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Colorado Water Conservation Board
Department of Natural Resources

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**TO:** Colorado Water Conservation Board Members

**FROM:** Pete Conovitz, Water Resource Specialist
Stream and Lake Protection Section

**DATE:** September 20, 2022

**AGENDA ITEM:** 6a. Proposed Water Use Agreement with the Colorado River District to Lease Ruedi Reservoir Water for Winter Instream Flow Use in the Fryingpan River, Water Division 5 (Pitkin and Eagle Counties)

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## Staff Recommendation

No formal action is required at this time.

Pursuant to Rule 6b. of the Rules Concerning the Colorado Instream Flow and Natural Lake Level Program ("ISF Rules"), the Board's consideration of this proposal at this meeting will initiate the 120-day period for Board review. The initial presentation of this proposal provides an opportunity for the Board and the public to identify questions or concerns that Staff will address at this or a subsequent meeting.

## Introduction

The Colorado River Water Conservation District, acting through its Colorado River Water Projects Enterprise ("District"), has offered to lease 3041 acre-feet of water that the District holds in Ruedi Reservoir to the Colorado Water Conservation Board ("CWCB") for winter instream flow ("ISF") use in the Fryingpan River. This would be the fourth of such leases with the District. This lease would be part of a new Water Use Agreement between CWCB and the District which would allow for up to four additional lease renewals.

Under the proposed lease, water would be released between January 1 and February 28, 2023 to maintain Fryingpan River flows up to a rate of 65 cfs. These flows will help prevent the formation of anchor ice during periods of cold air temperature and low streamflow. CWCB would use the leased water to supplement its existing decreed ISF water right to preserve and improve the natural environment to a reasonable degree on the Fryingpan River. After April 1, any unused water would be released to help meet U.S. Fish and Wildlife Service ("USFWS") target

flows for critical habitat in the 15-Mile reach of the Colorado River. A Location Map is attached as **Exhibit A**.

In addition to the proposed CWCB lease, the Colorado Water Trust (CWT) is also seeking to lease an additional 825 acre-feet from the District to in order maintain 65 cfs in the Fryingpan River between December 15 and January 1. This CWT lease would allow for anchor ice releases to begin two weeks earlier than would be possible under the CWCB lease alone; the District's Ruedi Reservoir contract with the Bureau of Reclamation does not allow for CWCB winter releases to be made before January 1. This CWT lease is not subject to CWCB approval but is mentioned to highlight additional stakeholder contribution towards an overall wintertime ISF release program on the Fryingpan River. In combination, the CWCB and CWT lease would make a total of 3,865 acre-feet available for wintertime ISF releases.

## Procedure and Timeline for Short Term Loan Acquisition

ISF Rule 6. governs the Board's procedures for acquiring water for ISF use, including short term acquisitions. Section 37-92-102(3), C.R.S. provides up to 120 days for the Board to determine what terms and conditions it will accept in an acquisition agreement for water, water rights, or interests in water to preserve or improve the natural environment. A minimum of two Board meetings is required to allow for public input prior to taking final action on a proposed acquisition. The Board's initial consideration of this proposal at this September 2022 meeting initiates the 120-day time period for the Board to consider the terms and conditions of the proposed acquisition. Final action on the proposal, including approval of the lease and Water Use Agreement, could occur at the November 2022 Board meeting. Any person may request the Board to hold a hearing on the proposed acquisition, and that such request must be filed within twenty days of this September Board meeting.

As required by statute, CWCB staff requested recommendations from the CPW, the U.S. Department of Agriculture, and the U.S. Department of Interior. Pursuant to ISF Rule 6m.(1), CWCB staff provided notice of the proposed acquisition to all persons on the appropriate ISF Subscription Mailing Lists, and provided notice to the State Engineer's Substitute Supply Plan Notification List for Water Division 5.

## Background

While anchor ice formation is a natural winter occurrence in northern hemisphere streams, it can have significant impacts on stream hydrology and ecology. Anchor ice formation occurs during cold temperatures when ice particles suspended in the water column grow and attach to the channel substrate. In addition to obstructing water flow, the ice occupies and disrupts fish and macroinvertebrate habitat. During break up, ice can scour the channel bottom and transport macroinvertebrates down river, which can impact the forage base for trout and other fish species.

In 2018, the District worked with the Roaring Fork Conservancy ("RFC") to evaluate supplementing instream flows in the Fryingpan River below Ruedi Reservoir in winter. Studies have suggested that winter flows between 60-70 cfs, 21-31 cfs above the decreed ISF rate of

39 cfs (November 1 – April 30), would benefit the natural environment by preventing and/or mitigating the effects of anchor ice.

Based upon those studies and a recommendation from Colorado Parks and Wildlife ("CPW"), the District and CWCB entered into a one-year lease agreement in 2018 for 3,500 acre-feet of stored water. Operation of that lease in 2019 provided an additional 26 cfs between January 1 and March 7 to maintain flows in the Fryingpan River flows up to 70 cfs. These releases were observed to help mitigate the effects of anchor ice formation. A portion of the leased water that remained in storage after April 1 (299 acre-feet) was released to the 15-Mile reach in later September of that year.

In 2020, the District and CWCB entered into a second lease for 3,500 acre-feet of water for ISF use on the Fryingpan River and 15-mile reach. Operation of that lease again provided additional flows up to a 70 cfs target rate from January 1, 2021 – February 28, 2021. A third lease was implemented in 2022 for 1,750 acre-feet and water was released between February 1 and March 18.

## Discussion

This year the District has offered to lease up to 3041 acre-feet of Ruedi Reservoir water for winter instream flow use and anchor ice mitigation. The three previous leases were structured as individual one-year contracts not subject to renewal. This year, CWCB and the District are proposing to structure the lease as part of a broader Water Use Agreement that would allow for four additional renewals, not to exceed 3500 acre-feet in any given year. A draft Water Use Agreement is attached as **Exhibit B**.

ISF Rule 6e requires the Board to evaluate the appropriateness of the acquisition and to determine how best to utilize the acquired water to preserve or improve the natural environment. ISF Rules 6e and 6f describe the Board's evaluation process, including specific factors that the Board must consider in determining the appropriateness of an acquisition. Information that the Board may use to evaluate the proposed lease is included below:

### *Amount and Source of Water Proposed for Lease*

The water rights proposed to be leased to the CWCB for use in 2023 include 3041 acre-feet of water available to the District in Ruedi Reservoir pursuant to its Ruedi Reservoir Round II Water Sales Contract No. 079D6C0106 that could be delivered to the Fryingpan River in Pitkin and Eagle Counties ("Leased Water"). The contract includes an explicit term that the water may be used "…to supplement winter instream flows in the Fryingpan River." After April 1, 2023 any remaining Leased Water could be delivered pursuant to the River District's Ruedi Reservoir Round II Water Sales Contract No. 139D6C0101. That contract authorizes municipal uses in the Colorado River Basin; the contract's definition of "municipal uses" includes "use of water by . . . piscatorial users, including delivery of water to supplement streamflow . . ." Ruedi Reservoir is decreed for several types of use: irrigation, domestic, municipal, generation of electrical energy, stockwatering, industrial, piscatorial, recreation, and other beneficial uses.

*Location of Use*

The reach of stream proposed for use of the Leased Water is the Fryingpan River from its confluence with Rocky Fork Creek, adjacent to the outlet of Ruedi Reservoir, down to its confluence with the Roaring Fork River in Pitkin and Eagle Counties. Any remaining Leased Water would be used on the 15-Mile Reach of the Colorado River. The reaches are described below and shown on **Exhibit A**.

*Existing ISF Water Rights*

The CWCB currently holds ISF water rights on the following reaches of the Fryingpan and Colorado Rivers on which it would use the Leased Water (Table 1):

**Table 1. Existing ISF Water Rights**

| Case No. | Stream | Segment | Length | Amount (Dates) | Appropriation Date |
|---|---|---|---|---|---|
| W-1945 (1973) | Fryingpan River | confl Rocky Fork Creek to confl Roaring Fork River | Approx. 14 miles | 39 cfs (11/1 - 4/30) 110 cfs (5/1 - 10/31) | 07/12/1973 |
| 5-92CW286 | Colorado River (15 mile reach) | Tailrace of Grand Valley Pumping Plant to confl Gunnison River | Approx. 15 miles | 581cfs (7/1-9/30) | 3/5/1992 |
| 5-94CW330 | Colorado River (15 mile reach) | 27.5 Road Gage to confl Gunnison River | Approx. 2 miles | 300 cfs (7/1-9/30) | 11/4/1994 |

*Natural Flow Regime*

The Fryingpan River originates in the central Rocky Mountains of Colorado northeast of Aspen in Pitkin County. The headwaters of the Fryingpan River are at the Continental Divide in the Hunter Fryingpan Wilderness at an elevation of about 12,000 feet. Streamflow in the Fryingpan River is primarily from snowmelt and local precipitation and influenced by reservoir operations and transmountain diversions. The largest storage facility in the basin is the Bureau of Reclamation's Ruedi Reservoir, located in the lower portion of the watershed approximately 11 miles above the point at which the Fryingpan River flows into the Roaring Fork River near the town of Basalt. Peak flows typically occur in May, June, and early July and diminish down to base flows in July through September; streamflow is characteristically low and steady from November through March of most years. The watershed above Ruedi Reservoir is approximately 230 square miles with an extensive tributary network; several of these tributaries are diverted to the eastern slope via facilities associated with the Fryingpan - Arkansas project. The Fryingpan River below Ruedi Reservoir flows in a westerly direction through a confined canyon fed by only a few small tributary streams. The streamflow of the Fryingpan River in this canyon

is almost entirely made up of Ruedi Reservoir releases, especially during the winter months. The thermal effects of the reservoir releases create open water conditions virtually year round, making the river a very popular fishery for both local residents and visitors to the area.

