cooperator's Property receives irrigation water from the [redacted] and is identified in the Association's records under Serial Nos. NUMBERS. Cooperator operates all of Cooperator's Property as one economic farm unit, and the Cooperator's Property enrolled in the Pilot Program ("Participating Lands") has been actively farmed by the Cooperator for a minimum of the past three irrigation seasons.

D. Cooperator desires to participate in the Pilot Program and the Association is willing to allow Cooperator to participate in the Pilot Program on the terms set forth in this Agreement.

Now, therefore, for good and valuable consideration, the sufficiency of which is hereby acknowledged, the Parties agree as follows:

1. Term. The term of this Contract shall commence on the Effective Date and terminate on December 31, 2018.

2. Enrollment of Participating Lands. Cooperator hereby enrolls NUMBER acres of irrigated lands located within Cooperator's Property in the Pilot Program ("Participating Lands"). The location of the Participating Lands is illustrated on Exhibit A, attached to and incorporated into this Contract. The Participating Lands shown on Exhibit A will remain enrolled in the Pilot Program during the entire Term of this Contract.

3. Program Activities for Participating Lands.

A. Cooperator agrees to take the actions described in the following paragraphs with respect to the Participating Lands during the Term of this Contract. The actions that will be taken are identified for specific fields on Exhibit A. Each of the actions described below shall be referred to as a "Program Activity." For purposes of this Contract, an irrigation season begins on the date that [redacted] water becomes available for the season at the Grand Valley Project headgate that serves the Participating Lands, and it ends on the date [redacted] water ceases to be available for the season at that headgate. The available Program Activities are described as follows:

i. Full Fallow (FF). Cooperator shall not apply any irrigation water from the [redacted] system or any other source (other than natural rainfall) to the Participating Lands from the end of the 2017 irrigation season through the end of the 2018 irrigation season. Cooperator shall actively manage the Participating Lands to ensure that no active plant growth occurs during the irrigation season.

ii Fallow Until October 1 (WW). Cooperator shall not apply any irrigation water from the [redacted] system or any other source (other than natural rainfall) to the Participating Lands from the end of the 2017 irrigation season through September 30, 2018. After September 30, 2018, Cooperator may irrigate the Participating Lands with water from the [redacted] or any other source. Cooperator shall actively manage the Participating Lands to ensure that no active plant growth occurs until after September 30, 2018.

iii. Fallow Until September 1 (SS). Cooperator shall not apply any irrigation water from the [redacted] system or any other source (other than natural rainfall) to the Participating Lands from the end of the 2017 irrigation season through August 31, 2018. After August 31, 2018, Cooperator may irrigate the Participating Lands with water from the [redacted] or any other source. Cooperator shall actively manage the Participating Lands to ensure that no active plant growth occurs until after August 31, 2018.

4. Payments to Cooperator.

A. Subject to the verification provisions set forth in Paragraph 5, below, the Association shall make the following payments to Cooperator for the following actions taken by Cooperator for the Participating Lands:

i. For those fields for which Cooperator chooses "Full Fallow" as the Program Activity under this Contract, the Association shall pay Cooperator a total of $623.00 per acre of Participating Lands for the 2018 irrigation season. This amount shall be paid to Cooperator as follows:

a. $312.00 per acre of Participating Lands shall be paid prior to the beginning of the irrigation season.

b. The remaining balance of $311.00 per acre of Participating Lands shall be paid within thirty days after the Association has verified that Cooperator has performed the Program Activity consistently with the terms of this Contract for the 2018 irrigation season pursuant to Paragraph 5, below.

ii. For those fields for which Cooperator chooses "Fallow Until October 1" as the Program Activity under this Contract, the Association shall pay Cooperator a total of $590.00 per acre of Participating Lands for the 2018 irrigation season. This amount shall be paid to Cooperator as follows:

a. $295.00 per acre of Participating Lands shall be paid prior to the beginning of the irrigation season.

b. The remaining balance of $295.00 per acre of Participating Lands shall be paid within thirty days after the Association has verified that Cooperator has performed the Program Activity consistently with the terms of this Contract for the 2018 irrigation season pursuant to Paragraph 5, below.

iii. For those fields for which Cooperator chooses "Fallow Until September 1" as the Program Activity under this Contract, the Association shall pay Cooperator a total of $512.00 per acre of Participating Lands for the 2018 irrigation season. This amount shall be paid to Cooperator as follows:

a. $256.00 per acre of Participating Lands shall be paid prior to the beginning of the irrigation season.

b. The remaining balance of $256.00 per acre of Participating Lands shall be paid within thirty days after the Association has verified that Cooperator has performed the Program Activity consistently with the terms of this Contract for the 2018 irrigation season pursuant to Paragraph 5, below.

B. If Cooperator fails to fallow and/or comply with Land Management Measures on any Participating Lands as set forth in paragraph 5 and paragraph 6, Cooperator agrees to reimburse the Association the full amount of the first payment on the deficient field(s) within 30 days of receipt of a bill from the Association, and the Association will make no further payments to the Cooperator on the deficient field(s).

C. The Association has the authority to make any adjustments to payments made to Cooperator if it discovers an error has been made in prior payments.

5. <u>Verification</u>.

A. The Association will verify that Cooperator has performed the Program Activity consistently with the terms of this Contract. The method of verifying performance is set forth in Exhibit B, attached to and incorporated into this Contract. Cooperator agrees to provide any information reasonably requested by the Association to assist in verification, and to provide access to the Cooperator's Property.

B. Following the initial payment to Cooperator for the 2018 irrigation season, the Association shall make the subsequent payment to Cooperator for that irrigation season only upon verification and determination by the Association that Cooperator has fulfilled all of the requirements of this Contract.

6. Land Management Measures. Cooperator shall, at Cooperator's sole expense:

A. Manage and control weeds and plant growth on the Participating Lands. Control measures shall be undertaken by the Cooperator to prevent the growth and spread of plants, their consumptive use of water and associated issues concerning the spread of plant disease, insects and other pests. Weeds and other plants will be controlled using effective measures of Cooperator's choice, including chemical, biological or mechanical methods.

B. Implement wind erosion control measures for the Participating Lands to minimize the creation and blowing of dust from the Participating Lands, using effective measures of Cooperator's choice. Wind erosion control measures shall take one of three forms:

i. Leaving non-living plant residues that are of sufficient height and/or density to prevent wind erosion.

ii. Mechanical tillage that creates conglomerated soil "clods" of sufficient size to prevent wind erosion.

iii. Mechanical tillage that creates soil crusting of sufficient depth, uniformity and durability to prevent wind erosion.

C. Activities undertaken during the term of this Contract on Participating Lands shall be limited to the Land Management Measures required in Paragraphs 6.A. and 6.B. above and normal farming operations associated with Cooperator's Property to the extent such operations do not conflict with the Program Activities for the Participating Lands.

7. Additional Agreements and Representations of Cooperator. In addition to any other agreements or representations set forth in this Contract, Cooperator further agrees and represents as follows:

A. Cooperator shall pay the Association all levies, assessments and other charges for water service or other services levied or imposed by the Association ("Association Charges") on or with respect to the portion of the Cooperator's Property that is owned by Cooperator, including the Participating Lands, when due. If any of the Cooperator's Property is leased by Cooperator from a third party, Cooperator shall be responsible for paying or ensuring payment of the Association Charges relating to the leased property, including the Participating Lands, in a timely manner. If the lease agreement between Cooperator and the owner of the property provides that the owner of the leased property is responsible for paying the Association Charges, and if the owner does not timely pay the Association Charges, Cooperator shall pay them to the Association within fifteen days after written demand from the Association.

B. Cooperator shall not lease or sublease the Participating Lands to any other person or entity during the term of this Contract.

C. Cooperator shall not sell, convey, transfer or assign (by deed, lease, license, easement, grant, or any other form of agreement, transfer or conveyance) any of the CCU that is created by the participation of the Participating Lands in the Pilot Program. Cooperator shall also not seek to include any of the CCU in an augmentation plan, substitute water supply plan or similar plan or otherwise seek to utilize the CCU for any purpose.

D. Cooperator represents that Cooperator is the fee owner of Cooperator's Property and/or that Cooperator leases some or all of Cooperator's Property under an existing lease that is valid through the term of this Contract. With respect to the portion of Cooperator's Property that is owned by Cooperator, Cooperator represents that Cooperator has the right and authority to enter into this Contract without the approval or consent from any other person or entity, including without limitation any lenders with a mortgage or deed of trust encumbering Cooperator's Property. With respect to any portion of Cooperator's Property that is leased by Cooperator, Cooperator represents that Cooperator has the right and authority to enter into this Contract pursuant to the terms of the lease or other consent or permission obtained by Cooperator from the owner of the leased property, and that any leased property is not owned in part or in whole by any other person or entity acting as a Cooperator during this pilot project.

E. Cooperator makes no representation, warranty, or guaranty with respect to the amount of CCU that may be developed by Cooperator's compliance with the terms of this Contract.

F. Cooperator has had an opportunity to consult with legal counsel regarding this Contract.

8. <u>Miscellaneous Provisions</u>.

A. This Contract shall be governed by and construed and interpreted in accordance with the laws of the State of Colorado and any federal laws applicable to the [redacted] without giving effect to any choice-of-law or conflicts-of-laws rule or principle that would result in the application of the laws of any other jurisdiction. Venue for any actions relating to this Contract shall be in the Colorado state courts located in [redacted]

B. The Parties do not intend to create rights in or to grant remedies to any third party or others as a beneficiary of this Contract or of any duty, covenant, obligation or undertaking established under this Contract.

C. No Party may assign, delegate, or otherwise transfer this Contract, any interest in this Contract, or the Party's rights or obligations under this Contract without the prior written consent of the other Party, which consent may be withheld at the Party's sole and absolute discretion. Any purported assignment or transfer without the other Party's consent shall be void and without effect.

D. This Contract constitutes the entire understanding of the Parties hereto, and supersedes any previous or contemporaneous agreements or understandings among the Parties with respect to the subject matter of this Contract, whether oral or written. It may not be modified or amended except in writing executed by the Parties.

E. Time is of the essence of this Contract and each of its provisions.

F. All notices, requests, demands and other communications under this Contract shall be in writing and shall be hand delivered or sent by certified U.S. mail, return receipt requested, to the Party to whom it is directed at the address set forth in the introductory paragraph of this Contract. In addition, notice also may be sent by e-mail message to the e-mail address of a Party as set forth below. Any Party from time to time may by written notice substitute addresses or persons to whom such notices shall be sent. All notices and other communications shall be effective upon receipt.

Association email[redacted]
Cooperator email: E-MAIL

G. Notwithstanding anything herein to the contrary, any provisions of this Contract requiring continued performance, compliance, or effect after termination of this Contract shall survive such termination and shall be enforceable by the Parties.

H. Either Party may record this Contract in the records of the [redacted] and Recorder.

I. This Contract and any amendments to it may be executed in counterparts, each of which shall be deemed an original and all of which taken together shall constitute one and the same instrument.

The Parties have executed this Contract effective as of the Effective Date set forth in the introductory paragraph.

ASSOCIATION:

[redacted]

ATTEST:

By: ______________________________
[redacted]

____
[redacted]

COOPERATOR:

____
NAME

State of Colorado)ss
County of Mesa)

The foregoing Contract was acknowledged before me this ____ day of _______________, 2017, by Joseph C. Bernal as President and D. Kim Albertson as Secretary of Grand Valley Water Users Association.

My commission expires: ____________

Witness my hand and official seal.

____
Notary Public

State of Colorado)ss
County of Mesa)

The foregoing Contract was acknowledged before me this ____ day of _______________, 2017, by NAME.

My commission expires: ____________

Witness my hand and official seal.

____
Notary Public

Appendix 5-H

New Mexico Sample Fallow Agreement

CONTRACT

Between the

UNITED STATES OF AMERICA
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

and the

FORT SUMNER IRRIGATION DISTRICT

for

FORBEARANCE OF IRRIGATED ACREAGE FOR
THE 2014 IRRIGATION SEASON

THIS CONTRACT (Contract), made this ______ day of ______________, 2014, authorized pursuant to the Act of June 17, 1902 (32 Stat. 388) and all acts amendatory thereof or supplementary thereto, between the UNITED STATES OF AMERICA, hereinafter called United States, acting through the Secretary of the Interior, hereinafter called Secretary, and the FORT SUMNER IRRIGATION DISTRICT, a municipal corporation organized and existing under the laws of the State of New Mexico, hereinafter called District;

WITNESSETH THAT:

RECITALS:

WHEREAS, the District comprises approximately 6,500 acres of land in De Baca County, New Mexico, of which 6,300 acres is in production this irrigation season and diverts water from the Pecos River through irrigation works under a decreed state water right with a priority date of 1903;

WHEREAS, the Secretary rehabilitated or constructed the District's diversion dam pursuant to Contract No. Ilr-1524, as amended and supplemented, between the District and the United States;

WHEREAS, the Pecos bluntnose shiner (shiner) has been listed as a threatened species pursuant to the Endangered Species Act and can be found in a reach of the Pecos River that is prone to critically low flows during the late summer and fall, especially during dry years;

WHEREAS, in 2009, the District and the United States executed a multi-year Contract No. 08-WC-40-292, dated August 21, 2009 for the purpose of accruing up to 2,500 acre-feet of water a year for the benefit of the shiner;

WHEREAS, because of unusually dry conditions and projections of especially low runoff in the Pecos River system in 2014, additional sources of supply to provide flows for the shiner are desirable and the District is willing to enter into temporary, one-time per annum, agreements with individual participating farmers within the District in order to further augment river flows during the 2014 irrigation season;

WHEREAS, the United States is willing to compensate participating farmers for crop loss for foregoing irrigation of lands currently in production and for the District returning the water otherwise allocated to those lands to the Pecos River to enhance flows for the shiner;

WHEREAS, the District and the United States desire to enter into this Contract to establish the terms and conditions under which water allocations to participating farmers may be temporarily foregone and for compensation for consequent crop loss;

NOW THEREFORE, the parties agree as follows:

1. **Term of Contract:** This Contract shall become effective upon the date of its execution and shall remain in effect until all its terms and conditions have been met, which is anticipated to be no later than December 31, 2014.

