COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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TO: Colorado Water Conservation Board Members

FROM: Linda Bassi, Chief
Jeff Baessler, Deputy Section Chief
Stream and Lake Protection Section

DATE: January 23, 2017

AGENDA ITEM: **24. Instream Flow and Natural Lake Level Appropriations in Water Divisions 1, 2, 4 , 5 and 6**

Introduction
This memo provides an overview of the technical analyses that were performed by both the recommending entities and CWCB staff to provide the Board with sufficient information to declare its intent to appropriate instream flow and natural lake level water rights in accordance with the Rules Concerning the Colorado Instream Flow and Natural Lake Level Program ("ISF Rules"). An executive summary for each stream and lake recommendation with appendices of the supporting scientific data, which provides the technical basis for each appropriation, was provided to the Board separately.

Staff Recommendation
Staff recommends that, pursuant to ISF Rule 5d., the Board declare its intent to appropriate an instream flow (ISF) water right on each stream segment listed and a natural lake level (NLL) water right for each lake listed on the attached Tabulation of Instream Flow and Natural Lake Level Recommendations, and direct Staff to publicly notice the Board's declaration of its intent to appropriate.

Background
Pursuant to ISF Rule 5d., staff requests the Board to declare its intent to appropriate ISF and NLL water rights on the stream segments and lakes identified in the attached tables. Staff has reviewed each proposed stream segment and lake to ensure that for each ISF and NLL recommendation, the data set is complete and standard methods and procedures were followed. In addition, staff has completed its water availability analyses. Staff has identified 13 stream segments and two natural lakes in Water Divisions 1, 2, 4, 5 and 6, and has compiled sufficient information and performed the analyses necessary to provide a basis for the Board to declare its intent to appropriate water rights on these streams and lakes. These stream segments and natural lakes are located in Park, Las Animas, Gunnison, Delta, Eagle, Garfield, Routt and Moffat Counties.

Technical Investigations
Staff's executive summary and technical analysis of each stream and lake are contained in the Instream Flow Recommendation Reports and form the basis for staff's recommendations. In addition to the reports, the scientific data and technical analyses performed by the recommending entity are accessible on the Board's web site at:

http://cwcb.state.co.us/environment/instream-flow-program/Pages/2017ProposedISFRecommendations.aspx

Natural Environment Studies
The Bureau of Land Management (BLM), Colorado Parks and Wildlife (CPW), High Country Conservation Advocates, and American Rivers have conducted field surveys of the natural environment resources on these streams and lakes and have found natural environments that can be preserved. To quantify the resources and to evaluate instream flow requirements, the recommending entities collected biologic and hydraulic data and performed R2CROSS modeling on all segments. The CWCB staff analyzed and/or reviewed all of the data and models used to support the recommendations, and worked with the recommending entities to develop final recommendations of the amount of water necessary to preserve the natural environment to a reasonable degree for each of the streams listed on the attached Tabulation of Instream Flow and Natural Lake Level Recommendations.

Water Availability Studies
Staff has conducted an evaluation of water availability for the streams and lakes listed. To determine the amount of water physically available for the Board's instream flow appropriations, staff analyzed available USGS gage records, available streamflow models, and/or utilized appropriate standard methods to develop a hydrograph of median daily and/or mean monthly flows for each stream flow recommendation. To determine water availability for the lakes, staff reviewed hydrology, and analyzed maps and aerial photos to assess the long-term persistence of the lakes. In addition, staff analyzed the water rights tabulation for each stream to identify any potential water availability problems. Based on these analyses, staff has determined that water is available for appropriation on each stream to preserve the natural environment to a reasonable degree without limiting or foreclosing the exercise of valid water rights.

On some of the listed streams, CWCB staff suggested modifications to the R2Cross biological recommendation due to water availability limitations. For these streams, staff met with the recommending entities to review the water availability analyses and discuss whether the modified recommendation would preserve the natural environment to a reasonable degree. After reviewing staff's hydrology, the original R2Cross results, and evaluating the indicator species and other aspects of the natural environment, the recommending entities concluded that the proposed modified recommendations would preserve the natural environment to a reasonable degree on each stream segment.

Stakeholder Outreach
Staff provided public notice of the recommendations in both March and November of 2016 and contacted or met with the County Commissioners for each county where the stream segments are located. In addition, staff contacted water commissioners, local land owners, and others when possible to further discuss the recommendations.

Instream Flow Rule 5d.
Rule 5d. provides that the Board may declare its intent to appropriate ISF and NLL water rights after reviewing Staff's recommendations for the proposed appropriations. Rule 5d. also sets forth the activities that take place after the Board declares its intent that initiate the public notice and comment procedure for the ISF appropriations. Specifically:

5d. Board's Intent to Appropriate. Notice of the Board's potential action to declare its intent to appropriate shall be given in the January Board meeting agenda and the Board will take public comment regarding its intent to appropriate at the January meeting.

(1) After reviewing Staff's ISF recommendations for proposed ISF appropriations, the Board may declare its intent to appropriate specific ISF water rights. At that time, the Board shall direct the Staff to publicly notice the Board's declaration of its intent to appropriate.

(2) After the Board declares its intent to appropriate, notice shall be published in a mailing to the ISF Subscription Mailing Lists for the relevant water divisions and shall include:

(a) A description of the appropriation (e.g. stream reach, lake location, amounts, etc.);

(b) Availability (time and place) for review of Summary Reports and Investigations Files for each recommendation; and,

(c) Summary identification of any data, exhibits, testimony or other information in addition to the Summary Reports and Investigations Files supporting the appropriation.

(3) Published notice shall also contain the following information:

(a) The Board may change flow amounts of contested ISF appropriations based on information received during the public notice and comment period.

(b) Staff will maintain, pursuant to Rule 5e.(3), an ISF Subscription Mailing List for each water division composed of the names of all persons who have sent notice to the Board Office that they wish to be included on such list for a particular water division. Any person desiring to be on the ISF Subscription Mailing List(s) must send notice to the Board Office.

(c) Any meetings held between Staff and members of the public will be open to the public. Staff may provide Proper Notice prior to any such meetings and may provide notice to persons on the ISF Subscription Mailing List(s).

(d) Any Notice to Contest must be received at the Board office no later than March 31st, or the first business day thereafter. All Notices of Party status and Contested Hearing Participant status must be received at the Board office no later than April 30th, or the first business day thereafter.

(e) Staff will announce its Final Staff ISF Recommendation concerning contested appropriations at the September Board meeting and will send notice of the Final Staff Recommendation to all persons on the Contested Hearing Mailing List.

(f) The Board may take final action on any uncontested ISF appropriations at the May Board meeting.

(4) After the Board declares its intent to appropriate, notice of the Board's action shall be mailed within five working days to the County Commissioners of the county(ies) in which the proposed reach is located.

Attachments

Colorado Water Conservation Board
Instream Flow Tabulation - Streams
Water Division 1

Water Court Div.	Case Number	Stream	Watershed	County	Upper Terminus (UTM)	Lower Terminus (UTM)	Length (miles)	Amount(dates) (CFS)	Approp Date
1		Rock Creek	South Platte Headwaters	Park	headwaters in the vicinity of E: 442888.09 N: 4363476.91	confl natural falls at E: 441520.48 N: 4357224.26	4.66	0.9 (09/01 - 04/30) 3.8 (05/01 - 08/31)	
1		Unnamed Tributary to Rough & Tumbling Creek	South Platte Headwaters	Park	headwaters in the vicinity of E: 401245.59 N: 4318074.94	confl Rough & Tumbling Creek at E: 403468.05 N: 4321559.19	2.78	0.3 (01/01 - 12/31)	

Totals for Water Division 1

Total # of Stream Miles = 7.44
Total # of Appropriations = 2

Instream Flow Tabulation - Water Division 2

Water Court Div.	Case Number	Stream	Watershed	County	Upper Terminus (UTM)	Lower Terminus (UTM)	Length (miles)	Amount(dates) (CFS)	Approp Date
2		Apishapa River	Apishapa	Las Animas	headwaters in the vicinity of E: 498440.80 N: 4134067.69	confl Herlick Canyon at E: 504368.80 N: 4131036.76	4.52	2.9 (05/01 - 06/30) 1.1 (07/01 - 08/31) 0.5 (09/01 - 04/30)	

Totals for Water Division 2

Total # of Stream Miles = 4.52
Total # of Appropriations = 1

Instream Flow Tabulation - Water Division 4

Water Court Div.	Case Number	Stream	Watershed	County	Upper Terminus (UTM)	Lower Terminus (UTM)	Length (miles)	Amount(dates) (CFS)	Approp Date
4		Brush Creek (increase)	East-Taylor	Gunnison	confl Middle & East Brush Creeks at E: 339317.46 N: 4308647.90	confl West Brush Creek E: 336872.42 N: 4307385.91	2.32	1.7 (01/01 - 04/14) 2.7 (10/16 - 12/31) 11 (04/15 - 04/30) 8 (05/01 - 08/31) 5 (09/01 - 09/30) 8 (10/01 - 10/15)	
4		Coal Creek (increase)	East-Taylor	Gunnison	Lake Irwin Outlet at E: 317839.25 N: 4304958.01	Spann Nettick Ditch hdgt at E: 326937.36 N: 4304124.83	7.67	1.3 (01/01 - 03/31) 5.9 (04/01 - 08/15) 3.7 (08/16 - 11/30) 2 (12/01 - 12/31)	
4		West Fork Terror Creek	North Fork Gunnison	Delta	headwaters in the vicinity of E: 268584.11 N: 4317217.31	confl East Fork Terror Creek at E: 276880.59 N: 4314191.79	5.85	2.2 (04/01 - 07/15) 1.1 (07/16 - 03/31)	

Totals for Water Division 4

Total # of Stream Miles = 15.84
Total # of Appropriations = 3

Instream Flow Tabulation - Water Division 5

Water Court Div.	Case Number	Stream	Watershed	County	Upper Terminus (UTM)	Lower Terminus (UTM)	Length (miles)	Amount(dates) (CFS)	Approp Date
5		Dry Fork Roan Creek	Parachute-Roan	Garfield	confl S Dry Fork & N Dry Fork at E: 210728.25 N: 4364215.13	Omundson & Frost Ditch hdgt at E: 213772.70 N: 4363665.66	2.54	0.5 (05/01 - 08/15) 0.2 (08/16 - 04/30)	
5		Piney River (increase)	Colorado Headwaters	Eagle	confl Grape Creek at E: 366932.04 N: 4405229.97	confl Colorado River at E: 359556.85 N: 4412971.89	7.83	55 (05/01 - 07/15) 16 (07/16 - 08/15) 4 (12/01 - 03/31) 16 (04/01 - 04/30) 8 (08/16 - 11/30)	

Totals for Water Division 5

Total # of Stream Miles = 10.37
Total # of Appropriations = 2

Instream Flow Tabulation - Water Division 6

Water Court Div.	Case Number	Stream	Watershed	County	Upper Terminus (UTM)	Lower Terminus (UTM)	Length (miles)	Amount(dates) (CFS)	Approp Date
6		Elkhead Creek	Upper Yampa	Routt	confl First Creek at E: 317014.13 N: 4511465.47	confl NF Elkhead Creek at E: 306665.08 N: 4504451.45	10.94	4.4 (10/16 - 03/31) 14 (04/01 - 07/15) 7 (07/16 - 07/31) 3 (08/01 - 10/15)	
6		Elkhead Creek	Upper Yampa	Routt	confl NF Elkhead Creek at E: 306665.08 N: 4504451.45	USGS Gage # 09246200 at E: 303600.63 N: 4496025.75	15.83	6.4 (10/01 - 02/29) 10 (03/01 - 03/15) 24 (03/16 - 06/30) 10 (07/01 - 07/15) 2.5 (07/16 - 09/30)	
6		Fourmile Creek	Little Snake	Moffat	headwaters in the vicinity of E: 296207.17 N: 4520769.45	Norma Ryan Ditch hdgt at E: 292918.30 N: 4523918.74	3.13	3.8 (05/01 - 06/30) 1.3 (04/01 - 04/30) 0.97 (07/01 - 07/31) 0.41 (08/01 - 03/31)	
6		North Fork Elkhead Creek	Upper Yampa	Routt	headwaters in the vicinity of E: 310855.20 N: 4515748.48	confl Elkhead Creek at E: 306665.08 N: 4504451.45	9.39	1.8 (12/01 - 03/31) 5.4 (04/01 - 06/30) 1.2 (07/01 - 07/31) 0.57 (08/01 - 09/17) 1.4 (09/18 - 11/30)	
6		Slater Creek	Little Snake	Moffat	confl Beaver Creek at E: 303385.46 N: 4529487.44	USGS Gage # 09255000 at E: 299527.79 N: 4539540.79	12.58	74 (04/16 - 06/30) 25 (07/01 - 07/15) 10 (07/16 - 07/31) 6.5 (08/01 - 09/15) 8.5 (09/16 - 10/15) 16 (10/16 - 03/15) 25 (03/16 - 04/15)	

Totals for Water Division 6

Total # of Stream Miles = 51.87
Total # of Appropriations = 5

Totals for Divisions: 1,2,4,5,6

Total # of Stream Miles = 90.04
Total # of Appropriations = 13

Colorado Water Conservation Board
Natural Lake Tabulation
Water Division 1

Water Court Div	Case Number	Name of Lake	Watershed	County	Lake Centerpoint (UTM)	Surface Acres	Elevation (ft)	Volume (AF)	Approp Date
1		Square Top Lake (Lower)	Upper South Platte	Clear Creek	E: 4382623.44 N: 436440.44	6.99	12,084	26.79	
1		Square Top Lake (Upper)	Upper South Platte	Clear Creek	E: 436057.06 N: 4382782.46	7.55	12,322	113.14	

Lake Recommendations in Water Division 1: 2

*-Donated/Acquired Water Right

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2017 Instream Flow and Natural Lake Level Recommendations

Water Division 1

1. Rock Creek Executive Summary (Park County)
   Appendices
2. Square Top Lakes (Upper & Lower) Executive Summary (Clear Creek County)
   Appendices
3. Unnamed Trib. to Rough & Tumbling Creek Executive Summary (Park County)
   Appendices

Water Division 2

4. Apishapa River Executive Summary (Las Animas County)
   Appendices

Water Division 4

5. Brush Creek (*Increase*) Executive Summary (Gunnison County)
   Appendices
   Public Comment
6. Coal Creek (*Increase*) Executive Summary (Gunnison County)
   Appendices
   Public Comment
7. West Fork Terror Creek Executive Summary (Delta County)
   Appendices

Water Division 5

8. Dry Fork Roan Creek Executive Summary (Garfield County)
   Appendices
9. Piney River (*Increase*) Executive Summary (Eagle County)
   Appendices

Water Division 6

10. Elkhead Creek (Upper) Executive Summary (Routt County)
    Appendices
11. Elkhead Creek (Lower) Executive Summary (Routt County)
    Appendices
12. Fourmile Creek Executive Summary (Moffat County)
    Appendices
13. North Fork Elkhead Creek Executive Summary (Routt County)
    Appendices
14. Slater Creek Executive Summary (Moffat County)
    Appendices

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Rock Creek

EXECUTIVE SUMMARY

CWCB STAFF INSTREAM FLOW RECOMMENDATION

UPPER TERMINUS:	Headwaters in the vicinity of	
	UTM North: 4363476.91	UTM East: 442888.09
LOWER TERMINUS:	Confluence with natural falls	
	UTM North: 4357224.26	UTM East: 441520.48
WATER DIVISION:	1	
WATER DISTRICT:	23	
COUNTY:	Park	
WATERSHED:	South Platte Headwaters	
CWCB ID:	16/1/A-004	
RECOMMENDER:	Colorado Parks and Wildlife (CPW), Park County	
LENGTH:	4.66 miles	
FLOW RECOMMENDATION:	0.9 (09/01 - 04/30) 3.8 (05/01 - 08/31)	

Rock Creek

Introduction

Colorado's General Assembly created the Instream Flow and Natural Lake Level Program in 1973, recognizing "the need to correlate the activities of mankind with some reasonable preservation of the natural environment" (see 37-92-102 (3), C.R.S.). The statute vests the Colorado Water Conservation Board (CWCB or Board) with the exclusive authority to appropriate and acquire instream flow (ISF) and natural lake level water rights (NLL). Before initiating a water right filing, the Board must determine that: 1) there is a natural environment that can be preserved to a reasonable degree with the Board's water right if granted, 2) the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made, and 3) such environment can exist without material injury to water rights.

Colorado Parks and Wildlife (CPW) and Park County recommended that the CWCB appropriate an ISF water right on a reach of Rock Creek. Rock Creek originates in the Lost Creek Wilderness at an elevation of approximately 11,460 ft. The creek flows in a southerly direction for 9.6 miles where it drops to an elevation of approximately 9,040 ft as it joins Tarryall Creek. This reach is located within Park County (See Vicinity Map) and extends from the headwaters downstream to the confluence with natural falls. One hundred percent of the land on the 4.66 mile proposed reach is publicly owned and managed by the U.S. Forest Service (See Land Ownership Map). CPW and Park County recommended this reach of Rock Creek because it has a natural environment that can be preserved to a reasonable degree with an ISF water right.

The information contained in this report and the associated supporting data and analyses (located at: http://cwcb.state.co.us/environment/instream-flow-program/Pages/2017ProposedISFRecommendations.aspx) form the basis for staff's ISF recommendation to be considered by the Board. This report provides sufficient information to support the CWCB findings required by ISF Rule 5i on the natural environment, water availability, and material injury.

Natural Environment

CWCB staff relies on the recommending entity to provide information about the natural environment. In addition, staff reviews information and conducts site visits for each recommended ISF appropriation. This information is used to provide the Board with a basis for determining that a natural environment exists.

The upper sections of Rock Creek have been identified by CPW biologists as an ideal location for the establishment of a conservation population of greenback cutthroat trout. This creek is a high elevation montane stream and therefore provides ideal habitat for this subspecies. Following this determination by CPW, in 2015, a reclamation project was conducted in the upper reaches to remove all of the non-native salmonids from the system. Non-native salmonids hybridize and compete with the native trout (Greenback Cutthroat Trout Recovery Team, 1977). Following the 2015 reclamation project, Rock Creek was stocked twice with the Bear Creek strain of greenback cutthroat trout. The last known population of genetically pure greenbacks was found in Bear Creek near Colorado Springs. To ensure long-term isolation of the stocked greenback cutthroat trout, the Rock Creek ISF segment has a waterfall which serves a fish passage barrier. Rock Creek above the barrier was sampled in 2016 and greenback cutthroat were the only species collected thus illustrating the effectiveness of the barrier (See Table 1).

Table 1. List of species identified in Rock Creek.

Species Name	Scientific Name	Status
Greenback cutthroat trout	Oncorhynchus clarki stomias	Federal - Threatened State - Threatened

ISF Quantification

CWCB staff relies upon the biological expertise of the recommending entity to quantify the amount of water required to preserve the natural environment to a reasonable degree. CWCB staff performs a thorough review of the quantification analyses completed by the recommending entity to ensure consistency with accepted standards.

Methodology

CPW staff used the R2Cross methodology to develop the initial ISF recommendation. The R2Cross method is based on a hydraulic model and uses field data collected in a stream riffle (Espegren, 1996). Riffles are most easily visualized as the stream habitat types that would dry up first should streamflow cease. The field data collected consists of streamflow measurements and surveys of channel geometry at a transect and of the longitudinal slope of the water surface.

The field data is used to model three hydraulic parameters: average depth, average velocity, and percent wetted perimeter. Maintaining these hydraulic parameters at adequate levels across riffle habitat types also will maintain aquatic habitat in pools and runs for most life stages of fish and aquatic macro-invertebrates (Nehring, 1979). CPW staff interprets the model results to develop an initial recommendation for summer and winter flows. The summer flow recommendation is based on meeting 3 of 3 hydraulic criteria. The winter flow recommendation is based on meeting 2 of 3 hydraulic criteria. The model's suggested accuracy range is 40% to 250% of the streamflow measured in the field. Recommendations that fall outside of the accuracy range may not give an accurate estimate of the hydraulic parameters necessary to determine an ISF rate.

The R2Cross methodology provides the biological quantification of the amount of water needed for summer and winter periods based on empirical studies of fish species preferences. The recommending entity uses the R2Cross results and its biological expertise to develop an initial ISF recommendation. CWCB staff then evaluates water availability for the reach typically based on median hydrology (see the Water Availability section below for more details). The water availability analysis may indicate less water is available than the initial recommendation. In that case, the recommending entity either modifies the magnitude and/or duration of the recommended ISF rates if the available flows will preserve the natural environment to a reasonable degree, or withdraws the recommendation.

Data Analysis

R2Cross data was collected at one transect for this proposed ISF reach (Table 2). The R2Cross model results in a winter flow of 2.16 cfs, which meets 2 of 3 criteria and is within the accuracy range of the R2Cross model. The R2Cross model results in a summer flow of 3.82 cfs, which meets 3 of 3 criteria and is within the accuracy range of the R2Cross model.

Table 2. Summary of R2Cross transect measurement and results for Rock Creek.

Entity	Date	Streamflow (cfs)	Accuracy Range (cfs)	Winter Rate (cfs)	Summer Rate (cfs)
CPW	09/27/2016 # 1	2.24	0.90 - 5.6	2.16	3.82
			Mean	2.16	3.82

ISF Recommendation

CPW and Park County recommend the following flows based on R2Cross modeling analyses, biological expertise, and staff's water availability analysis.

3.8 cfs is recommended for the summer high flow period May 1 through August 31 to provide spawning and fry emergence habitat.

0.9 cfs is recommended for the winter base flow period September 1 to April 30 to provide over-wintering adult habitat. This recommendation is limited by water availability.

Water Availability

CWCB staff conducts hydrologic analyses for each recommended ISF appropriation to provide the Board with a basis for making the determination that water is available.

Methodology

Each recommended ISF reach has a unique flow regime that depends on variables such as the timing, magnitude, and location of water inputs (such as rain, snow, and snowmelt) and water losses (such as diversions, reservoirs, evaporation and transpiration, groundwater recharge, etc). Although extensive and time-consuming investigations of all variables may be possible, staff takes a pragmatic and cost-effective approach to analyzing water availability. This approach focuses on streamflows and the influence of flow alterations, such as diversions, to understand how much water is physically available in the recommended reach.

Staff's hydrologic analysis is data-driven, meaning that staff gathers and evaluates the best available data and uses the best available analysis method for that data. Whenever possible, long-term stream gage data (period of record 20 or more years) will be used to evaluate streamflow. Other streamflow information such as short-term gages, temporary gages, spot streamflow measurements, diversion records, and StreamStats will be used when long-term gage data is not available. StreamStats, a statistical hydrologic program, uses regression equations developed by the USGS (Capesius and Stephens, 2009) to estimate mean flows for each month based on drainage basin area and average drainage basin precipitation. Diversion records will also be used to evaluate the effect of surface water diversions when necessary. Interviews with water commissioners, landowners, and ditch or reservoir operators can provide additional information. A range of analytical techniques may be employed to extend gage records, estimate streamflow in ungaged locations, and estimate the effects of diversions. The goal is to obtain the most detailed and reliable estimate of hydrology using the most efficient analysis technique.

The final product of the hydrologic analysis used to determine water availability is a hydrograph, which shows streamflow and the proposed ISF rate over the course of one year. The hydrograph will show median daily values when daily data is available; otherwise, it will present mean-monthly

streamflow values. Staff will calculate 95% confidence intervals for the median streamflow if there is sufficient data. Statistically, there is 95% confidence that the true value of the median streamflow is located within the confidence interval.

Basin Characteristics

The drainage basin of the proposed ISF on Rock Creek is 6.45 square miles, with an average elevation of 11,000 ft and average annual precipitation of 25.33 inches. There are no known surface water diversions within the basin tributary to the proposed ISF (See the Hydrologic Features Map). There are also no reservoirs or transbasin import or exports. Hydrology in this drainage basin represents natural flow conditions.

Available Data

There are no current or historic streamflow gages in the vicinity of the proposed ISF reach. There was a historic USGS gage approximately 5.6 miles downstream near the confluence with Jefferson Creek. The Rock Creek near Jefferson, CO gage (USGS 06699000) operated primarily seasonally from 5/1/1986 – 9/30/1990. This gage was reinstalled by the Colorado Division of Water Resources (DWR) in cooperation with Aurora Water in 1994 (DWR RCKTARCO) and continues to be operated seasonally. The drainage basin of the gage location on Rock Creek is 45.6 square miles, with an average elevation of 10,200 ft and average annual precipitation of 23.01 inches. There are a small number of spring and well water rights in the basin tributary to the gage. A number of historical irrigation rights were changed to municipal use in Case No. 84CW0057. This case transferred portions of the water right in the drainage tributary to Rock Creek to the gage location. Portions of the same water rights were abandoned in the same case.

CWCB staff made 3 streamflow measurements on the proposed reach of Rock Creek as summarized in Table 3. These measurements were made at a location near the canyon mouth, approximately 0.33 miles upstream from the proposed lower terminus.

Table 3. Summary of streamflow measurement visits and results for Rock Creek.

Visit Date	Flow (cfs)	Method
08/26/2016	2.24	Wading ADV
06/04/2015	28.20	Wading ADV
08/27/2015	3.72	Wading Marsh McBirney

Data Analysis

Streamflow data from the USGS 06699000 and RCKTARCO gages were combined and prorated to the proposed lower terminus on Rock Creek using a factor of 0.156 based on the weighted area-precipitation method. This analysis produced streamflow estimates that did not compare well with measurements made by Staff and CPW in the proposed reach. On 6/4/2015, CWCB staff measured 28.20 cfs approximately 0.33 miles upstream from the lower terminus, but the average daily streamflow from the prorated gage data was 7 cfs. The other measurements were made in late August and September after the gage was no longer operating for the season; however, those measurements were much higher than the gage data from July. It is staff's view that the proration factor for Rock Creek does not sufficiently estimate streamflow in the proposed reach. Therefore, StreamStats provides the best available estimate of streamflow on Rock Creek.

Water Availability Summary
The hydrograph (See Complete Hydrograph) shows StreamStats results for mean-monthly streamflow. Staff has concluded that water is available for appropriation.

Material Injury
Because the proposed ISF on Rock Creek is a new junior water right, the ISF can exist without material injury to other water rights. Under the provisions of section 37-92-102(3)(b), C.R.S. (2016), the CWCB will recognize any uses or exchanges of water in existence on the date this ISF water right is appropriated.

Citations
Capesius, J.P. and V.C. Stephens, 2009, Regional regression equations for estimation of natural streamflow statistics in Colorado, Scientific Investigations Report 2009-5136.

Espegren, G.D., 1996, Development of Instream Flow Recommendations in Colorado Using R2CROSS, Colorado Water Conservation Board.

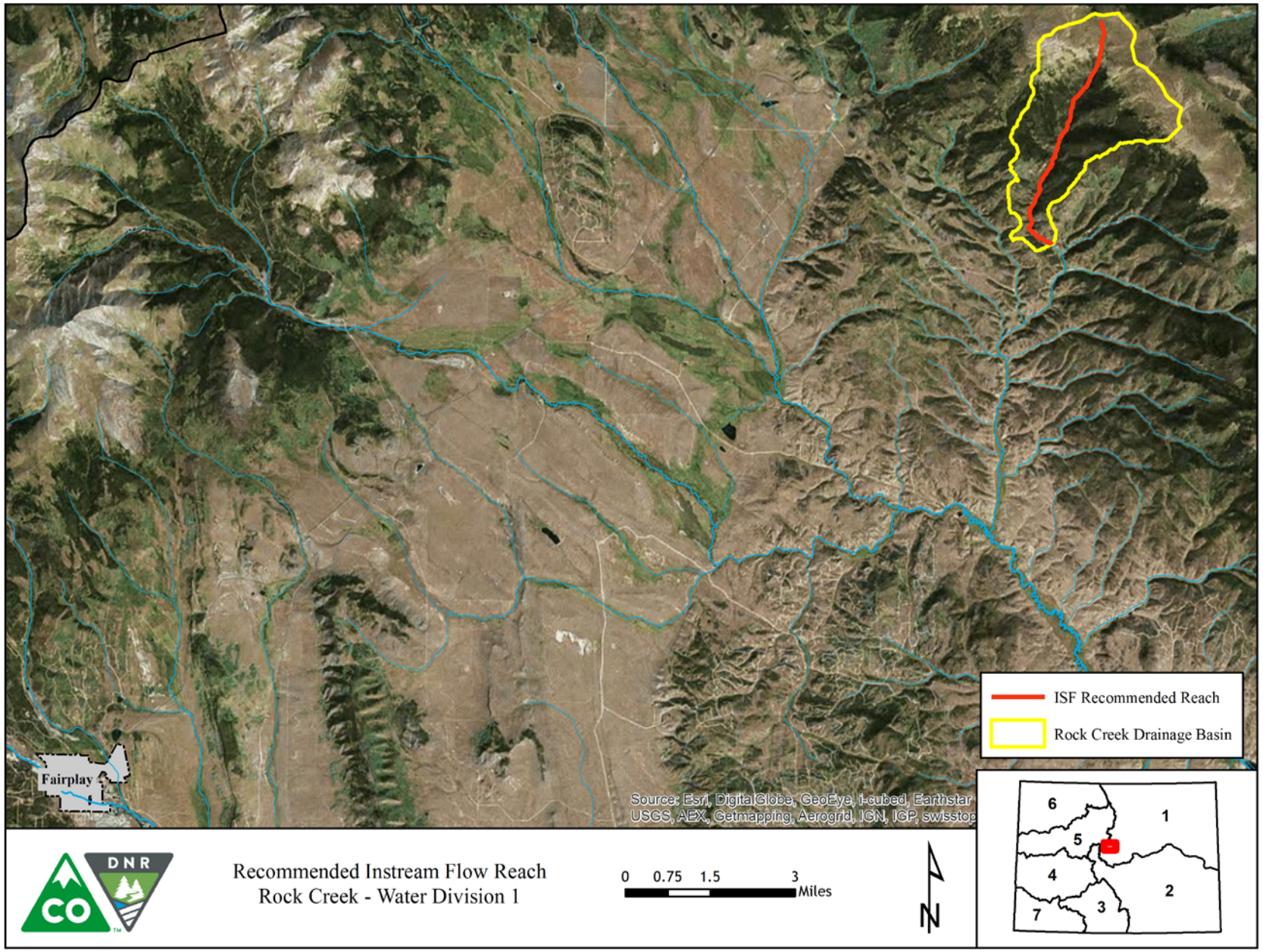
Nehring, B.R., 1979, Evaluation of Instream Flow Methods and Determination of Water Quantity Needs for Streams in the State of Colorado, Colorado Division of Wildlife.