The Colorado River originates in the southern Rocky Mountains of Colorado over 2 miles above sea level, flows past Glenwood Springs and Grand Junction, running parallel to I-70, and flows west out of Colorado into Utah. The 15-Mile Reach includes the portion of the river from the Grand Valley Diversion (River Mile 185.1) to the confluence with the Gunnison River in Grand Junction. Streamflow is primarily from snowmelt and local precipitation. Peak flows typically occur in May and June, and drop off quickly in July-September most years. Significant tributaries include the Blue, Eagle, and Roaring Fork Rivers.

*Existing Natural Environment*

The Fryingpan River is a Gold Medal trout fishery renowned for its abundant quality-sized trout, specifically a robust brown trout population and a burgeoning rainbow trout population recovering from the impacts of whirling disease. Mottled sculpin and aquatic invertebrates are the foundation of the diet that supports the Gold Medal fishery. The daily aquatic invertebrate hatches are well known for the consistency and timing such that anglers can "set their watches" to virtually guaranteed fish feeding frenzies and predictable conditions for dry fly fishing. The anglers drawn to this fishing opportunity provide a significant economic driver for local communities and the quality fishery is pivotal to the high quality of life for residents and visitors. Winter flow conditions below the reservoir and the thermal effects of the reservoir have, over time, created fairly predictable conditions for anchor ice formation when streamflow is below 60-70 cfs and when air temperatures are in the single digits.

The 15-Mile Reach of the Colorado River provides critical habitat for two species of endangered fish: the Colorado pikeminnow and razorback sucker. This reach is sensitive to water depletions because of its location downstream of several large diversions. It provides spawning habitat for these endangered fish species as well as high-quality habitat for adult fish.

Due to development on the Colorado River, this reach has experienced declining flows and significant dewatering during the late summer months, and at times there are shortages in the springtime. As a result, the USFWS has issued flow recommendations for the 15-Mile Reach since 1989 to protect instream habitat for the endangered fish.

*Proposed Method of Acquisition*

The lease being presently considered, in the amount of 3041 acre-feet, would be the first annual lease under the proposed Water Use Agreement between CWCB and the District. Under that Agreement, CWCB and the District could implement up to four additional short-term annual leases of Ruedi Reservoir water in an amount not to exceed 3,500 acre-feet for any given lease.

For the four remaining annual leases that could be implemented under the Water Use Agreement, the CWCB and District will meet no later than October 1 of each year to determine whether Ruedi Reservoir water will be available and in what amount. No minimum amount is

guaranteed in a given year and the decision to implement an annual lease shall be made mutually between the CWCB and the District. CWCB staff will request that the Board approve any annual lease and any accompanying funding request at a regularly scheduled Board meeting. The Agreement outlines the terms and conditions under which an annual lease is operated including accounting requirements as well as coordination with the District, CPW, The Bureau of Reclamation and Division of Water Resources on the timing, amount and administration of releases.

*Proposed Use of the Leased Water*

The Leased Water would supplement the existing ISF water right in the Fryingpan River to preserve and improve the natural environment. The objective of the lease would be to maintain Fryingpan River flows at a rate of 65 cfs to prevent the formation of anchor ice at times when temperatures and low flows could otherwise combine to create anchor ice. The proposed lease amount of 3041 acre-feet would be sufficient to maintain 65 cfs in the Fryingpan River from January 1 through the end of February.

After April 1, in an implementation year, any remaining Leased Water would be used to supplement existing ISF water rights in the 15-Mile Reach to preserve the natural environment, and to provide water to help meet or reduce shortfalls to the USFWS flow recommendations for the endangered fish critical habitat either during the "April Hole" period or during the summer and fall baseflow period. Releases to meet the USFWS flow recommendations that are in excess of the decreed ISF rates will improve the natural environment to a reasonable degree.

CPW has confirmed that the USFWS flow recommendations and related biological studies, developed in 1989, refined in 1995, and incorporated into the 1999 Programmatic Biological Opinion ("PBO") for the Upper Colorado River above its confluence with the Gunnison River, formed the basis for the ISF water rights held by the Board on the 15-Mile Reach of the Colorado River. Based upon the numerous actions of the State over the years supporting the Upper Colorado River Recovery Program and the PBO, and the ongoing need for water in the 15-Mile Reach, CPW recommends moving forward with this proposal and its letter of recommendation will be provided to the Board in advance of the September Board meeting.

*Historical Use and Return Flows*

Because this is a release of stored water and does not involve a change of water right, or other mechanism through which return flows would be owed, the Board does not need to consider this factor.

*Location of Other Water Rights and Potential Injury*

There are numerous water rights located on the Fryingpan River and Colorado River; however, they will not be affected by this release of stored water for ISF use on the Fryingpan River and delivery to and use on the 15-Mile Reach. Water previously stored in priority under the Ruedi Reservoir water rights would be released during times when temperature and flow conditions are conducive to the formation of anchor ice in the winter months, and when needed to

supplement flows in the 15-Mile Reach. Additionally, the proposed lease will not negatively affect any interstate compact.

*Stacking Evaluation*

When the Leased Water is available under this lease for ISF use on the Fryingpan River or made available for ISF use on the 15-Mile Reach, it can be used to supplement the Board's decreed ISF water rights and may be combined, or "stacked," with the existing ISF water right to achieve a greater level of protection for the natural environment and to help meet the USFWS flow targets for the endangered fish.

*Effect on Maximum Utilization of Waters of the State*

This proposed lease will promote maximum utilization of waters of the State by generating hydropower at the Ruedi power plant, supplementing winter instream flows on the Fryingpan River, supporting the recovery of endangered fish within the Upper Colorado River Basin, and making water available to downstream users.

*Availability for Downstream Use*

The Leased Water would be available for use by others below the confluence with the Roaring Fork River. Any remaining leased water released to the 15-Mile reach would be available for use by others below the confluence with the Gunnison River.

*Administration*

Communications with the Division 5 Division Engineer indicate that the release and delivery of the Leased Water from Ruedi Reservoir to and through the Fryingpan River and the 15-Mile Reach pursuant to an agreement between the District and the CWCB will be administrable.

*Cost to Complete Transaction*

The District determines the price per acre-foot annually according to its Water Marketing Policy for Colorado River Supplies. The District's current Water Marketing Policy establishes a lease price of $73.25 per acre-foot for in-channel use of Ruedi Reservoir water. Therefore the total transaction cost for a CWCB lease of 3,041 acre-feet would be $222,753.25.

It is anticipated that other project stakeholders will contribute matching funds towards both the CWCB and CWT lease amounts so the actual CWCB lease expenditure will likely be less than $222,753.25. A list of funding that has been tentatively identified as potential match for both the CWCB and CWT lease amounts is shown below:

| Entity/Source | Amount | Comment |
|---|---|---|
| Pitkin County Healthy Rivers | $50,000 | Approved by Advisory Board, needs BOCC approval |
| Colorado Water Trust | $30,000 | Earmarked for additional 825 AF CWT lease |

| | | |
|---|---|---|
| Roaring Fork Conservancy | $10,000 | Committed |
| Community Funding Partnership (Colorado River District) | $20,000 | Grant application to be submitted |
| Roaring Fork Fishing Guide Alliance | $1,000 | Committed |
| TOTAL | $111,000 | |

Additional stakeholder contributions in excess of the $111,000 dollar amount shown above may become available as well. More information on stakeholder cost sharing will be presented at the November Board meeting. Funding for any future leases under the proposed Water User Agreement will need to be annually authorized by the Board.

**Policy 19 Funding Request**

Because staff is requesting the Board to approve an expenditure of funds authorized by section 37-60-123.7, information required by CWCB's Financial Policy 19, which governs such expenditures, is set forth below:

*Financial Aspects of the Proposal*

The price for this lease is based upon the CRWCD's Water Marketing Policy, which sets a price of $73.25 per acre-foot for Ruedi water used in-channel in the Fryingpan and Roaring Fork Rivers to the confluence with the Colorado River. Costs related to negotiating and finalizing the lease agreement can be absorbed as part of the ordinary course of business of the CWCB staff. Consequently, staff will recommend that the Board authorize an expenditure of up to $222,753.25 for a 3,041 acre-foot lease. As mentioned above, the actual expenditure is likely to be less than this amount based on the anticipated availability of stakeholder contributions.

*Required Information from Colorado Parks and Wildlife*

Because the acquired water will be used to improve the natural environment to a reasonable degree on the Fryingpan River and on the 15-Mile Reach of the Colorado River, Policy 19 requires CPW to provide the following information regarding the subject ISF reaches:

**a.** The degree to which the acquired water will add useable habitat to riffles, pools and runs within the subject ISF reach; and **b.** the amount of additional useable area for fish and macroinvertebrates that the acquired water will provide:

> *Fryingpan River:* Flows up to 70 cfs resulting from the Leased Water will benefit brown trout adults and egg incubation over the winter. IFIM/PHABSIM studies show that flows up to 100 cfs provide benefits for brown trout adults and egg incubation and flows up to 250 cfs provide benefits for multiple life stages of rainbow trout. Additional site-specific studies have found that flows higher than 40 cfs are beneficial for invertebrates below Ruedi Reservoir, supporting a diverse food base for resident fish.

*15-Mile Reach:* Any remaining Leased Water above the decreed ISF flow rates will improve the natural environment by helping meet USFWS flow recommendations during low flow or baseflow conditions both before and after peak spring runoff. USFWS flow recommendations are based on IFIM/PHABSIM which models the relationship between flow and preferred habitat for the Colorado pikeminnow and razorback sucker. This modeling indicates that increases in preferred habitat are anticipated for any remaining Leased Water added to the 15-mile reach.

**c.** Where applicable, the amount of protection from high temperatures and low oxygen levels in hot summer months that the acquired water will provide:

*Fryingpan River:* Because Leased Water will be used in the Fryingpan River only in the winter, CPW concluded that this information is not relevant to this acquisition.