2. **Contract Schedules**: This contract contains the following two separate schedules:
   - **Full Season Forbearance;** beginning on April 30, 2014, and ending through midnight, local time, October 31, 2014.
   - **Partial Season Forbearance**; beginning on April 30, 2014 and ending through midnight, local time, August 1, 2014

3. **Agreements with Farmers:**

A. **For each above Schedule**, the District will execute a separate, written agreement, an example of which is attached hereto as Exhibit A (Full Season Forbearance) or Exhibit B (Partial Season Forbearance), with each District participating farmer who is willing to forego water deliveries pursuant to the terms of this Contract, specifying: 1) the number of acres to which water deliveries will be forgone; 2) terms and conditions, including compensation, under which water deliveries will be foregone; 3) penalties imposed for non-compliance with the terms of the agreement; 4) such other information required for the accurate administration of this Contract.

B. Using its regular, established operation and maintenance procedures, the District shall use the enforcement procedures described in "Exhibit A or B, as applicable," to ensure that individual participating farmers entering into agreements to forego the delivery of water to specified lands do not divert water to such lands during each scheduled forbearance period.

C. The lands designated for Full Season Forbearance period of April 30 through October 31, 2014, may change between the initial period of April 30, 2014 through August 1, 2014 and final period August 2 through October 31, 2014, as long as the total number of Full Season Forbearance acres remains unchanged.

D. Conditions include a minimum of 50 acres being fallowed. The United States may inspect the District's irrigation works and pertinent records to ensure that the terms of this Contract are being enforced.

4. **Compensation to Participating Farmers and District Administrative Fee:**

A. The United States shall compensate participating District farmers, by payment to be administered by the District pursuant to Section 4.B. through 4.D. herein, for crop loss in the amount of:

- $700.00 for each acre under the Full Season Forbearance Schedule
- $400.00 for each acre under the Partial Season Forbearance Schedule.
- Total payment for the combined full and partial forbearance shall not exceed $1,300,000

including the five (5) percent administrative fee.

B. By April 30, 2014, the District will provide to the United States both Schedules of participating farmers with corresponding acreages upon which irrigation is being foregone. Within 30 days of the date that the District provides the Schedules, the United States shall make the following first-half payments to the District, plus one half of a five (5) percent administrative fee:

- $350.00 multiplied by the number of participating Full Season Forbearance acres.
- $200.00 multiplied by the number of participating Partial Season Forbearance acres.

The United States shall make the final second-half payment, plus the remainder of the five (5) percent administrative fee, within 30 days of receipt of the District's invoice containing completed and adjusted Schedule(s).

C. The five (5) percent administrative fee paid to the District is for the purpose of covering the District's administrative costs of entering into agreements with, and distributing payments to, individual participating farmers and for operating the District works to assure return to the river of the forgone water as described in Section 5.

D. It shall be the District's responsibility to allocate and distribute among the participating farmers their respective shares of compensation within fifteen (15) days after the District's receipt of payments. A written accounting of the allocation and amount paid to each participating farmer will be included with the payments made by the District to each participating farmer.

E. Nothing in this Contract shall be construed as establishing a price for use in any future water contracts or negotiations for such contracts.

5. **Method of Calculating Fallowing Impacts on Quantity of Returned Water:**

A. The District shall determine the amount of water that results from fallowing pursuant to this Contract, based on a percentage of the District's total diversion amount. This percentage shall be calculated by dividing the total full and partial season Fallow Acreages, as adjusted at that time, by the total agreed irrigated acreage (6,300 acres) ("Fallow Percentage"). The District's diversion at the Ft. Sumner Diversion Dam ("Total District Diversion"), multiplied by the Fallow Percentage, will equal the total Fallow Water to be returned to the Pecos River. Fallow Water is the amount that must be returned to the Pecos River as described in paragraph 5.B.

B. The District shall make its Total District Diversion, run it through the Highline Canal Turbine, and thereafter release the Fallow Water at the Sandgate Weir to be returned through the wasteway directly to the Pecos River.

C. **Example:**

Assumption: 60 cfs = Total District Diversion

Fallow Acreage = 1,575 acres

Total Agreed Irrigated Acreage = 6,300 acres

Calculation: 1,575 / 6,300 acres = 0.25 (Fallowing Percentage)

0.25 x Total District Diversion (60 cfs) = 15 cfs = Fallow Water

D. The District will gage the Fallow Water flows with the cooperation of the Bureau of Reclamation.

E. The parties agree to coordinate all related operations associated with this Contract, as necessary, with the New Mexico Office of the State Engineer (NMOSE) District II, Pecos River Water Master.

6. **District's Water Rights:** Nothing in this Contract shall be construed as affecting in any way water rights held by the District or land owners within the District or in any way as diminishing or impairing any other rights or interests of the District, including exercise of the 2014-2015 winter run right, or in any way as diminishing or impairing any other rights or interests of the district or its constituents.

7. **Notices:** Any notice, demand, or request authorized or required by this Contract shall be deemed to have been given, on behalf of the District, when mailed, postage prepaid, or delivered to the Regional Director, Upper Colorado Region, Bureau of Reclamation, 125 South State Street, Salt Lake City, Utah 84138-1147, and on behalf of the United States when mailed, postage prepaid, or delivered to the Fort Sumner Irrigation District, PO Box 374, Fort Sumner NM 88991. The designation of the addressee or the address may be changed by notice given in the same manner as provided in this article for other notices.

8. **Officials Not to Benefit:** No Member of or Delegate to Congress, Resident Commissioner, or official of the District shall benefit from this Contract other than as a water user or land owner in the same manner as other water users or land owners. No officer, director, or employee of any entity or subdivision obligated to the District for repayment of obligations under this Contract shall benefit from this Contract other than as a water user or land owner in the same manner as other water users or land owners.

9. **Changes in District's Organization:** While this Contract is in effect, no change may be made in the District's organization by inclusion or exclusion of lands, dissolution, consolidation, merger, or otherwise, except upon the Secretary's or his agent's written consent.

10. **Assignment Limited Successors and Assigns Obligated:** The provisions of this Contract shall apply to and bind the successors and assigns of the parties hereto, but no assignment or transfer of this Contract or any right or interest therein shall be valid until approved in writing by the Secretary or his agent.

11. **Books, Records, and Reports:** The District shall establish and maintain accounts and other books and records pertaining to administration of the terms and conditions of this Contract. Reports thereon shall be furnished to the Reclamation in such form and on such date or dates as the Reclamation may request. Subject to applicable Federal laws and regulations, each party to this Contract shall have the right during office hours to examine and make copies of the other party's books and records relating to matters covered by this Contract.

12. **Rules, Regulations, and Determinations:**

A. The parties agree that the use of the water and facilities pursuant to this Contract is subject to applicable federal and state law and regulations.

B. The Secretary shall have the right to make determinations necessary to administer this Contract that are consistent with the expressed and implied provisions of this Contract, the laws of the United States and the State, and the applicable rules and regulations promulgated by the Secretary of the Interior. Such determinations shall be made in consultation with the District; provided, however that this paragraph 12(B) does not grant any authority or right to the Secretary not already provided by existing law.

13. **Compliance with Civil Rights Laws and Regulations:**

A. The District shall comply with Title VI of the Civil Rights Act of 1964 (42 U.S.C. 2000d), Section 504 of the Rehabilitation Act of 1973 (P.L. 93-112, as amended), the Age Discrimination Act of 1975 (42 U.S.C. 6101, et seq.) and other applicable civil rights laws, as well as with their respective implementing regulations and guidelines imposed by the U.S. Department of the Interior and/or Bureau of Reclamation.

B. These statutes require that no person in the United States shall, on the grounds of race, color, national origin, handicap, or age, be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity receiving financial assistance from the Bureau of Reclamation. By executing this Contract, the District agrees to immediately take any measures necessary to implement this obligation, including permitting officials of the United States to inspect premises, programs, and documents.

14. **Condition of Appropriations:** The expenditure or advance of any money or the performance of any obligation of the United States under this Contract shall be contingent upon appropriation or allotment of funds. Absence of appropriation or allotment of funds shall not relieve the contractor from any obligations under this Contract. No liability shall accrue to the United States in case funds are not appropriated or allotted.

IN WITNESS WHEREOF, the parties hereto have caused this Contract to be duly executed the day and year first written above.

Approved:	UNITED STATES OF AMERICA
______________________________	______________________________
Office of the Regional Solicitor	Regional Director Upper Colorado Region Bureau of Reclamation
Attest:	FT. SUMNER IRRIGATION DISTRICT
______________________________	______________________________
Legal Counsel	President, Board of Directors

EXHIBIT A

Full Season Forbearance: April 30 – October 31, 2014

COOPERATIVE IRRIGATION LAND FALLOWING CONTRACT

THIS AGREEMENT is made this _______ day of April 2014, between the Fort Sumner Irrigation District (hereinafter "FSID" or "District") and ____________________________ (hereinafter "Farmer").

WHEREAS, FSID is a municipal corporation and a political subdivision of the State of New Mexico with authority pursuant to NMSA 1978, Articles 9-11 to manage the affairs of the District and to contract with the United States acting through the Secretary of the interior (hereinafter "Secretary");

WHEREAS, the Secretary has offered to compensate farmers of irrigable lands within the District in the amount of $700 per acre in exchange for foregoing water deliveries to specified acres of land within the District so that such water can be returned to the Pecos River to enhance river flows for the shiner;

WHEREAS, because of the emergency nature of the current drought situation in the Pecos River, the District is willing to enter into temporary, one-time only contracts with individual farmers within the District by which those farmers agree to forego the irrigation of specified acres of land currently in production in exchange for compensation from the United States (hereinafter "Fallowing Program");

WHEREAS, FSID and the Secretary have entered into Contract No. 14-WC-40-543 to effectuate their agreement;

WHEREAS, participation in the Fallowing Program pursuant to this Agreement and the contract between FSID and the United States will not in any way infringe upon or jeopardize the water rights of FSID or individuals who elect to participate in this Fallowing Program. FSID will seek placement of the water rights that are the subject of this Agreement in a state-approved conservation program for the period of April 30, 2014, through October 31, 2014.

WHEREAS, Farmer wishes to voluntarily cease irrigating specified acreages owned or leased by him or her that are currently planned for production for the period April 30, 2014, through October 31, 2014.

NOW THEREFORE, the parties agree as follows:

I. Term of Agreement: This Agreement shall become effective upon execution and shall remain in effect until all its terms and conditions have been met, which is anticipated to be no later than December 31, 2014.

II. Responsibilities of Farmer:

A. Farmer agrees to cease irrigating _____ acres of land on April 30, 2014, said acreage identified on Attachment 1 hereto (hereinafter "Fallow Acreage").

B. Farmer agrees not to irrigate the Fallow Acreage from April 30, 2014 through October 31, 2014 (hereinafter "Fallowing Period"). The Fallow Acreage for the period August 2 through October 31, 2014 may be different lands, in whole or in part, from those designated for the initial period of April 30 through August 1, 2014, so long as the total number of acres of Fallow Acreage is the same throughout the entire Fallowing Period of April 30 through October 31, 2014.

C. Farmer certifies that he or she _________________ (owns or leases) the Fallow Acreage and would have otherwise irrigated said acreage during the Fallowing Period.

D. Farmer agrees that FSID will apply a portion of or all of the Fallow Payments to bring current delinquent taxes, levies, or assessments, if any, on the Fallow Acreage or other of Farmer's lands within FSID.

E. Farmer agrees and acknowledges that FSID and the Secretary or their designated representatives have the right of ingress and egress to the Fallow Acreage during the period of this Agreement for the sole purpose of inspecting to ensure that Farmer does not irrigate the Fallow Acreage described in paragraph II.A. The Interstate Stream Commission and/or State Engineer may also inspect irrigation works and flows to determine the hydrologic effect of fallowing.

F. This Agreement does not prevent Farmer from continuing to farm or to harvest crops from the acreage described in paragraph II.A. This Agreement only prevents Farmer from irrigating the acreage with Fallow Water.

III. Penalties for Non-Compliance:

A. Farmer agrees that Farmer's failure to abide by this Agreement will result in forfeiture of the entire Fallow Payment. Farmer will be assessed a penalty of fifty percent (50%) of the forfeited Fallow Payment, and Farmer will not be eligible to participate in future fallowing programs, if any, for the following irrigation season or for a longer period as determined by the FSID Board.

B. Farmer shall be liable to FSID for any overpayment for fallowing that may result from a violation of this Agreement.

C. Farmer shall be liable to FSID for all attorney fees and costs incurred by FSID should FSID have to employ an attorney to remedy any violation of this Agreement.