Greenback Cutthroat Trout Recovery Team, and David L. Langlois, 1977, *Greenback cutthroat trout recovery plan*, US Fish and Wildlife Service.

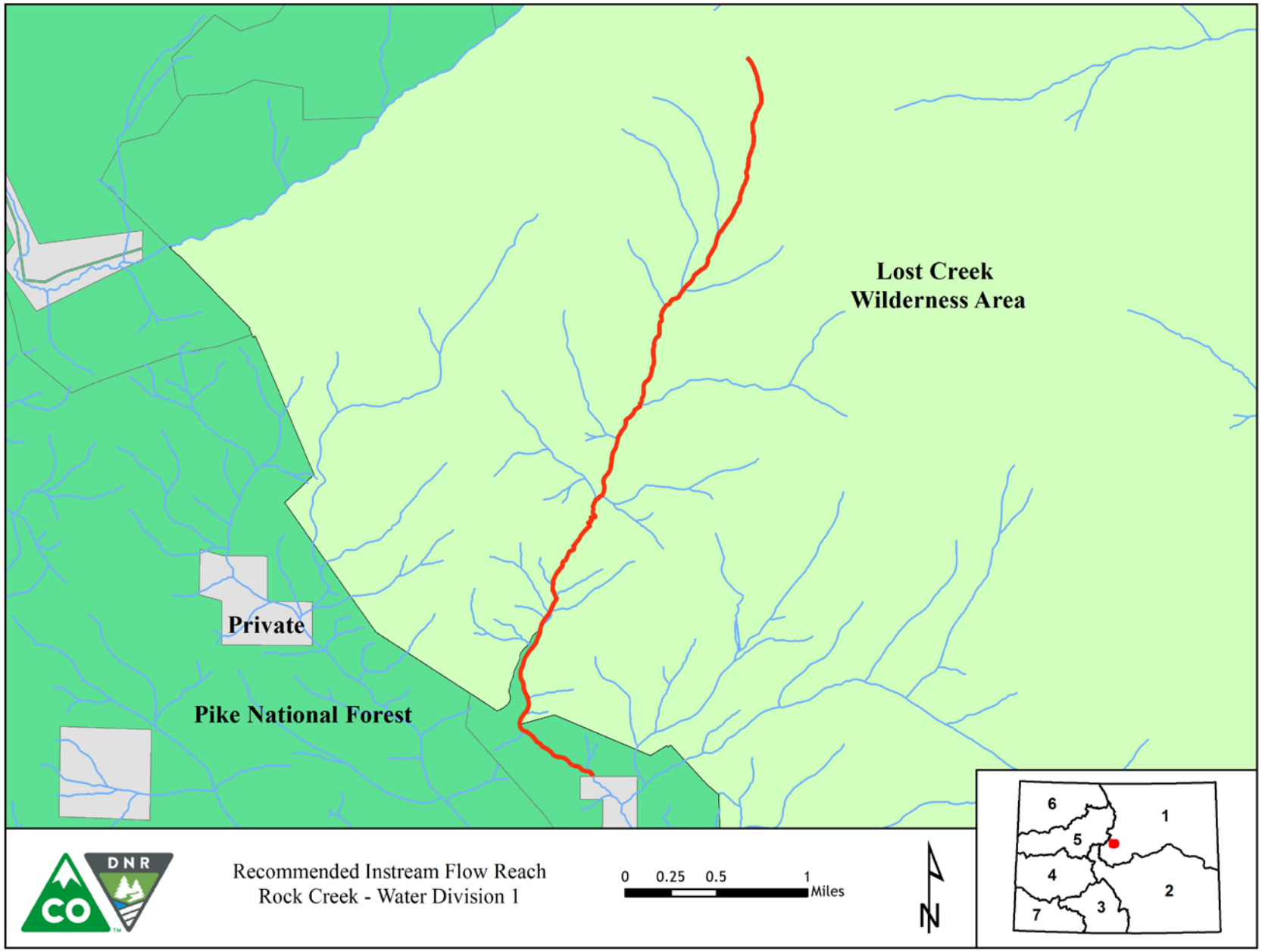
Metadata Descriptions
The UTM locations for the upstream and downstream termini were derived from CWCB GIS using the National Hydrography Dataset (NHD).

Projected Coordinate System: NAD 1983 UTM Zone 13N.

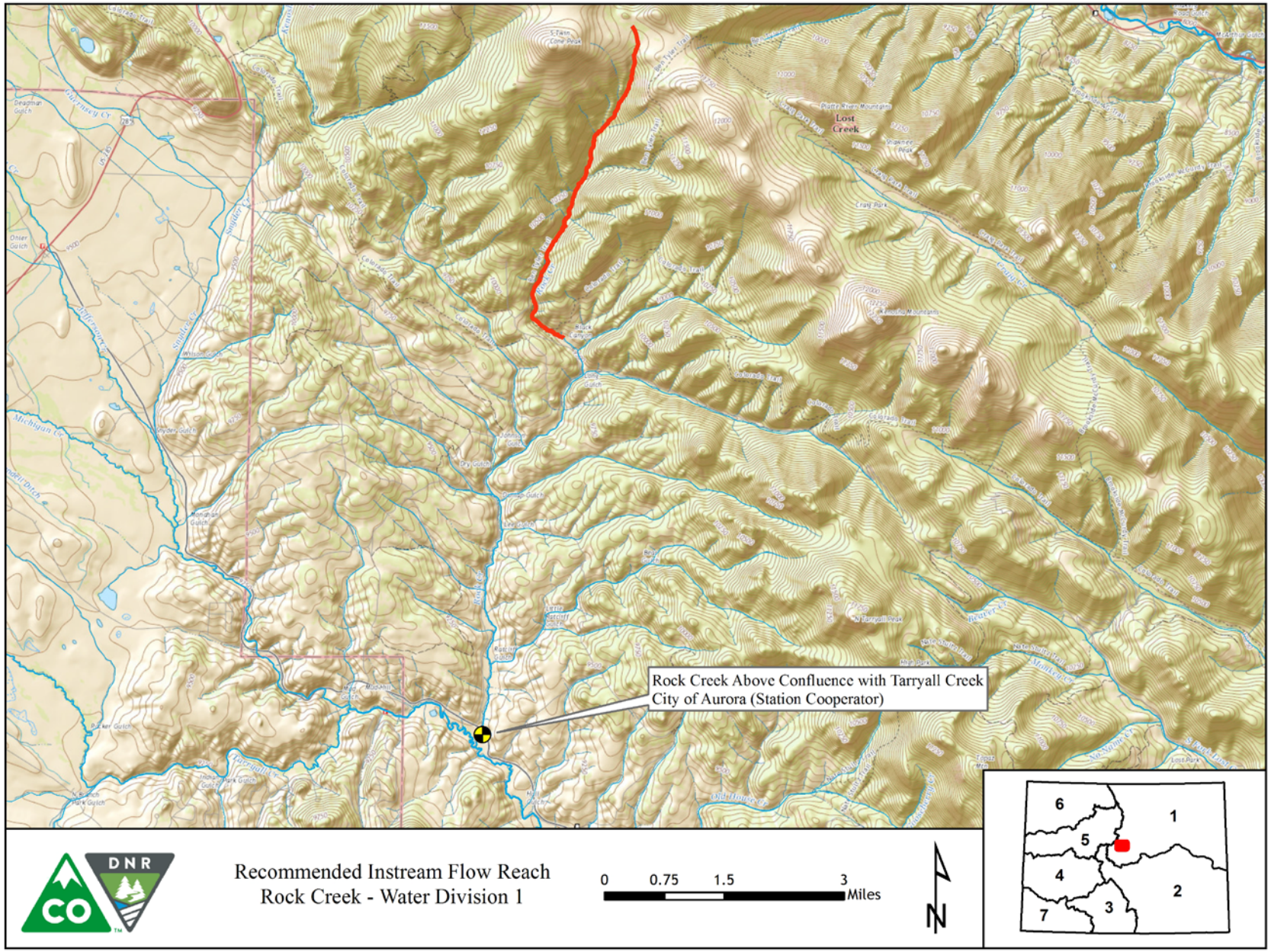
VICINITY MAP



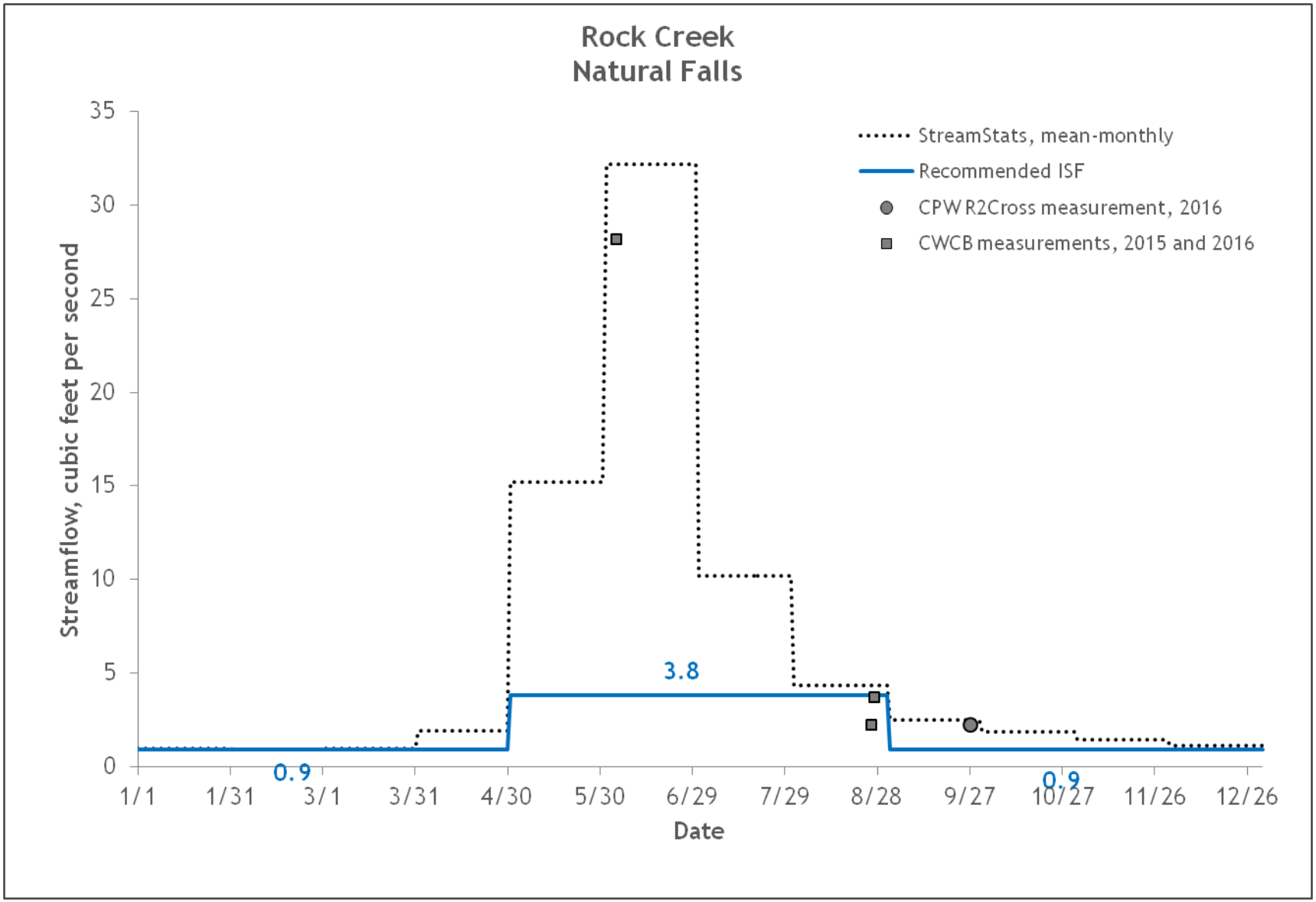
LAND OWNERSHIP MAP



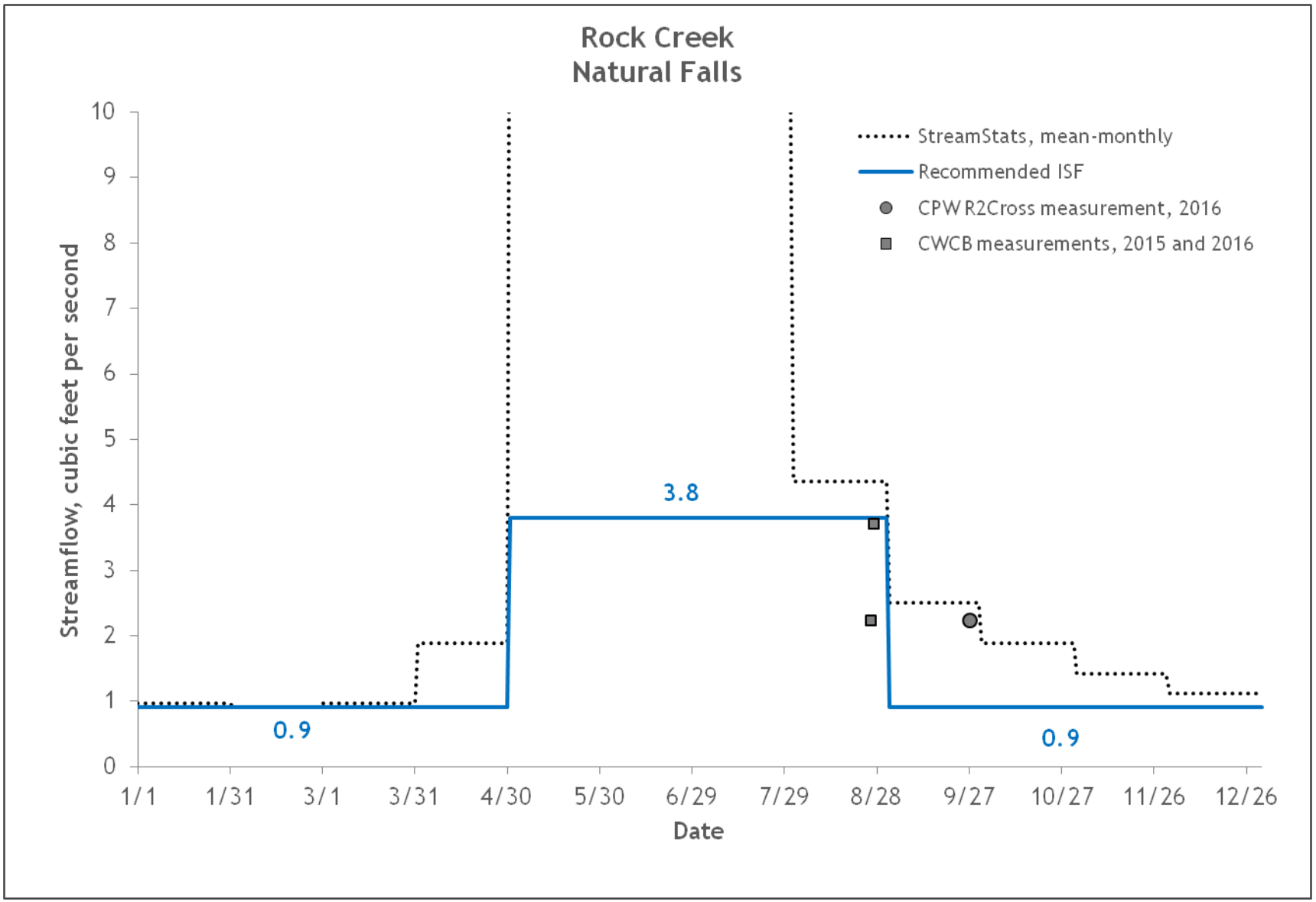
HYDROLOGIC FEATURES MAP



COMPLETE HYDROGRAPH



DETAILED HYDROGRAPH



COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Square Top Lakes (Upper & Lower)

EXECUTIVE SUMMARY

Square Top Lake (Upper)

Square Top Lake (Lower)

CWCB STAFF NATURAL LAKE LEVEL RECOMMENDATIONS

	Square Top Lake (Upper)	
LOCATION:	UTM North: 4382782.46	UTM East: 436057.06
RECOMMENDATION:	12,322 ft. (elevation)	113.14 Acre-Feet
	Square Top Lake (Lower)	
LOCATION:	UTM North: 4382623.44	UTM East: 436440.44
RECOMMENDATION:	12,084 ft. (elevation)	26.79 Acre-Feet
WATER DIVISION:	1	
WATER DISTRICT:	80	
COUNTY:	Clear Creek	
WATERSHED:	Upper South Platte	
CWCB ID:	16/1/A-011 & 16/1/A-010	
RECOMMENDER	Colorado Parks and Wildlife (CPW)	

Square Top Lakes (Upper & Lower)

Introduction

Colorado's General Assembly created the Instream Flow and Natural Lake Level Program in 1973, recognizing "the need to correlate the activities of mankind with some reasonable preservation of the natural environment" (see 37-92-102 (3), C.R.S.). The statute vests the Colorado Water Conservation Board (CWCB or Board) with the exclusive authority to appropriate and acquire instream flow (ISF) and natural lake level water rights (NLL). Before initiating a water right filing, the Board must determine that: 1) there is a natural environment that can be preserved to a reasonable degree with the Board's water right if granted, 2) the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made, and 3) such environment can exist without material injury to water rights.

Colorado Parks and Wildlife (CPW) recommended that the CWCB appropriate NLL water rights on Square Top Lakes Upper (STLU) & Lower (STLL). These lakes are located within Clear Creek County about 7.4 miles south of the town of Silver Plume (See Vicinity Map). One hundred percent of the land the subject natural lakes occupy is publicly owned and managed by the U.S. Forest Service (See Land Ownership Map). CPW recommended STLU and STLL because they have natural environments that can be preserved to a reasonable degree with a NLL water right.

The information contained in this report and the associated supporting data and analyses (located at: http://cwcb.state.co.us/environment/instream-flow-program/Pages/2017ProposedISFRecommendations.aspx) form the basis for staff's NLL recommendation to be considered by the Board. This report provides sufficient information to support the CWCB findings required by ISF Rule 5i on natural environment, water availability, and material injury.

Natural Environment

CWCB staff relies on the recommending entity to provide information about the natural environment. In addition, staff reviews information and conducts site visits for each recommended ISF appropriation. This information is used to provide the Board with a basis for determining that a natural environment exists.

STLU and STLL are high-elevation alpine lakes located east of Square Top Mountain in Clear Creek County. These are cirque basin lakes that possess typical cold water aquatic habitat. The main source of water for these natural lakes is snowmelt runoff, and the occasional precipitation event in this area. STLU is truly a headwaters lake since no identifiable creeks flow into the lake. STLU is located just a quarter of a mile west of STLL and water from STLU flows into STLL via a small unnamed creek. A very steep, cascading stream identified as an unnamed tributary to Duck Creek flows out of STLL to the next downstream lake (Duck Lake).

Several years ago, CPW researchers and aquatic biologists discovered whirling disease (WD) in the Square Top Lakes drainage basin. The WD lifecycle is complex and involves genetics of the intermediate host for the parasite, the tubifex worm. *Myxobolus cerebralis* (Mc) is a parasite that causes WD in fish; it has a two-stage life cycle by which it lives in two alternate hosts. The first stage of the Mc's life cycle is in the aquatic worm, *Tubifex tubifex*. The second host is the salmonid, where Mc lives in the cranial cartilage. The Mc life cycle is complicated by the fact that only a specific lineage of the tubifex worm can serve as the intermediate host for Mc (lineage III) (Nehring 2014). The other lineages (I, IV, and IV) are not able to transmit and therefore sustain Mc infection of

a water body. STLL contains lineage III tubifex worms and is therefore WD positive. STLU contains only lineage VI worms and is therefore incapable of sustaining a WD infection. Since Square Top Lakes are high elevation cold water habitats, the water is likely too cold for a WD infection to be severe. The tubifex genetics data makes these lakes good candidates for removal of WD by simply interrupting the Mc life cycle.

Interrupting the life cycle of Mc should result in a situation where the disease is removed from the system over time. The viability of Mc decreases exponentially when one of the hosts is eliminated, which apparently can occur over a time span of about one year (Nehring 2014). In 2010, CPW decided to remove all cutthroat trout from STLL using gill nets, and to keep the lake free of fish for 2-3 years (Nehring 2014). Gill nets were routinely set in STLL each summer for several weeks. Nets were also set at the outlet of STLU, and at the inlet of STLL to further isolate STLL from fish movement into and out of the lake. Even though STLU does not have WD, all fish were also removed from this lake so that greenback cutthroat trout (State and Federal Threatened species under ESA) can be introduced to the lake without the risk of hybridization between species (See Table 1).

Once WD disease and existing salmonid populations are removed, these lakes will become ideal water bodies for conservation activities to aid in the recovery of the greenback cutthroat trout because they: (1) will be completely isolated from any other species; (2) will have little risk of a re-infection by Mc; (3) will not have competition for food resources; and (4) will not be at risk of hybridization with other trout.

Table 1. List of species identified for reintroduction in Square Top Lakes.

Species Name	Scientific Name	Status
Greenback cutthroat trout	*Oncorhynchus clarkii stomias*	State – Threatened Federal - Threatened

NLL Quantification

CWCB staff relies upon the biological expertise of the recommending entity to quantify the amount of water required to preserve the natural environment to a reasonable degree. In natural lake level appropriations, CPW recommends that the entire volume of water in a natural lake be appropriated to preserve the natural environment to a reasonable degree. CPW has determined that appropriating a lesser volume would likely result in diminution of habitat to which species have become accustomed.

Standard survey methods were used to determine each lake's surface water elevation, surface area, and volume. The volume for each lake was calculated by taking several cross-sections of each lake and measuring depth across those sections. The longitudinal location of each of the sections was also measured. CPW's Engineering Section took this field data and calculated the volume using computer-aided design (CAD) software. Water surface elevations were determined by CWCB staff taking multiple GPS elevations at the surface of the water at locations around the lakes and averaging all readings for each lake.

NLL Recommendation

Table 2 shows the survey measurements for the NLL quantification of the Square Top Lakes. CPW and CWCB staff contributed to the collection and calculation of the quantification data.

Table 2. Survey measurements.

Name	Volume, AF	Elevation, ft	Max Depth, ft	Surface Area, ft^2
Square Top Lakes (Upper)	113.14	12,322	38.70	328,674
Square Top Lakes (Lower)	26.79	12,084	11.5	304,377

Water Availability

CWCB staff conducts hydrologic analyses for each recommended ISF appropriation to provide the Board with a basis for making the determination that water is available.

Basin Characteristics

The Square Top Lakes are small cirque lakes with small high-elevation drainage basins. The lakes are connected by a short (approximately 640 ft) unnamed perennial stream. The unnamed stream flows out of the STLL for approximately 1.1 miles before entering Duck Lake. The drainage basin of the proposed NLL on STLU is 0.23 square miles, with an average elevation of 12,700 ft and average annual precipitation of 28.02 inches (Hydrologic Features Map). The drainage basin of the proposed NLL on STLL is 0.42 square miles, with an average elevation of 12,600 ft and average annual precipitation of 27.71 inches. No water rights were identified in the basin tributary to the Square Top Lakes and all lake levels are natural.

Water Availability Summary

The Square Top Lakes are clearly identified on USGS 1:24000 scale maps and in the Geographic Names Information System (GNIS), a database of federally recognized feature names. Based on the persistence of these lakes through time and presence of water in the system, Staff concludes that water is available for appropriation.

Material Injury

Because the proposed NLLs on STLL and STLU are new junior water rights, the NLLs can exist without material injury to other water rights. Under the provisions of section 37-92-102(3)(b), C.R.S. (2016), the CWCB will recognize any uses or exchanges of water in existence on the date these NLL water rights are appropriated.

Citations:

AFS Blue Book, Characteristics of *Myxobolus cerebralis* and other Myxozoans common to salmonid fish, 2014.

Greenback Cutthroat Trout Recovery Team, and David L. Langlois, 1977, *Greenback cutthroat trout recovery plan*, US Fish and Wildlife Service.

Kowalski, D., 2013, Colorado River Aquatic Resource Investigations- Federal Aid Project F-237-R20, Colorado Parks and Wildlife.

Nehring, B.R., 2014, Fishery management interventions to eliminate *Myxobolus cerebralis* infection in Lower Square Top Lake, Clear Creek County, Colorado (1998-2014), Colorado Parks and Wildlife.

Metadata Descriptions

The UTM locations for the upstream and downstream termini were derived from CWCB GIS using the National Hydrography Dataset (NHD).

Projected Coordinate System: NAD 1983 UTM Zone 13N.

Lake Elevations: North American Vertical Datum of 1988 (NAVD 88).