*15-mile Reach:* Because Leased Water will be used for warm-water fish species, CPW concluded that this information is not relevant to this acquisition.

**d.** An analysis of the degree to which the additional water resulting from the acquisition: (1) benefits the natural environment, and (2) does not result in hydraulic conditions that are detrimental to the aspects of the natural environment intended to be benefited by the acquired water, such as habitat requirements for a particular life stage of a fish species:

*Fryingpan River:* Flows up to 70 cfs resulting from the Leased Water will benefit brown trout adults and egg incubation over the winter. IFIM/PHABSIM studies show that flows up to 100 cfs provide benefits for brown trout adults and egg incubation and flows up to 250 cfs provide benefits for multiple life stages of rainbow trout.

*15-mile Reach:* Any remaining Leased Water above the decreed ISF flow rates will improve the natural environment by helping meet the USFWS flow recommendations. USFWS flow recommendations are based on PHABSIM/IFIM studies, which model the relationship between flow and preferred habitat, specifically showing where habitat is increasing and/or declining for adult Colorado pikeminnow and razorback sucker. USFWS flow recommendations vary by hydrologic year type, but seek to maximize preferred habitat without detrimental hydraulic conditions for the endangered fish.

**e.** Where applicable, an estimate of the degree to which the acquired water will increase moisture levels in the alluvial aquifer to support the riparian vegetation in the subject stream reach:

*Fryingpan River:* Because Leased Water will be used in the Fryingpan River only in the winter, CPW concluded that this information is not relevant to this acquisition.

*15-mile Reach:* Because Leased Water will be used for warm-water fish species, CPW concluded that this information is not relevant to this acquisition.

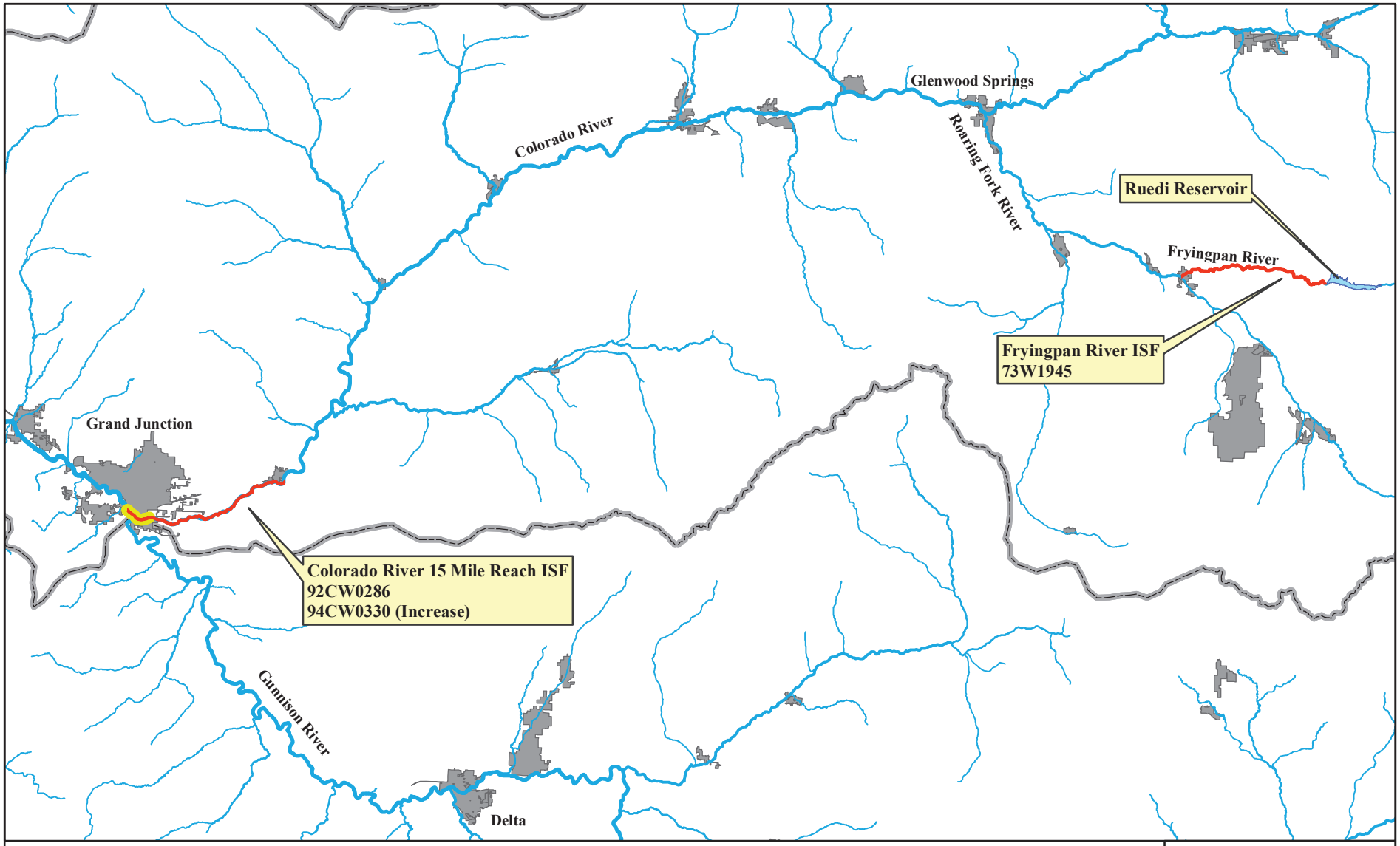
Additional information provided by CPW relevant to Policy 19 can be found in CPW's recommendation letter (to be provided in advance of this September Board meeting).

## Potential Benefits of This Proposed Lease

During the duration of this short-term lease when Leased Water is available for ISF use, such water will be protected through the subject reach of the Fryingpan River down to the confluence with the Roaring Fork River. The proposed acquisition would increase flows in the Fryingpan River and provide benefits to the fish species and aquatic community that live in this reach. In addition to mitigating the effects of anchor ice formation, CPW has observed that increased flows on the Fryingpan River during the winter months improve fish habitat, increase spawning success and fry emergence for brown trout and promote a more robust macroinvertebrate food base for fish. These observations confirm the results of previous studies that will also be described in CPW's letter of recommendation.

From December 2020 through March 2021, researchers from the RFC conducted a pilot study on the Lower Fryingpan River to better understand the parameters affecting anchor ice formation in the river **(Exhibit C)**. This study determined a correlation between anchor ice and water temperature, air temperature and streamflow. Observations during the study, and from previous years, suggest that additional streamflow releases from Ruedi Reservoir were effective in decreasing ice formation. The RFC is planning additional studies and monitoring to gather additional data on factors that control ice formation and the effect on river health. A letter of recommendation from the Roaring Fork Conservancy is attached as **Exhibit D**.

Additionally, releases will also increase the efficiency of hydropower production at the City of Aspen's hydropower plant located at the base of Ruedi Reservoir. Any remaining Leased Water will be used in the Colorado River and be protected through the 15-Mile Reach, down to the confluence with the Gunnison River. The proposed acquisition would increase stream flows in the Colorado River and provide benefits to the two species of endangered fish that live in this reach.

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September 20-21, 2022 CWCB Board Meeting. Exhibit A.
Agenda Item 6a: Proposed Water Use Agreement with the Colorado River District to Lease Ruedi Reservoir Water for Winter Instream Flow Use on the Fryingpan River, Water Division 5

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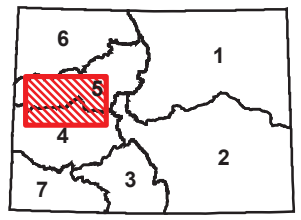


**DRAFT WATER USE AGREEMENT**

This Water Use Agreement ("Agreement") is entered into by and between the Colorado River Water Conservation District and the Colorado River Water Conservation District , acting by and through its Colorado River Projects Enterprise (collectively referred to as the "District"), and the Colorado Water Conservation Board, an agency of the State of Colorado ("CWCB"), Individually, "Party"; together, "Parties").

**RECITALS**

A. The CWCB is an agency of the State of Colorado whose mission is to conserve, develop, protect, and manage Colorado's water for present and future generations;
B. Pursuant to C.R.S. § 37-92-102(3) the CWCB may acquire water by contractual agreement for the purpose of preserving or improving the natural environment to a reasonable degree ("ISF Lease Program").
C. The District is a public agency whose mission is to lead in the protection, conservation, use, and development of the water resources of the Colorado River water basin for the welfare of the District, and to safeguard for Colorado all waters of the Colorado River to which the state is entitled.
D. The District has a perpetual contractual interest in 9,683.5 acre-feet of water stored in Ruedi Reservoir ("Ruedi Water") pursuant to Contract No. 07D6C0106 and Contract No. 139D6C0101 with the United States of America Department of Interior Bureau of Reclamation ("USBR Contracts", attached hereto as Exhibit A).
E. The CWCB holds an appropriated instream flow water right in the Fryingpan River decreed in Case No. W-1945 ("Fryingpan ISF Decree", attached hereto as Exhibit B) to preserve the natural environment to a reasonable degree by protecting flow rates up to 39 cfs on the reach of Fryingpan River extending from the confluence with Rocky Fork Creek to the confluence with the Roaring Fork River ("Fryingpan ISF Reach").
F. The CWCB also holds appropriated instream flow water rights on the Colorado River decreed in Case Nos. 92CW286 and 94CW330 ("Colorado River ISF Decrees, attached hereto as Exhibit C) to preserve the natural environment to a reasonable degree by protecting flow rates up to a cumulative total of 881 cfs within the 15-mile reach extending from the tailrace of the Grand Valley pumping plant to the confluence with the Gunnison River ("Colorado River ISF Reach").
G. Wintertime formation of anchor ice in the Fryingpan River below Ruedi Reservoir has been documented to adversely impact aquatic habitat in the Fryingpan River. Flows up to 70 cfs during the winter season have been shown to help prevent and mitigate the effects of anchor ice formation.
H. The District desires to lease Ruedi Water to the CWCB for use in both the Fryingpan ISF Reach and the Colorado River ISF Reach. The CWCB desires to accept temporary annual leases of the Ruedi Water for use in the Fryingpan ISF Reach and Colorado River ISF Reach ("Annual ISF Lease") subject to the terms of this Agreement.
I. The District's Water Marketing Policy requires that any lease of water in excess of 1,000 AF require Board approval.