IV. Responsibilities of FSID

A. FSID will collect Fallow Payments in the amount of $700 per acre and administrative fees from the Secretary, one-half of the total Fallow Payments to be collected initially and the remaining balance, less adjustments for any non-compliance, scheduled for no later than December 31, 2014.

B. FSID will allocate and distribute the Fallow Payments among Farmers participating in and complying with the Fallow Program within fifteen days after receipt of the Payments from the United States.

C. FSID is not responsible to Farmers for non-payment or late payment by the United States. FSID agrees to diligently prosecute for collection of non-payment or late payment of Fallow Payments owed to FSID and its Farmers by the United States.

D. FSID will maintain an accounting system of Fallow Acreage and Fallow Payments made to Farmers.

E. FSID will conduct inspections of the Fallow Acreage and irrigation works as necessary to ensure compliance with this Agreement.

V. Assignment: No party shall assign or transfer any interest in this Agreement or in the water which is the subject of this Agreement without the prior written approval of FSID.

VI. Release: Farmer, upon final payment of the amount due under the Agreement, release(s) FSID, its officers and employees, from all liabilities, claims, and obligations whatsoever arising from or under this Agreement. Farmer agrees not to purport to bind FSID to any obligation not assumed herein by FSID unless he or she has express authority to do so, and then only within the limits of that authority. If Farmer is leasing the Fallow Acreage, Farmer shall hold the District and the United States harmless and agrees to indemnify them from any claims by the owner of the Fallow Acreage related or arising from this Agreement.

VII. Scope of Agreement: This Agreement incorporates all the agreements, covenants, and understandings between the parties hereto concerning the subject matter hereof, and all such contracts, agreements, covenants and understandings have been merged into this written Agreement. No prior agreement or understanding, oral or otherwise, of the parties or their agents shall be valid or enforceable unless embodies in this Agreement.

VIII. Amendment: This Agreement shall not be altered, changed or amended except by an instrument in writing, executed by the parties hereto and the Secretary or his agent.

IX. Binding Effect of Agreement: The promises, obligations, and conditions set forth in this Agreement are binding on the parties, their heirs, successors, and assigns in interest.

X. Applicable Law and Venue: This Agreement shall be governed by the laws of the State of New Mexico. Venue for any dispute under this Agreement between Farmer and FSID shall be in De Baca County.

XI. Warranty of Authority: Each signatory to this Agreement expressly warrants and asserts full authority to execute this Agreement on behalf of the party identified above his signature and with respect to the Fallow Acreage that is the subject of this Agreement.

IN WITNESS WHEREOF, the parties hereto have caused this Agreement to be duly executed the day and year first written above.

FORT SUMNER IRRIGATION DISTRICT

By:________________________________
Clifford Kenyon, Chairman
Board of Directors

FARMER

____

Address:

____

____

Phone: ______________________________

EXHIBIT B

Partial Season Forbearance: April 30 – August 1, 2014

COOPERATIVE IRRIGATION LAND FALLOWING CONTRACT

THIS AGREEMENT is made this _______ day of April 2014, between the Fort Sumner Irrigation District (hereinafter "FSID" or "District") and ________________________ (hereinafter "Farmer").

WHEREAS, FSID is a municipal corporation and a political subdivision of the State of New Mexico with authority pursuant to NMSA 1978, Articles 9-11 to manage the affairs of the District and to contract with the United States acting through the Secretary of the interior (hereinafter "Secretary");

WHEREAS, the Secretary has offered to compensate farmers of irrigable lands within the District in the amount of $400 per acre in exchange for foregoing water deliveries to specified acres of land within the District so that such water can be returned to the Pecos River to enhance river flows for the shiner;

WHEREAS, because of the emergency nature of the current drought situation in the Pecos River, the District is willing to enter into temporary, one-time only contracts with individual farmers within the District by which those farmers agree to forego the irrigation of specified acres of land currently in production in exchange for compensation from the United States (hereinafter "Fallowing Program");

WHEREAS, FSID and the Secretary have entered into Contract No. 14-WC-40-543 to effectuate their agreement;

WHEREAS, participation in the Fallowing Program pursuant to this Agreement and the contract between FSID and the United States will not in any way infringe upon or jeopardize the water rights of FSID or individuals who elect to participate in this Fallowing Program. FSID will seek placement of the water rights that are the subject of this Agreement in a state-approved conservation program for the period of April 30, 2014, through August 1, 2014.

WHEREAS, Farmer wishes to voluntarily cease irrigating specified acreages owned or leased by him or her that are currently planned for production for the period April 30, 2014, through August 1, 2014.

NOW THEREFORE, the parties agree as follows:

I. Term of Agreement: This Agreement shall become effective upon execution and shall remain in effect until all its terms and conditions have been met, which is anticipated to be no later than December 31, 2014.

II. Responsibilities of Farmer:

A. Farmer agrees to cease irrigating _____ acres of land on April 30, 2014, said acreage identified on Attachment 1 hereto (hereinafter "Fallow Acreage").

B. Farmer agrees not to irrigate the Fallow Acreage from April 30, 2014 through August 1, 2014 (hereinafter "Fallowing Period").

C. Farmer certifies that he or she _________________ (owns or leases) the Fallow Acreage and would have otherwise irrigated said acreage during the Fallowing Period.

D. Farmer agrees that FSID will apply a portion of or all of the Fallow Payments to bring current delinquent taxes, levies, or assessments, if any, on the Fallow Acreage or other of Farmer's lands within FSID.

E. Farmer agrees and acknowledges that FSID and the Secretary or their designated representatives have the right of ingress and egress to the Fallow Acreage during the period of this Agreement for the sole purpose of inspecting to ensure that Farmer does not irrigate the Fallow Acreage described in paragraph II.A. The Interstate Stream Commission and/or State Engineer may also inspect irrigation works and flows to determine the hydrologic effect of fallowing.

F. This Agreement does not prevent Farmer from continuing to farm or to harvest crops from the acreage described in paragraph II.A. This Agreement only prevents Farmer from irrigating the acreage with Fallow Water.

III. Penalties for Non-Compliance:

A. Farmer agrees that Farmer's failure to abide by this Agreement will result in forfeiture of the entire Fallow Payment. Farmer will be assessed a penalty of fifty percent (50%) of the forfeited Fallow Payment, and Farmer will not be eligible to participate in future fallowing programs, if any, for the following irrigation season or for a longer period as determined by the FSID Board.

B. Farmer shall be liable to FSID for any overpayment for fallowing that may result from a violation of this Agreement.

C. Farmer shall be liable to FSID for all attorney fees and costs incurred by FSID should FSID have to employ an attorney to remedy any violation of this Agreement.

IV. Responsibilities of FSID

A. FSID will collect Fallow Payments in the amount of $400 per acre and administrative fees from the Secretary, one-half of the total Fallow Payments to be collected initially and the remaining balance, less adjustments for any non-compliance, scheduled for no later than December 31, 2014.

B. FSID will allocate and distribute the Fallow Payments among Farmers participating in and complying with the Fallow Program within fifteen days after receipt of the Payments from the United States.

C. FSID is not responsible to Farmers for non-payment or late payment by the United States. FSID agrees to diligently prosecute for collection of non-payment or late payment of Fallow Payments owed to FSID and its Farmers by the United States.

D. FSID will maintain an accounting system of Fallow Acreage and Fallow Payments made to Farmers.

E. FSID will conduct inspections of the Fallow Acreage and irrigation works as necessary to ensure compliance with this Agreement.

V. Assignment: No party shall assign or transfer any interest in this Agreement or in the water which is the subject of this Agreement without the prior written approval of FSID.

VI. Release: Farmer, upon final payment of the amount due under the Agreement, release(s) FSID, its officers and employees, from all liabilities, claims, and obligations whatsoever arising from or under this Agreement. Farmer agrees not to purport to bind FSID to any obligation not assumed herein by FSID unless he or she has express authority to do so, and then only within the limits of that authority. If Farmer is leasing the Fallow Acreage, Farmer shall hold the District and the United States harmless and agrees to indemnify them from any claims by the owner of the Fallow Acreage related or arising from this Agreement.

VII. Scope of Agreement: This Agreement incorporates all the agreements, covenants, and understandings between the parties hereto concerning the subject matter hereof, and all such contracts, agreements, covenants and understandings have been merged into this written Agreement. No prior agreement or understanding, oral or otherwise, of the parties or their agents shall be valid or enforceable unless embodies in this Agreement.

VIII. Amendment: This Agreement shall not be altered, changed or amended except by an instrument in writing, executed by the parties hereto and the Secretary or his agent.

IX. Binding Effect of Agreement: The promises, obligations, and conditions set forth in this Agreement are binding on the parties, their heirs, successors, and assigns in interest.

X. Applicable Law and Venue: This Agreement shall be governed by the laws of the State of New Mexico. Venue for any dispute under this Agreement between Farmer and FSID shall be in De Baca County.

XI. Warranty of Authority: Each signatory to this Agreement expressly warrants and asserts full authority to execute this Agreement on behalf of the party identified above his signature and with respect to the Fallow Acreage that is the subject of this Agreement.

IN WITNESS WHEREOF, the parties hereto have caused this Agreement to be duly executed the day and year first written above.

FORT SUMNER IRRIGATION DISTRICT

By:______________________________
Clifford Kenyon, Chairman
Board of Directors

FARMER

____

Address:

____
____

Phone: __________________________

Appendix 5-I

Palo Verde Sample Fallow Agreement

FORBEARANCE AND FALLOWING PROGRAM AGREEMENT

THIS FORBEARANCE AND FALLOWING PROGRAM AGREEMENT ("Program Agreement") is made, entered into, and effective as of August 18, 2004 ("Effective Date"), by and between Palo Verde Irrigation District ("PVID"), formed pursuant to the Palo Verde Irrigation District Act (West's Water Code Appendix, Chapter 33); and The Metropolitan Water District of Southern California ("Metropolitan"), organized and existing under the Metropolitan Water District Act (West's Water Code Appendix, Chapter 109). Each of said agencies is at times referred to individually as "Party" and both of which are at times collectively referred to as "Parties."

RECITALS

A. PVID, Metropolitan, and certain other California water agencies have water delivery contracts with the United States for the delivery and use of Colorado River water available for use within California ("Federal Water Delivery Contracts"). These contracts allocate Colorado River water among the contracting water agencies according to seven priorities, the first three of which aggregate 3.85 million acre-feet per year ("AFY") of consumptive use.

B. Notwithstanding the foregoing Federal Water Delivery Contract priorities, under The Law of the River, Colorado River water available for use in California is limited to 4.4 million AFY plus 50 percent of any surplus decreed by the Secretary of the Interior and any Colorado River water apportioned to, but unused in, Arizona and Nevada that the Secretary releases for use in California.

C. Metropolitan's Federal Water Delivery Contract provides for the delivery of the following quantities of Colorado River water: (1) A fourth priority for beneficial consumptive use on the Coastal Plain of Southern California of 550,000 AFY and (2) a fifth priority for beneficial consumptive use on the Coastal Plain of Southern California of 662,000 AFY. Metropolitan's Colorado River Aqueduct was sized to accommodate these entitlements.

D. Until recent years, Colorado River water available for use in California was sufficient to satisfy Metropolitan's fourth and fifth priority entitlements. Since then, however, there has been insufficient Colorado River water available for use in California to satisfy all of Metropolitan's fifth priority, a situation that Metropolitan desires to alleviate by a transfer to Metropolitan of higher priority Colorado River water.

E. PVID's priorities pursuant to the 1931 Seven Party Agreement and its Federal Water Delivery Contract are as follows: (1) A first priority for beneficial use exclusively upon lands in PVID (as it then existed) and upon lands between PVID (as it then existed) and the Colorado River, aggregating a gross area of 104,500 acres (such water being referred to herein as "Priority 1 Water" and such lands being referred to herein as "Priority 1 Lands"), (2) a third priority, shared with the Imperial Irrigation District ("IID") and the Coachella Valley Water District ("CVWD"), for use exclusively on 16,000 acres in that area known as the Lower Palo

Verde Mesa for beneficial consumptive use (such water being referred to herein as "Priority 3 Water" and such lands being referred to herein as "Priority 3 Lands"), and (3) certain water with a sixth priority shared with IID and CVWD. PVID also holds a present perfected right to Colorado River water with a priority date of 1877 pursuant to the Supreme Court's January 9, 1979 supplemental decree in *Arizona v. California*. PVID's Federal Water Delivery Contract entitlement includes the water to which PVID is entitled under its present perfected right.

F. Both Priority 1 Lands and Priority 3 Lands are currently being irrigated and farmed with Colorado River water delivered by the United States under PVID's Federal Water Delivery Contract. A reduction of irrigation of some of these lands through fallowing and a corresponding forbearance in the consumptive use of Colorado River water by PVID would, absent claims by other California water agencies under their Federal Water Delivery Contracts, increase the amount of Colorado River water available to Metropolitan under its Federal Water Delivery Contract. A transaction embodying these elements would constitute a forbearance (through fallowing) transaction between PVID and Metropolitan under applicable law.

G. While Metropolitan desires to enter into a long-term forbearance and fallowing transaction with PVID, Metropolitan has concluded that it should do so only with respect to (1) Priority 1 Water because of issues associated with the third priority which PVID shares with other California water agencies and (2) Priority 1 Land that is eligible to and receives delivery of Priority 1 Water with a recent history of crop irrigation. This is acceptable to PVID.