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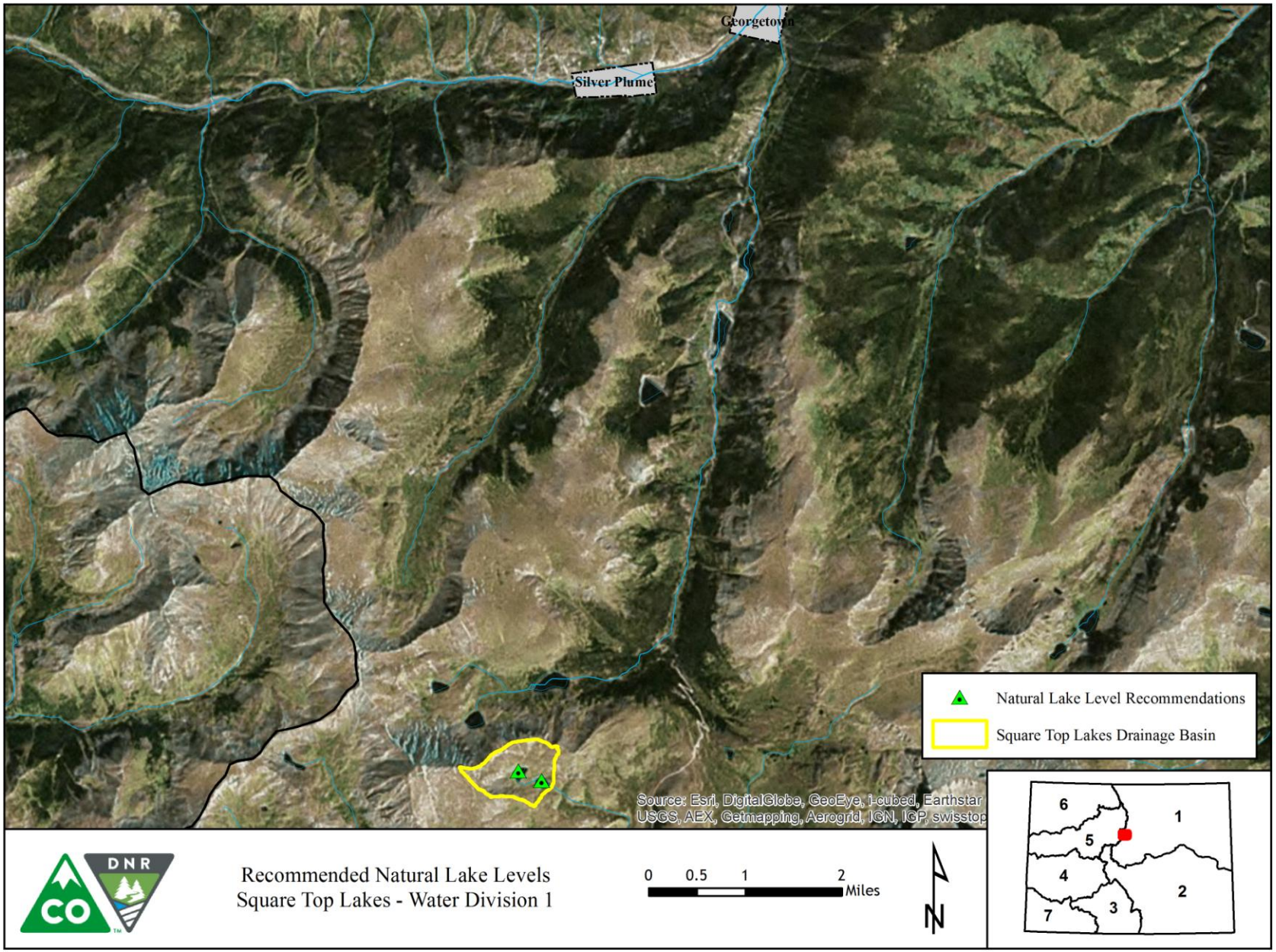
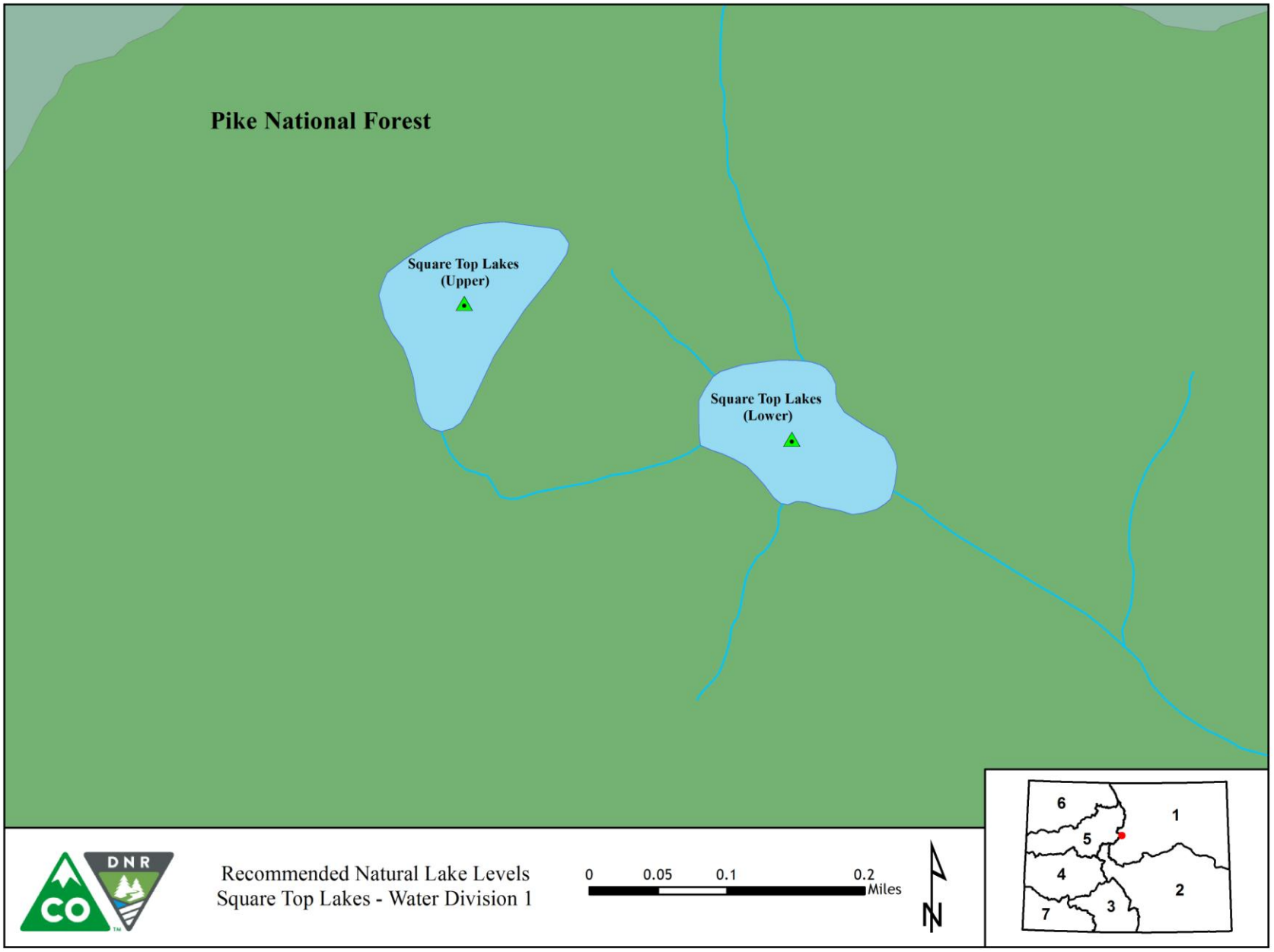
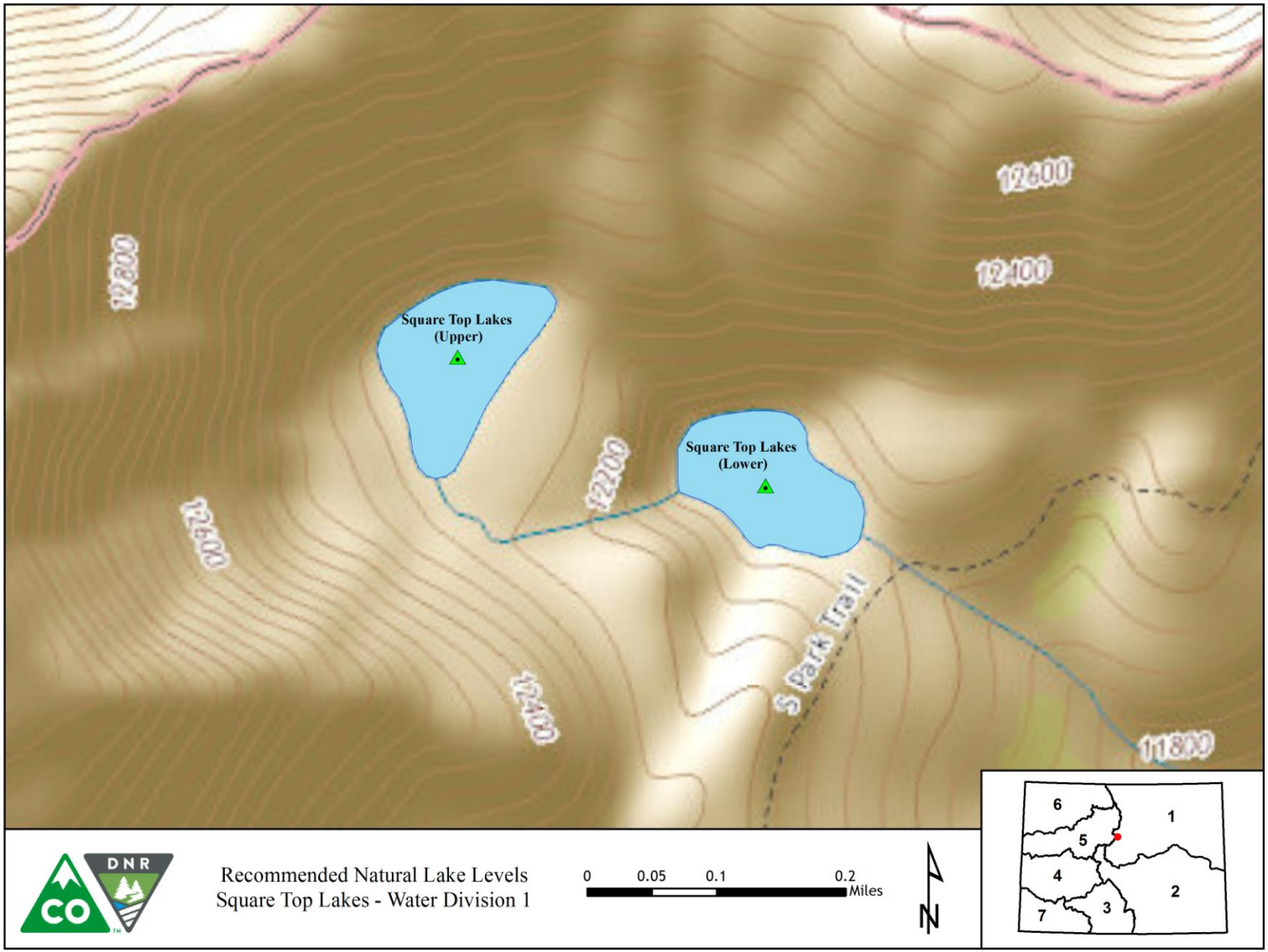
VICINITY MAP



LAND OWNERSHIP MAP



HYDROLOGIC FEATURES MAP



COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Unnamed Tributary to Rough and Tumbling Creek

EXECUTIVE SUMMARY

CWCB STAFF INSTREAM FLOW RECOMMENDATION

UPPER TERMINUS:	Headwaters in the Vicinity of UTM North: 4318074.94 UTM East: 401245.59
LOWER TERMINUS:	Confluence Rough and Tumbling Creek UTM North: 4321559.19 UTM East: 403468.05
WATER DIVISION:	1
WATER DISTRICT:	23
COUNTY:	Park
WATERSHED:	South Platte Headwaters
CWCB ID:	16/1/A-005
RECOMMENDER:	Colorado Parks and Wildlife (CPW), Park County
LENGTH:	2.78 miles
FLOW RECOMMENDATION:	0.3 (01/01 - 12/31)

Unnamed Tributary to Rough and Tumbling Creek

Introduction

Colorado's General Assembly created the Instream Flow and Natural Lake Level Program in 1973, recognizing "the need to correlate the activities of mankind with some reasonable preservation of the natural environment" (see 37-92-102 (3), C.R.S.). The statute vests the Colorado Water Conservation Board (CWCB or Board) with the exclusive authority to appropriate and acquire instream flow (ISF) and natural lake level water rights (NLL). Before initiating a water right filing, the Board must determine that: 1) there is a natural environment that can be preserved to a reasonable degree with the Board's water right if granted, 2) the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made, and 3) such environment can exist without material injury to water rights.

CPW and Park County recommended that the CWCB appropriate an ISF water right on a reach of an unnamed tributary to Rough and Tumbling Creek. The unnamed tributary of Rough and Tumbling Creek (Unnamed Tributary) originates in the Buffalo Peaks Wilderness Area at an elevation of approximately 11,800 ft. It flows in a northwesterly direction for 2.78 miles as it drops to an elevation of approximately 10,160 ft where it joins Rough and Tumbling Creek. The proposed reach is located within Park County (See Vicinity Map) and extends from its headwaters downstream to the confluence with Rough and Tumbling Creek. One hundred percent of the land on the 2.78 mile proposed reach is publicly owned and managed by the U.S. Forest Service (USFS) (See Land Ownership Map). CPW and Park County recommended this reach of an unnamed tributary of Rough and Tumbling Creek because it has a natural environment that can be preserved to a reasonable degree with an ISF water right.

The information contained in this report and the associated supporting data and analyses (located at: http://cwcb.state.co.us/environment/instream-flow-program/Pages/2017ProposedISFRecommendations.aspx) form the basis for staff's ISF recommendation to be considered by the Board. This report provides sufficient information to support the CWCB findings required by ISF Rule 5i on the natural environment, water availability, and material injury.

Natural Environment

CWCB staff relies on the recommending entity to provide information about the natural environment. In addition, staff reviews information and conducts site visits for each recommended ISF appropriation. This information is used to provide the Board with a basis for determining that a natural environment exists.

This stream reach is a mix of alpine and forested/montane habitat types with snowmelt driven hydrology. The aquatic habitat is very typical of headwaters boreal toad habitat (See Table 1). No fish have ever been sampled in this stream. On July 28, 2004 CPW aquatic biologist Jeff Spohn captured an adult boreal toad (*Bufo boreas boreas*) at location UTM 13S East 0399312 North 4320124. Since the initial discovery of boreal toads in the Unnamed Tributary in 2004, CPW, the USFS and the Colorado Natural Heritage Program (CNHP) have engaged in studies of toad populations here and elsewhere in the South Platte drainage.

The boreal toad is present throughout most of western North America, but it is believed that there is a distinct Southern Rocky Mountain population of this species. This species ranges from Wyoming to Southern Colorado. The boreal toad is believed to be extirpated from New Mexico. Colorado, New

Mexico and Wyoming have all placed state designations on the boreal toad (State Endangered or Protected)(Jackson 2006). In Colorado, the boreal toad is found throughout the Rocky Mountains from the northern state border south to Hinsdale and Mineral County (CPW 2016). Toads are found from 12,000 to 7,500 ft in elevation, but are more commonly found at 11,500 to 8,500 ft (CPW 2016). Boreal toads prefer habitats in close proximity to ponds, mountain lakes, wetlands, meadows, and subalpine forests (CPW 2016). It is thought that the main limiting factor to this species is proximity to suitable breeding habitat (CPW 2016). Breeding habitat consists of shallow lakes, ponds, marshes and bogs that have plentiful exposure to solar radiation (CPW 2016). Two boreal toad breeding sites have been documented in the Rough and Tumbling Creek drainage (See Table 1). These breeding sites seem to follow beaver activity and therefore come and go as beaver ponds come and go. Fortunately, the Rough and Tumbling Creek sites have tested negative for chytrid fungus, which makes these breeding sites and the drainage as a whole even more valuable from a conservation perspective.

Most of the suitable boreal toad habitats in the Unnamed Tributary are found in the upper half of the recommended ISF reach (see the description of habitat preferences above). The riparian corridor along the Unnamed Tributary has potential toad habitat in areas with low water velocities and disconnected pools (these habitat features are also important for toad survival). These habitat features are also prominent in and around the confluence (the lower terminus of the Unnamed Tributary ISF recommendation). In summary, CPW has documented that boreal toads are utilizing a number of sites within the ISF segment proposed herein; therefore, there is a natural environment in the form of critical boreal toad habitat that could benefit from the protection afforded by a CWCB ISF water right.

Table 1. List of species identified in unnamed tributary to Rough and Tumbling Creek.

Species Name	Scientific Name	Status
boreal toad	*Bufo boreas boreas*	State - Endangered

ISF Quantification

CWCB staff relies upon the biological expertise of the recommending entity to quantify the amount of water required to preserve the natural environment to a reasonable degree. CWCB staff performs a thorough review of the quantification analyses completed by the recommending entity to ensure consistency with accepted standards.

Methodology

CPW staff used the R2Cross methodology to develop the initial ISF recommendation. The R2Cross method is based on a hydraulic model and uses field data collected in a stream riffle (Espegren, 1996). Riffles are most easily visualized as the stream habitat types that would dry up first should streamflow cease. The field data collected consists of streamflow measurements and surveys of channel geometry at a transect and of the longitudinal slope of the water surface.

The field data is used to model three hydraulic parameters: average depth, average velocity, and percent wetted perimeter. Maintaining these hydraulic parameters at adequate levels across riffle habitat types also will maintain aquatic habitat in pools and runs for most life stages of fish and aquatic macro-invertebrates (Nehring, 1979). In the case of boreal toads, it is CPW's biologic expert opinion that flows quantified with R2Cross will also provide sufficient habitat to provide reasonable preservation of this species. CPW staff interprets the model results to develop an initial

recommendation for summer and winter flows. The summer flow recommendation is based on meeting 3 of 3 hydraulic criteria. The winter flow recommendation is based on meeting 2 of 3 hydraulic criteria. The model's suggested accuracy range is 40% to 250% of the streamflow measured in the field. Recommendations that fall outside of the accuracy range may not give an accurate estimate of the hydraulic parameters necessary to determine an ISF rate.

The R2Cross methodology provides the biological quantification of the amount of water needed for summer and winter periods based on empirical studies of fish species preferences. The recommending entity uses the R2Cross results and its biological expertise to develop an initial ISF recommendation. CWCB staff then evaluates water availability for the reach typically based on median hydrology (see the Water Availability section below for more details). The water availability analysis may indicate less water is available than the initial recommendation. In that case, the recommending entity either modifies the magnitude and/or duration of the recommended ISF rates if the available flows will preserve the natural environment to a reasonable degree, or withdraws the recommendation.

Data Analysis
R2Cross data was collected at 2 transects for this proposed ISF reach (Table 2). Results obtained at more than one transect are averaged to determine the R2Cross flow rate for the reach of stream.

Table 2. Summary of R2Cross transect measurements and results for the unnamed tributary to Rough and Tumbling Creek.

Entity	Date	Streamflow (cfs)	Accuracy Range (cfs)	Winter Rate (cfs)	Summer Rate (cfs)
CPW	09/27/2016 # 1	0.14	0.06 - 0.3	0.77[1]	0.3[2]
CPW	09/27/2016 # 2	0.18	0.07 - 0.4	0.52[1]	0.4[1]
			Mean	NA	0.35

[1] *Flow recommendations outside the range of R2CROSS model accuracy for this site measurement.*

[2] *The third R2CROSS hydraulic criterion (average velocity) was never met on the R2CROSS staging table - due to low gradient.*

ISF Recommendation
CPW recommends the following flows based on R2Cross modeling analyses, biological expertise, and staff's water availability analysis.

Based on the R2CROSS results (see Table 2) and the natural environment of the Unnamed Tributary, CPW believes that a single year-round flow in the 0.3 to 0.4 cfs range is both necessary and appropriate for the Unnamed Tributary. Flows in this range are the highest flows that can be accurately predicted with the R2CROSS data sets that we currently have. The average of these two values is 0.35 cfs. It is important to note that flows in this range fall short of the flows needed to meet even two of the R2CROSS hydraulic criteria, but flows in this range appear to be adequate to protect the state endangered boreal toad's habitat present in this stream segment. Because the

water availability analyses (described below) conclude that only 0.3 cfs is available, the ISF recommendation for the Unnamed Tributary is 0.3 cfs.

Water Availability
CWCB staff conducts hydrologic analyses for each recommended ISF appropriation to provide the Board with a basis for making the determination that water is available.

Methodology
Each recommended ISF reach has a unique flow regime that depends on variables such as the timing, magnitude, and location of water inputs (such as rain, snow, and snowmelt) and water losses (such as diversions, reservoirs, evaporation and transpiration, groundwater recharge, etc). Although extensive and time-consuming investigations of all variables may be possible, staff takes a pragmatic and cost-effective approach to analyzing water availability. This approach focuses on streamflows and the influence of flow alterations, such as diversions, to understand how much water is physically available in the recommended reach.

Staff's hydrologic analysis is data-driven, meaning that staff gathers and evaluates the best available data and uses the best available analysis method for that data. Whenever possible, long-term stream gage data (period of record 20 or more years) will be used to evaluate streamflow. Other streamflow information such as short-term gages, temporary gages, spot streamflow measurements, diversion records, and StreamStats will be used when long-term gage data is not available. StreamStats, a statistical hydrologic program, uses regression equations developed by the USGS (Capesius and Stephens, 2009) to estimate mean flows for each month based on drainage basin area and average drainage basin precipitation. Diversion records will also be used to evaluate the effect of surface water diversions when necessary. Interviews with water commissioners, landowners, and ditch or reservoir operators can provide additional information. A range of analytical techniques may be employed to extend gage records, estimate streamflow in ungaged locations, and estimate the effects of diversions. The goal is to obtain the most detailed and reliable estimate of hydrology using the most efficient analysis technique.

The final product of the hydrologic analysis used to determine water availability is a hydrograph, which shows streamflow and the proposed ISF rate over the course of one year. The hydrograph will show median daily values when daily data is available; otherwise, it will present mean-monthly streamflow values. Staff will calculate 95% confidence intervals for the median streamflow if there is sufficient data. Statistically, there is 95% confidence that the true value of the median streamflow is located within the confidence interval.

Basin Characteristics
The drainage basin of the proposed ISF on the unnamed tributary to Rough and Tumbling Creek is 2.08 square miles, with an average elevation of 11,500 ft and average annual precipitation of 25.30 inches. There are no known surface water diversions within the basin tributary to the proposed ISF. There are also no reservoirs or transbasin import or exports. Hydrology in this drainage basin represents natural flow conditions. See the Hydrologic Features Map.

Available Data
There are no current or historic streamflow gages in the vicinity of the proposed ISF reach. The closest gage is the South Fork South Platte River Above Fairplay, CO gage (USGS 026694400) located approximately 5 miles downstream. This historic gage operated for just 3 years from 1/1/1978 to

12/31/1980. The drainage basin of the proposed ISF on the unnamed tributary to Rough and Tumbling Creek is 50.3 square miles, with an average elevation of 11,100 ft and average annual precipitation of 24.55 inches. There are 60.5 cfs in absolute decreed water rights in the basin tributary to this historic gage, and many of the larger rights appear to be used consistently. Due to the combination of water diversions, small proration factor, and short record, this gage is not suitable for estimating streamflow on the proposed ISF reach.

CWCB staff made three streamflow measurements on the proposed reach of the unnamed tributary to Rough and Tumbling Creek as summarized in Table 3.

Table 3. Summary of streamflow measurement visits and results for unnamed tributary to Rough and Tumbling Creek.

Visit Date	Flow (cfs)	Method
08/26/2016	0.59	Wading ADV
07/28/2016	0.78	Wading ADV
08/27/2015	0.19	Wading Marsh McBirney

Data Analysis
StreamStats provides the best available estimate of streamflow on unnamed tributary to Rough and Tumbling Creek.

Water Availability Summary
The hydrographs (See Complete Hydrograph and Detailed Hydrograph) show StreamStats results for mean-monthly streamflow. Staff has concluded that water is available for appropriation.

Material Injury
Because the proposed ISF on unnamed tributary to Rough and Tumbling Creek is a new junior water right, the ISF can exist without material injury to other water rights. Under the provisions of section 37-92-102(3)(b), C.R.S. (2016), the CWCB will recognize any uses or exchanges of water in existence on the date this ISF water right is appropriated.

Citations
Capesius, J.P. and V.C. Stephens, 2009, Regional regression equations for estimation of natural streamflow statistics in Colorado, Scientific Investigations Report 2009-5136.

Colorado Parks and Wildlife, *Colorado Parks & Wildlife - Boreal Toad Research*, N.p., n.d. Web. 29 Nov. 2016.

Espegren, G.D., 1996, Development of Instream Flow Recommendations in Colorado Using R2CROSS, Colorado Water Conservation Board.

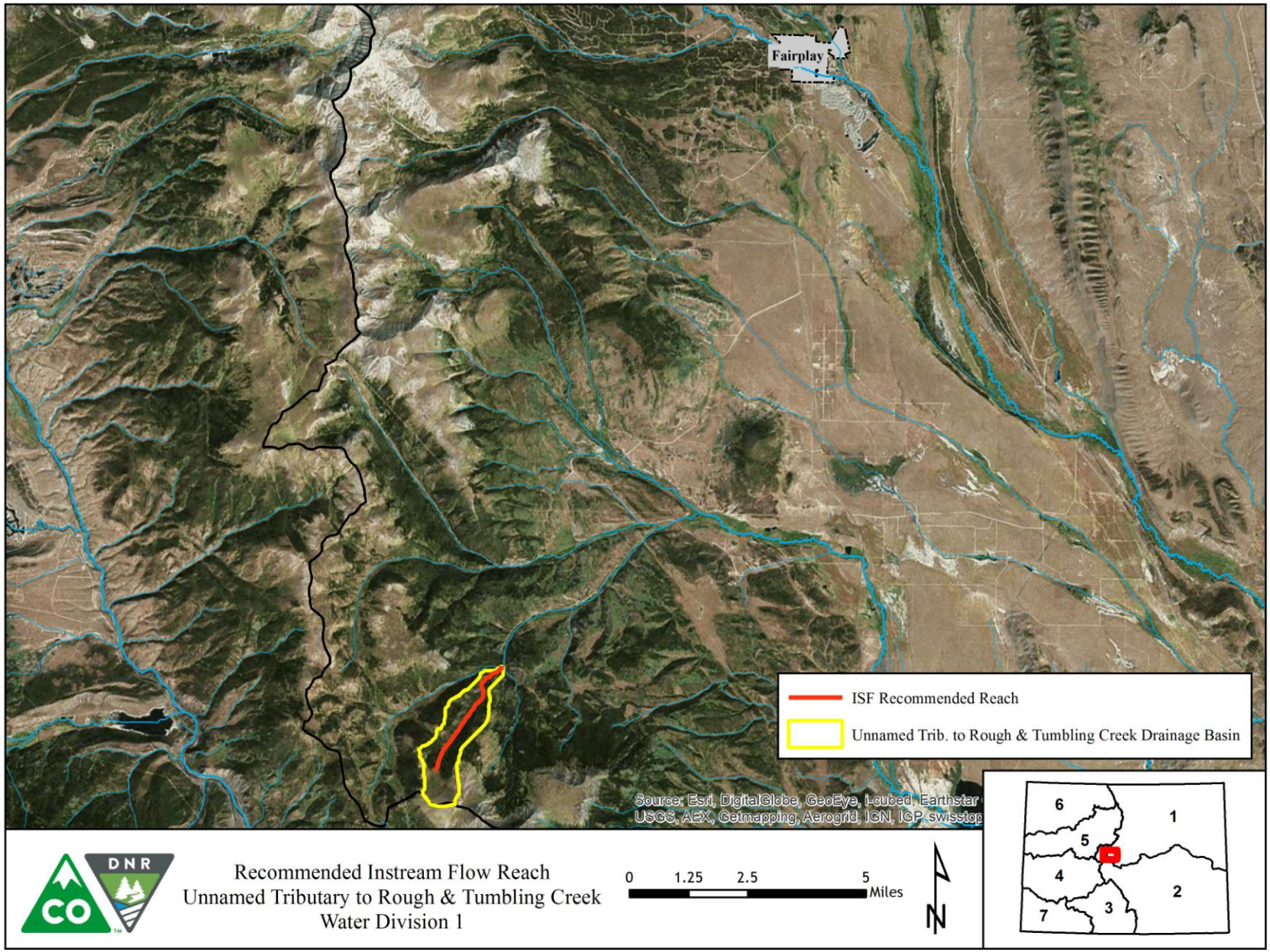
Jackson, T. (ed.), 2006, Report on the status and conservation of the boreal toad (*Bufo boreas boreas*) in the Southern Rocky Mountains 2006. Boreal Toad Recovery Team. 134 pp.

Nehring, B.R., 1979, Evaluation of Instream Flow Methods and Determination of Water Quantity Needs for Streams in the State of Colorado, Colorado Division of Wildlife.

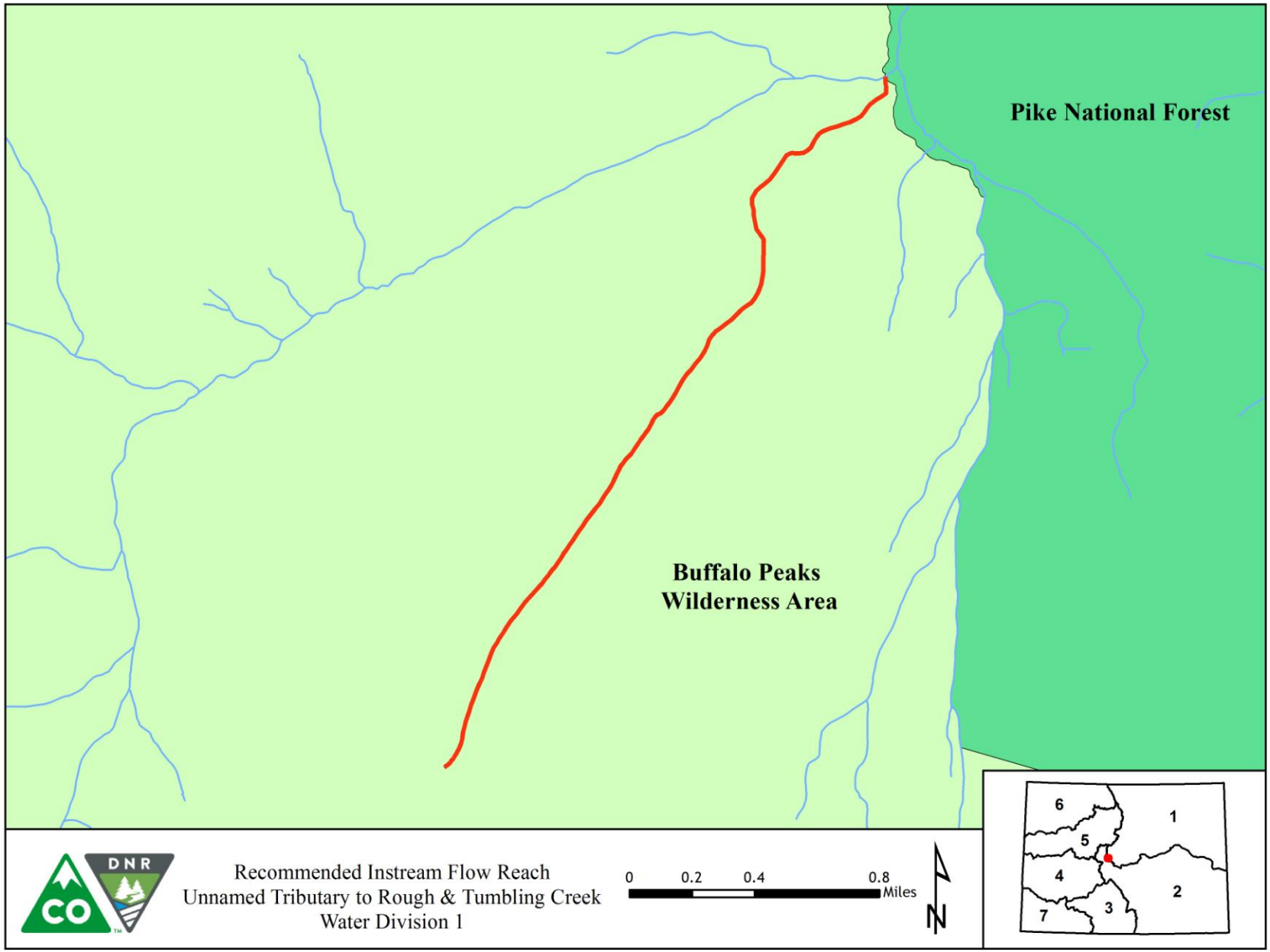
Metadata Descriptions
The UTM locations for the upstream and downstream termini were derived from CWCB GIS using the National Hydrography Dataset (NHD).

Projected Coordinate System: NAD 1983 UTM Zone 13N.