NOW THEREFORE, in consideration of the mutual agreements contained herein and other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, CWCB and District agree as follows:

**Exhibit B**
**Agenda Item 6a**
**Sept 20, 2022**

**AGREEMENT**

1. **Incorporation**. The Parties hereby incorporate by this reference the recitals set forth above.

2. **Term**.
   2.1 Effective Date. This Agreement shall become effective on the date in which the Agreement is signed by the CWCB and District.
   2.2 Expiration Date. Unless otherwise terminated pursuant to the terms set forth herein, this Agreement shall automatically expire after five years after the implementation of the first annual lease.
   2.3 Renewability. The Parties may renew this to implement an additional five (5) Annual ISF Leases upon written agreement of the parties.

3. **Source and Use of Water**
   3.1 Source. The source of water to be used in an Annual ISF Lease shall be Ruedi Water stored and released from Ruedi Reservoir pursuant to the USBR Contracts
   3.2 Use. Ruedi Water shall be used for instream flow purposes exclusively within the Fryingpan ISF Reach between January 1 and March 31. Any releases made prior to January 1 must be made with permission from the District and U.S. Bureau of Reclamation and consistent with the terms of the Districts' USBR Contracts. Any Ruedi Water remaining after March 31 may be used to preserve and improve the natural environment to a reasonable degree within the 15-Mle reach of the Colorado River. Use of Ruedi Water in the ISF Lease Program may be made following generation of hydropower at the facility located at the Ruedi Reservoir dam.
   3.3 Rates of Flow for ISF Use. Releases of Ruedi Water for use in the Fryingpan ISF Reach between January 1 and March 31 shall be used to preserve and improve the natural environment up to a rate of 70 cfs. After March 31, releases of Ruedi Water may be used to preserve and improve the natural environment within the 15-Mile reach up to the target flow rates set by the U.S. Fish and Wildlife Service as part of the Upper Colorado Endangered Fish Recovery Program. Releases made to the 15-Mile reach shall not cause the overall release from Ruedi Reservoir to exceed 300 cfs or cause the flow rate in the Fryingpan River below Ruedi Reservoir to exceed 350 cfs.
   3.4 Volume. The amount of Ruedi Water available subject to this Agreement shall not exceed 3500 acre-feet annually unless provided for by a written amendment to this Agreement.

4. **Operation of ISF Lease**
   4.1 Decision to implement ISF Lease. No later than October 1 of each year, CWCB and the District shall meet and determine whether Ruedi Water will be available and in what amount. It shall be within the District's sole discretion as to the determination of whether Ruedi Water will be available and in what amount. No minimum amount of Ruedi Water is guaranteed in a given year. The decision to execute an Annual ISF Lease in a given year shall be made mutually between CWCB and the District. The CWCB may approve an Annual ISF Lease at a regularly scheduled Board Meeting.
   4.2 Delivery. CWCB shall submit a delivery schedule to the District and the Bureau of Reclamation prior to the operation of an annual ISF lease. The District shall be responsible for arranging the delivery of Ruedi Water at the outlet works of Ruedi Reservoir into the Fryingpan River consistent with the CWCB delivery schedule, provided that the releases can

be made within the operational limitations of Ruedi Reservoir as determined by the Bureau of Reclamation.

4.3 Operations and Coordination. The District and CWCB shall coordinate with the Roaring Fork Conservancy, Colorado Parks and Wildlife, the Bureau of Reclamation, and the U.S. Fish and Wildlife Service on the timing and rate of releases of Ruedi Water.

4.4 Exclusivity. The CWCB shall have the exclusive right to use the Ruedi Water for instream flow use to preserve and improve the natural environment to a reasonable degree, provided that the Ruedi Water will be used consistent with the District's BOR Contracts and in accordance with the Fryingpan-Arkansas Act and Operating Principles.

5. **Approvals and Accounting**

5.1 Division Engineer Confirmation. The CWCB must obtain approval from the Water Division 5 Engineer that the lease set forth in this Agreement is administrable.

5.2 Accounting. The Parties agree to communicate, coordinate and cooperate, if needed, on any required accounting as set forth by the Colorado Division of Water Resources or U.S. Bureau of Reclamation.

6. **Price and Payment Procedure** The District shall set the price per acre-foot of Ruedi Water annually consistent with its Water Marketing Policy for Colorado River Supplies. The total cost of an Annual ISF Lease shall be the amount of Ruedi Water to be leased, in acre-feet, multiplied by the price per acre-foot ("Lease Amount"). In order to implement an ISF Lease, CWCB must determine that adequate funding is appropriated and available. If the District and CWCB mutually agree to implement an Annual ISF Lease in a given year, and the CWCB has approved the ISF Lease at a regularly scheduled Board meeting, and the District has approved the lease amount at a regularly scheduled Board meeting, the District will send the CWCB an invoice in order for the CWCB to issue a Purchase Order for the Lease Amount.

7. **Termination**

7.1 This Agreement may be terminated upon mutual agreement of the Parties or as described herein.

7.2 Material Breach. Either Party may terminate this Agreement for a material breach of the terms of this Agreement by the other Party; provided that the terminating Party has first given at least sixty (60) days prior written notice specifying in detail such alleged material breach and giving the other Party the right within such sixty (60) day period to cure and remedy such alleged material breach. Breach of any annual lease under this Agreement is not a breach of this Agreement.

7.3 Ability to Perform Impaired. Either Party may terminate this Agreement if its legal ability to deliver Ruedi Water is materially impaired or is eliminated because of the termination or adverse modification of the BOR Contracts, permits, decrees, or other authorizations or legal or administrative findings that are necessary to deliver Ruedi Water; provided that the terminating Party has first given at least sixty (60) days prior written notice to the other Party specifying the issue and steps taken to resolve the issue.

7.4 Notice of Breach. Prior to commencing any action for enforcement of this Agreement, the Party seeking enforcement shall give the other Party no less than sixty (60) days prior

written notice specifying in detail the basis for the enforcement action and the desired outcome that would resolve the perceived need for enforcement.

8. **Remedies**.
   8.1 Available Remedies. Remedies under this Agreement are limited to remedies available under Colorado law.
   8.2 Costs and Fees. In the event of a dispute under this Agreement, each Party shall bear its own costs and fees, including attorney's fees.

9. **Force Majeure**. In the event either Party is unable to perform its obligations under the terms of this Agreement because of acts of God; natural disasters; epidemics; actions or omissions by governmental authorities; unavailability of supplies or equipment critical to perform; major equipment or facility breakdown; changes in Colorado or federal law, including, without limitation, changes in any permit; or other causes reasonably beyond that Party's control, such Party shall not be liable to the other Party for any damages resulting from such failure to perform or otherwise from such causes.

10. **Notices.** Any notice required or permitted to be given by a Party under or in connection with this Agreement shall be in writing and shall be deemed duly given when personally delivered or sent by: (a) registered or certified mail, return receipt requested, postage prepaid, (b) expedited courier service, or (c) email with confirmation of receipt, to the following:

If to CWCB:
Colorado Water Conservation Board
Attention: Chief, Stream and Lake Protection Section
1313 Sherman Street, Room 718
Denver, CO 80203
Email: dnr_cwcbisf@state.co.us

*With a copy to*:
CWCB ISF Program
Attention: Pete Conovitz
1313 Sherman St., Rm.718
Denver, CO 80203
Email: pete.conovitz@state.co.us

If to District:
Colorado River Water Conservation District, acting by and through its Colorado River Water Projects Enterprise
Attention: Brendon Langenhuizen
P.O. Box 1120
Glenwood Springs, CO, 81602
Email: blangenhuizen@crwcd.org

11. **Miscellaneous.**
   11.1 No Agency. Nothing in this Agreement will be construed as creating any agency, partnership, joint venture or other form of joint enterprise between the Parties.

Notwithstanding the foregoing, the CWCB or District may elect to designate an agent to undertake specific responsibilities under this Agreement. Should the CWCB or District elect to do so, it shall provide written notice to the other party of such designation including the identity of such agent; contact information for such agent, including a principle point of contact; and clearly defined description(s) of the responsibilities such agent shall undertake on behalf of the CWCB or District.

11.2 Heirs and Assigns. This Agreement shall inure to and be binding on the heirs, executors, administrators, successors, and permitted assigns of the Parties.

11.3 Choice of Law. This Agreement shall be construed in accordance with the laws of the State of Colorado, as amended, without reference to conflicts of laws.

11.4 No Waiver of Immunities. No term or condition of this Agreement shall be construed or interpreted as a waiver, express or implied, of any of the immunities, rights, benefits, protections, or other provisions, of the Colorado Governmental Immunity Act, C.R.S. § 24-10-101 et seq.

11.5 No Waiver. No waiver of any of the provisions of this Agreement shall be deemed to constitute a waiver of any other of the provisions of this Agreement, nor shall such waiver constitute a continuing waiver unless otherwise expressly provided herein, nor shall the waiver of any default or breach hereunder be deemed a waiver of any subsequent default or breach hereunder.

11.6 Assignment. This Agreement may be assigned by either Party upon the prior written consent of the other Party.

11.7 Amendment. No amendment, modification, or novation of this Agreement or its provisions and implementation shall be effective unless subsequently documented in writing that is approved and executed by both Parties with the same formality as they have approved and executed the original Agreement.