H. Accordingly, the Parties have determined to establish and implement through this Program Agreement a verifiable PVID/Metropolitan forbearance and fallowing program (such program being referred to herein as the "Program"), the elements of which are described generally in this Recital.

(1) Owners of Priority 1 Land that elect to participate in the Program (such owners being described herein as "Participating Landowners") will commit to fallow owned or leased Program Qualified Land in a Base Amount each Contract Year and in an additional amount in accord with periodic fallowing calls issued by Metropolitan. PVID will forbear from diverting Colorado River water that otherwise would have been used to irrigate Fallowed Lands, with the objective that an equivalent amount of Colorado River water (less any conveyance losses) will then be available for diversion by Metropolitan pursuant to Metropolitan's Federal Water Delivery Contract.

(2) The maximum amount of Priority 1 Land that may be fallowed under the Program in each of any ten (10) full Contract Years is limited to approximately twenty-nine percent (29%) of the total Priority 1 Land (approximately 26,500 water toll acres) and approximately 24,000 water toll acres in each of the other Contract Years. The Program places essentially comparable limits on the amount of Program Qualified Land any Participating Landowner may fallow, such being pegged to the amount of Program Qualified Land owned by a Participating Landowner at the time of joining the Program.

(3) The Program will be open on an equal basis to all owners of Priority 1 Land receiving Priority 1 water. Participation in the Program will be through Landowner

Agreements ("Landowner Agreements") between each Participating Landowner and PVID and Metropolitan. The Program will become effective if certain conditions precedent are met or waived by the Parties by December 31, 2004, including the deposit into escrow of executed Landowner Agreements committing to fallow at least 13,250 water toll acres of Priority 1 Land in each of any ten (10) full Contract Years (each such commitment by a Participating Landowner being referred to herein as that landowner's "Maximum Fallowing Commitment").

I. In September 2002 pursuant to the requirements of the California Environmental Quality Act, PVID issued the "Final Environmental Impact Report for the Proposed Palo Verde Irrigation District Land Management, Crop Rotation and Water Supply Program" ("Final Program EIR"). The proposed program described in that Final Environmental Impact Report is the same as the Program that is the subject of this Program Agreement. The Final EIR concluded that "implementing the Program would result in less-than-significant effects on the environment and would not require mitigation," relying for such conclusion in part on certain land management measures that would be part of the proposed program. Those measures and commitments are specified in this Program Agreement as part of the Program.

J. By resolution dated August 17, 2004, PVID's board of trustees determined the following with respect to the Program that is the subject of this Program Agreement: (1) the opportunity to participate in the Program will be offered to all owners of Priority 1 Land that is eligible to and receives delivery of Priority 1 Water, (2) interest exists among owners of Priority 1 Lands in participating in the Program, (3) the Program will further the public policies of the state regarding the use of water, (4) the source of the water for the Program will be conservation by owners of Priority 1 Lands through fallowing; (5) accordingly, implementation of the Program will create water excess or surplus to the needs of PVID and will not affect PVID's ability to supply water to Priority 1 Lands that are not fallowed under the Program, (6) the Program will be otherwise consistent with PVID's obligations to landowners, (7) the Program will assist California in adhering to its basic 4.4 million acre-foot apportionment of Colorado River water, help provide a reliable and flexible water supply for urban southern California, and help stabilize the farm economy in the Palo Verde Valley, (8) the Program will be in the best interests of PVID and PVID landowners, and (9) the Program will conform to all requirements of applicable law.

K. The Parties propose to enter into this Program Agreement pursuant to the Palo Verde Irrigation District Act; the Metropolitan Water District Act; applicable provisions of the California Water Code, and federal Reclamation Law, including the Boulder Canyon Project Act.

AGREEMENT

NOW, THEREFORE, the Parties agree as follows:

1. Definitions

As used in this Program Agreement, the following terms shall have the following meanings:

1.1 "AFY" means acre-feet per year.

1.2 "Base Amount" means the amount of Program Qualified Land a Participating Landowner is required to fallow every Contract Year pursuant to subsection 3.7.1 (Base Amount Fallowing).

1.3 "Conditions Precedent Notice" means the Parties' notice, executed pursuant to section 6 (Conditions Precedent), that all conditions precedent to certain of their obligations and rights have been satisfied or waived.

1.4 "Contract Year" means the twelve-month period from August 1 through the following July 31 of the following year, the first full Contract Year commencing the August 1 immediately following satisfaction or waiver of the conditions precedent pursuant to section 6 (Conditions Precedent). In the event that the Operative Date does not fall on August 1, the period following the Operative Date and preceding August 1 shall be referred to herein as a partial Contract Year and shall not be counted as a full Contract Year.

1.5 "CVWD" means the Coachella Valley Water District.

1.6 "Effective Date" is the date set forth in the introductory paragraph of this Program Agreement on which this Program Agreement becomes effective.

1.7 "Fallowed Land" means Program Qualified Land owned by or leased to a Participating Landowner that is fallowed pursuant to a Landowner Agreement.

1.8 "Fallowing Calls" mean the calls by Metropolitan to Participating Landowners for fallowing of Program Qualified Land in addition to the Base Amount.

1.9 "Fallowing Easement" means the easement a Participating Landowner is required to deliver to PVID and Metropolitan pursuant to subsection 3.4.3.2 (Notice of Required Documents) for the purpose of ensuring that Program Qualified Land is fallowed as specified in this Program Agreement.

1.10 "Federal Water Delivery Contracts" means the contracts for the delivery of Colorado River water between the United States and CVWD, IID, Metropolitan, and PVID, respectively.

1.11 "Final Program EIR" means the "Final Environmental Impact Report for the Proposed Palo Verde Irrigation District Land Management, Crop Rotation and Water Supply Program" dated September 2002.

1.12 "IID" means the Imperial Irrigation District.

1.13 "Landowner Agreement" means the agreement with PVID and Metropolitan through which a Participating Landowner participates in the Program and commits to fallow Program Qualified Land.

1.14 "Landowner Participation Offer" means the offer by a landowner, described more particularly in subsection 3.2.2 (Offers by Landowners), to make a specified Maximum Fallowing Commitment and to participate in the Program.

1.15 "Late Arising Claim" means a claim described in subsection 9.17 (Pending and Late Arising Claims).

1.16 "Maximum Fallowing Commitment" means the largest amount of Program Qualified Land Metropolitan may require a Participating Landowner to fallow during any Contract Year (Base Amount fallowing plus Fallowing Call), such being limited to ten (10) consecutive or non-consecutive full Contract Years.

1.17 "Metropolitan" means The Metropolitan Water District of Southern California.

1.18 "Operative Date" is the date on which the initial partial Contract Year, or first full Contract Year if there is no partial Contract Year, begins and is the earlier of (1) the date that the Parties execute Conditions Precedent Notices if the conditions precedent have been satisfied or waived prior to December 31, 2004, or (2) January 1, 2005 if neither Party has given notice on or before December 31, 2004 that the conditions precedent will not be satisfied or waived and that the Program shall terminate in accordance with clause (3) of subsection 2.1(Term).

1.19 "Participating Landowner" means a landowner that is participating in the Program through a Landowner Agreement.

1.20 "Participation Waiver" has the meaning set forth in subsection 3.5.5.

1.21 "Party" means Metropolitan or PVID; and when used in the plural, it means Metropolitan and PVID.

1.22 "Priority 1 Lands" means those lands described in section 1 of Article (6) of the Federal Water Delivery Contract between the United States and PVID dated February 7, 1933.

1.23 "Priority 1 Water" means the water delivered to PVID pursuant to section 1 of Article (6) of the Federal Water Delivery Contract between the United States and PVID dated February 7, 1933.

1.24 "Priority 3 Lands" means those lands described in section 3(b) of Article (6) of the Federal Water Delivery Contract between the United States and PVID dated February 7, 1933.

1.25 "Priority 3 Water" means the water delivered to PVID pursuant to section 3(b) of Article (6) of the Federal Water Delivery Contract between the United States and PVID dated February 7, 1933.

1.26 "Program" means the PVID/Metropolitan Forbearance and Fallowing Program that is the subject of this Program Agreement.

1.27 "Program Agreement" means this agreement entered into by and between Metropolitan and PVID.

1.28 "Program Encumbered Land" means land owned by a Participating Landowner that meets the requirements for fallowing set forth in subsection 3.7.5.2 (Land Designated for Fallowing) and is subject to a Fallowing Easement.

1.29 "Program Qualified Land" means land that (1) is eligible to and receives delivery of Priority 1 Water, and (2) has produced irrigated crops in two of the five Contract Years (or the August 1 to July 31 periods prior to the Effective Date) immediately prior to the year in which the landowner (i) makes a Landowner Participation Offer pursuant to subsection 3.2.2 (Offers by Landowners), (ii) proposes the land for substitution as Program Encumbered Land pursuant to subsection 3.7.8 (Substitution of Program Encumbered Land), or (iii) designates the land for fallowing pursuant to subsection 3.7.5 (Designation of Fallowed Land).

1.30 "PVID" means the Palo Verde Irrigation District.

1.31 "Reimbursable Costs" means those costs of PVID that Metropolitan is required to reimburse, as more particularly described in subsection 5.2.1 (General Obligation).

1.32 "Reimbursable Cost Budget" means the budget developed by the Parties for each Contract Year for the Reimbursable Costs to be incurred by PVID as more specifically described in subsection 5.2.2 (Annual Budget).

1.33 "Saved Water" means water that is conserved by fallowing pursuant to the Program and this Program Agreement.

1.34 "Solicitation Notice" means the notice, described more particularly in subsection 3.2.1 (Solicitation of Landowner Participation Offers), by which PVID is to solicit participation in the Program by Participating Landowners.

1.35 "Termination Date" means the date this Program Agreement terminates as more particularly specified in section 2 (Term of Agreement).

1.36 "USBR" means the United States Bureau of Reclamation.

2. Term of Agreement

2.1 Term

This Program Agreement shall be effective as of the Effective Date and, subject to the provisions of subsection 2.2 (Early Termination by Metropolitan), shall terminate on the earliest of (1) July 31 of the thirty-fifth (35^{th}) full Contract Year following the Operative Date, (2) July 31 of the Contract Year in which an early termination is effective in the event that Metropolitan should exercise its right of termination under subsection 2.2 (Early Termination by Metropolitan), or (3) December 31, 2004 if either Party gives notice on or before that date that the conditions precedent described in section 6 (Conditions Precedent) will not be timely satisfied or waived (such date of termination being referred to herein as the "Termination Date").

2.2 Early Termination by Metropolitan

Metropolitan may terminate this Program Agreement as of July 31 of the tenth (10^{th}) or any subsequent full Contract Year following the Operative Date by giving notice of such termination and the effective date thereof to PVID and all Participating Landowners at least five (5) calendar years prior to the effective date of the termination.

2.3 Continuing Obligations

The obligations and rights of the Parties under the following provisions shall survive termination of this Program Agreement: section 1 (Definitions); subsection 5.1 (Payments by Metropolitan to Landowners) as to obligations incurred prior to termination; subsection 5.2 (Payments by Metropolitan to PVID) as to obligations incurred prior to termination; section 8 (Remedies and Dispute Resolution); and section 9 (Miscellaneous Agreements).

3. PVID/Metropolitan Forbearance and Fallowing Program

3.1 Program Established

3.1.1 This Program Agreement establishes the PVID/Metropolitan Forbearance and Fallowing Program ("Program").

3.2 Landowner Participation in Program

3.2.1 Solicitation of Landowner Participation Offers

As soon as practicable after the Effective Date, PVID shall, by notice to all PVID landowners, including Metropolitan, solicit offers to participate in the Program through the fallowing of Program Qualified Land pursuant to Landowner Agreements (such notice being referred to herein as the "Solicitation Notice" and such offers being referred to herein as "Landowner Participation Offers").

3.2.2 Offers by Landowners

Landowner Participation Offers by landowners, including Metropolitan, (1) shall be made within seventy-five (75) days after the date of the Solicitation Notice, (2) shall be on forms supplied by PVID and approved by Metropolitan, (3) shall be submitted to both PVID and Metropolitan, and (4) shall be tiered and contain information as specified in this subsection 3.2.2 (Offers by Landowners). Landowner Participation Offers may be made by individual landowners or, as provided in subsection 3.5 (Participating Landowner Groups), by groups of landowners.

3.2.2.1 The first tier of a Landowner Participation Offer shall specify a Maximum Fallowing Commitment the landowner proposes to make, the acreage of which shall not exceed an amount equal to twenty-nine percent (29%) of the total Program Qualified Land then owned by the landowner.

3.2.2.2 If the first tier of a Landowner Participation Offer specifies the maximum acreage permitted by subsection 3.2.2.1, the Landowner Participation Offer may contain a second tier specifying an additional Maximum Fallowing Commitment the landowner proposes to make, the acreage of which, when added to the acreage specified in the first tier, may not exceed an amount equal to thirty-five percent (35%) of the total Program Qualified Land then owned by the landowner.

3.2.2.3 All Landowner Participation Offers other than by Metropolitan shall also include, separately for each tier, a legal description and PVID Water Toll Number of the Program Qualified Land the landowner proposes as Program Encumbered Land, the proposed land for each tier being equal in acreage to the proposed Maximum Fallowing Commitment for that tier and in parcels that are reasonably compact and at least five (5) water toll acres in size.