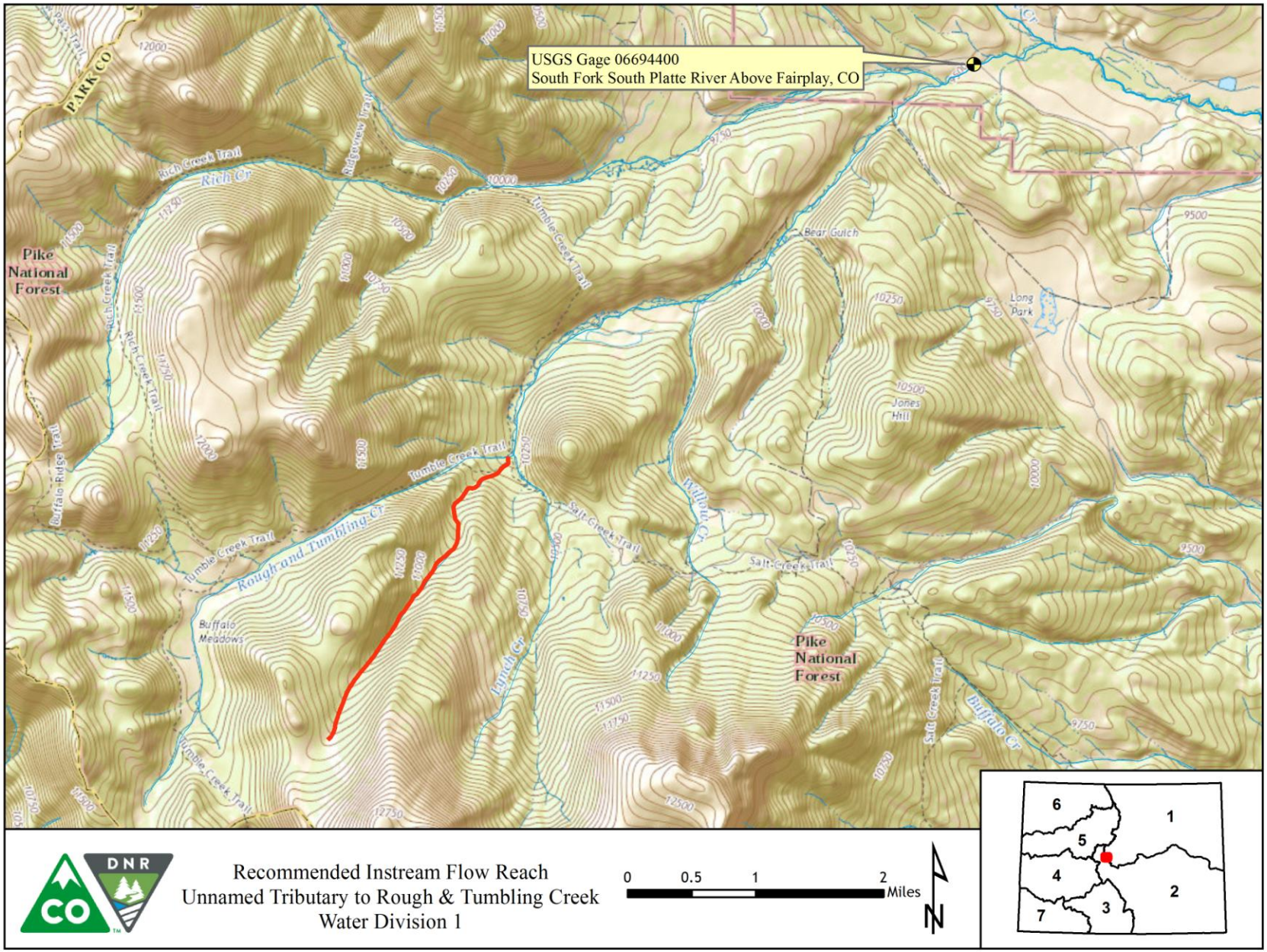
VICINITY MAP



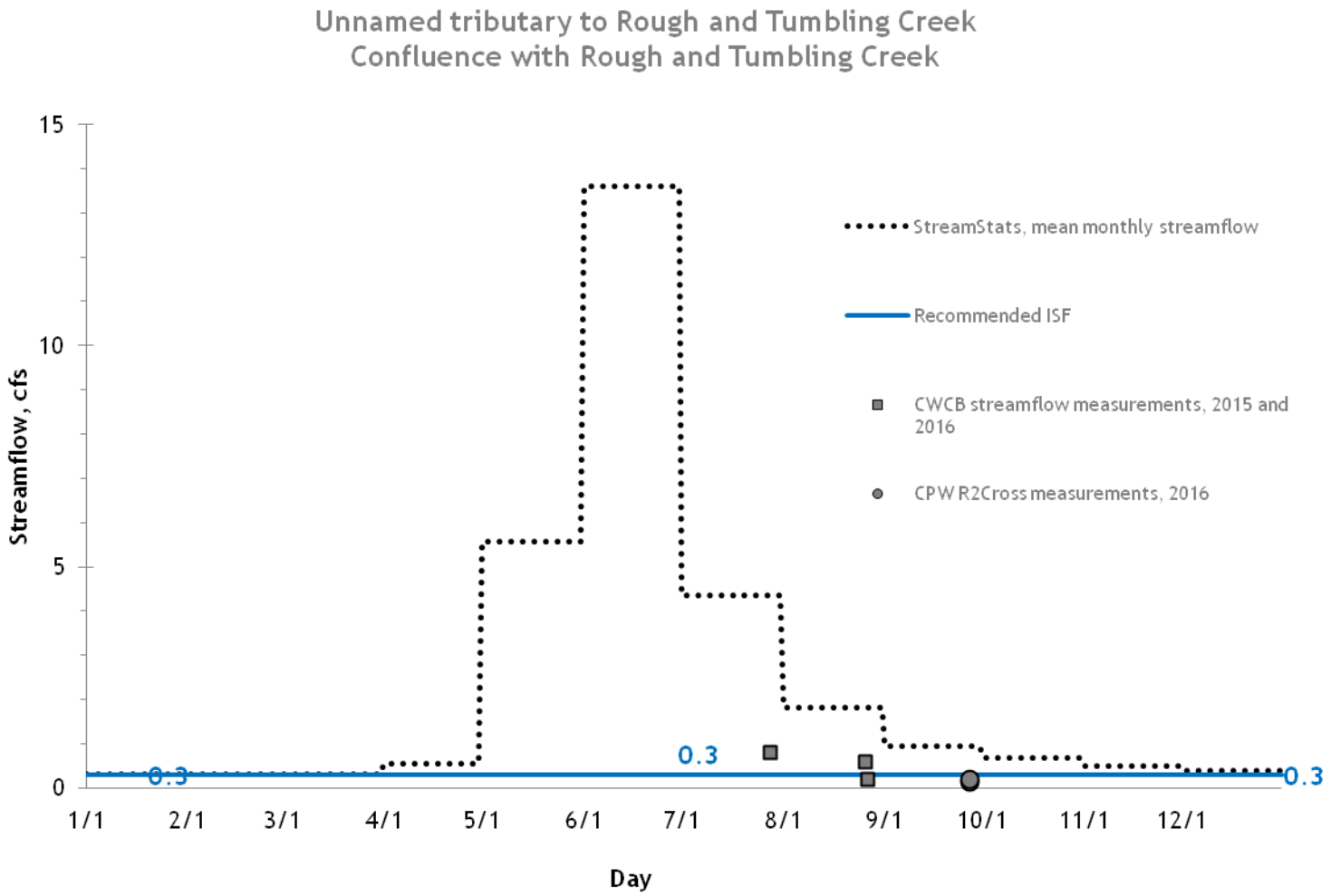
LAND OWNERSHIP MAP



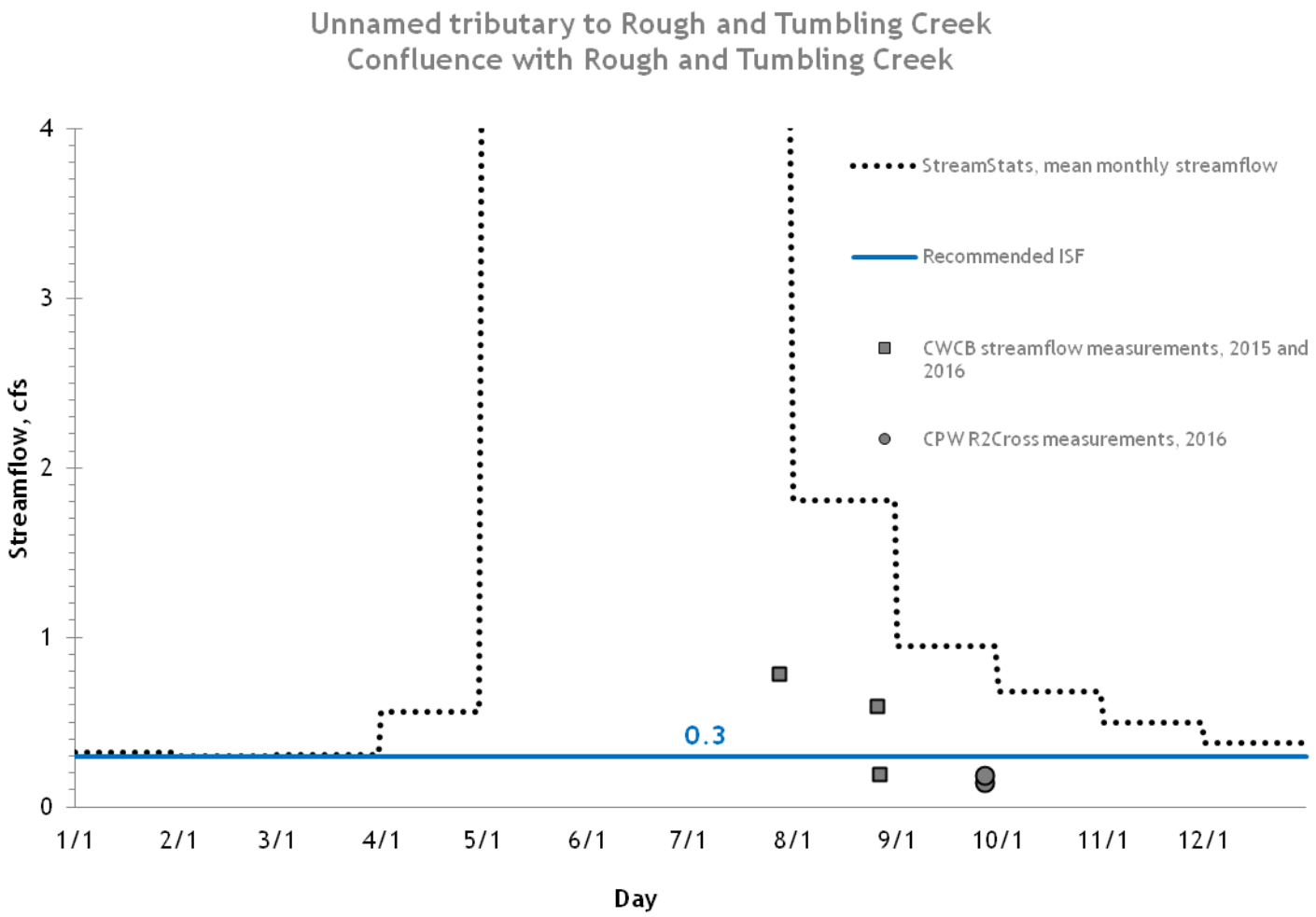
HYDROLOGIC FEATURES MAP



COMPLETE HYDROGRAPH



DETAILED HYDROGRAPH



COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Apishapa River
EXECUTIVE SUMMARY

CWCB STAFF INSTREAM FLOW RECOMMENDATION

UPPER TERMINUS:	Headwaters in the vicinity of UTM North: 4134067.69	UTM East: 498440.80
LOWER TERMINUS:	Confluence with Herlick Canyon UTM North: 4131036.76	UTM East: 504368.80
WATER DIVISION:	2	
WATER DISTRICT:	18	
COUNTY:	Las Animas	
WATERSHED:	Apishapa	
CWCB ID:	12/2/A-001	
RECOMMENDER:	Colorado Division of Wildlife (CPW)	
LENGTH:	4.52 miles	
FLOW RECOMMENDATION:	2.9 (05/1 - 06/30) 1.1 (7/01 - 8/31) 0.5 (09/01 - 04/30)	

Apishapa River

Introduction

Colorado's General Assembly created the Instream Flow and Natural Lake Level Program in 1973, recognizing "the need to correlate the activities of mankind with some reasonable preservation of the natural environment" (see 37-92-102 (3), C.R.S.). The statute vests the Colorado Water Conservation Board (CWCB or Board) with the exclusive authority to appropriate and acquire instream flow (ISF) and natural lake level water rights (NLL). Before initiating a water right filing, the Board must determine that: 1) there is a natural environment that can be preserved to a reasonable degree with the Board's water right if granted, 2) the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made, and 3) such environment can exist without material injury to water rights.

The CPW recommended that the CWCB appropriate an ISF water right on a reach of the Apishapa River. The Apishapa River originates at an elevation of approximately 10,880 ft in the Spanish Peaks Wilderness and flows in a northeasterly direction for one hundred thirty miles dropping to an elevation of approximately 4,280 ft where it joins the Arkansas River. The proposed reach is located within Las Animas County (See Vicinity Map) and extends from its headwaters downstream to the confluence with Herlick Canyon. Forty-seven percent of the land on the 4.52 mile proposed reach is publicly owned and managed by the U.S. Forest Service (USFS); the remaining land is privately owned (See Land Ownership Map). The CPW recommended this reach of the Apishapa River because it has a natural environment that can be preserved to a reasonable degree with an ISF water right.

The information contained in this report and the associated supporting data and analyses (located at: http://cwcb.state.co.us/environment/instream-flow-program/Pages/2017ProposedISFRecommendations.aspx) form the basis for staff's ISF recommendation to be considered by the Board. This report provides sufficient information to support the CWCB findings required by ISF Rule 5i on the natural environment, water availability, and material injury.

Natural Environment

CWCB staff relies on the recommending entity to provide information about the natural environment. In addition, staff reviews information and conducts site visits for each recommended ISF appropriation. This information is used to provide the Board with a basis for determining that a natural environment exists.

In August of 2010, CPW personnel collected stream cross-section information, natural environment data, and other data needed to quantify the instream flow needs for this reach of Apishapa River. The Apishapa River is classified as a small stream (between 10 to 19 ft wide). The Apishapa River basin supports a very diverse fishery - the lower reaches of the stream (downstream of this ISF segment) supports populations of native fish including black Bullhead (*Ameiurus melas*), flathead chub (*Platygobio gracilis*, Species of Concern), plains killifish (*Fundulus zebrinus*), sand shiner (*Notropis stramineus*), green sunfish (*Lepomis cyanellus*), central stoneroller (*Campostoma anomalum*), and white sucker (*Catostomus comersonii*). The lower reaches of the Apishapa River also support populations of nonnative fish including common carp (*Cyprinus carpio*), fathead minnow (*Pimephales promelas*), longnose dace (*Rhinichthys cataractae*), and red shiner (*Cyprinella lutrensis*). While CPW does not currently have fisheries data within the ISF segment, based on samples of similar nearby streams, it is our professional opinion that this stream segment likely has populations of brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*), see Table 1. In

addition, Mark Uppendahl (formerly the CPW ISF coordinator when this recommendation was initially made), observed brook trout in the proposed ISF segment on August 4, 2010.

Table 1. List of species identified in Apishapa River.

Species Name	Scientific Name	Status
brook trout	*Salvelinus fontinalis*	None
brown trout	*Salmo trutta*	None

ISF Quantification

CWCB staff relies upon the biological expertise of the recommending entity to quantify the amount of water required to preserve the natural environment to a reasonable degree. CWCB staff performs a thorough review of the quantification analyses completed by the recommending entity to ensure consistency with accepted standards.

Methodology

CPW staff used the R2Cross methodology to develop the initial ISF recommendation. The R2Cross method is based on a hydraulic model and uses field data collected in a stream riffle (Espegren, 1996). Riffles are most easily visualized as the stream habitat types that would dry up first should streamflow cease. The field data collected consists of streamflow measurements and surveys of channel geometry at a transect and of the longitudinal slope of the water surface.

The field data is used to model three hydraulic parameters: average depth, average velocity, and percent wetted perimeter. Maintaining these hydraulic parameters at adequate levels across riffle habitat types also will maintain aquatic habitat in pools and runs for most life stages of fish and aquatic macro-invertebrates (Nehring, 1979). CPW staff interprets the model results to develop an initial recommendation for summer and winter flows. The summer flow recommendation is based on meeting 3 of 3 hydraulic criteria. The winter flow recommendation is based on meeting 2 of 3 hydraulic criteria. The model's suggested accuracy range is 40% to 250% of the streamflow measured in the field. Recommendations that fall outside of the accuracy range may not give an accurate estimate of the hydraulic parameters necessary to determine an ISF rate.

The R2Cross methodology provides the biological quantification of the amount of water needed for summer and winter periods based on empirical studies of fish species preferences. The recommending entity uses the R2Cross results and its biological expertise to develop an initial ISF recommendation. CWCB staff then evaluates water availability for the reach typically based on median hydrology (see the Water Availability section below for more details). The water availability analysis may indicate less water is available than the initial recommendation. In that case, the recommending entity either modifies the magnitude and/or duration of the recommended ISF rates if the available flows will preserve the natural environment to a reasonable degree, or withdraws the recommendation.

Data Analysis

R2Cross data was collected at two transects for this proposed ISF reach (Table 2). Results obtained at more than one transect are averaged to determine the R2Cross flow rate for the reach of stream. The R2Cross model results in a winter flow of 2.00 cfs, which meets 2 of 3 criteria and is within the accuracy range of the R2Cross model. The R2Cross model results in a summer flow of 2.85 cfs, which meets 3 of 3 criteria and is within the accuracy range of the R2Cross model.

Table 2. Summary of R2Cross transect measurements and results for the Apishapa River.

Entity	Date	Streamflow (cfs)	Accuracy Range (cfs)	Winter Rate (cfs)	Summer Rate (cfs)
CPW	08/04/2010 # 1	3.79	1.5 - 9.5	Out of range	2.90
CPW	08/04/2010 # 2	4.89	2.0 - 12.2	2.00	2.80
			Mean	2.00	2.85

ISF Recommendation

CPW recommended flow rates of 2.85 cfs (4/15 – 6/30), 2.0 cfs (7/1 – 7/31), 1.1 cfs (8/1 – 10/31), and 0.75 cfs (11/1 – 4/14) based on R2Cross modeling analyses, biological expertise, and a preliminary water availability analysis.

The CPW recommendation was modified by staff as a result of water availability and to conform to a standard number of significant digits in ISF water court applications. The final recommended flow rates are as follows:

2.9 cfs is recommended from May 1 through June 30.

1.1 cfs is recommended from July 1 through August 31. This recommendation is limited by water availability.

0.50 cfs is recommended from September 1 through April 30.This recommendation is limited by water availability.

However, if additional water is determined to be available in the future, CPW would recommend appropriating the additional water up to the recommended flow amounts to preserve the natural environment to a reasonable degree. Otherwise, the above modified flow regime should be adequate to preserve the natural environment in the Apishapa River to a reasonable degree.

Water Availability

CWCB staff conducts hydrologic analyses for each recommended ISF appropriation to provide the Board with a basis for making the determination that water is available.

Methodology

Each recommended ISF reach has a unique flow regime that depends on variables such as the timing, magnitude, and location of water inputs (such as rain, snow, and snowmelt) and water losses (such as diversions, reservoirs, evaporation and transpiration, groundwater recharge, etc). Although extensive and time-consuming investigations of all variables may be possible, staff takes a pragmatic and cost-effective approach to analyzing water availability. This approach focuses on streamflows and the influence of flow alterations, such as diversions, to understand how much water is physically available in the recommended reach.

Staff's hydrologic analysis is data-driven, meaning that staff gathers and evaluates the best available data and uses the best available analysis method for that data. Whenever possible, long-term stream gage data (period of record 20 or more years) will be used to evaluate streamflow. Other streamflow

information such as short-term gages, temporary gages, spot streamflow measurements, diversion records, and StreamStats will be used when long-term gage data is not available. StreamStats, a statistical hydrologic program, uses regression equations developed by the USGS (Capesius and Stephens, 2009) to estimate mean flows for each month based on drainage basin area and average drainage basin precipitation. Diversion records will also be used to evaluate the effect of surface water diversions when necessary. Interviews with water commissioners, landowners, and ditch or reservoir operators can provide additional information. A range of analytical techniques may be employed to extend gage records, estimate streamflow in ungaged locations, and estimate the effects of diversions. The goal is to obtain the most detailed and reliable estimate of hydrology using the most efficient analysis technique.

The final product of the hydrologic analysis used to determine water availability is a hydrograph, which shows streamflow and the proposed ISF rate over the course of one year. The hydrograph will show median daily values when daily data is available; otherwise, it will present mean-monthly streamflow values. Staff will calculate 95% confidence intervals for the median streamflow if there is sufficient data. Statistically, there is 95% confidence that the true value of the median streamflow is located within the confidence interval.

Basin Characteristics

The drainage basin of the proposed ISF on the Apishapa River is 6.03 square miles, with an average elevation of 10,100 ft and average annual precipitation of 31.37 inches. There are a number of small ponds and springs in the drainage basin and two surface water diversions from the proposed reach on the Apishapa River. The surface water diversions include the Spanish Peaks P/L No 1 (0.5 cfs appropriation date 1932), which is used to fill a pond, and the Apishapa Picnic Pipeline (0.011 cfs, appropriation date 1962). Based on available information, these diversions do not appear to significantly impact the stream. See the Hydrologic Features Map.

Available Data

There is not a current streamflow gage on the proposed reach of the Apishapa River. There are two historic gages located downstream on the Apishapa River near the town of Aguilar. The nearest gage is the Apishapa River near Aguilar, CO (USGS 07118000, 1939 to 1950). This gage was located roughly 5 miles east of the proposed lower terminus and has a drainage basin area of approximately 141.7 square miles. The Apishapa River at Aguilar, CO (USGS 07118500) was located roughly 6.8 miles downstream. This gage has a short period of record starting in 1938 to 1939 and again from 1978 to 1981. This gage is below the Borrego Ditch that diverts up to 20.53 cfs of flow from the Apishapa River. Both gages have significantly larger drainage basins than the proposed reach of the Apishapa River, and both gages include significant diversions. These factors make the gages unsuitable to estimate streamflow on the proposed reach of the Apishapa River.

In some cases, diversion records can be used to provide an indication of water availability in a stream reach. The Spanish Peaks P/L No 1 has diversion records; however, the median diversion for the period of record is 0 cfs due to a large number of years without reported use. The diversion records contain the water commissioner comment “no water available,” particularly in recent years (2005-2007, 2008-2009, 2012-2015). One comment in 2000 says “Never in priority.” Water commissioner Doug Brgoch indicated that this pipeline is a junior water right and must bypass streamflow (personal communication, 8/2/2013). Based on this information, this diversion likely does not significantly impact the stream.

Due to the lack of available data, CWCB staff installed a temporary streamflow gage in the spring of 2012. This gage was located approximately 1.3 miles upstream from the lower terminus due to accessibility constraints, rather than at the lower terminus. The gage operated from 4/2/2012 until 9/12/2013 when the gage was destroyed by a high flow event. In addition, CWCB staff made a number of streamflow measurements on the proposed reach of the Apishapa River. Most of these measurements were taken at or above the pressure transducer location. Norwest Corporation also collected spot streamflow measurements periodically between 2010 and the present. These measurements were made at a location 0.7 miles upstream from the lower terminus. All known spot measurements in the proposed reach are summarized in Table 3.

Table 3. Summary of streamflow measurement visits and results for the Apishapa River.

Visit Date	Flow (cfs)	Method	Party
8/4/2010	3.79	Marsh-McBirney	CPW
8/4/2010	4.89	Marsh-McBirney	CPW
9/17/2010	0.24	Marsh-McBirney	Norwest
9/28/2010	0.24	Marsh-McBirney	Norwest
10/22/2010	0.35	Marsh-McBirney	Norwest
4/22/2011	0.60	Marsh-McBirney	Norwest
5/20/2011	1.49	Marsh-McBirney	Norwest
6/30/2011	0.092	Flume	Norwest
7/30/2011	0.52	Marsh-McBirney	Norwest
8/26/2011	0.13	Marsh-McBirney	Norwest
9/1/2011	0.21	FlowTracker	CWCB
9/8/2011	0.23	FlowTracker	CWCB
9/22/2011	0.092	Flume	Norwest
10/28/2011	0.31	Marsh-McBirney	Norwest
11/21/2011	0.15	Marsh-McBirney	Norwest
1/26/2012	0.23	Flume	Norwest
4/10/2012	5.18	FlowTracker	CWCB
5/3/2012	4.31	Marsh-McBirney	Norwest
5/22/2012	2.48	FlowTracker	CWCB
6/1/2012	0.93	Marsh-McBirney	Norwest
6/28/2012	0.20	FlowTracker	CWCB
7/11/2012	1.3	Marsh-McBirney	Norwest
8/1/2012	0.41	FlowTracker	CWCB
8/10/2012	0.064	Flume	Norwest
9/7/2012	0.059	Flume	Norwest
10/5/2012	0.17	Flume	Norwest
11/1/2012	0.23	FlowTracker	CWCB
4/29/2013	0.79	FlowTracker	CWCB
5/9/2013	0.19	Marsh-McBirney	Norwest
5/30/2013	0.63	FlowTracker	CWCB

6/13/2013	0.038	Marsh-McBirney	Norwest
7/8/2013	0.14	FlowTracker	CWCB
7/9/2013	0.018	Marsh-McBirney	Norwest
8/13/2013	0.85	Pygmy	Norwest
10/8/2013	0.75	Marsh-McBirney	Norwest
10/30/2013	0.59	FlowTracker	CWCB
11/12/2013	0.58	Marsh-McBirney	Norwest
4/15/2014	3.40	Marsh-McBirney	Norwest
5/14/2014	4.88	Marsh-McBirney	Norwest
6/13/2014	2.08	Marsh-McBirney	Norwest
7/10/2014	0.47	2" Baski Flume	Norwest
8/12/2014	1.66	Marsh-McBirney	Norwest
9/9/2014	0.30	Marsh-McBirney	Norwest
10/13/2014	0.49	Marsh-McBirney	Norwest
5/13/2015	4.47	Marsh-McBirney	CWCB-JB
6/8/2015	3.81	Marsh-McBirney	Norwest
8/12/2015	0.91	Marsh-McBirney	Norwest
10/14/2015	0.27	2" Baski Flume	Norwest
3/10/2016	1.42	8" Baski Flume	Norwest
5/12/2016	8.37	Marsh-McBirney	Norwest
8/9/2016	0.55	8" Baski Flume	Norwest

The only other available information about streamflow on the Apishapa River comes from discussions with the Water Commissioner for District 18, Doug Brgoch (personal communication 8/2/2013). According to Mr. Brgoch, spring runoff starts around mid-April and ends around mid-June with peak flow typically between 8-10 cfs. Baseflows on the Apishapa River above the confluence with Herlick Creek are about 1 cfs.

Data Analysis

The period for which temporary gage data and streamflow measurements exist on the proposed reach of the Apishapa River was evaluated by looking at longer term precipitation data. The Trinidad climate station was the closest climate station identified with a relatively long period of record (USC00058429). This gage is located roughly 27 miles southeast from the proposed lower terminus on the Apishapa River. The Trinidad climate station records precipitation data from 1898 - 2016, with a number of gaps. The average annual precipitation for years with largely complete data (86 years had data for more than 95% of the year) between 1900 and 2015 is 15.6 inches. The average annual precipitation between 2010 and 2015 is 14.3 inches. 2010 and 2015 had above average precipitation while 2011, 2013, 2014 had below average precipitation. 2012 had missing data, but was a low runoff year in most of the state. Therefore, the available streamflow data from 2012-2013 was collected during below average precipitation conditions. The spot measurements were taken over a range of precipitation conditions.

All CWCB temporary gage data is shown on the hydrograph. Due to the short period of record, median streamflow and 95% confidence intervals for median streamflow were not calculated.

StreamStats provides an estimate of mean-monthly streamflow. It should be noted that 6% of the drainage basin of the proposed reach of the Apishapa River is located in area that does not have defined flow equations. Therefore, the flow estimates are based entirely on the Rio Grande Region.

Water Availability Summary
The hydrograph (See Complete Hydrograph) shows StreamStats results for mean-monthly streamflow, all spot streamflow measurements, and the data collected by the temporary streamflow gage installed by CWCB staff. The proposed ISF is below the StreamStats mean-monthly streamflow for all months. The proposed ISF is less than the available measured streamflow information at some times and higher than it during others. The available temporary gage measurements occurred during dry to exceptionally dry precipitation conditions. In addition, all streamflow measurements occurred upstream from the proposed lower terminus and likely underestimate streamflow at the proposed lower terminus. Based on the combination of gage data, Streamstats, and water commissioner opinion, staff concludes that water is available for appropriation on the Apishapa River.

Material Injury
Because the proposed ISF on Apishapa River is a new junior water right, the ISF can exist without material injury to other water rights. Under the provisions of section 37-92-102(3)(b), C.R.S. (2016), the CWCB will recognize any uses or exchanges of water in existence on the date this ISF water right is appropriated.

Citations
Capesius, J.P. and V.C. Stephens, 2009, Regional regression equations for estimation of natural streamflow statistics in Colorado, Scientific Investigations Report 2009-5136.