11.8 Severability. If any provision of this Agreement is held illegal or unenforceable in a judicial proceeding, such provision shall be severed and shall be inoperative, and the remainder of this Agreement shall remain operative and binding on the Parties.

11.9 Merger. This Agreement constitutes the entire Agreement between the Parties and sets forth the rights, duties, and obligations of each to the other as of the Effective Date. Any prior Agreements, promises, negotiations, or representations not expressly set forth in this Agreement are of no force and effect.

11.10 No Third-Party Beneficiaries. This Agreement does not and is not intended to confer any rights or remedies upon any person or entity other than the Parties. It is expressly understood and agreed that enforcement of the terms and conditions of this Agreement and all rights of action relating to such enforcement shall be strictly reserved to the Parties.

11.11 Headings. The headings contained in this Agreement are for reference purposes only and shall not affect the meaning or interpretation of this Agreement.

11.12 Non-Discrimination. The Parties will fulfill their obligations under this Agreement without discriminating, harassing, or retaliating on the basis of race, color, national origin, ancestry, sex, age, pregnancy status, religion, creed, disability sexual orientation, genetic

information, spousal or civil union status, veteran status, or any other status projected by applicable law.

11.13 Authority. Each Party represents that it has obtained all necessary approvals, consents, and authorizations to enter into this Agreement and to perform its duties under this Agreement; the person executing this Agreement on its behalf has the authority to do so; upon execution and delivery of this Agreement by the Parties, it is a valid and binding Agreement, enforceable in accordance with its terms; and the execution, delivery, and performance of this Agreement does not violate any bylaw, charter, regulation, law, or any other governing authority of that Party.

**[SIGNATURES TO FOLLOW]**

IN WITNESS WHEREOF, CWCB and CWT execute this Agreement on the dates set forth below.

**COLORADO WATER CONSERVATION BOARD**, an agency of the State of Colorado:

_____ Date: _____

Name: Rebecca Mitchell
Title: Director

**COLORADO RIVER WATER CONSERVATION DISTRICT,** acting by and through its Colorado River Water Projects Enterprise

Date: _____

Name: Andrew A. Mueller
Title: General Manager

**LIST OF EXHIBITS**

Exhibit A. USBR Contracts
Exhibit B. Fryingpan ISF Decree
Exhibit C. Colorado River ISF Decrees

# Fryingpan River Anchor Ice Report 2020-2021

Shaylyn Austin
Matthew P Anderson

ROARING FORK CONSERVANCY
Celebrating 25 years
Bringing People Together to Protect Our Rivers

**Exhibit C**
**Agenda Item 6a**
**Sept 20, 2022**

## Executive Summary

Stationary ice formation, a natural occurrence in northern hemisphere streams during winter, has significant impacts on the hydrology and ecology of a stream. From December 2020 through March 2021, Roaring Fork Conservancy researchers conducted a pilot study on the Lower Fryingpan River to better understand the parameters affecting anchor ice formation in the river. Anchor ice presence was observed 13 out of the 32 survey days. A decrease in anchor ice presence started in the second half of January 2021 and continued through the end of the study period. This decrease in anchor ice aligned with observed increases in water temperature, air temperature, and stream flow rate. Logistic regression modeling substantiated these observations with statistically significant results showing a negative correlation between those three independent variables and anchor ice presence. While the results from this initial period of anchor ice monitoring provides a strong basis for future studies, improvements can be made to protocol and methodology to strengthen the integrity of the data moving forward. Additionally, continuing the study for at least five more years will provide more evidence necessary to make definitive conclusions about the influence of water temperature, air temperature, and stream flow rate on anchor ice formation in the Lower Fryingpan River.

## Introduction

Ice formation in rivers occurs when water becomes supercooled, meaning it cools to below 0°C. Conditions for supercooling are sub-zero air temperatures, little to no surface ice, and turbulent water flow (Brown et al. 2011). Under these conditions tiny ice particles on the surface of the water can become suspended in the water column, forming frazil ice. From there, frazil ice grows and is transported to the streambed in turbulent water. Frazil ice attached to the channel bottom is called anchor ice, a form of stationary ice attached to the streambed (Brown et al. 2011).

Left: Anchor ice at Site 1 (in Basalt). Right: Anchor ice on boulders at Site 2 (near Mile Marker 1). Cover Page Photo: Anchor ice and border ice at Site 5 (near confluence of Fryingpan and Seven Castles Creek).

Anchor ice formation, a natural occurrence in northern hemisphere streams in the winter, has significant impacts on the hydrology and ecology of a stream. Anchor ice dams can obstruct water flow, as well as increase and decrease water levels, upstream and downstream, respectively. Additionally, anchor ice can occupy fish and macroinvertebrate habitat, forcing them to make energetically costly movements, and anchor ice release events or ice jam releases can carry sediments and invertebrates down river (Brown et al. 2011).

Ice jam releases also have implications for human safety and the integrity of infrastructure nearby the stream. Large ice jams can cause flooding upriver. Moreover, release of these large ice jams at high stream velocity can damage bridges or similar structures as well as severely harm anyone recreating in the river (Huokuna et al. 2017).

In winter, discharges from Reudi Dam have a noticeable effect on the thermal regime of the river, water level, and temporal and spatial characteristics of the stream flow. All of these are factors in anchor ice formation. In a study of North American rivers, Huokuna et al. (2017) found that greater discharges of warm water from reservoirs in the winter increased open water areas, therefore creating more area for frazil ice formation and subsequently more anchor ice formation in downstream river reaches (Huokuna et al. 2017). Ultimately, local river conditions, year-to-year weather conditions, and dam structure and operation determine the impact that reservoirs have on stream flow and ice formation.

It is important to understand the processes underlying anchor ice formation to better predict how the management of rivers will impact anchor ice formation and, subsequently, the hydrology and ecology of the river. These factors are especially pertinent to the Lower Fryingpan River as a Gold Medal Fishery. This report addresses how stream flow regulation by Ruedi Dam may be affecting ice formation within the Lower Fryingpan River in Basalt, CO. Findings from this study could help inform management decisions regarding future winter flow discharge out of Ruedi Dam.

## Research Goals

The goal of the Fryingpan River Anchor Ice Study 2020-2021 was firstly to establish and execute an objective-driven protocol for assessing anchor ice formation within the Lower Fryingpan River. Secondly, we hoped to better understand the factors that affect anchor ice formation within the river, as well as establish a temperature gradient for the study area.

## Predictions

It was hypothesized that anchor ice abundance would increase with distance from Reudi Dam, and be negatively correlated with water temperature, air temperature, and stream flow rate.

## Methods

*Study Area*

Surveys were conducted at six sites along the Lower Fryingpan River in Basalt, CO. The Lower Fryingpan River is the approximately 14 mile stretch of river downstream of Ruedi Dam that flows into the Roaring Fork River. Site 1 was chosen at a location directly above the Roaring Fork River confluence. The other five sites were chosen at approximately one-mile intervals leading upstream with Site 6 at the Taylor Creek confluence. Convenience of access was prioritized.

| Site | Latitude (N) | Longitude (W) | Elevation (ft.) |
|---|---|---|---|
| Site 1 | 39.36827 ° | 107.03179° | 6657 |
| Site 2 | 39.37517 ° | 107.01622° | 6730 |
| Site 3 | 39.37444° | 107.00636° | 6772 |

| | | | |
|---|---|---|---|
| Site 4 | 39.37507° | 106.98652° | 6875 |
| Site 5 | 39.37949° | 106.96993° | 6930 |
| Site 6 | 39.37617° | 106.94305° | 7040 |

**Table 1** Fryingpan River Anchor Ice Study survey sites. Sites are numbered from downstream to upstream.

Surveying took place over the course of four months, December 3, 2020 through March 31, 2021. Surveyors assessed ice characteristics at each site at least once per week on days following at least two consecutive nights of below 20°F air temperature. In order to ensure frequent surveying, seven survey events were conducted on days without two prior consecutive nights of sub 20°F, predominately later in the study period. A total of 32 surveys were conducted: nine in December, eight in January, eight in February, and seven in March.

*Physical Parameters*

The latitude, longitude, and elevation were recorded for each survey site. Additionally, water temperature and air temperature were recorded at each site for every survey event using a digital thermometer. Stream flow rate data for each survey event was collected from the USGS Gauge below Ruedi Reservoir. Previous weather history was collected from the NCDC weather history database using the Aspen Pitkin County Airport Sardy Field weather station.

*Observational Parameters*

Notes were taken on specific stream characteristics at each site that could affect ice formation, including relative stream velocity, water depth, exposure to sun, and any drastic changes in ice presence between surveys, among other observed characteristics

*Ice Surveying*

The percent coverage and thickness of anchor ice was visually estimated for each site. The type of anchor ice formation was recorded, including the relative size of the clumps and the density of distribution among them. When opportune, an anchor ice sample was taken from the riverbed by pulling off an intact piece the size of at least one fist, while wearing rubber gloves. The sample was then photographed, individual crystal length was measured using a ruler, and any sediment lodged within the sample was recorded. Additional ice formation types were also recorded. Border ice width, the distance of border ice from the river bank to the outer edge of the ice, was estimated at each site, as well as whether or not the border ice had been flooded. Presence of slush ice, or ice floating down the stream of the river, was also recorded. The

Anchor ice sample from Site 1 (in Basalt).

presence of anchor ice dams and anchor ice weirs were recorded at each site. If present, heights of anchor ice dams were estimated. Photographs and videos were taken at each site. Lastly, the time and location of any witnessed anchor ice release event was recorded using photographs, videos and written descriptions of the event.