3.2.2.4 All Landowner Participation Offers shall include a legal description, PVID Water Toll Number, and acreage of the total amount of Program Qualified Land then owned by the landowner.

3.2.3 Provisional Approval of Landowner Participation Offers

3.2.3.1 As soon as practicable after the period specified in subsection 3.2.2 (Offers by Landowners) for making Landowner Participation Offers, the Parties shall, as provided in this subsection 3.2.3 (Provisional Approval of Landowner Participation Offers) provisionally approve Landowner Participation Offers that were timely made and in compliance with this Program Agreement, such approval being for the purpose of determining those offers as to which an escrow is to be established pursuant to subsection 3.4.1 (Escrow). A Landowner Participation Offer shall be subject to further approval by the Parties only (1) provisionally by Metropolitan, pursuant to subsection 3.2.4 (Metropolitan Approval of Proposed Program Encumbered Land), with respect to land proposed in the offer as Program Encumbered Land, and (2) for verification by the Parties, pursuant to subsection 3.2.5 (Verification of Program Qualified Land), of the landowner's ownership of the land identified in the offer as Program Qualified Land and its eligibility to receive Priority 1 Water.

3.2.3.2 First Tier Landowner Participation Offers

The Parties shall provisionally approve the first tier of all Landowner Participation Offers.

3.2.3.3 Second Tier Landowner Participation Offers

If the first tier of Landowner Participation Offers aggregate less than 26,500 water toll acres of Maximum Fallowing Commitments, the Parties shall first provisionally approve the second tier of all Landowner Participation Offers to the extent of the smallest percentage of total Program Qualified Land specified in the second tier of any offer. The Parties shall next provisionally approve the second tier of all Landowner Participation Offers to the extent of the next smallest percentage of total owned Program Qualified Land specified in any offer. The Parties shall follow this process until the second tier of all Landowner Participation Offers have been provisionally approved or the provisionally approved first and second tiers of Maximum Fallowing Commitments in Landowner Participation Offers aggregate approximately 26,500 water toll acres, whichever first occurs.

3.2.3.3.1 Notwithstanding the foregoing, Metropolitan may elect to reserve a portion of the Maximum Fallowing Commitments in its second tier equal to an amount of up to two percentage points of its Program Qualified Land. If Metropolitan makes this election, it shall be authorized to use the reserved portion of its Maximum Fallowing Commitments in an amount equal to any shortfall in the aggregate amount of provisionally approved Maximum Fallowing Commitments resulting from the reasons stated in subsection 3.6.1, provided that the final approved percentage of Metropolitan's Maximum Fallowing Commitments shall not exceed the highest approved percentage of other Landowner Participation Offers. Metropolitan shall utilize any reserved second tier Maximum Fallowing Commitments in accordance with subsection 3.6 (Subsequent Solicitation of Participation Offers).

3.2.3.4 Subject to the satisfaction of conditions in subsection 3.2.3.1, the Maximum Fallowing Commitment to be incorporated into a Landowner Agreement, expressed in terms of acreage and percentage of Program Qualified Land, shall be the sum of the first and second tiers of the Landowner Participation Offer as provisionally approved.

3.2.4 Metropolitan Approval of Proposed Program Encumbered Land

The provisions of this subsection shall apply to Landowner Participation Offers from all landowners other than Metropolitan.

3.2.4.1 Within thirty (30) days after the period specified in subsection 3.2.2 (Offers by Landowners) for making Landowner Participation Offers, Metropolitan shall, by notice to PVID and the landowner, either provisionally approve or disapprove the land proposed in such offer as Program Encumbered Land. Metropolitan may disapprove proposed land only to the extent it (1) does not meet the requirements specified in subsection 3.7.5.2 (Land Designated for Fallowing) for land that is to be fallowed under Landowner Agreements, or (2) is not feasible, in Metropolitan's reasonable judgment, for fallowing by Metropolitan in the event of a default by the Participating Landowner. Metropolitan may not unreasonably withhold provisional approval of land offered as Program Encumbered Land. Any notice of disapproval given by Metropolitan shall describe the land disapproved and state with particularity the reasons for the disapproval.

3.2.4.2 Any land proposed by a landowner as Program Encumbered Land under subsection 3.2.2.3 that Metropolitan does not provisionally approve or disapprove within the period specified in subsection 3.2.4.1, shall nonetheless be deemed to have been provisionally approved by Metropolitan.

3.2.4.3 Any landowner as to whom Metropolitan has disapproved proposed Program Encumbered Land pursuant to subsection 3.2.4.1 shall have the right, on notice given to PVID and Metropolitan within seven (7) days after the date of giving notice of such disapproval, to require a meeting with the PVID and Metropolitan Agreement Administrators for purposes of either disputing the basis for Metropolitan's disapproval or offering substitute land for the disapproved Program Encumbered Land. PVID and Metropolitan Agreement Administrators shall meet with any such disputing landowner within seven (7) days after the date of the landowner's notice.

3.2.4.4 If a meeting held pursuant to subsection 3.2.4.3 does not resolve the dispute between the landowner and Metropolitan regarding land proposed as Program Encumbered Land, the landowner shall have the further right, on notice given to PVID and Metropolitan within seven (7) days after such meeting, to require a meeting with the chief executive officer of Metropolitan and general manager of PVID for purposes of resolving the dispute. The Metropolitan chief executive officer and PVID general manager, or persons they individually designate as representing their respective agencies, shall meet with any disputing landowner within seven (7) days of the landowner's notice. If Metropolitan and the landowner are unable to resolve the dispute, Metropolitan's decision on the land proposed as Program Encumbered Land shall be final and shall not be subject to the provisions of section 8 (Remedies and Dispute Resolution). In such event, however, the landowner shall have the following rights, which must be exercised within ten (10) days following the notice of Metropolitan's final decision: (1) to propose one further offer of substitute Program Encumbered Land, as to which the provisions of subsection 3.2.4 (Metropolitan Approval of Proposed Program Encumbered Land) shall apply, or (2) to withdraw the Landowner Participation Offer.

3.2.4.5 If subsequent to a disapproval of proposed Program Encumbered Land by Metropolitan under subsection 3.2.4.1, Metropolitan subsequently provisionally approves such lands or provisionally approves alternate lands proposed by the landowner as Program Encumbered Land, Metropolitan shall promptly give notice to that effect to PVID and the landowner.

3.2.4.6 Proposed Program Encumbered Land provisionally approved by Metropolitan under this subsection 3.2.4 (Metropolitan Approval of Proposed Program Encumbered Land) remains subject to verification of its eligibility for and receipt of Priority 1 Water and of its ownership by the landowner making the Landowner Participation Offer and similar verification of other Program Qualified Land described in the Landowner Participation Offer, and upon such verification shall be the Program Encumbered Lands described in the Landowner Agreement and Fallowing Easement provided to the landowner for execution and delivery into escrow pursuant to subsection 3.4.2 (Notice of Provisional Acceptance to Landowners; Documents for Delivery by Landowners into Escrow).

3.2.5 Verification of Program Qualified Land

3.2.5.1 Metropolitan shall, as expeditiously as possible, obtain title reports on all Priority 1 Land with respect to (1) ownership of the land, and (2) liens, encumbrances on, and security interests in, such land.

3.2.5.2 As soon as practicable after (1) receipt of each Landowner Participation Offer and (2) receipt of a title report respecting the Program Qualified Land identified in such offer, the Parties will verify ownership of such land by the offering landowner(s) and its eligibility for and receipt of Priority 1 Water.

3.2.5.3 If a title report obtained by Metropolitan reflects that the Program Qualified Land identified in a Landowner Participation Offer either is not owned by the landowner(s) making the offer or is ineligible to receive Priority 1 Water, the Parties shall promptly confer with the affected landowner to (1) modify the offer to conform to the title report, (2) identify any errors in the Landowner Participation Offer, (3) identify any errors in the title report, or (4) otherwise remedy the situation.

3.3 Metropolitan as Participating Landowner

Metropolitan's participation in the Program as a Participating Landowner shall be governed by and in accord with the provisions of this Program Agreement and the provisions of the form of Landowner Agreement attached hereto as Exhibit A other than those provisions relating to Program Encumbered Land and payments to Participating Landowners. No separate Landowner Agreement shall be required of Metropolitan.

3.4 Process for Incorporating Landowner Participation Offers into Landowner Agreements

3.4.1 Escrow

As soon as practicable after a Landowner Participation Offer has been provisionally approved pursuant to subsection 3.2 (Landowner Participation in Program), but not later than required by each Landowner Agreement, Metropolitan shall establish an escrow respecting such agreement with a qualified escrow agent selected by Metropolitan, subject to reasonable approval by PVID.

3.4.2 Notice of Provisional Acceptance to Landowners; Documents for Delivery by Landowners into Escrow

As soon as practicable after a Landowner Participation Offer has been provisionally approved as provided in subsection 3.2.3 (Provisional Approval of Landowner Participation Offers), the proposed Program Encumbered Land has been provisionally approved as provided in subsection 3.2.4 (Metropolitan Approval of Proposed Program Encumbered Land), and the status of the lands offered for fallowing has been verified as provided in subsection 3.2.5 (Verification of Program Qualified Land), the Parties shall give the landowner notice that the landowner's offer has been accepted, accompanied by the documents specified in this subsection 3.4.2 (Notice of Provisional Acceptance to Landowners; Documents for Delivery by Landowners into Escrow).

3.4.2.1 A copy of this Program Agreement.

3.4.2.2 Escrow instructions consistent with this Program Agreement for execution by the landowner and delivery into escrow.

3.4.2.3 For execution by the landowner and delivery into escrow, a Landowner Agreement substantially in the form attached to this Program Agreement as Exhibit A that includes the landowner's provisionally accepted Maximum Fallowing Commitment.

3.4.2.4 Metropolitan's notice of the initial Fallowing Call.

3.4.3 Deliveries by PVID and Metropolitan into Escrow

3.4.3.1 Executed Counterparts of the Landowner Agreement

As soon as practicable after each Participating Landowner has duly executed and delivered to the Parties the Landowner Agreement and escrow instructions, the Parties shall execute counterparts of the Landowner Agreement and escrow instructions. Metropolitan shall establish an escrow within seven (7) days after the Landowner Agreement is duly executed and the Parties shall deposit the Landowner Agreement and escrow instructions into the escrow.

3.4.3.2 Notice of Required Documents

In accordance with the terms of the Landowner Agreement, Metropolitan shall give the Participating Landowner written notice, based on a current preliminary title report obtained by Metropolitan, of each owner of Program Encumbered Land who appears to be required to execute a fallowing easement under subsection 4.2 (Fallowing Easement) of the Landowner Agreement, each encumbrance for which an encumbrance subordination agreement appears to be required under subsection 4.5.2 (Encumbrance Subordination Agreement) of the Landowner Agreement, each lease reflected in the preliminary title report or disclosed by the Participating Landowner for which a tenant subordination agreement appears to be required under subsection 4.5.1 (Tenant Subordination Agreement) of the Landowner Agreement, and each landowner in a Participating Landowner Group who is not a party to the Landowner Agreement from whom a participation waiver appears to be required by subsection 3.5.5 of this Program Agreement.

3.4.3.3 Conditions Precedent Notice

Promptly upon the satisfaction or waiver of the conditions precedent set forth in section 6 (Conditions Precedent), PVID and Metropolitan shall execute and deliver the Conditions Precedent Notice into escrow. In the event that the Conditions Precedent Notice is not executed and deposited into escrow prior to December 31, 2004 and this Program Agreement and the Landowner Agreements are not terminated by notice given pursuant to clause (3) of subsection 2.1 (Term), the requirement for a Conditions Precedent Notice shall be deemed to be waived.

3.4.3.4 Deposit of Funds by Metropolitan

In accordance with the terms of the Landowner Agreement, Metropolitan shall deposit into escrow the funds for the initial payment to the Participating Landowner and sufficient funds to cover the estimate of costs of escrow.

3.4.4 Closure or Termination of Escrow

The escrow for each Landowner Agreement shall close when the escrow agent has received in proper form the funds and documents specified in the Landowner Agreement, provided that Metropolitan or PVID may terminate any escrow if the Participating Landowner fails to deliver all required documents into escrow within the time allowed by the Participating Landowner's Landowner Agreement.

3.5 Participating Landowner Groups

3.5.1 Landowners, including Metropolitan, may join together for purposes of pooling their participation in the Program as to (1) a Landowner Participation Offer; (2) Program Qualified Land for purposes of calculating the limitations on first and second tier Maximum Fallowing Commitments specified in Landowner Participation Offers; (3) Maximum Fallowing Commitments; (4) Program Encumbered Land; (5) Fallowed Land; and (6) receipt of Initial Payments and Annual Payments by Metropolitan. As among the Participating Landowners in the group, the pooling shall be on such terms and conditions as the Participating Landowners may agree.

3.5.2 There shall be a single Landowner Participation Offer for each group which shall (1) identify and be signed by all landowners who are in the group; (2) specify which landowners are to be Participating Landowners and parties to the Landowner Agreement for the group; (3) identify all owners of the Program Qualified Land that is to be considered for purposes of calculating the limitations on the first and second tier Maximum Fallowing Commitments specified in the Landowner Participation Offer in the same manner as specified in subsection 3.2.2.4 for the description of the land; and (4) designate a single landowner as agent for the group for all purposes in connection with the Landowner Participation Offer other than execution of the Landowner Agreement and other instruments required in connection with the Landowner Agreement.