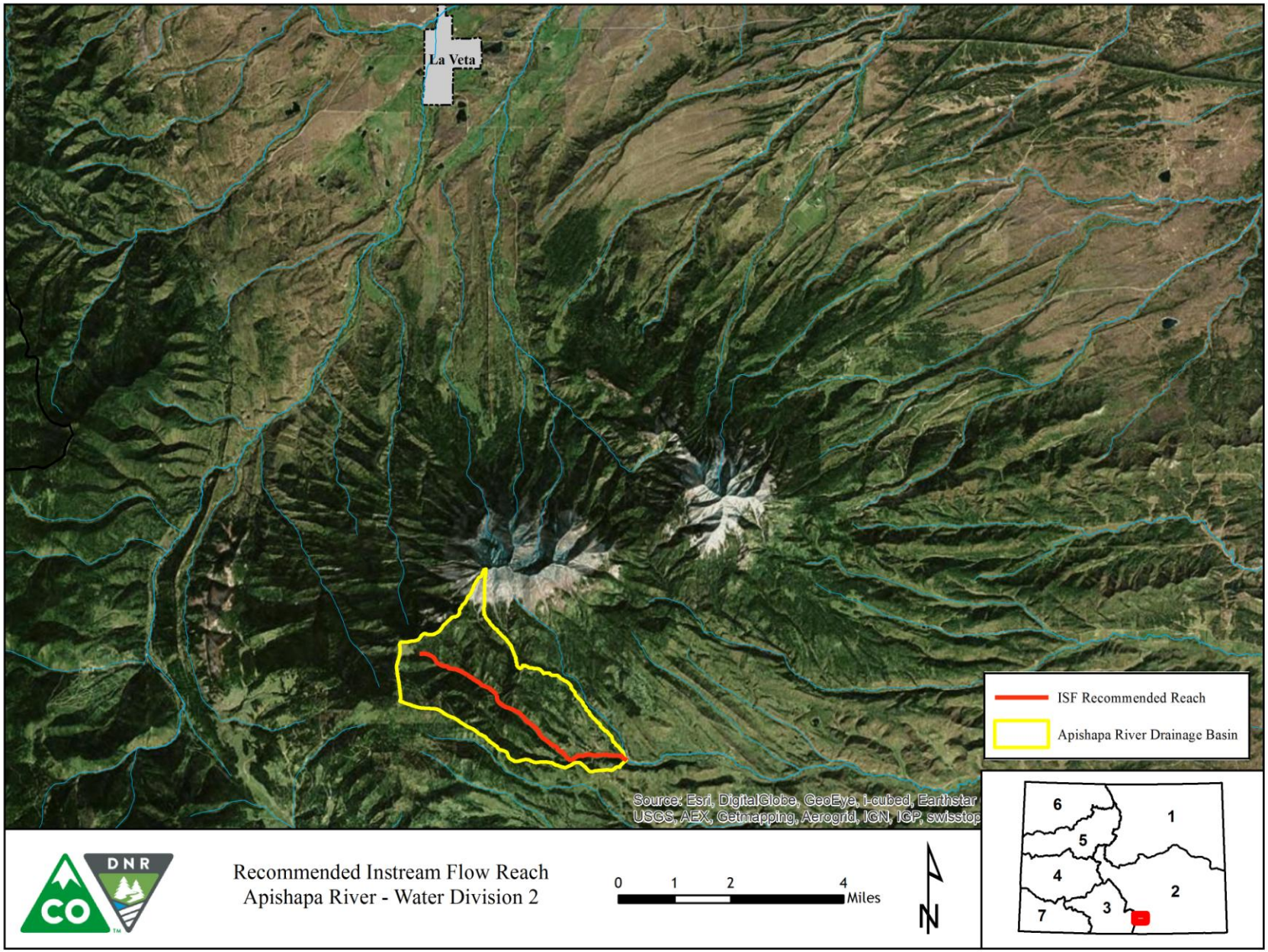
Espegren, G.D., 1996, Development of Instream Flow Recommendations in Colorado Using R2CROSS, Colorado Water Conservation Board.

Nehring, B.R., 1979, Evaluation of Instream Flow Methods and Determination of Water Quantity Needs for Streams in the State of Colorado, Colorado Division of Wildlife.

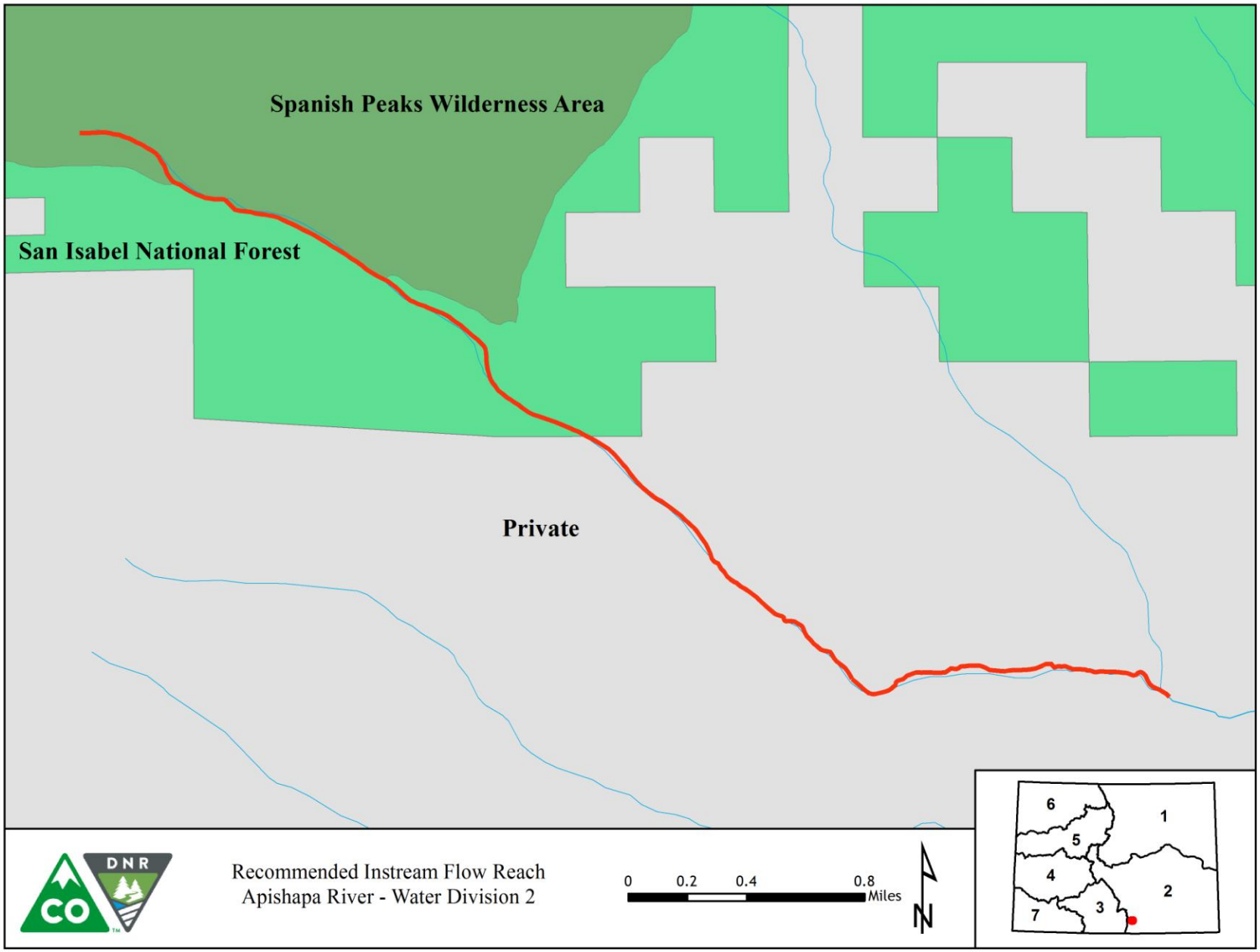
Metadata Descriptions
The UTM locations for the upstream and downstream termini were derived from CWCB GIS using the National Hydrography Dataset (NHD).

Projected Coordinate System: NAD 1983 UTM Zone 13N.

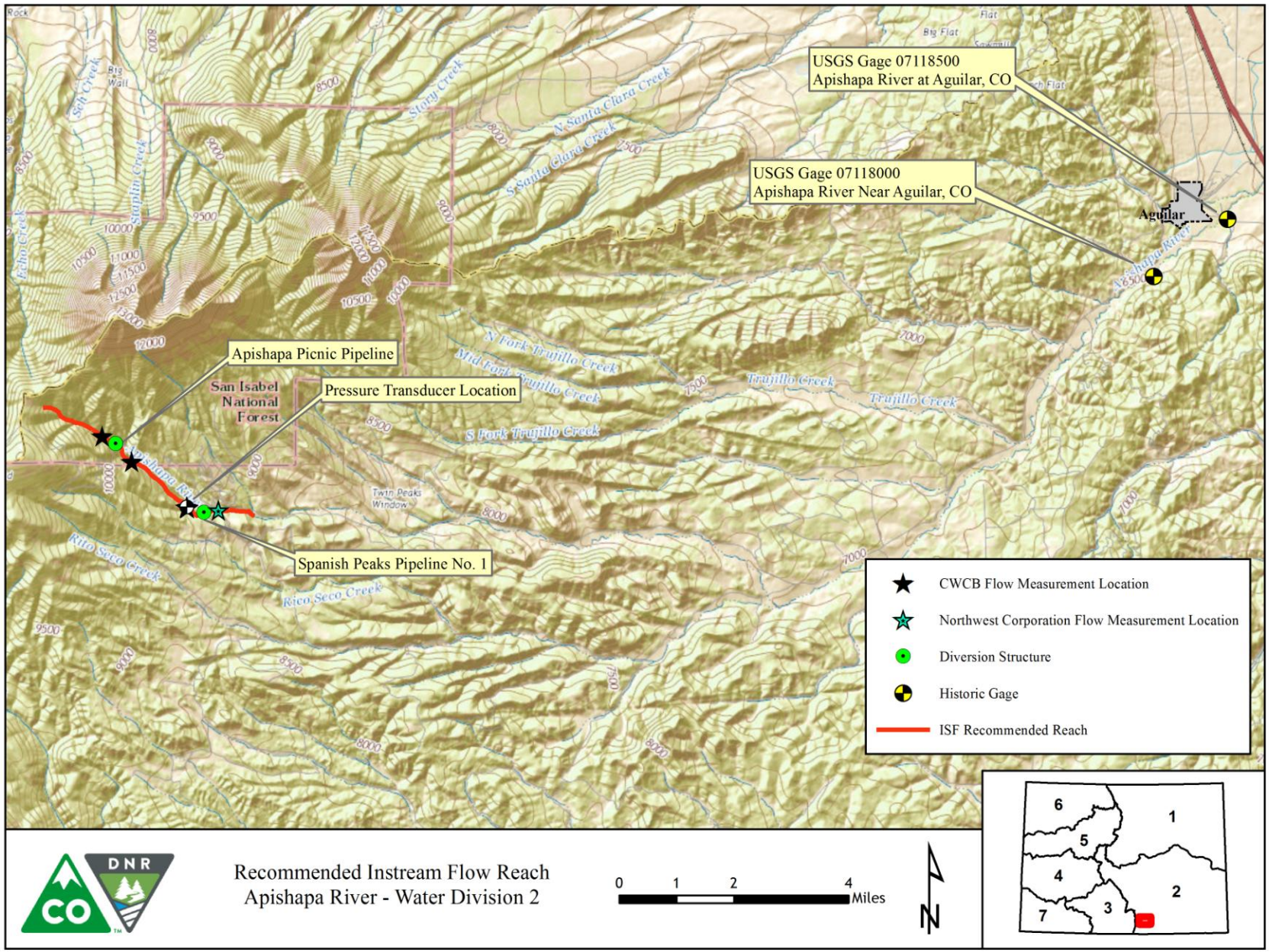
VICINITY MAP



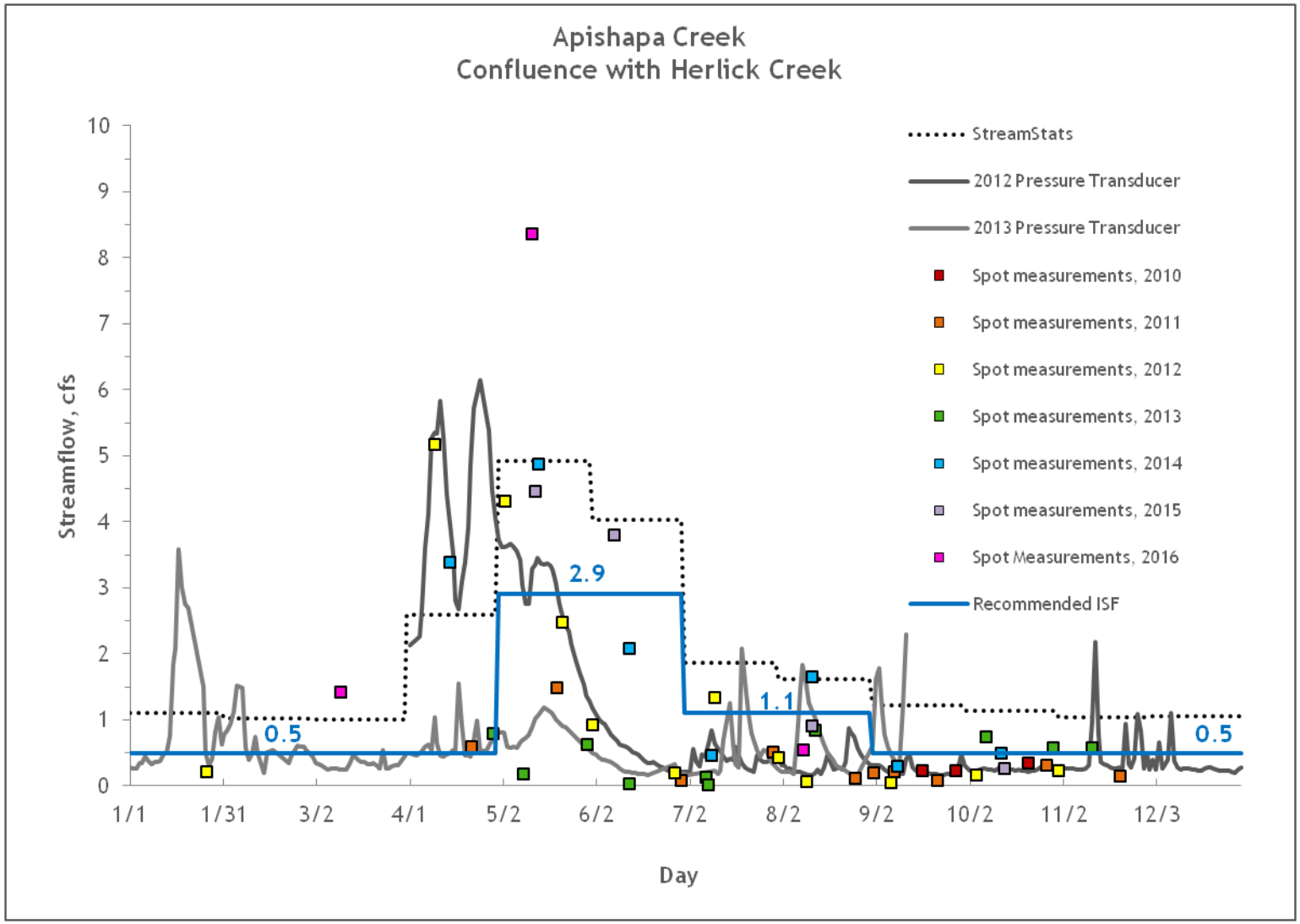
LAND OWNERSHIP MAP



HYDROLOGIC FEATURES MAP



COMPLETE HYDROGRAPH



COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Brush Creek
EXECUTIVE SUMMARY

CWCB STAFF INSTREAM FLOW RECOMMENDATION

UPPER TERMINUS:	Confluence Middle and East Brush Creeks UTM North: 4308647.90 UTM East: 339317.46
LOWER TERMINUS:	Confluence West Brush Creek UTM North: 4307385.91 UTM East: 336872.42
WATER DIVISION:	4
WATER DISTRICT:	59
COUNTY:	Gunnison
WATERSHED:	East-Taylor
CWCB ID:	17/4/A-002
RECOMMENDER:	American Rivers, High Country Conservation Advocates (HCAA)
LENGTH:	2.32 miles
Existing ISF:	83CW0236, 5 cfs (10/1-4/30) and 8 cfs (5/1-9/30)
FLOW RECOMMENDATION:	1.7 (01/01 - 04/14) 11 (04/15 - 04/30) 8 (05/01 - 08/31) 5 (09/01 - 09/30) 8 (10/01 - 10/15) 2.7 (10/16 - 12/31)

Brush Creek

Introduction

Colorado's General Assembly created the Instream Flow and Natural Lake Level Program in 1973, recognizing "the need to correlate the activities of mankind with some reasonable preservation of the natural environment" (see 37-92-102 (3), C.R.S.). The statute vests the Colorado Water Conservation Board (CWCB or Board) with the exclusive authority to appropriate and acquire instream flow (ISF) and natural lake level water rights (NLL). Before initiating a water right filing, the Board must determine that: 1) there is a natural environment that can be preserved to a reasonable degree with the Board's water right if granted, 2) the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made, and 3) such environment can exist without material injury to water rights.

American Rivers and HCAA recommended that the CWCB appropriate an increase to the existing ISF water right on a reach of Brush Creek. The CWCB currently holds an instream flow water right on Brush Creek for 5.0 cfs (10/1-4/30) and 8.0 cfs (5/1-9/30), decreed in Case No. 83CW0236. The recommenders do not consider the existing ISF water right to be sufficiently protective of the natural environment in Brush Creek, in light of CWCB's current application of R2Cross. The existing instream flow water right does not meet all three instream flow criteria during the spring and summer, which is a critical growth and spawning period for the fish population.

Brush Creek forms at the confluence of Middle Brush Creek and East Brush Creek at an elevation of approximately 9,390 ft. The creek flows in a southwesterly direction as it drops to an elevation of approximately 8,920 ft where it joins the East River. This proposed reach is located within Gunnison County (See Vicinity Map) and extends from the confluence of Middle Brush Creek and East Brush Creek downstream to the confluence with West Brush Creek. One hundred percent of the land on the 2.32 mile reach is federally owned and managed by the U.S. Forest Service (See Land Ownership Map). American Rivers and HCAA recommended this reach of Brush Creek because it has a natural environment that can be preserved to a reasonable degree with an ISF water right.

The information contained in this report and the associated supporting data and analyses (located at: http://cwcb.state.co.us/environment/instream-flow-program/Pages/2017ProposedISFRecommendations.aspx) form the basis for staff's ISF recommendation to be considered by the Board. This report provides sufficient information to support the CWCB findings required by ISF Rule 5i on natural environment, water availability, and material injury.

Natural Environment

CWCB staff relies on the recommending entity to provide information about the natural environment. In addition, staff reviews information and conducts site visits for each recommended ISF appropriation. This information is used to provide the Board with a basis for determining that a natural environment exists.

The headwaters of Brush Creek originate in and adjacent to the Maroon Bells-Snowmass Wilderness area. Brush Creek forms at the confluence of East Brush Creek and Middle Brush Creek, both popular locations for local fly-fishing companies to take customers on guided fly-fishing excursions. This segment of Brush Creek supports a Colorado River cutthroat trout population (See Table 1). Brush

Creek hosts an important recreational fishery and a healthy riverine ecosystem. Brush Creek, East Brush Creek, and Middle Brush Creek also offer numerous recreational opportunities, including beautiful waterfalls that are easily accessible from hiking and single-track trails.

Table 1. List of species identified in Brush Creek.

Species Name	Scientific Name	Status
Colorado River cutthroat trout	*Oncorhynchus clarkii pleuriticus*	State – Species of Special Concern

ISF Quantification

CWCB staff relies upon the biological expertise of the recommending entity to quantify the amount of water required to preserve the natural environment to a reasonable degree. CWCB staff performs a thorough review of the quantification analyses completed by the recommending entity to ensure consistency with accepted standards.

Methodology

American Rivers and HCAA used the R2Cross methodology to develop the initial ISF recommendation. The R2Cross method is based on a hydraulic model and uses field data collected in a stream riffle (Espegren, 1996). Riffles are most easily visualized as the stream habitat types that would dry up first should streamflow cease. The field data collected consists of streamflow measurements and surveys of channel geometry at a transect and of the longitudinal slope of the water surface.

The field data is used to model three hydraulic parameters: average depth, average velocity, and percent wetted perimeter. Maintaining these hydraulic parameters at adequate levels across riffle habitat types also will maintain aquatic habitat in pools and runs for most life stages of fish and aquatic macro-invertebrates (Nehring, 1979). American Rivers and HCAA interpret the model results to develop an initial recommendation for summer and winter flows. The summer flow recommendation is based on meeting 3 of 3 hydraulic criteria. The winter flow recommendation is based on meeting 2 of 3 hydraulic criteria. The model's suggested accuracy range is 40% to 250% of the streamflow measured in the field. Recommendations that fall outside of the accuracy range may not give an accurate estimate of the hydraulic parameters necessary to determine an ISF rate.

The R2Cross methodology provides the biological quantification of the amount of water needed for summer and winter periods based on empirical studies of fish species preferences. The recommending entity uses the R2Cross results and its biological expertise to develop an initial ISF recommendation. CWCB staff then evaluates water availability for the reach typically based on median hydrology (see the Water Availability section below for more details). The water availability analysis may indicate less water is available than the initial recommendation. In that case, the recommending entity either modifies the magnitude and/or duration of the recommended ISF rates if the available flows will preserve the natural environment to a reasonable degree, or withdraws the recommendation.

Data Analysis

R2Cross data was collected at one transect for this proposed ISF reach (Table 2). The R2Cross model results in a winter flow of 8.31 cfs, which meets 2 of 3 criteria and is within the accuracy range of

the R2Cross model. The R2Cross model results in a summer flow of 15.86 cfs, which meets 3 of 3 criteria and is within the accuracy range of the R2Cross model.

Table 2. Summary of R2Cross transect measurements and results for Brush Creek.

Entity	Date	Streamflow (cfs)	Accuracy Range (cfs)	Summer Rate (cfs)	Winter Rate (cfs)
HCCA	10/08/2015	15.91	6.36 - 39.78	15.86	8.31
			Mean	15.86	8.31

ISF Recommendation

American Rivers and HCCA recommend an increase to reach a total ISF rate of 15.86 cfs (4/15 – 10/5), which maintains all three of the R2CROSS hydrologic criteria (average velocity, average depth, and wetted perimeter). This flow helps to scour fine sediments from important spawning areas, provide opportunities for upstream and downstream fish passage, and promote aquatic macroinvertebrate and fish productivity during the summer months. American Rivers and HCCA also recommend increases to reach a total ISF rate of 8.31 cfs (10/16 – 12/31), which satisfies two of three hydraulic criteria and 7.17 (1/1 – 4/14), which satisfies the wetted perimeter criteria and results in an average velocity 0.96 ft/s.

The American Rivers and HCCA recommendation was modified by staff as a result of water availability and to conform to a standard number of significant digits in ISF water court applications. The final recommendations numbers are as follows:

An increase of 1.7 cfs to the existing 5.0 cfs ISF water right is recommended 1/1 to 4/14 to bring the total ISF water right up to 6.7 cfs. This satisfies the wetted perimeter criteria and results in an average velocity of 0.94 ft/s.

An increase of 11 cfs to the existing 5.0 cfs ISF water right is recommended 4/15 to 4/30 to bring the total water right up to 16 cfs.

An increase of 8 cfs to the existing 8.0 cfs ISF water right is recommended 5/1 to 8/31 to bring the total ISF water right up to 16 cfs.

An increase of 5 cfs to the existing 8.0 cfs ISF water right is recommended 9/1 to 9/30 to bring the total ISF water right up to 13 cfs.

An increase of 8 cfs to the existing 8.0 cfs ISF water right is recommended 10/1 to 10/15 to bring the total ISF water right up to 13 cfs.

An increase of 2.7 cfs to the existing 5.0 cfs ISF water right is recommended 10/16 to 12/31 to bring the total ISF water right up to 7.7 cfs. This satisfies the wetted perimeter criteria and results in an average velocity of 0.98 ft/s.

Water Availability
CWCB staff conducts hydrologic analyses for each recommended ISF appropriation to provide the Board with a basis for making the determination that water is available.

Methodology
Each recommended ISF reach has a unique flow regime that depends on variables such as the timing, magnitude, and location of water inputs (such as rain, snow, and snowmelt) and water losses (such as diversions, reservoirs, evaporation and transpiration, groundwater recharge, etc). Although extensive and time-consuming investigations of all variables may be possible, staff takes a pragmatic and cost-effective approach to analyzing water availability. This approach focuses on streamflows and the influence of flow alterations, such as diversions, to understand how much water is physically available in the recommended reach.

Staff's hydrologic analysis is data-driven, meaning that staff gathers and evaluates the best available data and uses the best available analysis method for that data. Whenever possible, long-term stream gage data (period of record 20 or more years) will be used to evaluate streamflow. Other streamflow information such as short-term gages, temporary gages, spot streamflow measurements, diversion records, and StreamStats will be used when long-term gage data is not available. StreamStats, a statistical hydrologic program, uses regression equations developed by the USGS (Capesius and Stephens, 2009) to estimate mean flows for each month based on drainage basin area and average drainage basin precipitation. Diversion records will also be used to evaluate the effect of surface water diversions when necessary. Interviews with water commissioners, landowners, and ditch or reservoir operators can provide additional information. A range of analytical techniques may be employed to extend gage records, estimate streamflow in ungaged locations, and estimate the effects of diversions. The goal is to obtain the most detailed and reliable estimate of hydrology using the most efficient analysis technique.

The final product of the hydrologic analysis used to determine water availability is a hydrograph, which shows streamflow and the proposed ISF rate over the course of one year. The hydrograph will show median daily values when daily data is available; otherwise, it will present mean-monthly streamflow values. Staff will calculate 95% confidence intervals for the median streamflow if there is sufficient data. Statistically, there is 95% confidence that the true value of the median streamflow is located within the confidence interval.

Basin Characteristics
The drainage basin of the proposed ISF on Brush Creek is 27.1 square miles, with an average elevation of 11,300 ft and average annual precipitation of 38.43 inches (Hydrologic Features Map). There is one surface water diversion within the basin tributary to the proposed ISF, the Wilde Ditch, which is a conditional right for 2 cfs. Hydrology in this drainage basin represents natural conditions.

Available Data
There is not a current or historic streamflow gage on Brush Creek. The closest gage identified was the historic East River near Crested Butte, CO gage (USGS 09110500). The gage was located approximately 4.8 miles downstream from the proposed lower terminus. The gage had a continuous period of record from 11/1/1939 to 9/30/1951. The drainage basin of the East River gage was 89.3 square miles, with an average elevation of 10,900 ft and average annual precipitation of 38.35 inches. The USGS also operates the East River below Cement Creek near Crested Butte, CO gage

(USGS 09112200). This gage is located downstream from the East River near Crested Butte gage. The gage has a sporadic record that includes 10/1/1963 to 9/30/1972, 10/1/1979 to 9/30/1981, and 10/1/1993 to present. The drainage basin of this gage is 239 square miles, with an average elevation of 10,500 ft and average annual precipitation of 36.8 inches. Further downstream, the USGS operates the East River at Almont, CO gage (USGS 09112500). This gage operated from 10/1/1910 to 9/30/1922 and 10/1/1934 to present. The drainage basin of this gage is 289 square miles, with an average elevation of 10,300 ft and average annual precipitation of 31.76 inches. In general, the number of diversions and other water use practices increases from the upstream most to the downstream most gages. Therefore, the two lower gages do not represent natural streamflow conditions and use of the gages in analysis will likely under-estimate streamflow on Brush Creek. However, the long-term record of the lowest gage was found to be useful in extending the gage record for the uppermost gage.

CWCB staff made two streamflow measurements on the proposed reach of Brush Creek as summarized in Table 3.

Table 3. Summary of streamflow measurement visits and results for Brush Creek.

Visit Date	Flow (cfs)	Method
07/13/2016	47.00	Wading Marsh McBirney
08/03/2016	24.70	Wading ADV

Data Analysis

Due to the short period of record available for the East River near Crested Butte gage, staff took additional steps to evaluate the record. The East River at Almont gage was the only gage that had a contemporary period of record. This gage was found to correlate well with the East River near Crested Butte gage (r^2=0.9644). Regression analysis was used to extend the record of the upper gage. Given the long period of record, Staff did not examine climate station data to assess the representativeness of the gage data. The area-precipitation method was used to scale the extended East River near Crested Butte gage data to the lower terminus on Brush Creek. The method estimates streamflow based on the ratio of the precipitation weighted drainage area. The scaling factor for Brush Creek basin at the lower terminus is 0.30. The scaled and extended data was analyzed for the entire period of record (1920 to 1922 and 1934 to 8/2/2016, approved data available through HydroBase as of 11/23/2016). Median streamflow and 95% confidence intervals for median streamflow were calculated.

Water Availability Summary

The hydrographs (See Complete and Detailed Hydrographs) show median and 95% confidence interval for median streamflow estimated at the lower terminus of Brush Creek. The proposed ISF is below the median streamflow estimate most of the time and below the 95% confidence interval for median streamflow at all times. Staff concludes that water is available for appropriation on Brush Creek.

Material Injury
Because the proposed ISF on Brush Creek is a new junior water right, the ISF can exist without material injury to other water rights. Under the provisions of section 37-92-102(3)(b), C.R.S. (2016), the CWCB will recognize any uses or exchanges of water in existence on the date this ISF water right is appropriated.

Citations
Capesius, J.P. and V.C. Stephens, 2009, Regional regression equations for estimation of natural streamflow statistics in Colorado, Scientific Investigations Report 2009-5136.