## Results

*Overall Anchor Ice Presence and Coverage*

Anchor ice surveying took place 32 times from December 3, 2020 to March 31, 2021, resulting in 192 unique site visits. Out of the 32 survey days, anchor ice was observed 13 out of the 32 days, and out of the 192 unique site visits, anchor ice was observed 54 times. Site-specific observations by month are depicted in **Table 2**. There was a decrease in anchor ice presence in January, and anchor ice remained largely absent for the rest of the survey period. Throughout the season, anchor ice presence was observed most frequently at Site 2 (11 times) and least frequently at Site 1 (7 times).

| | Site | | | | | | |
|---|---|---|---|---|---|---|---|
| **Month** | **Site 1** | **Site 2** | **Site 3** | **Site 4** | **Site 5** | **Site 6** | *Total* |
| **December** | 4 | 5 | 5 | 6 | 5 | 4 | *29* |
| **January** | 0 | 4 | 2 | 2 | 4 | 4 | *16* |
| **February** | 1 | 0 | 0 | 0 | 0 | 0 | *1* |
| **March** | 2 | 2 | 1 | 1 | 1 | 1 | *8* |
| *Total* | *7* | *11* | *8* | *9* | *10* | *9* | *54* |

**Table 2.** Number of times anchor ice presence was recorded at each site and for each month throughout the survey period (December 3, 2020 through March 21, 2021).

Anchor ice was absent the majority of the survey days. Anchor ice was not observed at 138 out of the 198 unique site visits. When excluding recordings of 0% coverage, the average estimated anchor ice coverage for each month was as follows: 61% in December, 42% in January, 10% in February, and 39% in March. Specific estimated coverages for each site visit are shown in **Table 3**.

| | **Site 1** | **Site 2** | **Site 3** | **Site 4** | **Site 5** | **Site 6** |
|---|---|---|---|---|---|---|
| **December** | | | | | | |
| 12/3/20 | 50 | 75 | 75 | 75 | 90 | 50 |
| 12/4/20 | 25 | 75 | 90 | 75 | 50 | 75 |
| 12/8/20 | 10 | 80 | 25 | 95 | | |
| 12/11/20 | | | | | | |
| 12/15/20 | | | | 75 | 90 | |
| 12/16/20 | | | | | | |
| 12/21/20 | | | | | | |
| 12/24/20 | 40 | 70 | 90 | 40 | 50 | 75 |
| 12/30/20 | | 10 | 50 | 25 | 70 | 75 |
| **January** | | | | | | |
| 1/1/21 | | 90 | 5 | | 60 | 30 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1/5/21 | | | | | | |
| 1/7/21 | | 70 | 20 | 40 | 50 | 75 |
| 1/11/21 | | 75 | | 5 | 35 | 40 |
| 1/15/21 | | 10 | | | 45 | 45 |
| 1/18/21 | | | | | | |
| 1/21/21 | | | | | | |
| 1/28/21 | | | | | | |
| **February** | | | | | | |
| 2/1/21 | 10 | | | | | |
| 2/5/21 | | | | | | |
| 2/8/21 | | | | | | |
| 2/12/21 | | | | | | |
| 2/17/21 | | | | | | |
| 2/19/21 | | | | | | |
| 2/22/21 | | | | | | |
| 2/26/21 | | | | | | |
| **March** | | | | | | |
| 3/1/21 | 75 | 60 | 45 | 30 | 45 | 45 |
| 3/3/21 | 5 | 5 | | | | |
| 3/12/21 | | | | | | |
| 3/15/21 | | | | | | |
| 3/24/21 | | | | | | |
| 3/25/21 | | | | | | |
| 3/31/21 | | | | | | |

**Table 3.** Estimated anchor ice coverage recordings for every anchor ice presence observed throughout the 4-month survey period. Blanks correspond with 0% estimated coverage of anchor ice.

**Physical Parameters**

Air and water temperature data were not collected prior to December 12, 2021 because a digital thermometer was not yet attained. Absences in water temperature data after that date were due to unsafe river access conditions.

Average recorded air temperatures for December, January, February, and March were -12.3°C, -2.9°C, 1.5°C, and 4.4°C, respectively (**Figure 1**). There was a noticeable shift in air temperatures starting after January 15$^{th}$. Prior to January 15$^{th}$, air temperatures were all below freezing. Following that date, temperatures remained consistently above freezing, falling to an average of below freezing across the six sites only on February 5$^{th}$, February 19$^{th}$, and March 1$^{st}$.

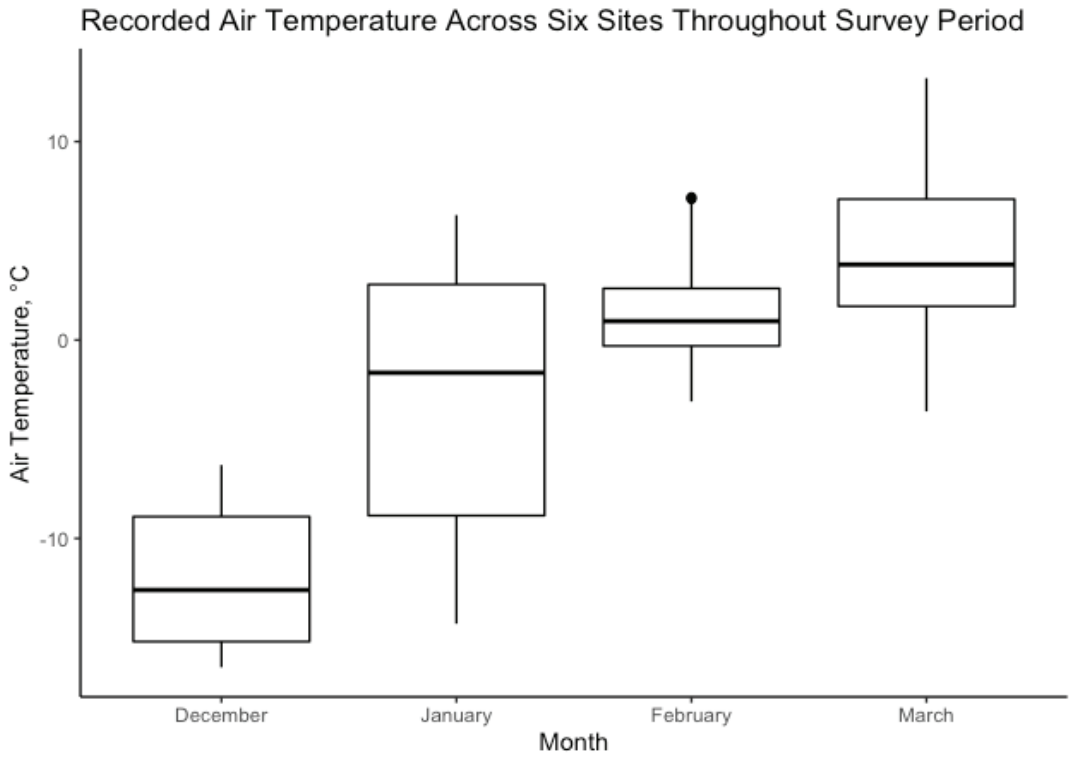
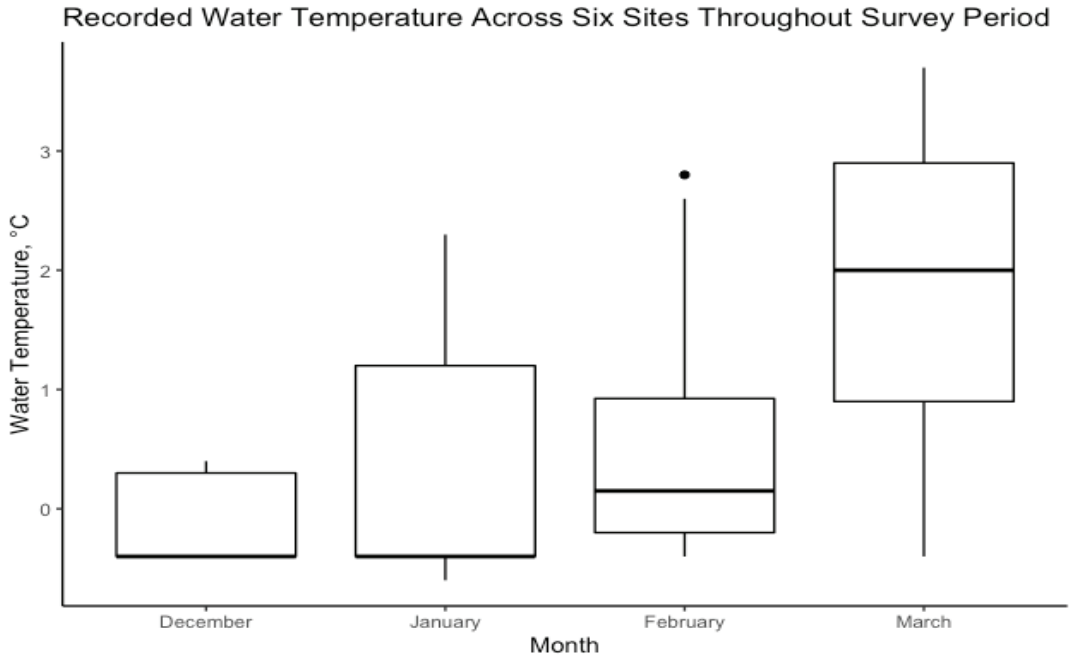



**Figure 1 (above).** Recorded air temperatures at each site by month throughout the survey period (December 3, 2020 through March 31, 2021). A general increasing trend is observed. **Figure 2 (below)**. Recorded water temperatures at each site by month throughout the survey period (December 3, 2020 through March 31, 2021). A general increasing trend is observed.



Average water temperatures for December, January, February, and March were -0.17°C, 0.25°C, 0.54°C, and 2.8°C, respectively (**Figure 2**). After Water temperatures began to be consistently above freezing starting January 18th. There was a notable increase in water temperature starting February 12th, when temperatures above 2°C were recorded for the first time in the season. One of the survey goals was to establish a temperature gradient of anchor ice formation leading up the stream. We were unable to detect significant differences in recorded water temperatures amongst the sites.