3.5.3 The Maximum Fallowing Commitment and annual fallowing requirements for the group shall be determined with respect to the aggregate of Program Qualified Land owned by all landowners signing the Landowner Participation Offer, and Program Encumbered Land under the Landowner Agreement may be designated on Program Qualified Land of any one or more of the Participating Landowners. References to "landowner" and "Participating Landowner" in this Program Agreement and in the Landowner Agreements shall be deemed to refer to all landowners and Participating Landowners in the group collectively, and references to Program Qualified Land owned by a landowner or a Participating Landowner shall be deemed to refer to the aggregate Program Qualified Land owned by all landowners and Participating Landowners in the group collectively.

3.5.4 There shall be a single Landowner Agreement for each group which shall designate a single Participating Landowner as agent for all purposes under the Landowner Agreement, including designating and substituting Program Encumbered Land, receiving Fallowing Calls, making designations of Program Qualified Land to be fallowed, receiving all payments by Metropolitan, and giving and receiving notices and other communications to or from PVID and Metropolitan. The Participating Landowners in a group may change the Participating Landowner that is to act as agent for all Participating Landowners in the group by notice signed by all Participating Landowners in the group to PVID and Metropolitan. The change shall be effective on the tenth (10^{th}) day after the date on which the notice is given.

3.5.5 All landowners in a group whose Program Qualified Land is to be designated as Program Encumbered Land pursuant to subsection 3.2.4 (Metropolitan Approval of Proposed Program Encumbered Land) or may be substituted for Program Encumbered Land pursuant to subsection 3.7.8 (Substitution of Program Encumbered Land) shall be parties to the Landowner Agreement. In addition, each landowner who is not a party to the Landowner Agreement but who owns Program Qualified Land that is described in the Landowner Participation Offer for the group shall provide, as a part of the escrow under subsection 3.4.2 (Notice of Provisional Approval to Landowners; Documents for Delivery by Landowners into Escrow), a Participation Waiver, in recordable form, by which the landowner authorizes the use of that landowner's Program Qualified Land described in the Landowner Participation Offer for purposes of calculating the limitations on first and second tier Maximum Fallowing Commitments specified in the Landowner Participation Offer and irrevocably waives the right to have such land used for such purpose in connection with any other Landowner Participation Offer.

3.6 Subsequent Solicitation of Participation Offers

3.6.1 This subsection 3.6 (Subsequent Solicitation of Participation Offers) shall apply if and to the extent the Maximum Fallowing Commitments contained in provisionally approved Landowner Participation Offers aggregate approximately 26,500 water toll acres and (1) subsequently Landowner Agreements are executed for less than 26,500 water toll acres or (2) escrows are terminated pursuant to subsection 3.4.4 (Closure or Termination of Escrow).

3.6.2 If the conditions specified in subsection 3.6.1 occur, Metropolitan may utilize the portion of its own Maximum Fallowing Commitments reserved pursuant to subsection 3.2.3.3.1 to increase the aggregate Maximum Fallowing Commitments to the amount provisionally approved, provided that the percentage of Metropolitan's Maximum Fallowing Commitment shall not exceed the percentage of the highest approved Maximum Fallowing Commitment for other Participating Landowners. If, after Metropolitan has applied its reserved Maximum Fallowing Commitments, the aggregate Maximum Fallowing Commitments continues to be less than 26,500 water toll acres, the Parties will, on Metropolitan's request, solicit additional offers from PVID landowners for participation in the Program on terms essentially similar to those specified for Landowner Participation Offers under subsection 3.2 (Landowner Participation in Program) and otherwise consistent with this Program Agreement.

3.7 Fallowing of Program Qualified Land

3.7.1 Base Amount Fallowing

Except as provided in subsection 3.7.4.2 (Temporary Reductions), Participating Landowners shall fallow Program Qualified Land in an amount equal to twenty-five percent (25%) of the Participating Landowner's total Maximum Fallowing Commitment during each partial or full Contract Year occurring after the conditions precedent in the applicable Landowner Agreement have been satisfied or waived, such amount being referred to herein as "Base Amount."

3.7.2 Calls by Metropolitan for Additional Fallowing

Periodically during the term of this Program Agreement, Metropolitan shall, by notice, issue Fallowing Calls to Participating Landowners for fallowing of Program Qualified Land in addition to the applicable Base Amount. Metropolitan's Fallowing Calls shall be such that:

(1) For each Landowner Agreement in effect on termination of this Program Agreement, the annual average (based on Contract Years) of the lands required to be fallowed pursuant to subsection 3.7.1 (Base Amount Fallowing) and Fallowing Calls for all full Contract Years following the Operative Date will be an amount equal to at least forty-five and three-tenths percent (45.3%) of the landowner's Maximum Fallowing Commitment, adjusted for any temporary reductions pursuant to subsection 3.7.4.2 (Temporary Reductions); and

(2) Fallowed Land under each Landowner Agreement shall not exceed (i) an amount equal to the Maximum Fallowing Commitment in such agreement in any Contract Year and (ii) an amount equal to ninety and six-tenths percent (90.6%) of Maximum Fallowing Commitments in more than a total of ten (10) full Contract Years (consecutive or nonconsecutive).

Each Metropolitan Fallowing Call shall require fallowing for at least two full consecutive Contract Years. For a Fallowing Call that involves fallowing for the partial Contract Year in which the Conditions Precedent Notice is executed or deemed waived, the Fallowing Call shall require fallowing for only one (1) full Contract Year, in addition to the remainder of such partial Contract Year. A Fallowing Call once made may not be rescinded or diminished.

3.7.3 Notice of Fallowing Calls; Acreage Specification

Metropolitan shall give Participating Landowners notice of Fallowing Calls as follows: (1) concurrently with delivery of the notice to the Participating Landowner that the Landowner's Participation Offer has been provisionally accepted in accordance with subsection 3.4.2 (Notice of Provisional Acceptance to Landowners; Documents for Delivery by Landowners into Escrow) for fallowing that is to occur during the initial partial Contract Year, if any, and the first full Contract Year; and (2) at least one Contract Year in advance for fallowing that is to occur in subsequent Contract Years. Fallowing Calls issued by Metropolitan shall specify (1) the percentage of the Participating Landowner's Maximum Fallowing Commitment that the

Fallowed Land must equal, with the percentage being the same for all Participating Landowners, and (2) the amount of Program Qualified Land to be fallowed.

3.7.4 Special Fallowing Circumstances

3.7.4.1 Commencement of Fallowing Prior to First Full Contract Year

In response to the first Fallowing Call issued to a Participating Landowner by Metropolitan, the Participating Landowner shall not be required to begin to fallow any parcel of Program Qualified Land designated for Base Amount fallowing or for fallowing pursuant to the initial Fallowing Call by Metropolitan until the earlier of (1) the date on which any crop growing on such parcel as of the Effective Date of the Participating Landowner's Landowner Agreement has been harvested, or (2) one hundred twenty (120) days after the closing date of escrow for the Participating Landowner's Landowner Agreement.

3.7.4.2 Temporary Reductions

Participating Landowners may, for any Contract Year, request approval to reduce or eliminate land to be fallowed. Such approval may be given or denied by Metropolitan, in its sole discretion. Metropolitan shall promptly notify PVID of any such request, of Metropolitan's action on the request, and, if the request is granted to any extent, the identity by PVID Water Toll Number of the land withdrawn from fallowing.

3.7.5 Designation of Fallowed Land

3.7.5.1 Time and Manner of Designation

Participating Landowners shall give written notice to PVID and Metropolitan designating the parcels of Program Qualified Land to be fallowed pursuant to the Landowner Agreement as follows:

> (1) As to Program Qualified Land that will be fallowed to meet the Participating Landowner's obligation to fallow a Base Amount, and as to Program Qualified Land that will be fallowed to meet the Participating Landowner's obligation to fallow in response to Metropolitan's initial Fallowing Call, such notice shall be given at least thirty (30) days in advance of the date on which fallowing is to begin, and
>
> (2) As to Program Qualified Land to be fallowed to meet the Participating Landowner's obligation pursuant to a Fallowing Call, other than the first Fallowing Call, issued by Metropolitan, such notice shall be given at least sixty (60) days in advance of the date on which such fallowing is to begin.

All designations shall be made by the applicable PVID Water Toll Number, on forms provided by PVID and approved by Metropolitan, which forms shall authorize PVID and Metropolitan to enter the designated land for purposes of ascertaining whether it is being fallowed in accordance with the applicable Landowner Agreement. Any Participating Landowner's designation that includes land leased to the Participating Landowner shall be accompanied by a copy of the applicable lease(s). Participating Landowners may change any such designations with respect to land that has been fallowed for twelve (12) consecutive months by giving PVID and Metropolitan notice, sixty (60) days in advance of such change, specifying (1) the effective date of the change, (2) the Program Qualified Land that no longer will be fallowed, and (3) the Program Qualified Land that thereafter will be fallowed.

3.7.5.2 Land Designated for Fallowing

All land designated for fallowing under Landowner Agreements shall be (1) Program Qualified Land that otherwise would be irrigated, and (2) in parcels that are reasonably compact and are at least five (5) water toll acres in size.

3.7.6 Requirements for Fallowing

Participating Landowners shall fallow, or cause to be fallowed, all land designated for Base Amount fallowing pursuant to clause (1) of subsection 3.7.5.1 (Time and Manner of Designation) and, in accord with the applicable Metropolitan Fallowing Call, all land designated for fallowing pursuant to clause (2) of subsection 3.7.5.1 (Time and Manner of Designation). Participating Landowners shall comply with their obligations respecting fallowing by not undertaking or permitting the following activities on Fallowed Land: (1) growing of agricultural crops or any other vegetation; (2) application of water (other than rain that naturally falls on the Fallowed Land); (3) extraction of or application of groundwater; and (4) use or collection of surface water provided, however, that water may be utilized for dust control as permitted under the applicable Landowner Agreement. Participating Landowners shall also comply with those land management measures identified in the Final Program EIR and incorporated as an exhibit to the form of Landowner Agreement attached hereto as Exhibit A.

3.7.7 Limitations on Fallowing

No land shall be fallowed for purposes of the Program for more than five (5) consecutive Contract Years, provided that this requirement shall not apply to any Program Encumbered Land which Metropolitan is causing to be fallowed through the exercise of its rights under the Fallowing Easement applicable to such land on default in the performance of the Participating Landowner's fallowing obligations under the applicable Landowner Agreement.

3.7.8 Substitution of Program Encumbered Land

Participating Landowners may, subject to Metropolitan's approval given in the same manner as specified in subsection 3.2.4 (Metropolitan Approval of Proposed Program Encumbered Land), substitute other Program Qualified Land for Program Encumbered Land by giving notice to PVID and Metropolitan of the Participating Landowner's intent to do so. Such notice shall specify, by PVID Water Toll Number and legal description, the land proposed to be removed as Program Encumbered Land and the Program Qualified Land proposed to be substituted for it. Upon approval by Metropolitan it shall give the substituting Participating Landowner notice to that effect. The substitution shall be effective as provided in subsection 4.3 (Substitution of Program Encumbered Land) of the Landowner Agreement.

3.7.9 Re-conveyance of Program Encumbered Land

PVID and Metropolitan shall execute, deliver and record a re-conveyance of Fallowing Easements

(1) As to all Program Encumbered Land, within thirty (30) days after the termination of this Program Agreement, and

(2) As to land that is to be removed as Program Encumbered Land under subsection 3.7.8 (Substitution of Program Encumbered Land), promptly on receipt of, and concurrently with recording of, a Fallowing Easement for the substituted Program Encumbered Land.

3.7.10 Payment of Taxes, Tolls

Participating Landowners shall pay to PVID or ensure that there are paid all taxes, water tolls, standby charges, and assessments imposed by PVID on Program Qualified Land fallowed, and Program Encumbered Land owned, by them.

3.8 Forbearance by PVID

PVID shall not divert, take delivery of, authorize the diversion or use of, or transfer to third parties any Saved Water.

3.9 USBR Determination of Saved Water

It is the expectation of the Parties that USBR will determine the amount of Saved Water developed under Landowner Agreements and available for diversion by Metropolitan under its Federal Water Delivery Contract each calendar year. PVID and Metropolitan shall cooperate in gathering and furnishing to USBR information pertinent to this determination. The Parties shall use their best efforts to have USBR establish a methodology, acceptable to the Parties, that can be used both to estimate at the beginning of any Contract Year the amount of Saved Water that will be conserved under Landowner Agreements and to determine after the end of the Contract Year the amount of Saved Water that was conserved under Landowner Agreements. Metropolitan's and PVID's non-privileged data and records relative to the calculation of Program Saved Water shall be available to the other Party and the USBR for inspection and copying during their normal business hours in their respective headquarters, building or storage space.

3.10 Diversion of Saved Water by Metropolitan

The amount of water that will be available for diversion by Metropolitan by virtue of this Program Agreement will be the amount of Saved Water as determined by USBR less any conveyance losses determined by USBR, subject to any challenge by Metropolitan to the extent permitted by federal law and its Federal Water Delivery Contract. PVID makes no representations, warranties, or guaranties with respect to the amount of water available to Metropolitan by virtue of this Program Agreement.