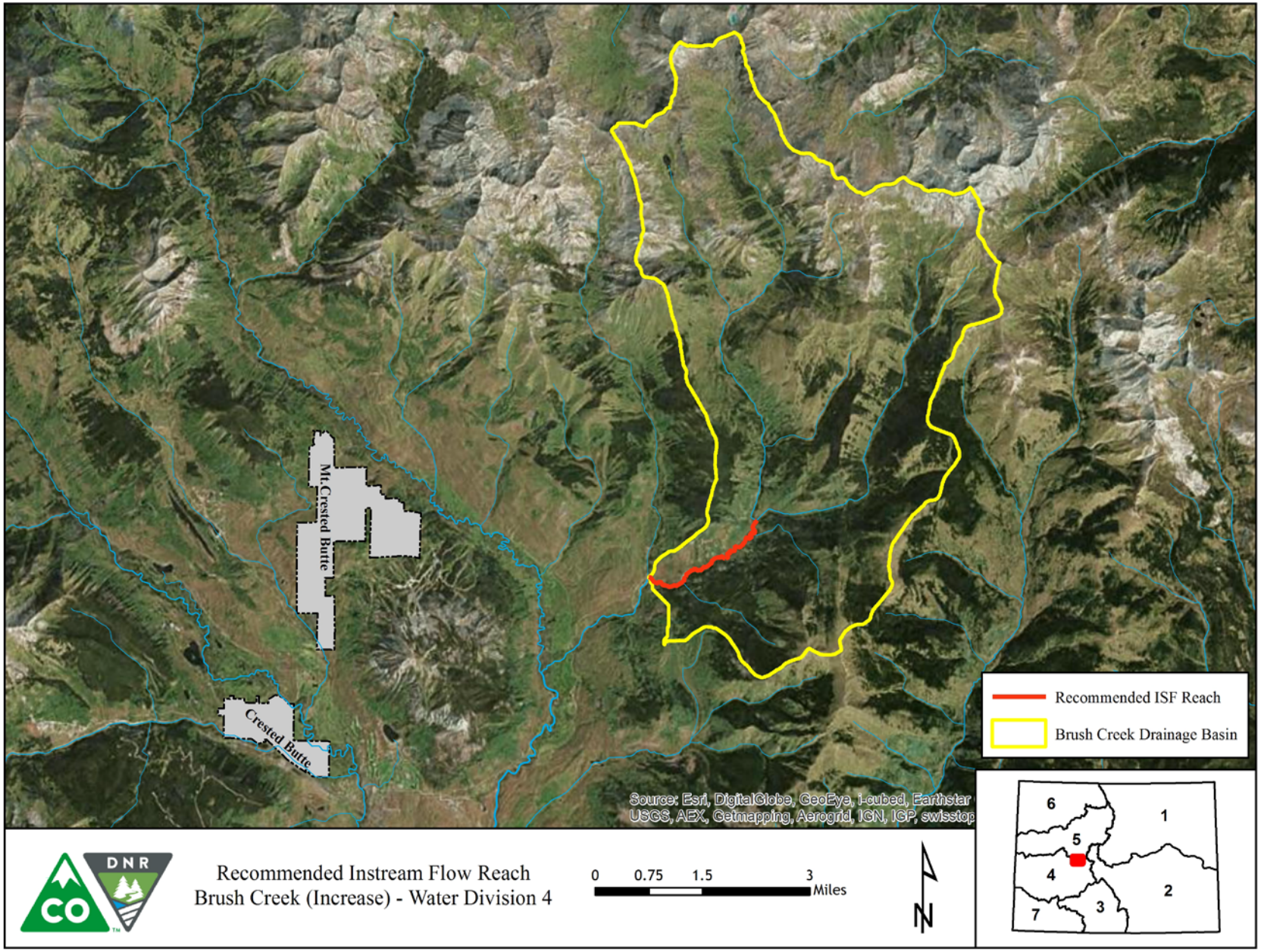
Espegren, G.D., 1996, Development of Instream Flow Recommendations in Colorado Using R2CROSS, Colorado Water Conservation Board.

Nehring, B.R., 1979, Evaluation of Instream Flow Methods and Determination of Water Quantity Needs for Streams in the State of Colorado, Colorado Division of Wildlife.

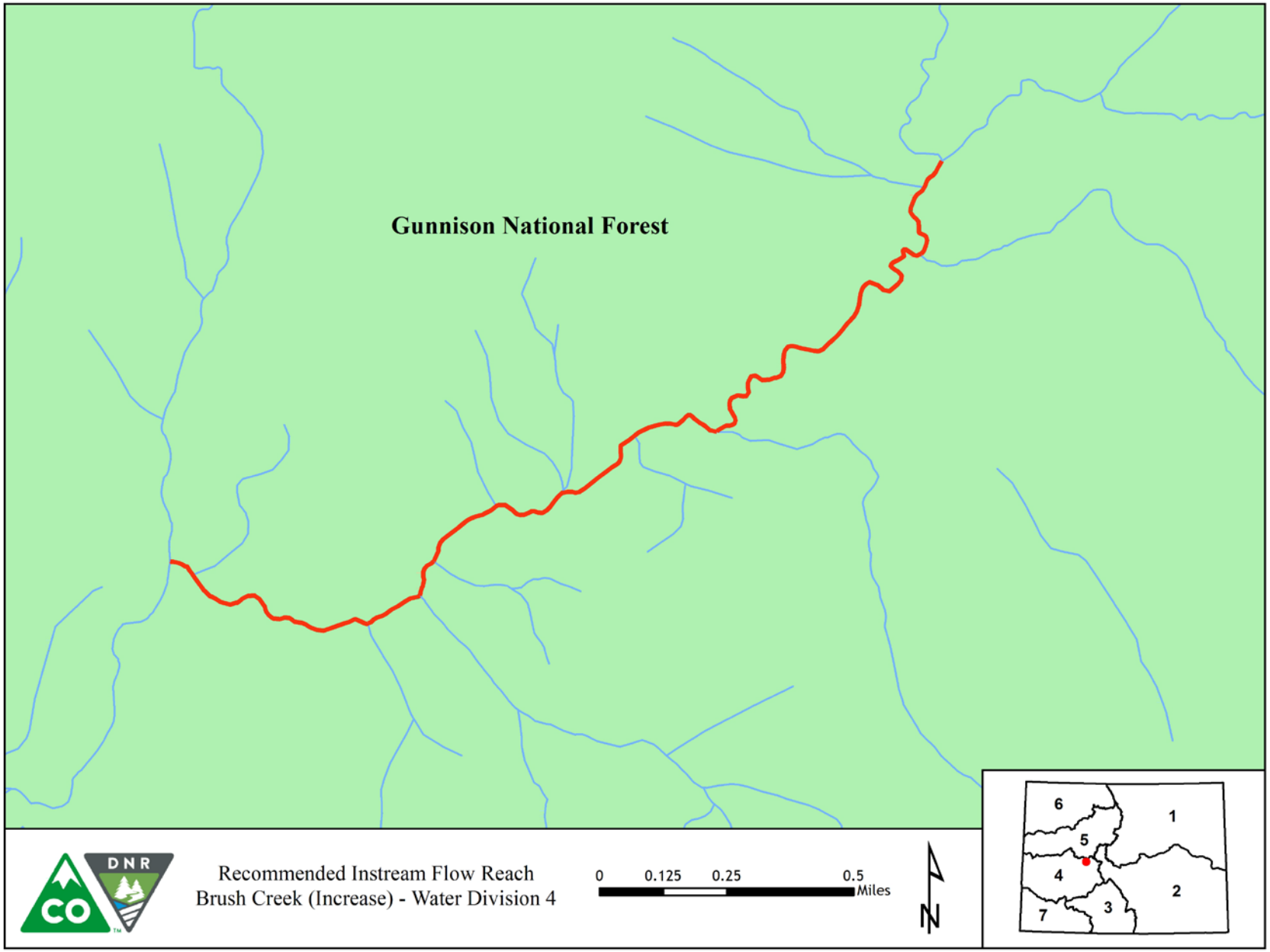
Metadata Descriptions
The UTM locations for the upstream and downstream termini were derived from CWCB GIS using the National Hydrography Dataset (NHD).

Projected Coordinate System: NAD 1983 UTM Zone 13N.

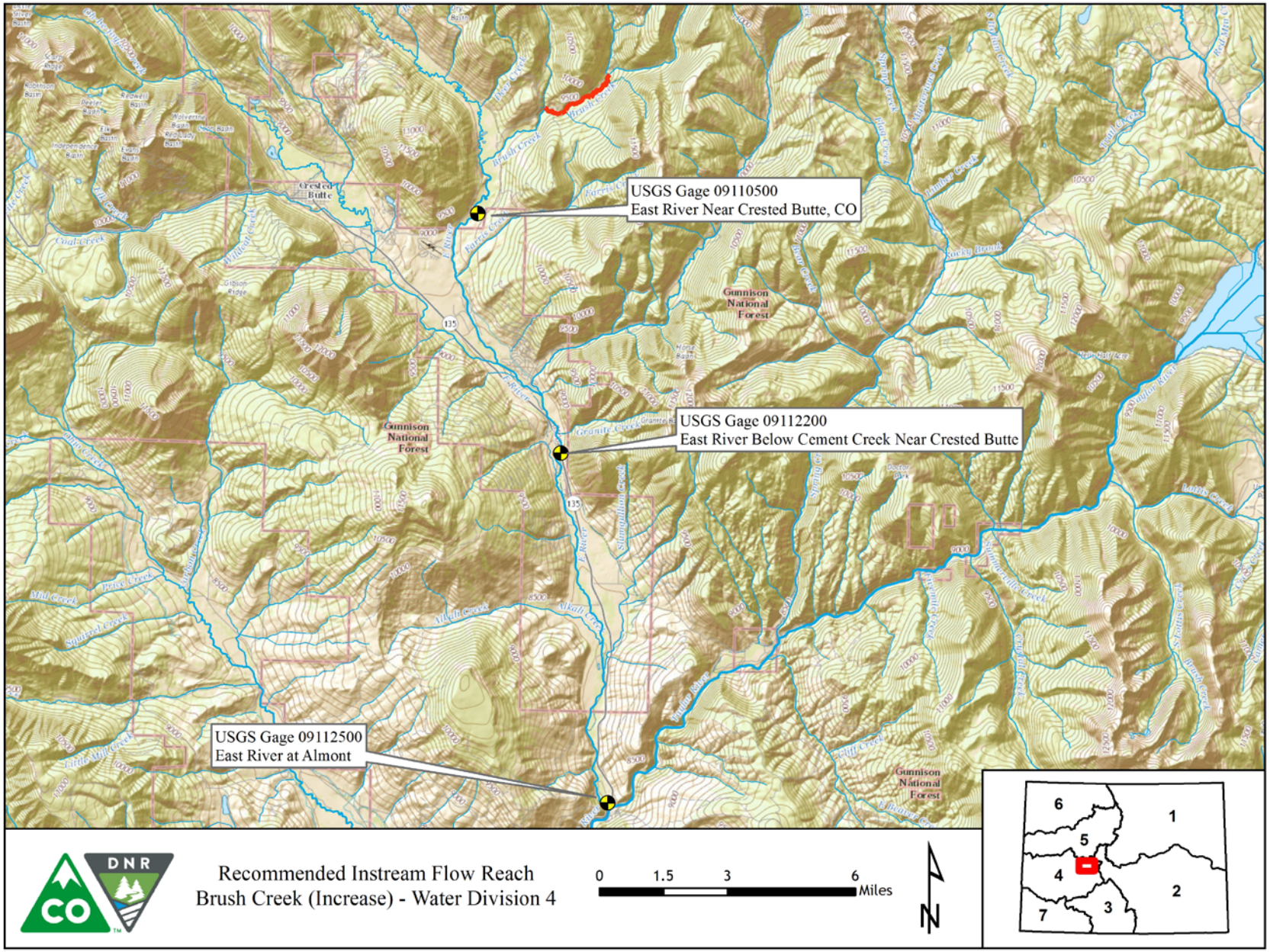
VICINITY MAP



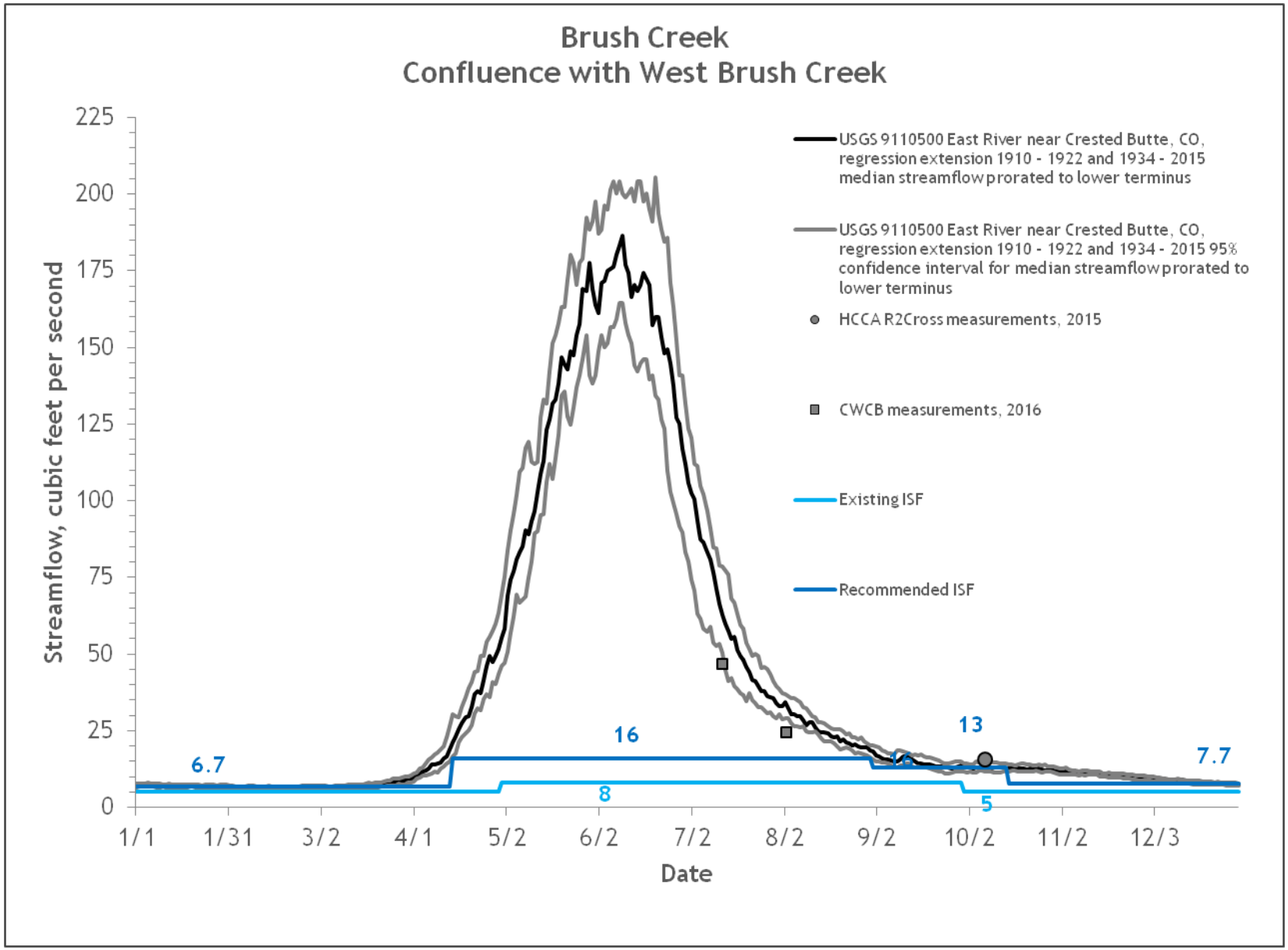
LAND OWNERSHIP MAP



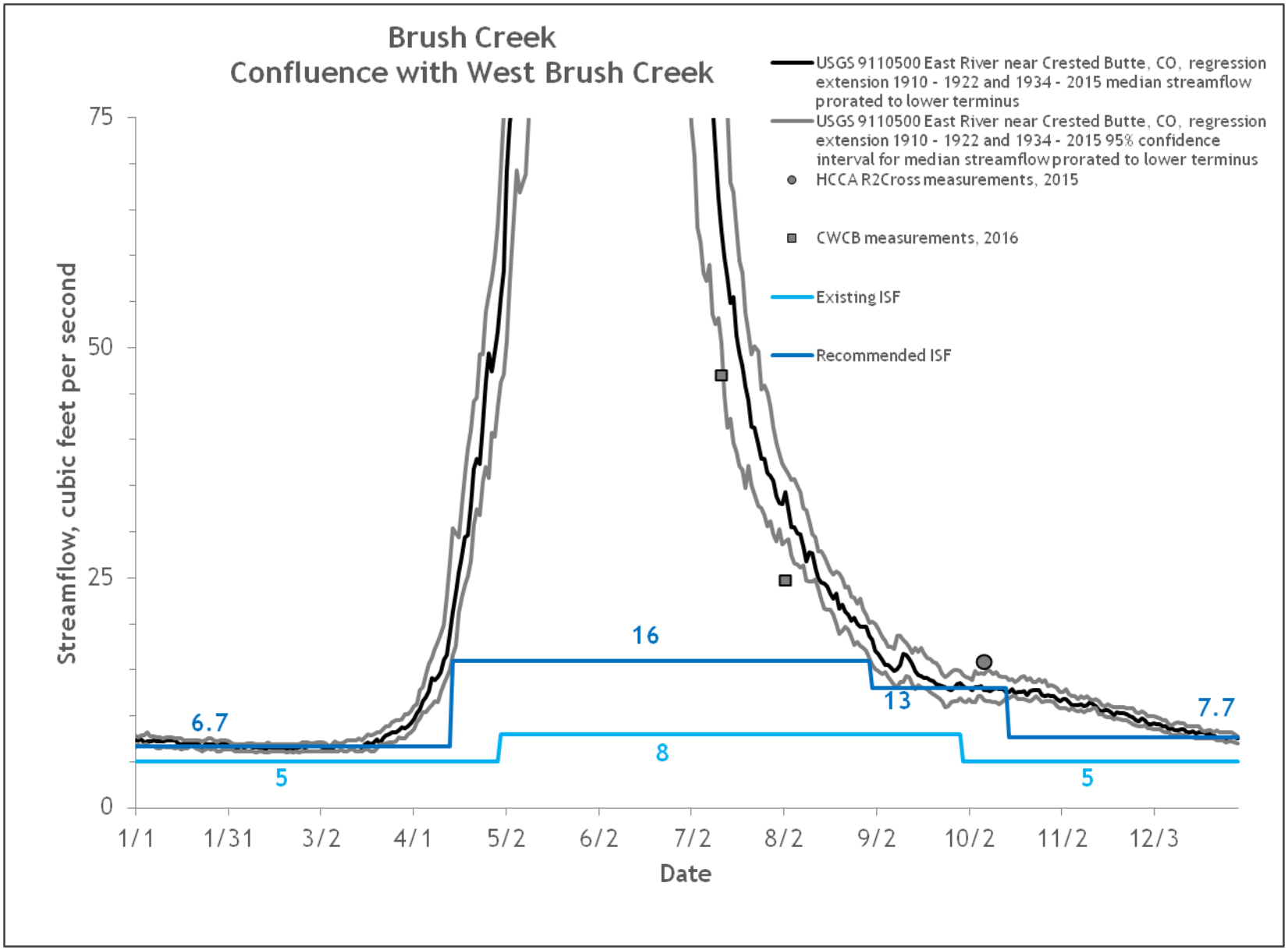
HYDROLOGIC FEATURES MAP



COMPLETE HYDROGRAPH



DETAILED HYDROGRAPH



COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Coal Creek
EXECUTIVE SUMMARY

CWCB STAFF INSTREAM FLOW RECOMMENDATION

UPPER TERMINUS:	Lake Irwin Outlet UTM North: 4304958.01	UTM East: 317839.25
LOWER TERMINUS:	Spann Nettick Ditch hdgt UTM North: 4304124.83	UTM East: 326937.36
WATER DIVISION:	4	
WATER DISTRICT:	59	
COUNTY:	Gunnison	
WATERSHED:	East-Taylor	
CWCB ID:	17/4/A-003	
RECOMMENDER:	American Rivers, High Country Conservation Advocates (HCCA)	
LENGTH:	7.67 miles	
Existing ISF:	80CW0102, 2 cfs (1/1-12/31)	
FLOW RECOMMENDATION:	1.3 (01/01 - 03/31) 5.9 (04/01 - 08/15) 3.7 (08/16 - 11/30) 2.0 (12/01 - 12/31)	

Coal Creek

Introduction

Colorado's General Assembly created the Instream Flow and Natural Lake Level Program in 1973, recognizing "the need to correlate the activities of mankind with some reasonable preservation of the natural environment" (see 37-92-102 (3), C.R.S.). The statute vests the Colorado Water Conservation Board (CWCB or Board) with the exclusive authority to appropriate and acquire instream flow (ISF) and natural lake level water rights (NLL). Before initiating a water right filing, the Board must determine that: 1) there is a natural environment that can be preserved to a reasonable degree with the Board's water right if granted, 2) the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made, and 3) such environment can exist without material injury to water rights.

American Rivers and HCCA recommended that the CWCB appropriate an increase to the existing ISF water right on a reach of Coal Creek. The CWCB currently holds an instream flow water right on Coal Creek for 2.0 cfs (1/1-12/31), decreed in Case No. 80CW0102. The recommenders do not consider the current ISF water right to be sufficiently protective of the natural environment in Coal Creek, in light of CWCB's current application of R2Cross. The current instream flow water right does not meet all three instream flow criteria during the spring and summer, which is a critical growth and spawning period for the fish population.

Coal Creek originates near Lake Irwin at an elevation of approximately 10,250 ft. The creek flows in an easterly direction as it drops to an elevation of approximately 8,860 ft where it joins the Slate River. The proposed reach is located within Gunnison County (See Vicinity Map) and extends from the Outlet of Lake Irwin downstream to the Spann Nettick Ditch headgate. Sixty-three percent of the land on the 7.67 mile proposed reach is publicly owned and managed by the U.S. Forest Service (USFS); the remaining land is privately held (See Land Ownership Map). American Rivers and HCCA recommended this reach of Coal Creek because it has a natural environment that can be preserved to a reasonable degree with an ISF water right.

The information contained in this report and the associated supporting data and analyses (located at: http://cwcb.state.co.us/environment/instream-flow-program/Pages/2017ProposedISFRecommendations.aspx) form the basis for staff's ISF recommendation to be considered by the Board. This report provides sufficient information to support the CWCB findings required by ISF Rule 5i on natural environment, water availability, and material injury.

Natural Environment

CWCB staff relies on the recommending entity to provide information about the natural environment. In addition, staff reviews information and conducts site visits for each recommended ISF appropriation. This information is used to provide the Board with a basis for determining that a natural environment exists.

Coal Creek supports a brook and brown trout fishery (See Table 1). Colorado Parks and Wildlife (CPW) has done stream sampling on Coal Creek and has reported that the Coal Creek stream ecosystem supports a healthy brook trout population. Coal Creek joins the Slate River in the Town of Crested Butte. Fishery surveys in the Slate River drainage have revealed self-sustaining populations of brook trout and brown trout, with individuals up to 20 inches in length.

In addition to supporting a healthy aquatic ecosystem, flows in Coal Creek support a robust riparian area. The Coal Creek watershed is predominantly a subalpine spruce-fir forest with drier, primarily south facing slopes being dominated by sagebrush steppe and grasslands. The riparian zones are dominated by willows and alders with some active and abandoned beaver ponds along with wet meadows. There are many wetland plants in the narrow riparian corridor that are not found in drier soils found upslope. As a result, and as is typical of most riparian areas, wildlife use of these wetlands is high, which contributes to local biodiversity and high plant and animal productivity. The riparian zone is also important for essential functions such as dissipating flood energy and filtering sediment and pollution.

Table 1. List of species identified in Coal Creek.

Species Name	Scientific Name	Status
brook trout	*Salvelinus fontinalis*	None
brown trout	*Salmo trutta*	None

ISF Quantification

CWCB staff relies upon the biological expertise of the recommending entity to quantify the amount of water required to preserve the natural environment to a reasonable degree. CWCB staff performs a thorough review of the quantification analyses completed by the recommending entity to ensure consistency with accepted standards.

Methodology

American Rivers and HCCA used the R2Cross methodology to develop the initial ISF recommendation. The R2Cross method is based on a hydraulic model and uses field data collected in a stream riffle (Espegren, 1996). Riffles are most easily visualized as the stream habitat types that would dry up first should streamflow cease. The field data collected consists of streamflow measurements and surveys of channel geometry at a transect and of the longitudinal slope of the water surface.

The field data is used to model three hydraulic parameters: average depth, average velocity, and percent wetted perimeter. Maintaining these hydraulic parameters at adequate levels across riffle habitat types also will maintain aquatic habitat in pools and runs for most life stages of fish and aquatic macro-invertebrates (Nehring, 1979). American Rivers and HCAA interpret the model results to develop an initial recommendation for summer and winter flows. The summer flow recommendation is based on meeting 3 of 3 hydraulic criteria. The winter flow recommendation is based on meeting 2 of 3 hydraulic criteria. The model's suggested accuracy range is 40% to 250% of the streamflow measured in the field. Recommendations that fall outside of the accuracy range may not give an accurate estimate of the hydraulic parameters necessary to determine an ISF rate.

The R2Cross methodology provides the biological quantification of the amount of water needed for summer and winter periods based on empirical studies of fish species preferences. The recommending entity uses the R2Cross results and its biological expertise to develop an initial ISF recommendation. CWCB staff then evaluates water availability for the reach typically based on median hydrology (see the Water Availability section below for more details). The water availability analysis may indicate less water is available than the initial recommendation. In that case, the recommending entity either modifies the magnitude and/or duration of the recommended ISF rates if the available flows will preserve the natural environment to a reasonable degree, or withdraws the recommendation.

Data Analysis
R2Cross data was collected at one transect for this proposed ISF reach (Table 2). The R2Cross model results in a winter flow of 6.81 cfs, which meets 2 of 3 criteria and is within the accuracy range of the R2Cross model. The R2Cross model results in a summer flow of 7.85 cfs, which meets 3 of 3 criteria and is within the accuracy range of the R2Cross model.

Table 2. Summary of R2Cross transect measurements and results for Coal Creek.

Entity	Date	Streamflow (cfs)	Accuracy Range (cfs)	Winter Rate (cfs)	Summer Rate (cfs)
HCCA	10/07/2015	3.85	1.54 - 9.63	6.81	7.85
			Mean	6.81	7.85

ISF Recommendation
American Rivers and HCCA recommended an instream flow of 7.85 cfs between April 15 and October 15. This flow rate would protect all three of the CWCB's R2Cross hydrologic criteria (average velocity, average depth, and wetted perimeter). Protecting this flow rate would require an increase of 5.85 cfs between April 15 and October 15. Protection of a higher flow rate will help scour fine sediments from important spawning areas, provide opportunities for upstream and downstream fish passage, and promote aquatic macroinvertebrate and fish productivity during the summer months.

HCCA also recommends that the current instream flow water right of 2 cfs be increased to 4 cfs for the winter period between October 16 and April 14. R2Cross results indicate that a flow of 6.81 cfs would satisfy 2 of the CWCB's R2Cross hydrologic criteria (wetted perimeter and average depth). However, a preliminary analysis of water availability suggests that only 4 cfs is physically available between Oct 16 and April 14. A flow rate of 4 cfs would continue to satisfy the average depth criteria and would result in only a small decrease in wetted perimeter from 50% to 48%. Therefore, HCCA recommends that the existing 2 cfs instream flow water right be increased by 2 cfs to 4 cfs during the October 16 to April 14 time period. Thus, HCCA is requesting an additional 2 cfs appropriation on Coal Creek between October 16 and April 14.

The American Rivers and HCCA recommendation was modified by staff as a result of water availability and to conform to a standard number of significant digits in ISF water court applications. The final recommended flow rates are as follows:

An increase of 1.3 cfs to the existing 2.0 cfs ISF water right is recommended 1/1 to 3/31 to bring the total ISF water right up to 3.3 cfs.

An increase of 5.9 cfs to the existing 2.0 cfs ISF water right is recommended 4/1 to 8/15 to bring the total water right up to 7.9 cfs.

An increase of 3.7 cfs to the existing 2.0 cfs ISF water right is recommended 8/16 to 11/30 to bring the total ISF water right up to 5.7 cfs.

An increase of 2 cfs to the existing 2.0 cfs ISF water right is recommended 12/1 to 12/31 to bring the total ISF water right up to 4 cfs.

Water Availability
CWCB staff conducts hydrologic analyses for each recommended ISF appropriation to provide the Board with a basis for making the determination that water is available.

Methodology
Each recommended ISF reach has a unique flow regime that depends on variables such as the timing, magnitude, and location of water inputs (such as rain, snow, and snowmelt) and water losses (such as diversions, reservoirs, evaporation and transpiration, groundwater recharge, etc). Although extensive and time-consuming investigations of all variables may be possible, staff takes a pragmatic and cost-effective approach to analyzing water availability. This approach focuses on streamflows and the influence of flow alterations, such as diversions, to understand how much water is physically available in the recommended reach.

Staff's hydrologic analysis is data-driven, meaning that staff gathers and evaluates the best available data and uses the best available analysis method for that data. Whenever possible, long-term stream gage data (period of record 20 or more years) will be used to evaluate streamflow. Other streamflow information such as short-term gages, temporary gages, spot streamflow measurements, diversion records, and StreamStats will be used when long-term gage data is not available. StreamStats, a statistical hydrologic program, uses regression equations developed by the USGS (Capesius and Stephens, 2009) to estimate mean flows for each month based on drainage basin area and average drainage basin precipitation. Diversion records will also be used to evaluate the effect of surface water diversions when necessary. Interviews with water commissioners, landowners, and ditch or reservoir operators can provide additional information. A range of analytical techniques may be employed to extend gage records, estimate streamflow in ungaged locations, and estimate the effects of diversions. The goal is to obtain the most detailed and reliable estimate of hydrology using the most efficient analysis technique.

The final product of the hydrologic analysis used to determine water availability is a hydrograph, which shows streamflow and the proposed ISF rate over the course of one year. The hydrograph will show median daily values when daily data is available; otherwise, it will present mean-monthly streamflow values. Staff will calculate 95% confidence intervals for the median streamflow if there is sufficient data. Statistically, there is 95% confidence that the true value of the median streamflow is located within the confidence interval.

Basin Characteristics
The drainage basin of the proposed ISF on Coal Creek is 20.2 square miles, with an average elevation of 10,400 ft and average annual precipitation of 31.834 inches (See the Vicinity Map). The Coal Creek basin supports agriculture and municipal uses, among other uses. Surface water diversions in the basin include Bench Ditch (appropriation date 1989, 2 cfs absolute), the Crested Butte Water Ditch and Wild Cat Pipeline (appropriation date 1893, 6 cfs absolute), and the Rayder Pipeline (appropriation date 1984, 0.067 cfs absolute). In addition, some water in Coal Creek is imported from District 40 via Lake Irwin. Hydrology is altered by water use within the basin.

Available Data
Coal Creek has a USGS gage located approximately 0.7 miles downstream from the proposed lower terminus (USGS 09111250 Coal Creek abv McCormick Ditch at Crested Butte, CO) This gage was installed in the fall of 2014 and is operated seasonally from April 1 to November 15. The gage is located downstream from the Spann Nettick Ditch (appropriation date 1954, 13.17 cfs absolute decreed water rights) and the Halazon Ditch (appropriation date 1907, 2.933 absolute decreed water

rights). In addition, a historic gage was located upstream about midway through the proposed ISF reach. The Coal Creek near Crested Butte, CO gage (USGS 09111000) was operated from 1941 to 1946. Streamflow estimates from this gage were determined to be less representative of the current proposed reach compared to the new gage due to location.