Three noticeable changes in stream flow rate occurred within the survey period at the beginning of January, the end of February, and mid-March (**Figure 3**). Throughout December, the stream flow remained between 46 and 48 cubic square feet (cfs). The stream flow rate then increased in January, consistently staying between 58.9 and 61.7csf for all of January. Stream flow remained about 60csf in February, between 61.3 and 63.9csf. Then on February 27th it decreased to around 4csf, and in the evening of February 28th it decreased again to 35csf. For the next few weeks, stream flow remained at an average of 35csf and, then increased slightly the last week of March to about 45csf.

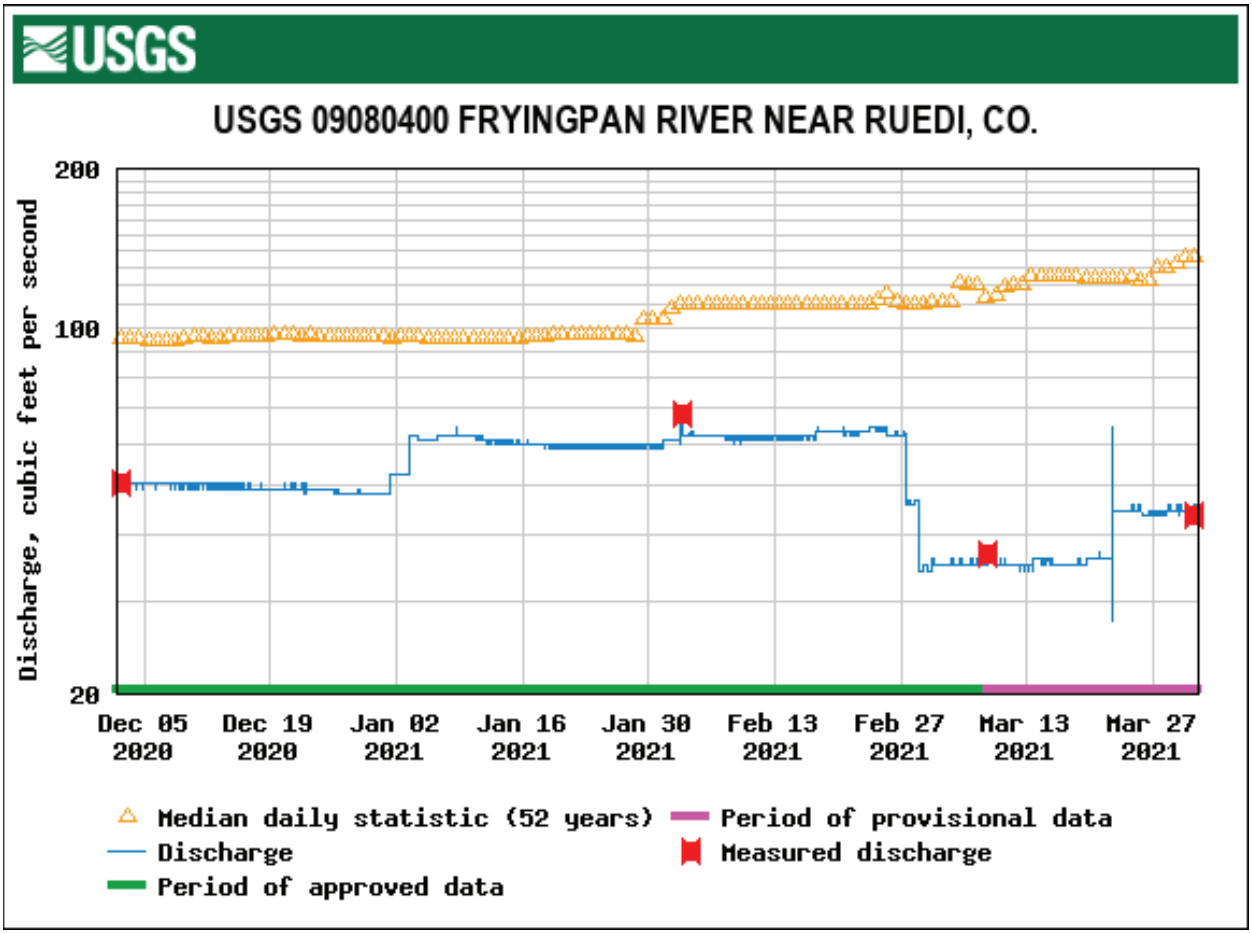



**Figure 3:** Discharge recorded by USGS gauge below Ruedi Dam within the period of ice surveying, December 3, 2020 through March 31, 2021. Noticeable changes occurred at the beginning of January (increase), the end of February (decrease), and mid-March (increase). Source: USGS

## Modeling

While regression modeling was attempted for estimated coverage of anchor ice, results were unhelpful because the overwhelming majority of 0% coverage recordings caused unequal variance and non-normal residuals. Instead, logistic regression was conducted to determine the probability of anchor ice presence in relation to stream flow rate, air temperature, and water temperature. The logistic regression found that all three variables are negatively correlated with the odds of anchor ice being present. Specifically, for a one-unit increase in water temperature, the odds of anchor ice presence decrease by 99.19% (p=0.002). For a one-unit increase in stream flow, the odds of anchor ice presence decrease by 10.75% (p=0.002). Lastly, for a one-unit increase in air temperature, the odds of anchor ice presence decrease by 12.92% (p=0.01).

## Discussion of Results

A clear pattern of anchor ice presence is evident throughout the survey period. Anchor ice was consistently present and abundant throughout December and early January, then was largely absent throughout the second half of January and throughout February and March, except for one day in March when it was present at all six sites. Logistic regression modeling for anchor ice presence found that the odds of anchor ice presence are negatively correlated with air temperature, water temperature, and stream flow rate. These findings make sense when looking at the trends of these variables throughout the duration of the survey period. Stream flow rate, water temperature, and stream flow rate all increased in January, while anchor ice presence decreased at that same time.

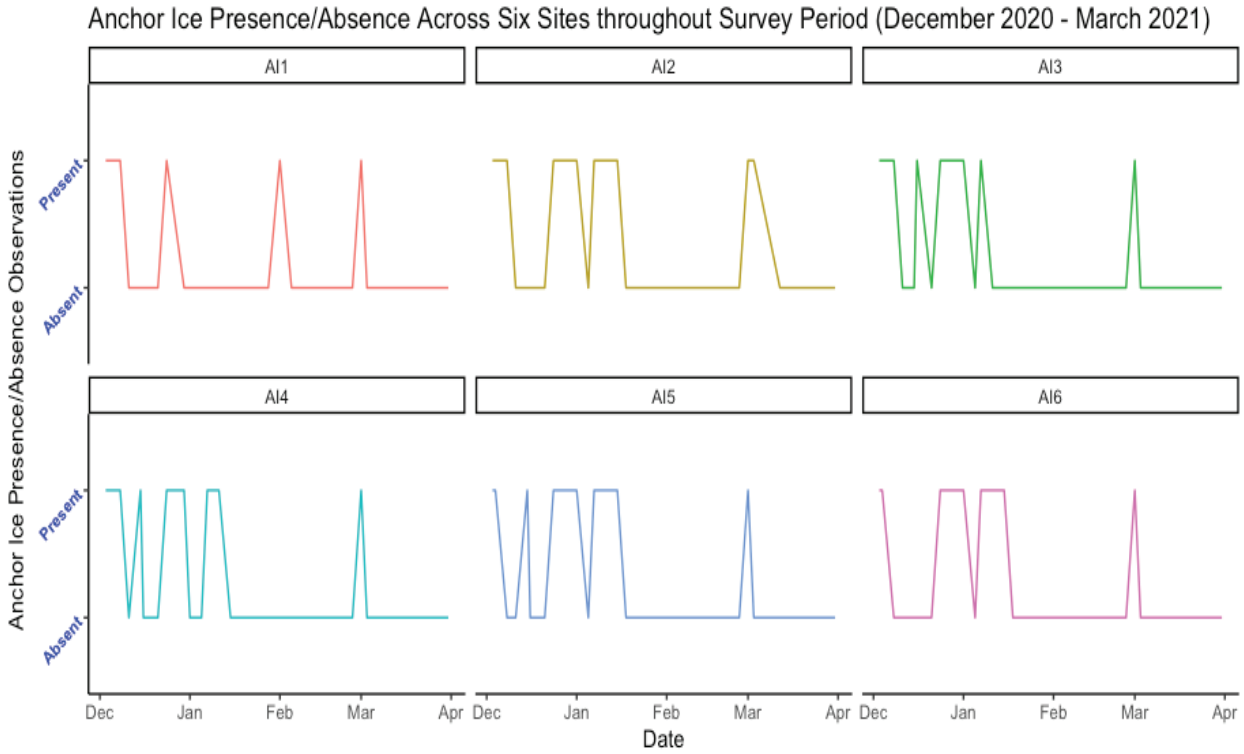



**Figure 4.** Anchor ice presence/absence at each site throughout the survey period (December 3, 2020 through March 31st, 2021) for all 32 survey days. Anchor ice was largely absent throughout late January, February, and March. Anchor ice was observed across all six sites on March 1st.