4. Administration of Program

4.1 PVID Responsibilities

4.1.1 Data Base

PVID shall maintain a computerized data base management system to maintain current records of (1) Landowner Agreements, (2) Maximum Fallowing Commitments under Landowner Agreements, (3) parcels of Program Qualified Land designated by Participating Landowners for fallowing and changes in such designations, (4) Program Encumbered Land and substitutions for such land, (5) water orders by District landowners, and (6) delivery of water pursuant to such water orders.

4.1.2 Notice of Violations

PVID shall promptly notify Metropolitan of any apparent violations of Landowner Agreements such as irrigation of Fallowed Land.

4.1.3 Canal Breaks

PVID shall promptly repair any break in its canals that may inundate Fallowed Land and shall return the surface water, through pumping or otherwise, to either its drain or supply canals; and provide required weed control, if any, for Fallowed Land flooded by a canal break.

4.1.4 Provision of Data

PVID shall provide Metropolitan with related Program data including, but not limited to, water applied to Fallowed Land and other lands within PVID; and the listing and number of acres of crops grown within PVID.

4.1.5 Default Notification

PVID shall notify Metropolitan of any default by a Participating Landowner in payment of PVID water toll, standby charges or assessment fees.

4.1.6 Water Delivery

PVID shall terminate deliveries of water to land that is subject to a designation for fallowing pursuant to subsection 3.7.5 (Designation of Fallowed Land) to the maximum extent permitted by the configuration of PVID's water delivery system and in the same manner as PVID customarily curtails water deliveries to landowners that are delinquent in the payment of water tolls and assessments to PVID.

4.1.7 No Charges on Saved Water

Other than taxes, water tolls, standby charges, and assessments levied by PVID on land within the District, including Fallowed Land and Program Encumbered Land, PVID shall not levy any additional taxes, fees or other charges on Saved Water to be made available for diversion by Metropolitan.

4.2 Metropolitan Responsibilities

Metropolitan shall have exclusive responsibility for enforcing fallowing obligations under Landowner Agreements, including the prohibition against fallowing any parcel for more than five (5) years.

4.3 Allocation of Responsibilities by Parties

The Agreement Administrators may jointly from time to time, in writing and in the sole discretion of the Parties they represent, allocate responsibilities for administration of the Program not otherwise allocated in this Program Agreement between the Parties in a manner consistent with this Program Agreement.

4.4 Agreement Administrators

Metropolitan shall, at its own cost, retain a Metropolitan Agreement Administrator to coordinate its activities under this Program Agreement and the Landowner Agreements with PVID and to monitor, enforce, audit, and prepare reports regarding implementation of the Program as provided in this Program Agreement and the Landowner Agreements. PVID shall, as a Reimbursable Cost, retain a PVID Agreement Administrator to coordinate its activities under this Program Agreement and the Landowner Agreements with Metropolitan and to monitor, enforce, audit, and prepare reports regarding implementation of the Program as provided in this Program Agreement and the Landowner Agreements. PVID and Metropolitan each agrees to fully cooperate and to meet regularly with the Agreement Administrator of the other Party for purposes of sharing information and coordination of Program administration.

5. Payments

5.1 Payments by Metropolitan to Landowners

5.1.1 Metropolitan Obligation

All payments to be made by Metropolitan to a Participating Landowner under its Landowner Agreement shall be made by Metropolitan, and PVID will not have any obligation respecting such payments.

5.1.2 Initial Payment

Metropolitan shall make an initial payment to each Participating Landowner at a base rate of three thousand one hundred seventy dollars ($3,170.00) per water toll acre of its Maximum Fallowing Commitment. The initial payment shall be made in installments over a two to five year period as elected by each Participating Landowner in the Landowner Agreement, the amount of each installment being as specified in the form of Landowner Agreement attached hereto as Exhibit A.

5.1.3 Annual Payments

Each Contract Year Metropolitan shall make an annual payment to each Participating Landowner for each water toll acre of Program Qualified Land to be fallowed by it during the Contract Year. The annual payment (1) shall be at the rate of six hundred two dollars ($602.00) per water toll acre for the first full Contract Year, (2) thereafter shall be subject to adjustment as provided in the form of Landowner Agreement attached hereto as Exhibit A, (3) shall be pro-rated for any period in which fallowing occurs prior to the first full Contract Year, and (4) shall be subject to deductions for any water applied to Fallowed Land as provided more specifically in the form of Landowner Agreement attached hereto as Exhibit A. Annual payments for fallowing that is to occur prior to the first full Contract Year following the Operative Date shall be made within fifteen (15) days of the close of escrow, and for all subsequent Contract Years shall be made by September 1 of the Contract Year to which the payment relates.

5.2 Payments by Metropolitan to PVID

5.2.1 General Obligation

Metropolitan shall reimburse PVID for all Reimbursable Costs. Reimbursable Costs are costs reasonably incurred by PVID in (1) developing the Program, this Program Agreement, and the Landowner Agreement, provided that the amount of reimbursement for the cost of legal services shall not exceed $192,500.00, and (2) performing its obligations with respect to administration of the Program, this Program Agreement, and the Landowner Agreements. Reimbursable Costs shall include, without limitation, capital outlays for computers, computer programs, and other purposes, but shall not include costs incurred by PVID under subsection 4.1.3 (Canal Breaks) to repair any break in its canals.

5.2.2 Annual Budget

5.2.2.1 PVID and Metropolitan shall jointly develop, through their respective Agreement Administrators, a budget for the Reimbursable Costs the Parties anticipate PVID will incur during each partial and full Contract Year (the "Reimbursable Cost Budget"). The Parties shall develop the Reimbursable Cost Budget for the initial partial Contract Year within fifteen (15) days after the Effective Date and thereafter by June 1 prior to the beginning of each full Contract Year or at such other date as the PVID and Metropolitan Agreement Administrators may agree.

5.2.2.2 If the PVID and Metropolitan Agreement Administrators cannot agree on all elements of a Reimbursable Cost Budget, then the Parties shall proceed as follows.

(1) The Agreement Administrators shall identify in writing the administrative responsibilities as to which there is agreement and the Reimbursable Cost Budget for such responsibilities (such budget being referred to herein as "Partial Reimbursable Cost Budget").

(2) The Agreement Administrators shall identify in writing those administrative responsibilities as to which there is disagreement and which are not required by this

Program Agreement to be performed by PVID. Metropolitan shall assume responsibility for performing such administrative responsibilities.

(3) The Agreement Administrators shall identify in writing (i) those administrative responsibilities as to which there is disagreement and which are required by this Program Agreement to be performed by PVID (such responsibilities being referred to herein as "Disputed Responsibilities") and (ii) the extent of the budget disagreement with respect to each, noting separately PVID's estimate of the proper Reimbursable Cost Budget for each such Disputed Responsibility (such estimate being referred to herein as the "PVID Disputed Responsibility Cost Budget") and Metropolitan's estimate of the proper Reimbursable Cost Budget for each such Disputed Responsibility (such estimate being referred to herein as the "Metropolitan Disputed Responsibility Cost Budget"). Neither Party may institute dispute resolution proceedings under section 8 (Remedies and Dispute Resolution) of this Program Agreement with respect to the proper budget for Disputed Responsibilities, provided that this provision is without prejudice to the right of either Party to institute dispute resolution proceedings with regard to the Parties' respective rights and obligations under subsection 5.2.1 (General Obligation) after the conclusion of the Contract Year in question in connection with the "Annual True-Up" provided for in subsection 5.2.4 (Annual "True Up") with regard to the Parties' respective rights and obligations under subsection 5.2.1 (General Obligation).

5.2.2.3 PVID shall use all reasonable efforts to remain within any Reimbursable Cost Budget adopted pursuant to subsection 5.2.2.1, any Partial Reimbursable Cost Budget adopted pursuant to clause (1) of subsection 5.2.2.2, and any PVID Disputed Responsibility Reimbursable Cost Budget under clause (3) of subsection 5.2.2.2 and shall notify Metropolitan whenever PVID has reason to believe it may exceed any such budget.

5.2.3 Annual Advance Payments

Metropolitan shall make advance payments to PVID to be applied to PVID's Reimbursable Costs for the initial partial Contract Year and for each subsequent Contract Year in an amount that, unless the Parties agree otherwise in writing shall be either (1) the amount of the Reimbursable Cost Budget adopted pursuant to subsection 5.2.2.1, or (2) the sum of any Partial Reimbursable Cost Budget adopted pursuant to clause (1) of subsection 5.2.2.2, and any Metropolitan Disputed Responsibility Reimbursable Cost Budget under clause (3) of subsection 5.2.2.2. The advance payment for the initial partial Contract Year shall be made within thirty (30) days after the Effective Date and shall be made on or before August 31 of each subsequent Contract Year.

5.2.4 Annual "True-Up"

By August 15 of each Contract Year and the August 31 following the Termination Date, PVID shall provide Metropolitan with a statement of the Reimbursable Costs incurred by PVID during the prior Contract Year (such statement being referred to herein as PVID's "Reimbursable Cost Statement") and the advance payments made by Metropolitan for that Contract Year. If such costs exceed the advance payment made by Metropolitan, Metropolitan shall pay such excess within thirty (30) days after presentation. If the advance payment exceeded such costs, the amount of such excess shall be credited to the advance payment due August 31 of the Contract Year, with any remaining excess returned to Metropolitan within thirty (30) days after the Reimbursable Cost Statement is due. Any payment by Metropolitan or credit or return by PVID shall be without prejudice to Metropolitan's right to dispute any element of PVID's Reimbursable Cost Statement pursuant to subsection 5.2.6 (Audit).

5.2.5 Record Keeping

PVID shall keep full, true and accurate records of all Reimbursable Costs incurred by PVID in accordance with generally accepted accounting practices.

5.2.6 Audit

Annually, Metropolitan may at its expense audit or cause to be audited PVID's Reimbursable Cost Statement and PVID's records relating to the statement. All costs reflected on any PVID Reimbursable Cost Statement shall be deemed to have been accepted by Metropolitan except to the extent Metropolitan institutes dispute resolution proceedings with respect to such statement pursuant to section 8 (Remedies and Dispute Resolution) of this Program Agreement within one year after the date on which PVID submitted the Reimbursable Cost Statement to Metropolitan under subsection 5.2.4 (Annual "True-Up").

6. Conditions Precedent

The effectiveness of the Landowner Agreements is subject to the satisfaction or waiver by both Parties of subsections 6.1 (Required Agreement) through 6.3 (Landowner Agreements), such being conditions precedent, on or before December 31, 2004. The conditions precedent shall be deemed to have been satisfied or waived unless either Party provides written notice to the other Party, on or before December 31, 2004, that any one of the conditions will not be timely met and will not be waived. In the event that the conditions precedent have been satisfied or waived prior to December 31, 2004, the Parties shall promptly execute Conditions Precedent Notices and deposit them into each open escrow in accordance with subsection 3.4.3.3 (Conditions Precedent Notice).

6.1 Required Agreement

The written agreement by CVWD, and IID, dated October 10, 2003, that these agencies will consent to Metropolitan's diversion and use of the Saved Water made available by virtue of this Program Agreement for the entire thirty-five (35) year term of this Program Agreement irrespective of conditions on the Colorado River, and that these agencies will not assert any claim or right under their Federal Water Delivery Contracts or otherwise to any of the Saved Water made available for diversion by Metropolitan by virtue of this Program Agreement, shall not have been revoked or amended on or before the date on which the remaining conditions precedent have been satisfied or waived.

6.2 No Litigation or Administrative Proceedings

No litigation or proceeding before a federal or state administrative agency shall be pending or, to the actual knowledge of either Party, be threatened which relates to this Program

Agreement or the subject matter hereof or which, if adversely determined, would materially and adversely affect the ability of the Parties, or either of them, to perform their respective obligations under this Program Agreement or which raises a question as to the validity of the Landowner Agreements. Without limiting the generality of the foregoing, no challenge to this Program Agreement or the Landowner Agreements under the California Environmental Quality Act, the National Environmental Policy Act, the California Endangered Species Act, or the Federal Endangered Species Act shall be pending.

6.3 Landowner Agreements

Landowner Participation Offers have been solicited from all owners of Priority 1 Land and Landowner Agreements and related documents with Maximum Fallowing Commitments aggregating at least 13,250 water toll acres have been deposited into escrow pursuant to subsections 3.4.2 (Notice of Provisional Acceptance to Landowners; Documents for Delivery by Landowners into Escrow) and 3.4.3.1 (Executed Counterparts of the Landowner Agreement).

7. Representations and Warranties

7.1 Representations and Warranties of PVID

As a material inducement to Metropolitan to enter into this Program Agreement, PVID represents, warrants, and covenants as follows:

7.1.1 Power and Authority

PVID is a special district duly organized and validly existing under the laws of the State of California. The execution and delivery hereof to Metropolitan and the performance by PVID of its obligations hereunder will not violate the terms or provisions of any agreement, document or instrument to which PVID is a party or by which PVID is bound.

7.1.2 Authorization; Valid Obligation

Subject to satisfaction or waiver of all the Conditions Precedent specified in subsections 6.1 (Required Agreement) through 6.3 (Landowner Agreements), all proceedings required to be taken by or on behalf of PVID to authorize it to make, deliver and carry out the terms have been duly and properly taken.