Downstream on the Slate River, two additional gages provide information. The upstream most gage is the Slate River near Crested Butte, CO (USGS 09111500, operated from 1940 to 1951 and again from 1993 to 2006). This gage has a 68.9 square miles drainage basin, with an average elevation of 10,300 ft and average annual precipitation of 33.66 inches. The drainage basin includes the Slate River, Coal Creek, and Washington Gulch. In 2006, USGS 09111500 was discontinued and a new gage was installed approximately 1.5 miles (straight line distance) downstream, Slate River above Baxter Gulch at Highway 135 near Crested Butte, CO (USGS 385106106571000, operated 2006 to present). This gage has a 73.3 square miles drainage basin, with an average elevation of 10,300 ft and average annual precipitation of 33.14 inches. This gage includes approximately 4.4 additional square miles of drainage basin and a few minor tributaries.

Data Analysis

Streamflow at the proposed lower terminus was estimated by adding the daily diversion records from the Spann Nettick Ditch to the Coal Creek gage. This analysis was done from 10/1/2014 to 11/15/2016, for days the gage was operational. The gage data was not scaled due to small differences in drainage basin size between the gage location and the proposed lower terminus (less than 1% difference in size). Because the available record is relatively short, nearby gages were assessed to see if any were suitable for use in extending the record. The Slate River above Baxter Gulch gage (USGS 385106106571000) was the nearest gage that operated concurrently with the Coal Creek gage and produced a reasonable regression coefficient ($r^2=0.92$). Streamflow measurements from the Slate River above Baxter Gulch and the Slate River near Crested Butte gages (USGS 385106106571000 and USGS USGS 09111500) were combined to produce a longer period of record on the Slate River. Combining the gage data assumes that streamflow measured between the two gages is essentially the same despite a small difference in drainage basin area (less than 1%). The only intervening water right structures between the two gages are either conditional, non-existent, or related to CWCB's acquisition on Washington Gulch, which should not affect streamflow. The regression equation developed using the Slate River above Baxter gage data was applied to the combined Slate River dataset to estimate streamflow on Coal Creek from 1940 to 1951 and 1993 to 2016). It should be noted that the regression equation is based on seasonal gage data, but the equation is applied to extend the gage record during the entire year. Median streamflow and 95% confidence intervals for median streamflow were calculated using the extended record. Confidence intervals were not calculated due to record length.

Water Availability Summary

The hydrographs (See Complete Hydrograph and Detailed Hydrograph) show median streamflow and 95% confidence intervals for median streamflow based on the extended diversion adjusted gage record. The proposed ISF rates are below the median at most times and below the 95% confidence interval at all times. Staff has concluded that water is available for appropriation.

Material Injury

Because the proposed ISF on Coal Creek is a new junior water right, the ISF can exist without material injury to other water rights. Under the provisions of section 37-92-102(3)(b), C.R.S. (2016), the CWCB will recognize any uses or exchanges of water in existence on the date this ISF water right is appropriated.

Citations

Capesius, J.P. and V.C. Stephens, 2009, Regional regression equations for estimation of natural streamflow statistics in Colorado, Scientific Investigations Report 2009-5136.

Espegren, G.D., 1996, Development of Instream Flow Recommendations in Colorado Using R2CROSS, Colorado Water Conservation Board.

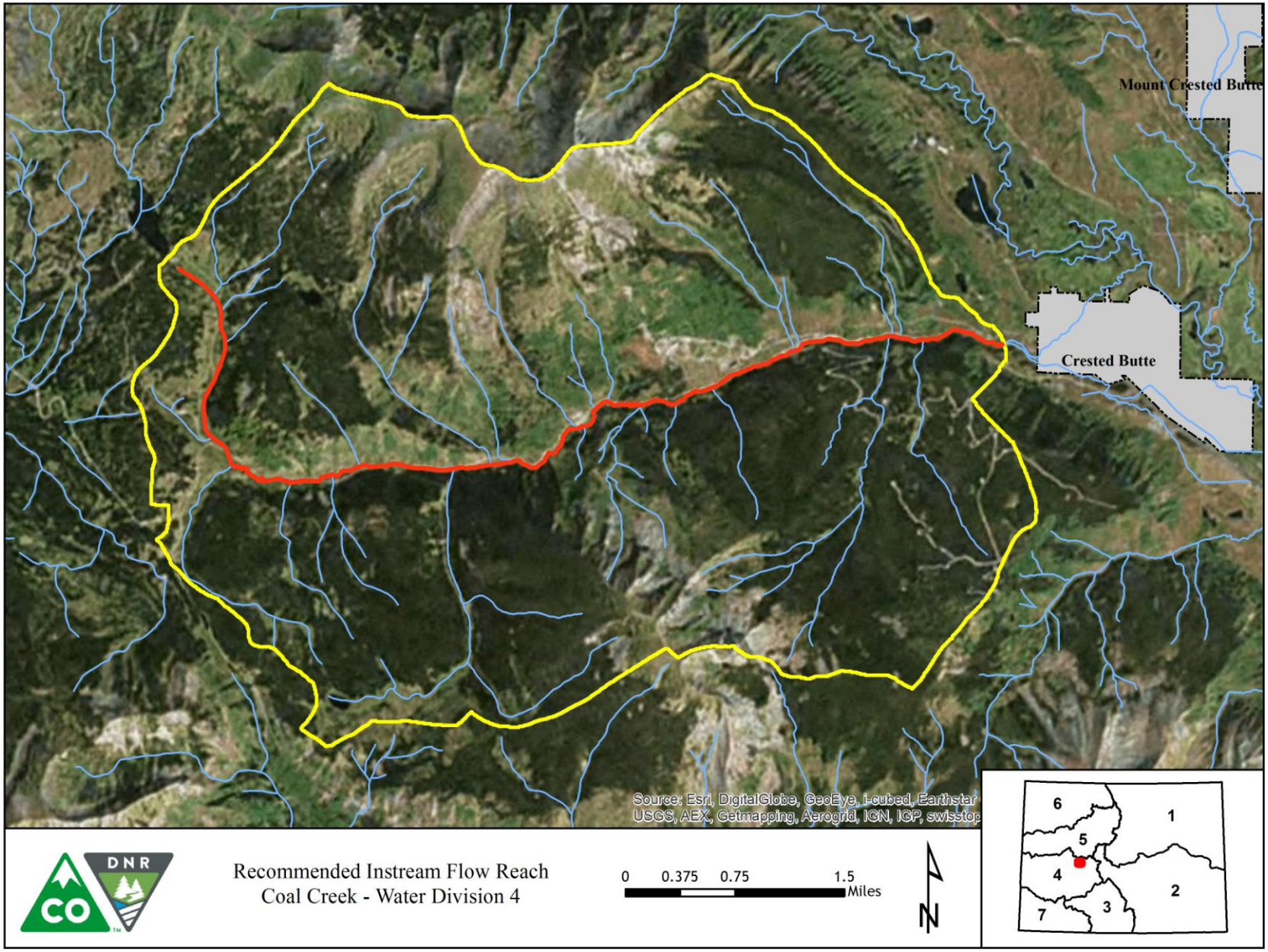
Nehring, B.R., 1979, Evaluation of Instream Flow Methods and Determination of Water Quantity Needs for Streams in the State of Colorado, Colorado Division of Wildlife.

Metadata Descriptions

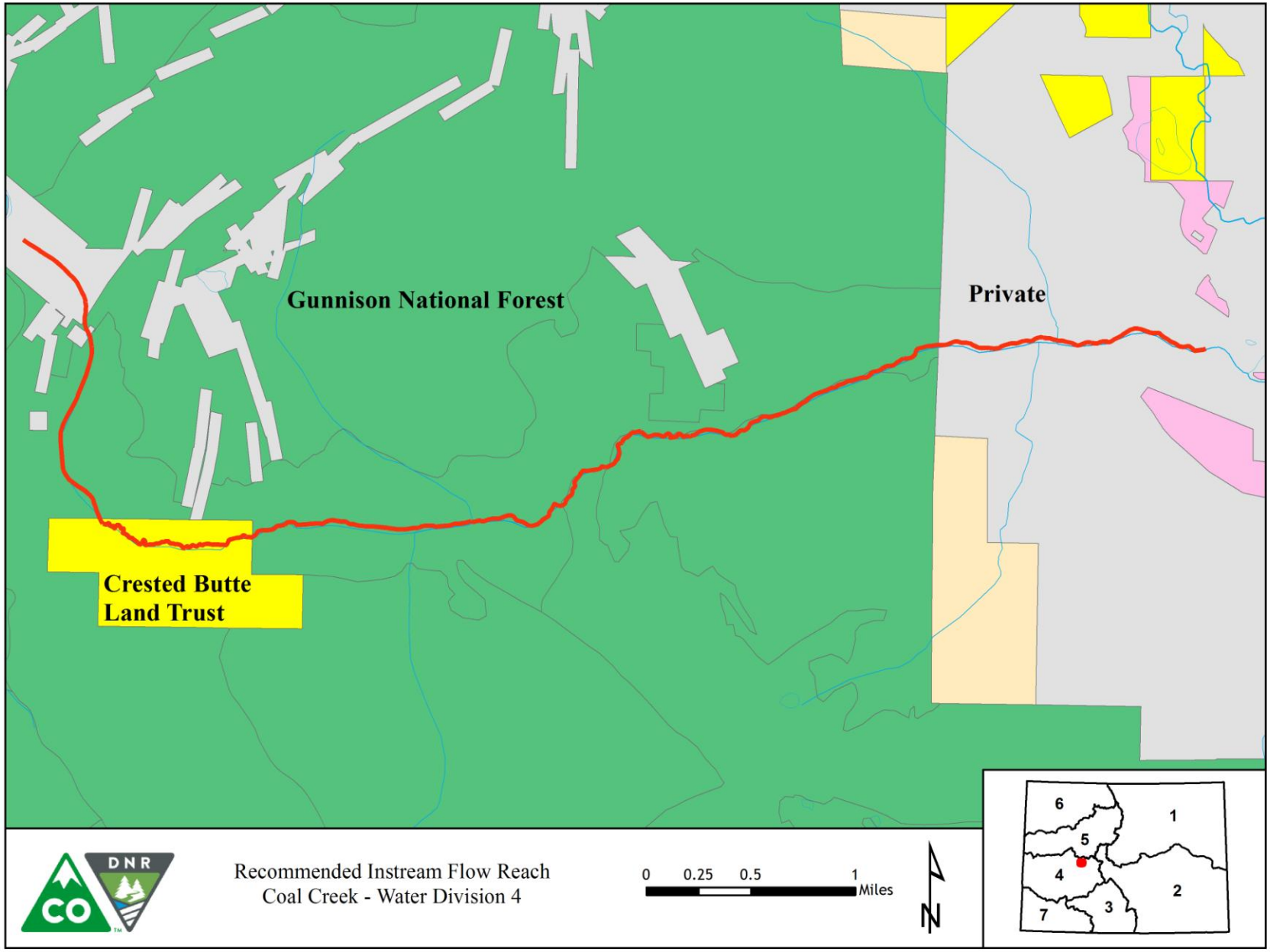
The UTM locations for the upstream and downstream termini were derived from CWCB GIS using the National Hydrography Dataset (NHD).

Projected Coordinate System: NAD 1983 UTM Zone 13N.

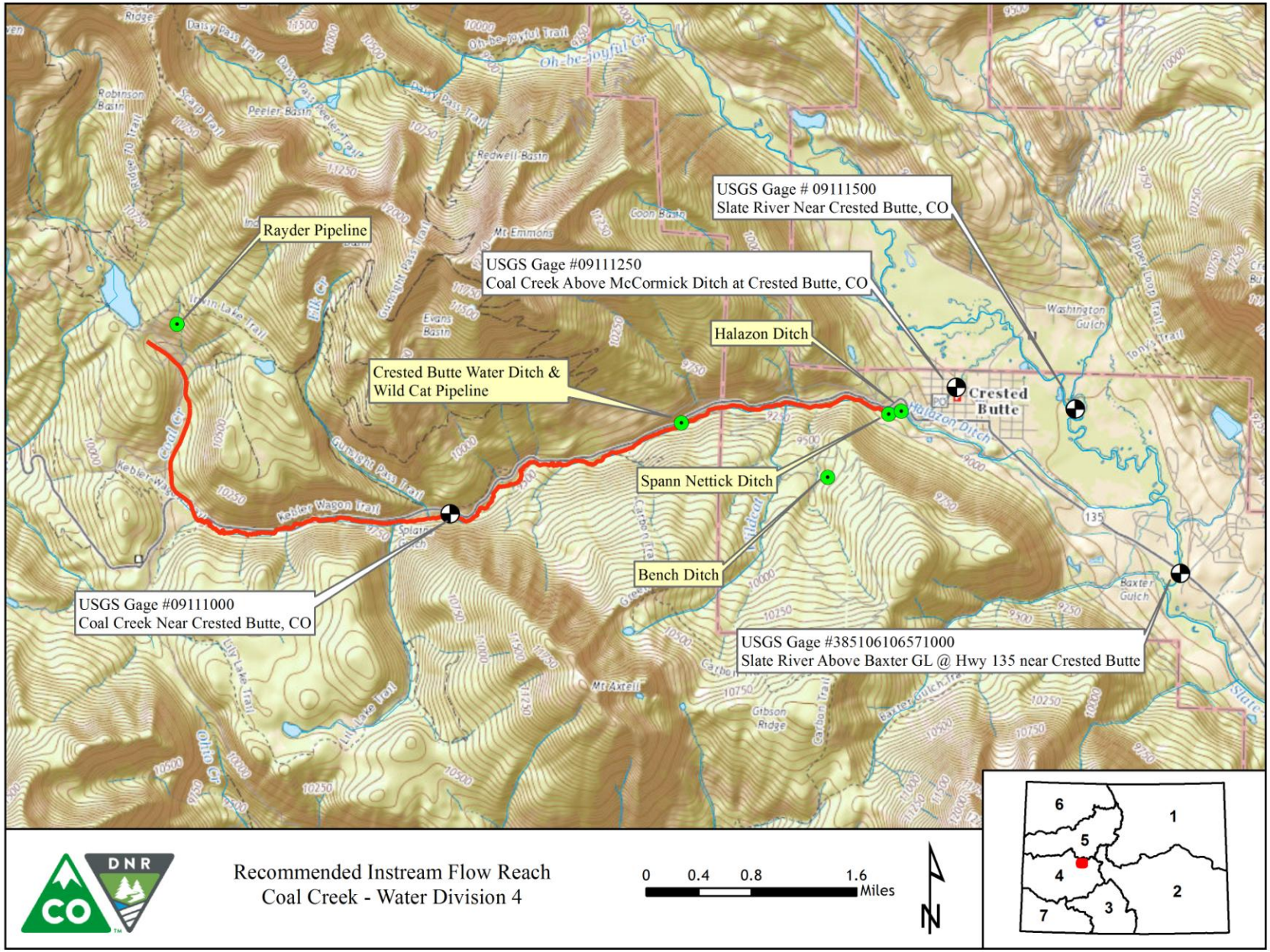
VICINITY MAP



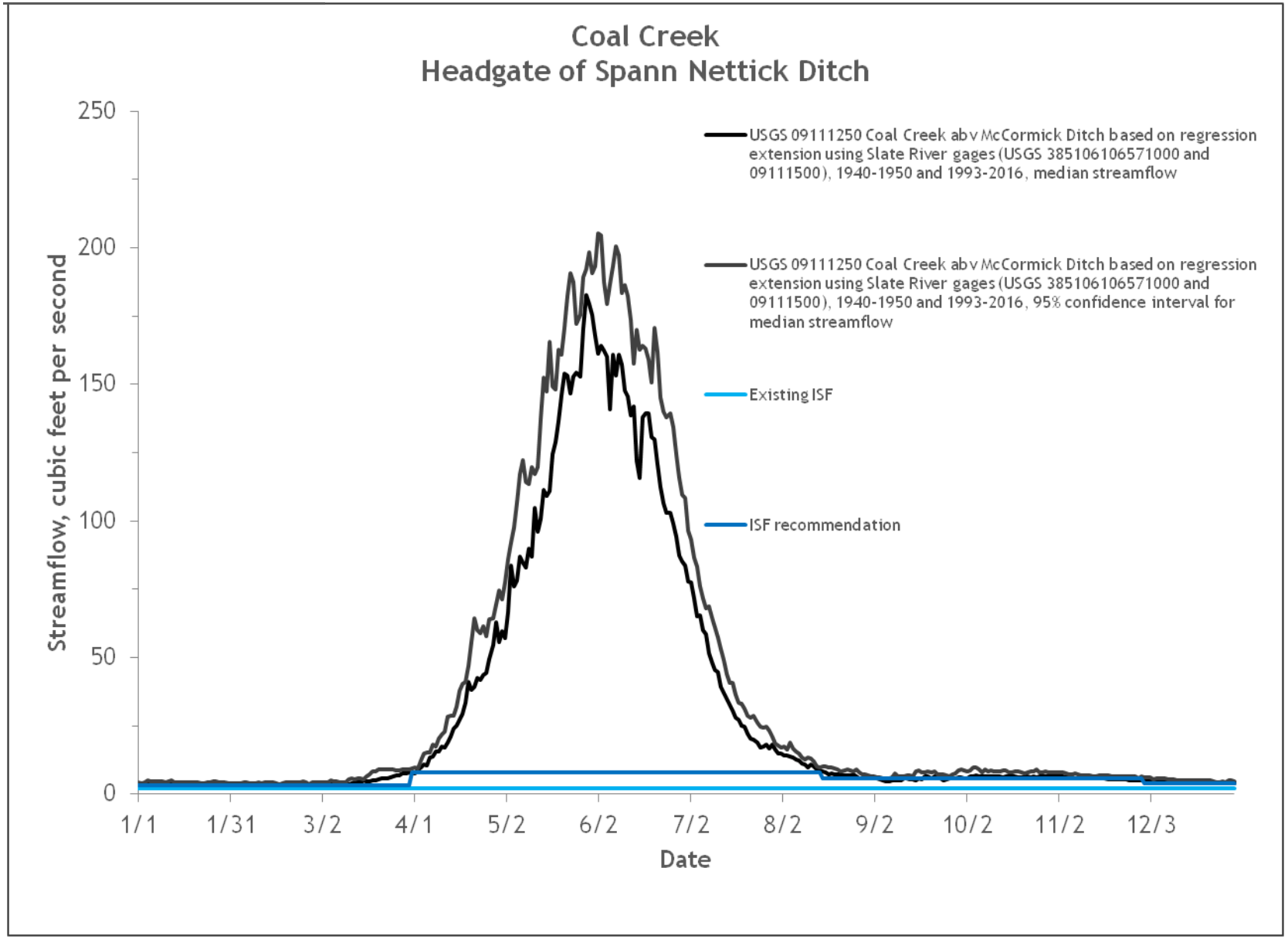
LAND OWNERSHIP MAP



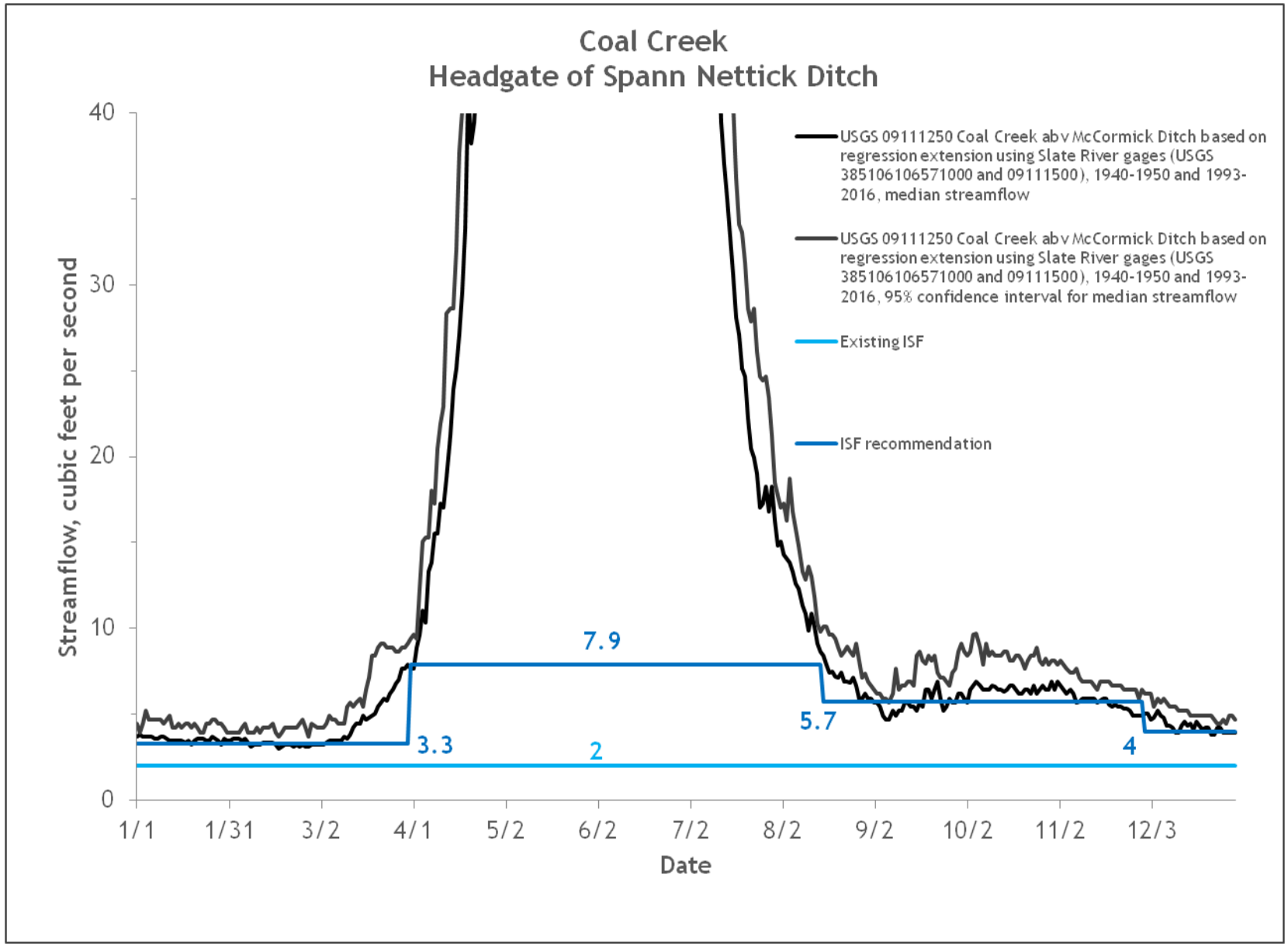
HYDROLOGIC FEATURES MAP



COMPLETE HYDROGRAPH



DETAILED HYDROGRAPH



COLORADO
Colorado Water Conservation Board
Department of Natural Resources

West Fork Terror Creek

EXECUTIVE SUMMARY

CWCB STAFF INSTREAM FLOW RECOMMENDATION

UPPER TERMINUS:	Headwaters in the Vicinity of UTM North: 4317217.31 UTM East: 268584.11
LOWER TERMINUS:	Confluence East Fork Terror Creek UTM North: 4314191.79 UTM East: 276880.59
WATER DIVISION:	4
WATER DISTRICT:	40
COUNTY:	Delta
WATERSHED:	North Fork Gunnison
CWCB ID:	17/4/A-001
RECOMMENDER:	Bureau of Land Management (BLM)
LENGTH:	5.85 miles
FLOW RECOMMENDATION:	1.1 cfs (7/16-3/31) 2.2 cfs (4/1-7/15)

West Fork Terror Creek

Introduction

Colorado's General Assembly created the Instream Flow and Natural Lake Level Program in 1973, recognizing "the need to correlate the activities of mankind with some reasonable preservation of the natural environment" (see 37-92-102 (3), C.R.S.). The statute vests the Colorado Water Conservation Board (CWCB or Board) with the exclusive authority to appropriate and acquire instream flow (ISF) and natural lake level water rights (NLL). Before initiating a water right filing, the Board must determine that: 1) there is a natural environment that can be preserved to a reasonable degree with the Board's water right if granted, 2) the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made, and 3) such environment can exist without material injury to water rights.

The BLM recommended that the CWCB appropriate an ISF water right on a reach of West Fork Terror Creek. West Fork Terror Creek originates roughly 12 miles northwest of Paonia on the south slopes of the Grand Mesa, near Mount Darline at an elevation of approximately 10,300 ft. The creek flows in an easterly direction as it drops to an elevation of approximately 7,070 ft where it joins East Fork Terror Creek to from Terror Creek. The proposed reach is located within Delta County (See Vicinity Map) and extends from its headwaters downstream to the confluence with East Fork Terror Creek. Seventy-eight percent of the land on the 5.85 mile proposed reach is publicly owned and managed by the BLM and the U.S. Forest Service; the remaining land is privately owned (See Land Ownership Map). The BLM recommended this reach of West Fork Terror Creek because it has a natural environment that can be preserved to a reasonable degree with an ISF water right.

The information contained in this report and the associated supporting data and analyses (located at: http://cwcb.state.co.us/environment/instream-flow-program/Pages/2017ProposedISFRecommendations.aspx) form the basis for staff's ISF recommendation to be considered by the Board. This report provides sufficient information to support the CWCB findings required by ISF Rule 5i on the natural environment, water availability, and material injury.

Natural Environment

CWCB staff relies on the recommending entity to provide information about the natural environment. In addition, staff reviews information and conducts site visits for each recommended ISF appropriation. This information is used to provide the Board with a basis for determining that a natural environment exists.

West Fork Terror Creek is a cold-water, high gradient stream. It flows through a narrow canyon that is typically less than 1,000 ft in width. The stream is generally constrained by bedrock, especially in locations where the stream comes close to the canyon walls. The stream generally has large-sized substrate, ranging from four-inch cobbles to boulders up to two ft in diameter. The stream has a high percentage of pool habitat, but sufficient riffle and side channel habitat exists to support salmonid fish reproduction.

Fisheries surveys have revealed self-sustaining populations of speckled dace and native cutthroat trout (See Table 1). Genetic testing has revealed that the trout population is comprised of genetically pure Colorado River Cutthroat Trout of the Colorado-Gunnison (GB) lineage, and that fish density is high. As such, the fishery has been identified as a core conservation population by the

Colorado River Cutthroat Conservation Team. Pending a status review, this population is currently being provided interim protection as a threatened species under the Endangered Species Act (ESA).

The riparian community in West Fork Terror Creek is generally comprised of willow species, alder, blue spruce, and narrowleaf cottonwood. In general, the riparian community is in very good condition, provides adequate shading and cover for fish habitat, and provides stream stability during flood events.

Table 1. List of species identified in West Fork Terror Creek.

Species Name	Scientific Name	Status
Colorado River cutthroat trout	*Oncorhynchus clarkii pleuriticus*	State – Species of Special Concern; BLM – Threatened (Interim protection pending status review under ESA)
speckled dace	*Rhinichthys osculus*	

ISF Quantification

CWCB staff relies upon the biological expertise of the recommending entity to quantify the amount of water required to preserve the natural environment to a reasonable degree. CWCB staff performs a thorough review of the quantification analyses completed by the recommending entity to ensure consistency with accepted standards.

Methodology

BLM staff used the R2Cross methodology to develop the initial ISF recommendation. The R2Cross method is based on a hydraulic model and uses field data collected in a stream riffle (Espegren, 1996). Riffles are most easily visualized as the stream habitat types that would dry up first should streamflow cease. The field data collected consists of streamflow measurements and surveys of channel geometry at a transect and of the longitudinal slope of the water surface.

The field data is used to model three hydraulic parameters: average depth, average velocity, and percent wetted perimeter. Maintaining these hydraulic parameters at adequate levels across riffle habitat types also will maintain aquatic habitat in pools and runs for most life stages of fish and aquatic macro-invertebrates (Nehring, 1979). BLM staff interprets the model results to develop an initial recommendation for summer and winter flows. The summer flow recommendation is based on meeting 3 of 3 hydraulic criteria. The winter flow recommendation is based on meeting 2 of 3 hydraulic criteria. The model's suggested accuracy range is 40% to 250% of the streamflow measured in the field. Recommendations that fall outside of the accuracy range may not give an accurate estimate of the hydraulic parameters necessary to determine an ISF rate.

The R2Cross methodology provides the biological quantification of the amount of water needed for summer and winter periods based on empirical studies of fish species preferences. The recommending entity uses the R2Cross results and its biological expertise to develop an initial ISF recommendation. CWCB staff then evaluates water availability for the reach typically based on median hydrology (see the Water Availability section below for more details). The water availability analysis may indicate less water is available than the initial recommendation. In that case, the recommending entity either modifies the magnitude and/or duration of the recommended ISF rates if

the available flows will preserve the natural environment to a reasonable degree, or withdraws the recommendation.

Data Analysis

R2Cross data was collected at five transects for this proposed ISF reach (Table 2). Results obtained at more than one transect are averaged to determine the R2Cross flow rate for the reach of stream. The R2Cross model results in a winter flow of 1.56 cfs, which meets 2 of 3 criteria and is within the accuracy range of the R2Cross model. The R2Cross model results in a summer flow of 2.15 cfs, which meets 3 of 3 criteria and is within the accuracy range of the R2Cross model.

Table 2. Summary of R2Cross transect measurements and results for West Fork Terror Creek.