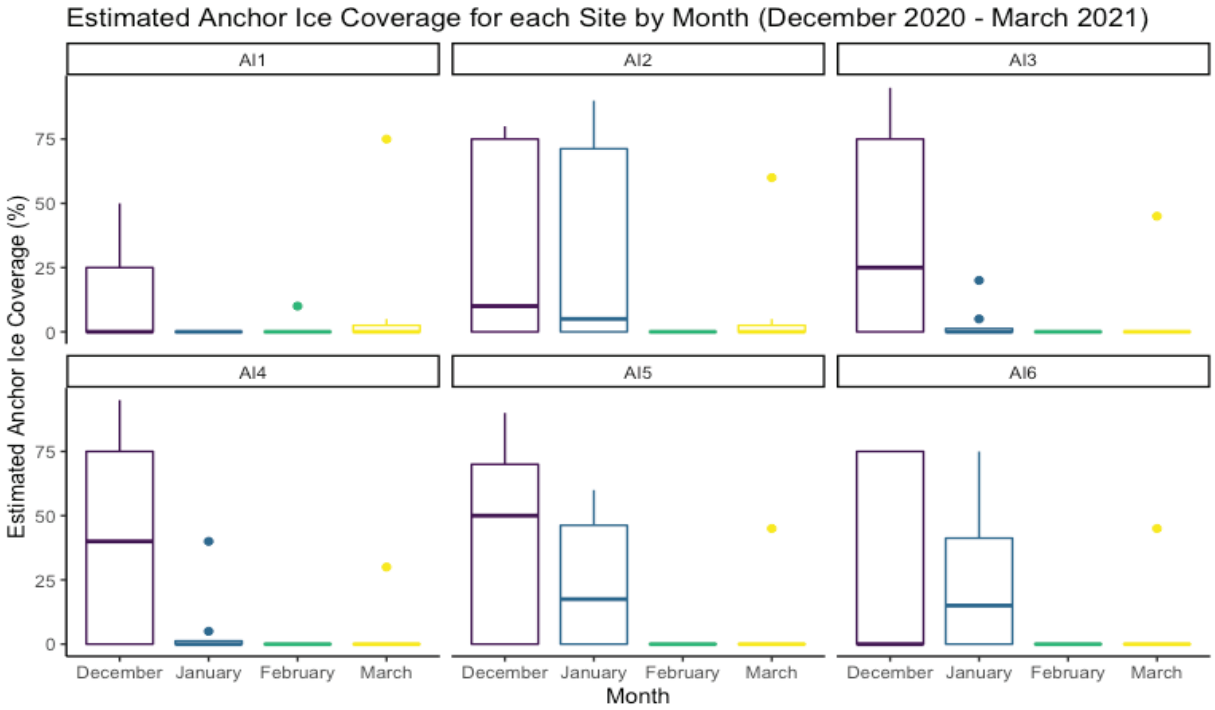



**Figure 5:** Estimated anchor ice coverage for each site by month throughout the survey period.

The one-day spike in anchor ice presence on March 1st then subsequent reduction two days later is the only time this occurred this season. Stream flow discharge rate decreased two days prior to March 1st, and to the lowest levels of the season the night before March 1st. It is possible that this sudden drop in discharge rate contributed to this ice formation. However, anchor ice presence did not persist in the river despite consistently low stream flow rates in the following weeks (**Figure 5**).

Although the logistic regression shows significant results that align with our hypotheses, it is not clear how well the choice of variables for this study directly align with anchor ice formation. Kempema (2008) identifies the rates of mixing in flowing water, heat transfer from water to air, and latent heat of fusion released as anchor ice grows as important parameters controlling anchor ice formation. While stream flow rate, water temperature, and air temperature can be used as proxies for these more specific parameters, they may not provide the degree of preciseness necessary to correlate these values directly with anchor ice formation.

*Site Differences*

Prior to surveying it was hypothesized that anchor ice presence and abundance would decrease with proximity to Ruedi Dam, due to relatively warm water discharged by Ruedi Dam. The data do not show evidence consistent with this hypothesis. The fewest number of anchor ice sighting across sites occurred at Site 1, the site furthest from Reudi Dam. However, it is important to note that for most of the season Site 1 was covered entirely by border ice, preventing observations of potential anchor ice.

Each of the sites were unique in grade, width, shade coverage, stream depth, and flow speed (rapid vs. runs). It is likely that while anchor ice formation within a stream requires certain environmental conditions, such as low air and water temperatures, the precise location that the anchor ice forms as well as the abundance of ice is highly subjective to local stream conditions. In order to better understand the effects of discharge from Reudi Dam on the formation of anchor ice in the Lower Fryingpan, it may be beneficial to incorporate more sites further upstream into this study. Similar anchor ice presence and coverage was observed at Sites 3 and 4 and Sites 5 and 6, respectively (**Table 3**). Therefore, researchers could consider eliminating Sites 3 and 5 from the study and adding at least two more sites further upstream.

Anchor ice dam at Site 2 (near Mile Marker 1).

*Recommendations*

Perhaps one of the most significant outcomes of this pilot study is determining areas where methodology can be improved moving forward. In order to maintain consistency of reporting throughout the season and integrity of data, inter-observer reliability must be prioritized. Anchor ice can be difficult to spot and estimations of its coverage are highly subjective. Fluctuating stream depth levels further complicate observations; it is more difficult to see anchor ice in deeper waters. All potential observers should spend one at least one full day of sampling together at the beginning of the season. This will allow them to establish focal areas for surveying at each of the sites, as well as provide the opportunity to calibrate their individual estimations to ultimately achieve observations of at least 80% sameness. Continuity from season to season, whether it be the same observer or comprehensive training conducted by the previous observer is ideal. Additionally, adding more sites further upstream will increase variability in water temperature and air temperature amongst the study sites, potentially illuminating more

significant results on the scale that the level of data collection warrants. Increasing the survey period, particularly in the early season could also help to understand formation influences. Adding additional observational factors such as border ice depth and water depth could also prove useful.

## Conclusion

This anchor ice monitoring pilot season on the Lower Fryingpan River provides a strong basis for continuing this study long-term. There were noticeable correlations between anchor ice presence and the primary independent variables of interest: air temperature, water temperature, and stream flow rate. However, it is difficult to attribute changes in anchor ice to any single variable since all of them changed substantially in January alongside changes in anchor ice presence. Continuing this study for at least five more years is necessary to gain a stronger understanding of these trends. Additionally, taking measures to ensure inter-observer reliability and expanding the overall stretch of river to include more sites further upstream will result in a more robust data set moving forward.

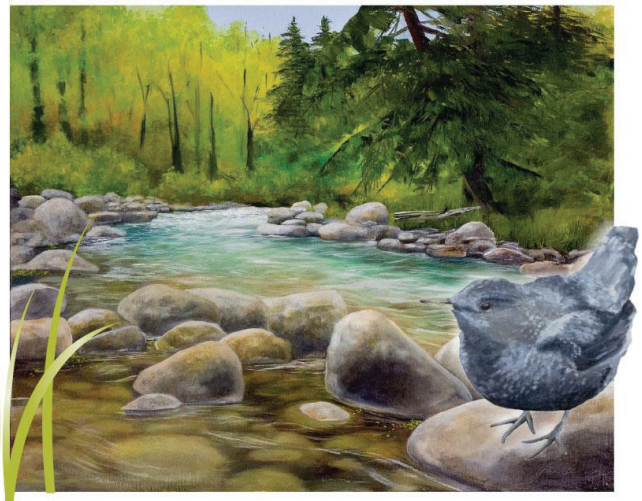
## Works Cited

Brown, R.S., W.A. Hubert & S.F. Daly. 2011. *A Primer on Winter, Ice, and Fish: What Fisheries Biologists Should Know about Winter Ice Processes and Stream-dwelling Fish.* Fisheries. 36:8-26.

Huokuna, M., M. Morris, S. Beltaos & B, Burrell. 2017. *Ice in Regulated Rivers and Reservoirs*. CGU HS Committee on River Ice Processes and the environment. 19th Workshop on the Hydraulics of Ice Covered Rivers.

Kempema, E., R. Ettema & B. McGee. 2008. *Insights from Anchor Ice Formation in the Laramie River, Wyoming*. 19th IAHR International Symposium on Ice. 113-126.

ROARING FORK



CONSERVANCY

Celebrating 25 years

*Bringing People Together to Protect Our Rivers*

ROARING FORK CONSERVANCY
*Bringing People Together to Protect Our Rivers*



September 8, 2022

Colorado Water Conservation Board
1313 Sherman Street
Denver, CO 80203

Re: Support for Ruedi Reservoir Winter Release Program

Dear Madam Chair and Members of the Board,

Roaring Fork Conservancy wishes to voice its support for the Ruedi Reservoir Winter Release Program funding submitted to the Colorado Water Conservation Board. This will provide approximately an additional 25cfs to the Fryingpan River during winter months to mitigate anchor ice and benefit aquatic life.

Increased pressure on the lower Fryingpan River due to growing population, recreation, and climate change has led to the need for strategic management of Ruedi Reservoir to ensure the long-term health and viability of this headwaters ecosystem and Gold Medal fishery. The Lower Fryingpan River runs 13 miles from the outflow of Ruedi Reservoir to its confluence with the Roaring Fork River in Basalt. The continued ecological and economic benefits of a vibrant stream system are dependent on Ruedi Reservoir management that benefits local and downstream West Slope needs. The Fryingpan River sees artificially high flows in the late summer and early fall due to downstream demand, followed by an abrupt drop to minimum flow lasting up to 6 months. Studies commissioned by RFC show that supplementing winter flows may be the most important factor in influencing macroinvertebrate community structure and function during winter months. Maintaining winter flows at 60-70 cfs minimizes anchor ice formation, decreases stress to macroinvertebrate communities, and allows macroinvertebrate populations to recover from previous low flow durations. In recent years, the Lower Fryingpan River has seen increased angling pressure as the Roaring Fork, Colorado, and Eagle Rivers have all experienced temperature related closures in summer, pushing anglers further upstream to the Fryingpan. Additionally, lower snowpack and higher temperatures in the winter bring increased angling as a winter recreation alternative, enhancing year-round pressures on the resource. Maintaining minimum winter flows at 60-70cfs increases both ecological resiliency and recreational opportunities.

In short, using contract water held by the Colorado River Water Conservation District in Ruedi Reservoir during winter months will have long and short-term ecological benefits to the Fryingpan community, as well as supporting recreation and tourism demands.

Thank you for your consideration and continued support.

Sincerely,

Rick Lofaro, Executive Director

**Exhibit D**
**Agenda Item 6a**
**Sept 20, 2022**