7.1.3 No Litigation

To PVID's actual knowledge, there is no litigation or administrative proceeding described in subsection 6.2 (No Litigation or Administrative Proceedings) to which PVID is (or, with respect to threatened litigation, would be) a party.

7.2 Representations and Warranties of Metropolitan

As a material inducement to PVID to enter into this Program Agreement, Metropolitan represents, warrants and covenants as follows:

7.2.1 Power and Authority

Metropolitan is a metropolitan water district, duly organized and validly existing under the laws of the State of California. The execution and delivery hereof by Metropolitan and the performance by Metropolitan of its obligations hereunder will not violate the terms or provisions of any agreement, document or instrument to which Metropolitan is a party or by which Metropolitan is bound.

7.2.2 Authorization; Valid Obligation

Subject to satisfaction or waiver of all the Conditions Precedent specified in subsections 6.1 (Required Agreement) through 6.3 (Landowner Agreements), all proceedings required to be taken by or on behalf of Metropolitan to authorize it to make, deliver and carry out the terms of this Program Agreement have been duly and properly taken.

7.2.3 No Litigation

To Metropolitan's actual knowledge, there is no litigation or administrative proceeding described in subsection 6.2 (No Litigation or Administrative Proceedings) to which Metropolitan is (or, with respect to threatened litigation, would be) a party.

8. Remedies and Dispute Resolution

8.1 Remedies of Metropolitan

In the event PVID fails to perform any of the obligations of PVID under this Program Agreement, Metropolitan shall have the remedies through binding arbitration: (1) of recovery and/or offset of amounts advanced, or to be advanced, under subsection 5.2.3 (Annual Advance Payments); or (2) to compel PVID to specifically perform its obligations under this Program Agreement. Under no circumstances shall PVID be required to pay indirect or consequential damages to Metropolitan.

8.2 Remedies of PVID

In the event Metropolitan fails to perform any of its obligations, or fails to make any payment due to PVID, under this Program Agreement, PVID shall have the remedies through binding arbitration: (1) for a failure to pay monies due to PVID, suspending all performance hereunder until payment is made; (2) to compel Metropolitan to specifically perform its obligations under this Program Agreement; or (3) of a monetary award for amounts determined to be owing to PVID pursuant to this Program Agreement.

8.3 Limitation on Remedies

No Party shall be entitled to seek any remedy for a breach of, or default under, this Program Agreement by the other Party unless (1) such Party has first given written notice specifically stating the alleged breach or default, (2) the Party claimed to be in default fails to cure the default within ten (10) days of receipt of such written notice as to alleged breaches of the obligation to pay money and thirty (30) days of receipt of such written notice as to all other alleged breaches, and (3) the Parties have attempted to resolve their dispute respecting such asserted breach or default as provided in subsections 8.4 (Negotiation) and 8.5 (Resolution by Executives).

8.4 Negotiation

If a Party gives notice of breach or default under subsection 8.3 (Limitation on Remedies) and the other Party disputes any aspect of such notice, representatives of the Parties below the level of chief executive officer authorized to settle the matter shall meet within thirty (30) days of such notice and attempt to negotiate a resolution of the issues in dispute.

8.5 Resolution by Executives

If Party representatives are unable to resolve a notice of breach or default within thirty (30) days of negotiation commencement, the chief executive officer of Metropolitan and general manager of PVID, or comparable officials, shall meet within thirty (30) days thereafter to endeavor to resolve the dispute. The obligations imposed by this subsection on the Parties' chief executive officer and general manager, respectively, may not be delegated.

8.6 Arbitration

If the claim is not resolved within sixty (60) days after negotiation commences, either Party may submit to binding arbitration as provided in this subsection 8.6 (Arbitration) and in the California Arbitration Act (Part 3 [commencing with §1280], Title 9, California Code of Civil Procedure), including section 1283.05.

8.6.1 Selection of Arbitrators

The Parties may agree on a sole arbitrator. In the absence of such agreement, the Parties agree on a three-member panel to be selected as follows:

(a) One member shall be selected by PVID;

(b) One member shall be selected by Metropolitan; and

(c) The third member shall be selected by the other two members of the panel.

If the two members selected by Metropolitan and by PVID are unable to agree on the selection of a third member, either Party may petition a court to appoint the third member pursuant to Code of Civil Procedure section 1281.6. Two votes shall be required for any decision by the panel.

8.6.2 Arbitration Fees and Expenses

Each Party shall be responsible for any fees and expenses of the member of the panel appointed by that Party, and the fees and expenses of the third member of the panel (or of the sole arbitrator if there is only one) shall be shared fifty percent (50%) by PVID and fifty percent (50%) by Metropolitan. Each Party shall bear its other costs of arbitration.

8.6.3 Award of Arbitration Panel

The arbitration panel may order any relief specified in this section 8 (Remedies and Dispute Resolution), and not otherwise. The award of the panel (including orders and directives contained therein) shall be judicially enforceable.

9. Miscellaneous Agreements

9.1 Non-Waiver

None of the provisions of this Program Agreement shall be considered waived by any of the Parties unless such waiver is given in writing. The waiver of a breach of any term or condition of this Program Agreement shall not be deemed to constitute the waiver of any other breach of the same or any other term or condition.

9.2 Effect of Agreement

Nothing in this Program Agreement shall affect other rights and obligations of Metropolitan or PVID pursuant to applicable law or regulations, or separate agreements, except as expressly provided herein. The Parties do not intend to create rights in or to grant remedies to any third party or others as a beneficiary of this Program Agreement or of any duty, covenant, obligation or undertaking established hereunder.

9.3 Governing Law

This Program Agreement shall be interpreted in accordance with, governed by and construed under the laws of the State of California and any applicable federal laws without giving effect to any choice-of-law or conflicts-of-laws rule or principles that would result in the application of the laws of any other jurisdiction.

9.4 Assignment

Neither Party may assign, delegate, or otherwise transfer this Program Agreement, any interest therein, or the Party's rights or obligations under this Program Agreement without the prior written consent of the other Party, which consent may be withheld at such other Party's absolute discretion. Any such purported assignment or transfer shall be void and without effect.

9.5 Metropolitan Indemnity

Metropolitan shall defend, indemnify and hold PVID harmless from and against all claims asserted by a third party (or parties) for direct or indirect damages, losses, judgments, costs and expenses arising out of an act or omission of Metropolitan, its employees or agents in the performance of its obligations under this Program Agreement. Metropolitan shall also defend, indemnify and hold PVID harmless from and against all claims asserted by third parties arising out of or in connection with this Program Agreement or its validity. PVID shall have the right of reasonable approval of any counsel retained by Metropolitan pursuant to this subsection.

9.6 Insurance

PVID shall, at Metropolitan's request, acquire, at Metropolitan's expense, commercial general liability and comprehensive automobile liability insurance in form and from insurers acceptable to the other, naming Metropolitan, its board of directors, officers, and employees as additional insureds.

9.7 Notice Procedures and Designation of Mailing Address

All notices, requests, demands and other communications under this Program Agreement must be (1) in writing, (2) delivered in person or sent by certified mail, postage prepaid, overnight delivery, or facsimile transmission, and (3) dated as of the day the notice is delivered or sent. Notices relating to a breach of, or default under, this Program Agreement shall be addressed as follows:

If to PVID:

General Manager
Palo Verde Irrigation District
180 West 14th Avenue
Blythe, California 92225
Facsimile number: (760) 922-8294

If to Metropolitan:

Chief Executive Officer
The Metropolitan Water District of Southern California
Post Office Box 54153 (for certified mail)
700 North Alameda Street (for overnight delivery)
Los Angeles, California 90054-0153
Facsimile number: (213) 217-5704

All other notices shall be addressed as follows:

If to PVID:

General Manager
Palo Verde Irrigation District
180 West 14th Avenue
Blythe, California 92225
Facsimile number: (760) 922-8294

If to Metropolitan, to the designated Agreement Administrator as follows:

Fadi Kamand, Agreement Administrator
The Metropolitan Water District of Southern California
Post Office Box 54153 (for certified mail)
700 North Alameda Street (for overnight delivery)
Los Angeles, California 90054-0153
Facsimile number: (213) 830-4557

Any Party may change the person or address to which notice or communication is forwarded upon ten (10) days written notice to the other Party. All notices and other communications required or permitted under this Program Agreement which are addressed as provided in this subsection are effective (1) upon delivery, if delivered personally, (2) upon delivery, if delivered by overnight mail or certified mail and confirmed in writing by the delivery service or by return receipt, and (3) upon delivery, if delivered by facsimile and written confirmation is received by the addressee's facsimile machine, provided that any notice given by facsimile shall be deemed received on the next business day if it is received after 4:30 pm Pacific time or on a nonbusiness day.

9.8 Construction of Agreement

The language in all parts of this Program Agreement shall be in all cases construed simply according to its fair meaning and not strictly for or against any of the Parties hereto and section 1654 of the Civil Code has no application to interpretation of this Program Agreement. If the day on which performance of any act or the occurrence of any event hereunder is due is not a business day, the time when such performance or occurrence shall be due shall be the first business day occurring after the day on which performance or occurrence would otherwise be due hereunder. All times provided in this Program Agreement for the performance of any act are to be strictly construed, time being of the essence of this Program Agreement.

9.9 Amendment

Neither this Program Agreement nor any provision hereof may be waived, modified, amended, or discharged, except by an instrument in writing signed by both Parties, and then only to the extent set forth in such writing.

9.10 Entire Agreement

This Program Agreement and the agreements provided herein constitute the entire understanding between the Parties with respect to the matters set forth herein and supersede all prior or contemporaneous understandings or agreements among the Parties with respect to the subject matter hereof, whether oral or written. This Program Agreement may not be modified or amended except in writing executed by the Parties.

9.11 Cumulative Rights; Waiver

The rights created under this Program Agreement, or by law or equity, shall be cumulative and may be exercised at any time and from time to time. No failure by any Party to exercise, and no delay in exercising, any rights shall be construed or deemed to be a waiver thereof, nor shall any single or partial exercise by any Party preclude any other or future exercise thereof or the exercise of any other right. Any waiver of any provision or of any breach of any provision of this Program Agreement must be in writing, and any waiver by any Party of any breach of any provision of this Program Agreement shall not operate as or be construed to be a waiver of any other breach of that provision or of any breach of any other provision of this Program Agreement. The failure of any Party to insist upon strict adherence to any term of this Program Agreement on one or more occasions shall not be considered or construed or deemed a waiver of any provision or any breach of any provision of this Program Agreement or deprive that Party of the right thereafter to insist upon strict adherence to that term or provision or any other term or provision of this Program Agreement. No delay or omission on the part of any of the Parties in exercising any right under this Program Agreement shall operate as a waiver of any such right or any other right under this Program Agreement.

9.12 Severability

In the event that a court of competent jurisdiction determines that a provision included in this Program Agreement is legally invalid, illegal or unenforceable, and such decision becomes final, such provision shall be deemed to be severed and deleted from this Program Agreement and the balance of this Program Agreement shall be reasonably interpreted so as to effect the intent of the Parties hereto. The Parties further agree to replace such void or unenforceable provision of this Program Agreement with a valid and enforceable provision that will achieve, to the extent possible, the economic, business and other purposes of the void or unenforceable provision.

9.13 Counterparts

This Program Agreement and any amendment thereto may be executed in two or more counterparts, and by each Party on a separate counterpart, each of which, when executed and delivered, shall be an original and all of which together shall constitute one instrument, with the same force and effect as though all signatures appeared on a single document. Any signature page of this Program Agreement or of such an amendment, may be detached from any counterpart without impairing the legal effect of any signatures thereon, and may be attached to another counterpart identical in form thereto but having attached to it one or more additional signature pages. In proving this Program Agreement or any such amendment, it shall not be necessary to produce or account for more than one counterpart thereof signed by the Party against whom enforcement is sought.

9.14 Further Assurances

Each Party hereto, upon the request of another Party, agrees to perform such further acts and to execute and deliver such other documents as are reasonably necessary to carry out the provisions of this Program Agreement.

9.15 Opinions and Determinations

Where the terms of this Program Agreement provide for an action or decision to be based upon the approval, review, or determination of a Party, in other than its sole discretion, such terms are not intended to be and shall be not be construed as permitting such opinion, judgment, approval, review or determination to be arbitrary, capricious, or unreasonable.

9.16 Ambiguities

Each Party has participated fully in the drafting of this Program Agreement. A rule of construction to the effect that ambiguities are to be resolved against the drafting Party is not to apply in interpreting this Program Agreement, including any amendments or modifications.

9.17 Pending and Late Arising Claims

If a claim arising under or with respect to one or more terms of this Program Agreement has not been resolved when such term terminates, or if such a claim is brought after this Program Agreement has terminated but within the period of time for bringing such a claim under California law ("Late Arising Claim"), the applicable provisions of this Program Agreement shall continue in full force and effect for such additional period of time for the purpose only of resolving such claims and to satisfy the rights and obligations of the Parties hereto with respect thereto.

IN WITNESS WHEREOF, the Parties have caused this Program Agreement to be executed by their respective duly authorized representatives as of the date first set forth hereinabove.

PALO VERDE IRRIGATION DISTRICT

By: ______________________
Edward W. Smith
General Manager

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

By: ______________________
Ronald R. Gastelum
Chief Executive Officer

APPROVED AS TO FORM:

By: ______________________
Jeffrey Kightlinger
General Counsel