Entity	Date	Streamflow (cfs)	Accuracy Range (cfs)	Winter Rate (cfs)	Summer Rate (cfs)
BLM	08/13/2015 # 1	1.11	0.44 - 2.78	0.83	out of range
BLM	07/23/2014 # 1	1.52	0.61 - 3.80	2.63	out of range
BLM	07/23/2014 # 2	1.46	0.58 - 3.65	1.13	out of range
BLM	07/23/2014 # 3	1.70	0.68 - 4.25	out of range	out of range
BLM	07/23/2014 # 4	1.80	0.72 - 4.50	1.65	2.15
			Mean	1.56	2.15

ISF Recommendation

BLM's analysis of these data, coordinated with Colorado Parks and Wildlife, indicates that the following flows are needed to preserve the fishery and natural environment to a reasonable degree:

2.2 cfs is recommended for the snowmelt runoff period from April 1 to July 15. This recommendation is driven by the wetted perimeter and velocity criteria. This flow rate will provide important physical habitat during a time of year when the fish population is completing key life cycle functions.

1.1 cfs is recommended during the base flow period between July 16 and March 31. This recommendation is driven by the wetted perimeter and average depth criteria. This flow rate should prevent excessively high stream temperatures during summer and should prevent icing in pools, allowing the fish population to successfully overwinter.

Water Availability

CWCB staff conducts hydrologic analyses for each recommended ISF appropriation to provide the Board with a basis for making the determination that water is available.

Methodology

Each recommended ISF reach has a unique flow regime that depends on variables such as the timing, magnitude, and location of water inputs (such as rain, snow, and snowmelt) and water losses (such as diversions, reservoirs, evaporation and transpiration, groundwater recharge, etc). Although extensive and time-consuming investigations of all variables may be possible, staff takes a pragmatic and cost-

effective approach to analyzing water availability. This approach focuses on streamflows and the influence of flow alterations, such as diversions, to understand how much water is physically available in the recommended reach.

Staff's hydrologic analysis is data-driven, meaning that staff gathers and evaluates the best available data and uses the best available analysis method for that data. Whenever possible, long-term stream gage data (period of record 20 or more years) will be used to evaluate streamflow. Other streamflow information such as short-term gages, temporary gages, spot streamflow measurements, diversion records, and StreamStats will be used when long-term gage data is not available. StreamStats, a statistical hydrologic program, uses regression equations developed by the USGS (Capesius and Stephens, 2009) to estimate mean flows for each month based on drainage basin area and average drainage basin precipitation. Diversion records will also be used to evaluate the effect of surface water diversions when necessary. Interviews with water commissioners, landowners, and ditch or reservoir operators can provide additional information. A range of analytical techniques may be employed to extend gage records, estimate streamflow in ungaged locations, and estimate the effects of diversions. The goal is to obtain the most detailed and reliable estimate of hydrology using the most efficient analysis technique.

The final product of the hydrologic analysis used to determine water availability is a hydrograph, which shows streamflow and the proposed ISF rate over the course of one year. The hydrograph will show median daily values when daily data is available; otherwise, it will present mean-monthly streamflow values. Staff will calculate 95% confidence intervals for the median streamflow if there is sufficient data. Statistically, there is 95% confidence that the true value of the median streamflow is located within the confidence interval.

Basin Characteristics

The drainage basin of the proposed ISF on West Fork Terror Creek is 18.8 square miles, with an average elevation of 9,130 ft and average annual precipitation of 28.05 inches (See the Vicinity Map). The drainage basin tributary to the lower terminus has two primary diversions, the Overland Ditch and the Pitkin Mesa Pipeline. The Overland Ditch can divert from the headwaters of Muddy Creek, Hubbard Creek, Terror Creek, and Leroux Creek. This ditch appears to be able to divert a maximum of 150 cfs (appropriation date 1893 and 1919) from each basin; however, the total from all basins cannot exceed 150 cfs. Pitkin Mesa Pipeline pipes water from 6 springs located near a tributary to West fork Terror Creek (2.5 cfs, appropriation dates 1883 and 1961) to a neighborhood for domestic uses. There are also a number of small reservoirs and two larger reservoirs including the Holy Terror Reservoir (168.6 AF, appropriation date 1893) and Rex Reservoir (18.4 AF, appropriation date 1907 and 1949). Water from the basins tributary to Rex and Holy Terror Reservoirs can end up in one of 3 places depending on the calling right: (1) the reservoirs are typically filled during spring runoff and then stored water is released to Leroux Creek, the basin to the west of Terror Creek; (2) the Overland Ditch may place a call and water is routed to the Overland Ditch via a portion of West Fork Terror Creek; or (3) the Terror Creek Ditch, located downstream on Terror Creek (appropriation dates 1884 and 1901) places a call and water is routed through West Fork Terror Creek to the Terror Creek Ditch.

Table 3. List of diversion structures in the drainage basin tributary to the lower terminus of West Fork Terror Creek.

Name	WDID	Adjudication Date	Appropriation Date	Administration Number	Amount cfs
Overland Ditch	4001739	6/23/1914	8/1/1893	21263.15919	75.00
		8/28/1919	4/10/1919	25301.00000	75.00
Pitkin Mesa Pipeline	4001191	6/17/1889	11/13/1883	12370.00000	0.49
		1/31/1964	8/13/1961	40767.00000	2.02

Available Data

There are two historic streamflow gages in the vicinity of the proposed ISF reach. The East Fork Terror Creek below Cottonwood Stomp near Bowie gage (USGS 09132985) measures streamflow on the East Fork of Terror Creek. This gage was not used in analysis as it only measures flow in East Fork Terror Ditch. The second gage is the Terror Creek at mouth near Bowie, CO gage (USGS 09132995) which is located approximately 3.4 miles downstream from the proposed lower terminus. This gage measures the streamflow from both East Fork Terror Creek and West Fork Terror Creek. The Terror Creek at mouth gage (Terror Creek gage) was operated from 2001 to 2013 and discontinued in 2014 due to funding issues. The Terror Creek gage has a 29.5 square miles drainage basin and is influenced by the same diversions that affect the proposed ISF reach as well as the diversion structures shown in Table 4. In addition, Bruce Park Reservoir is located on a tributary to East Fork of Terror Creek (631.99 AF, appropriation dates 1913 and 1950) and is used to supplement irrigation diversions. The Terror Ditch Extension (29 cfs total, appropriation dates 1894 and 1976) diverts water from the headwaters of Hubbard Creek into Bruce Park Reservoir (Steve Tuck, water commissioner, stated that there is a pipe to bypass the reservoir, but it is rarely used (personal communication, 11/17/2017)).

Table 4. List of additional diversion structures that affect the Terror Creek gage.

Name	WDID	Adjudication Date	Appropriation Date	Administration Number	Amount cfs
Terror Ditch	4001208	4/12/1901	12/11/1884	14413.12764	6.00
		2/10/1930	5/01/1901	25807.18748	6.00
		3/20/1954	12/11/1884	31924.12764	1.50
Holybee Ditch	4001155	6/17/1989	11/13/1883	12370.00000	0.40
Fire Mt Canal	4001809	2/10/1930	7/1/1903	25807.19539	70.00
Fawcett Ditch	4001130	6/17/1889	11/13/1883	12370.00000	0.12
		3/20/1954	4/15/1944	34438.00000	1.25
		12/31/2005	5/1/1986	56613.49794	0.13

CWCB staff made one streamflow measurement on the proposed reach of West Fork Terror Creek as summarized in Table 5. In addition, four USGS streamflow measurements from 1982 and 2003 were identified in the West Fork Terror Creek reach.

Table 5. Summary of streamflow measurement visits and results for West Fork Terror Creek.

Visit Date	Flow (cfs)	Method	Party
10/5/1982	1.6	unknown	USGS
6/17/2003	3.17	unknown	USGS
6/18/2003	2.82	unknown	USGS
9/16/2003	2.21	unknown	USGS
09/14/2016	1.14	Wading, Marsh McBirney	CWCB

Data Analysis

Due to the short period of record available at the Terror Creek gage, staff took additional steps to evaluate the record. Staff examined other gages in the region in an attempt to find a gage that could be used to extend the record through regression analysis. However, none of the gages evaluated produced a reasonable regression coefficient and none were found suitable for regression extension. Staff also examined streamflow gages and climate stations and found that the Paonia climate station (Paonia 1 SW, Station ID USC00056306, downloaded 11/7/2014) has a relatively long period of record and is located about 7 miles from the lower terminus. The average annual precipitation at the Paonia Station for the period of record (1893 to 1930, 1957 to 2014) is 15.14 inches. During the 13 years the Terror Creek gage operated (2001 to 2013), only two years (2005 and 2007) had above average precipitation at the Paonia Station and all others were below average. Therefore, the Terror Creek gage record likely represents below average streamflow conditions and likely underestimates the amount of water typically available in this drainage.

The Terror Creek gage was analyzed using the approved period of record (6/28/2001 to 12/31/2013) available through HydroBase on 11/17/2016. A number of calculations were made to estimate natural streamflow on Terror Creek at the gage location. First, diversion records from Terror Ditch and Fawcett Ditch were added to the gage record. Fire Mountain Canal diversions were not added because there were no recorded diversions during the period analyzed. Holybee Ditch diversions were not added to avoid double counting flow because it was unclear if return flows accrue to Terror Creek. The portion of the diversions from the Terror Creek ditch that originate as releases from Bruce Park Reservoir were subtracted from the adjusted gage record because those flows largely originate from Hubbard Creek via the Terror Ditch Extension. The adjusted gage record was then scaled by 0.689 to the lower terminus using the area-precipitation method. The area-precipitation method estimates streamflow based on the ratio of the precipitation weighted drainage area at the lower terminus location to that of the gage location. The effects of diversions from the Overland Ditch, the Pitkin Mesa Pipeline, Holy Terror Reservoir, and Rex Reservoir were assumed to be included in the gage data.

Median streamflow was calculated using the adjusted scaled Terror Creek gage record. 95% confidence intervals were not calculated due to the short period of record at the Terror Creek gage.

Water Availability Summary
The hydrographs (See Complete Hydrograph and Detailed Hydrograph) show the median streamflow based on the adjusted Terror Creek gage record. The proposed ISF is less than the median adjusted streamflow. Staff has concluded that water is available for appropriation.

Material Injury
Because the proposed ISF on West Fork Terror Creek is a new junior water right, the ISF can exist without material injury to other water rights. Under the provisions of section 37-92-102(3)(b), C.R.S. (2016), the CWCB will recognize any uses or exchanges of water in existence on the date this ISF water right is appropriated.

Citations
Capesius, J.P. and V.C. Stephens, 2009, Regional regression equations for estimation of natural streamflow statistics in Colorado, Scientific Investigations Report 2009-5136.

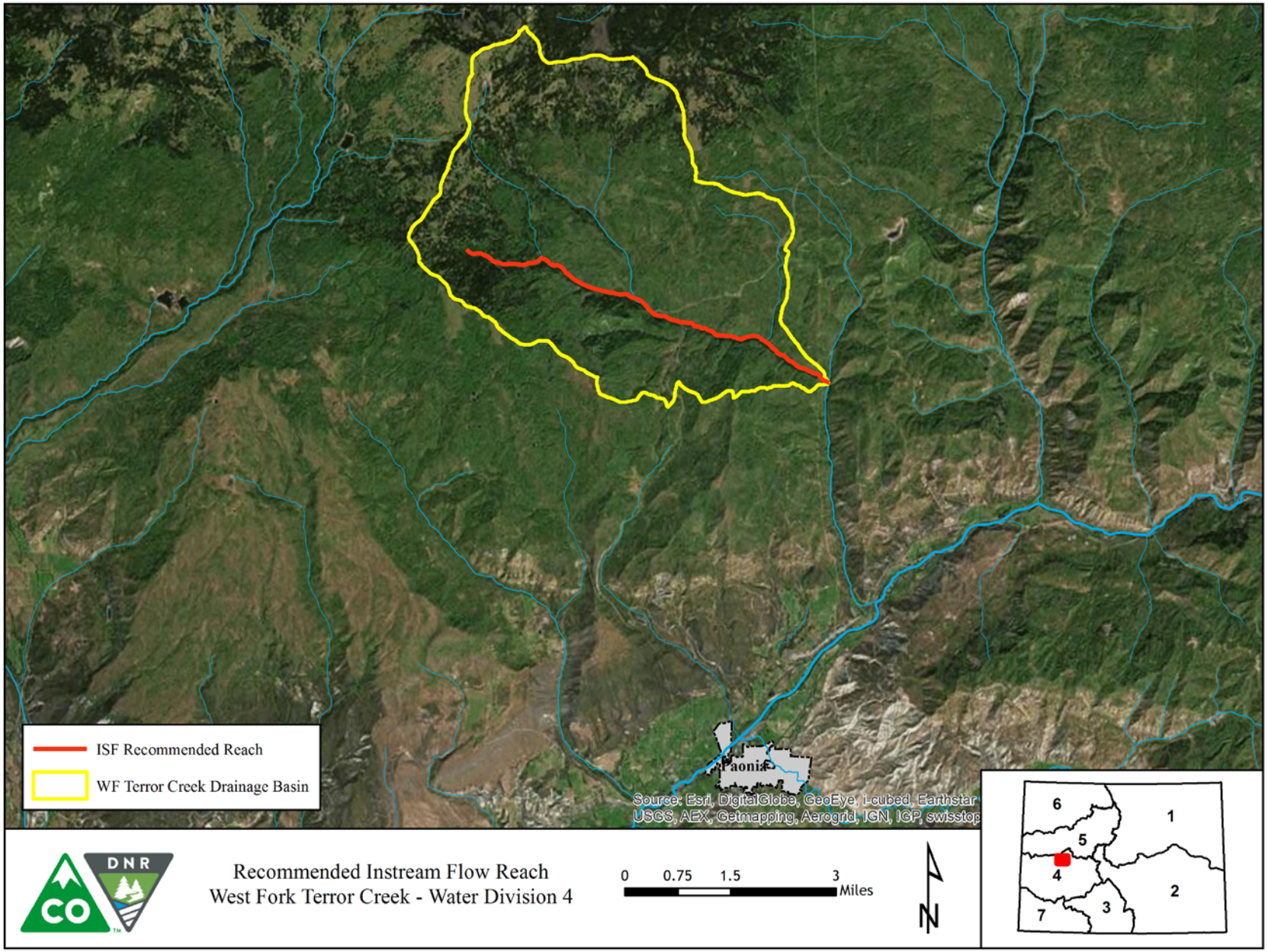
Espegren, G.D., 1996, Development of Instream Flow Recommendations in Colorado Using R2CROSS, Colorado Water Conservation Board.

Nehring, B.R., 1979, Evaluation of Instream Flow Methods and Determination of Water Quantity Needs for Streams in the State of Colorado, Colorado Division of Wildlife.

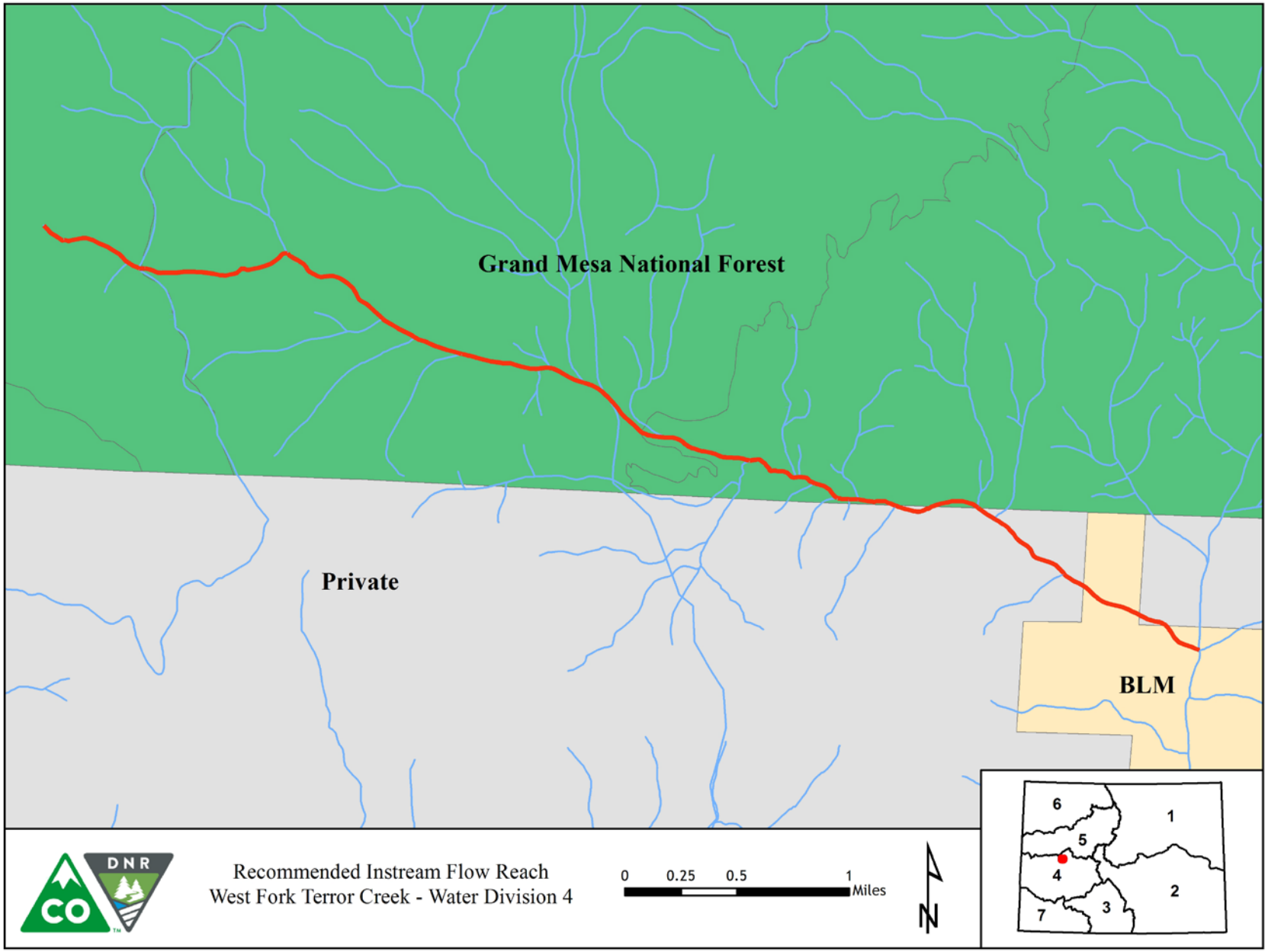
Metadata Descriptions
The UTM locations for the upstream and downstream termini were derived from CWCB GIS using the National Hydrography Dataset (NHD).

Projected Coordinate System: NAD 1983 UTM Zone 13N.

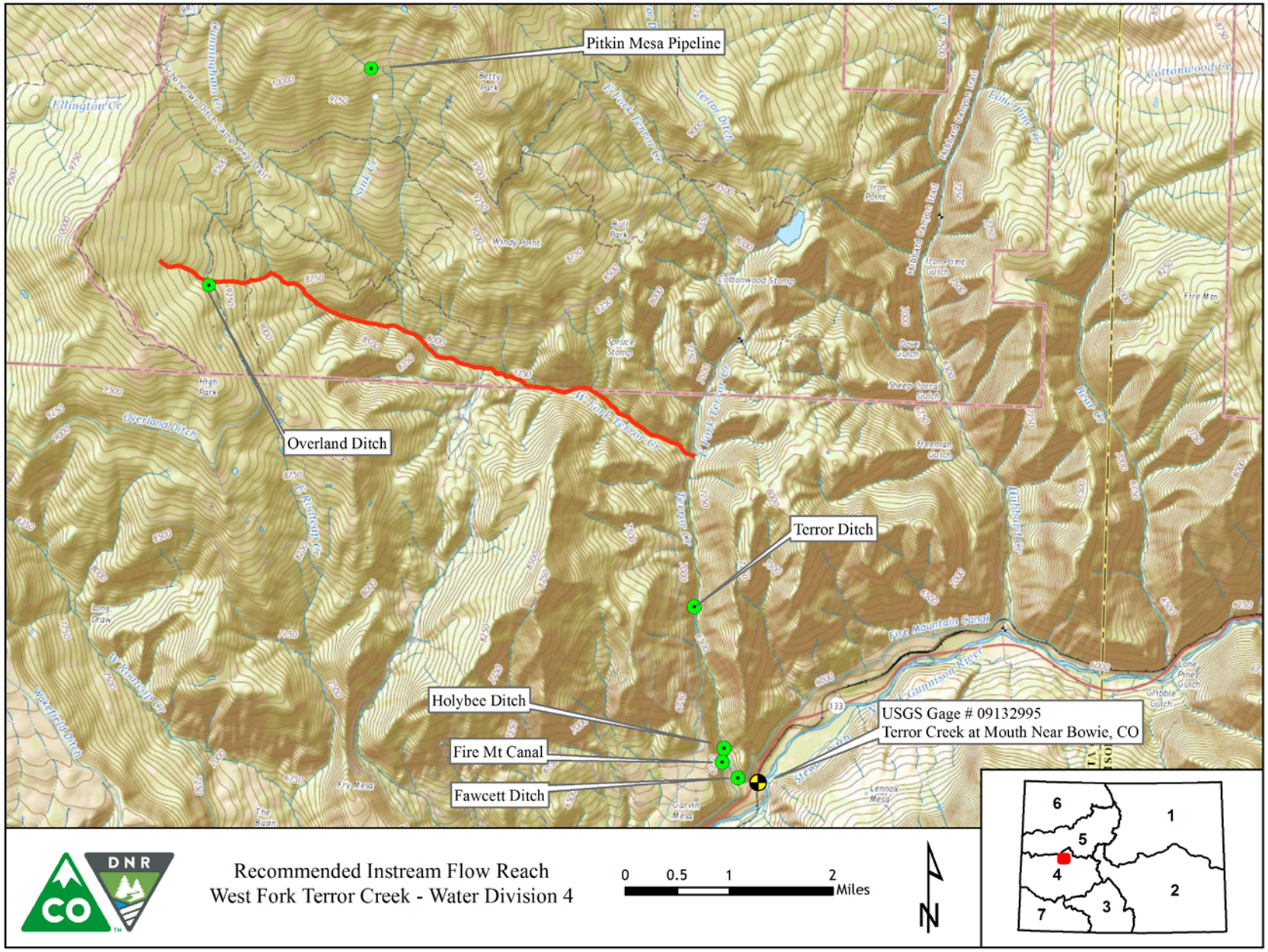
VICINITY MAP



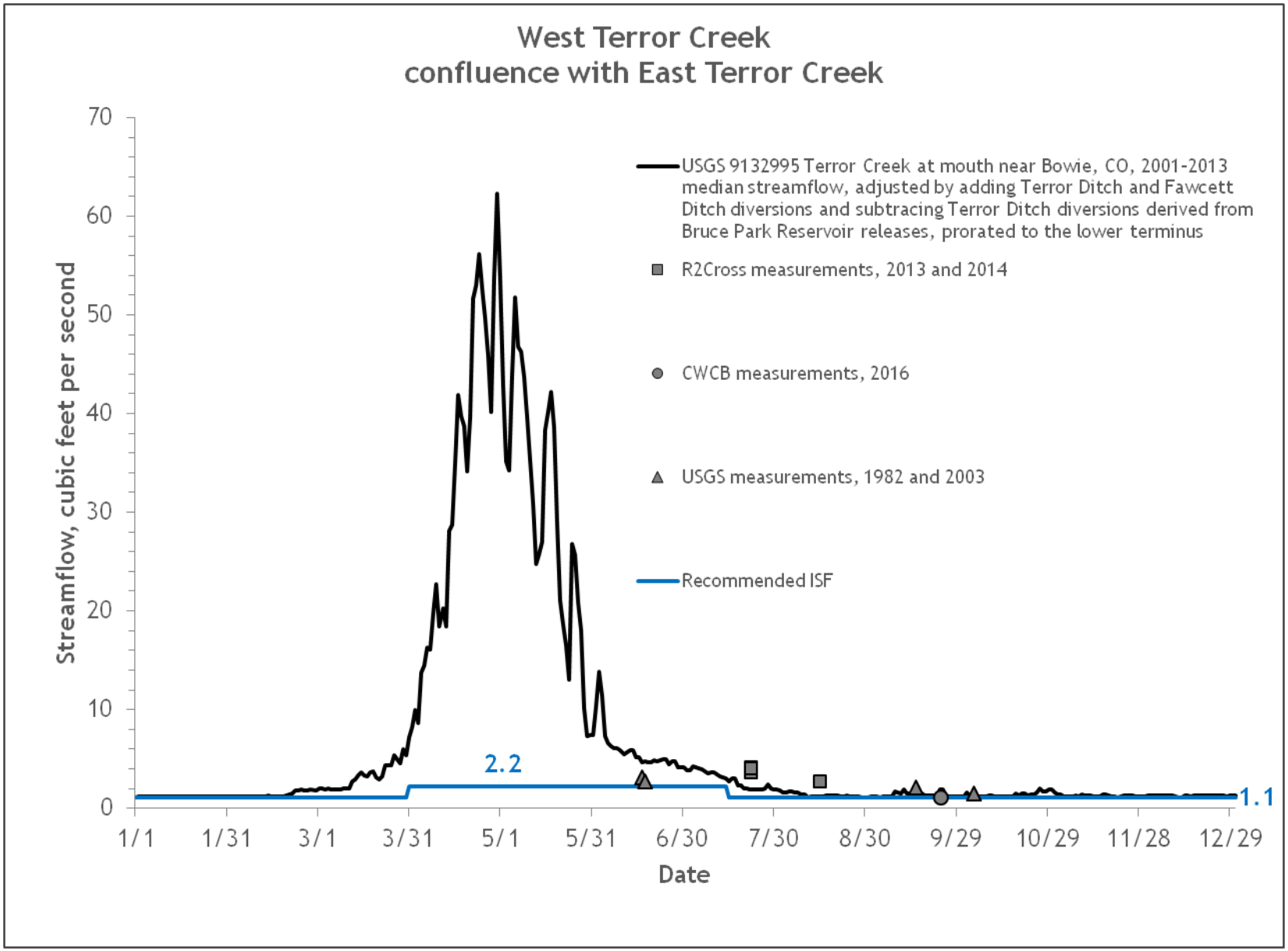
LAND OWNERSHIP MAP



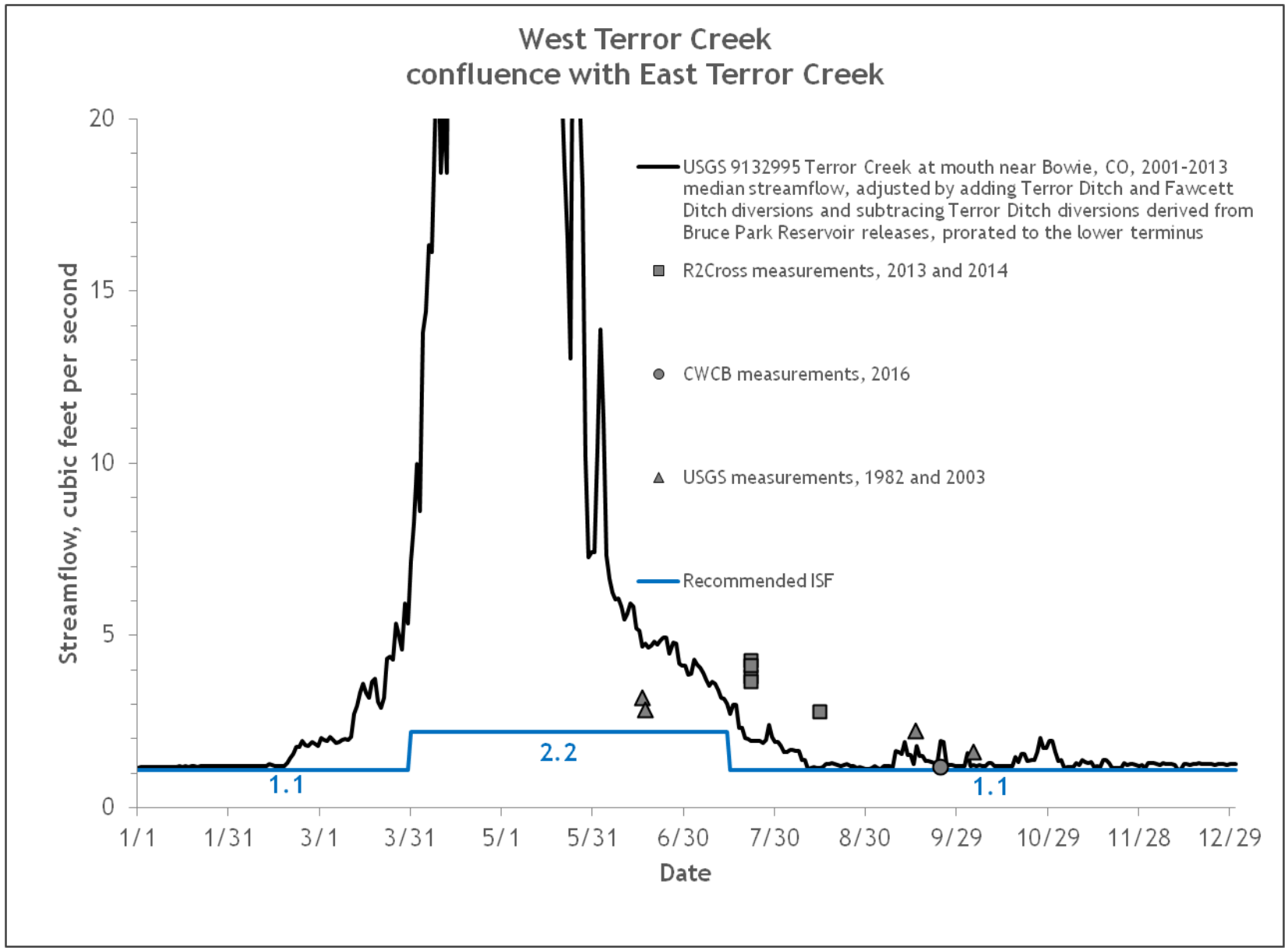
HYDROLOGIC FEATURES MAP



COMPLETE HYDROGRAPH



DETAILED HYDROGRAPH



COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Dry Fork Roan Creek

EXECUTIVE SUMMARY

CWCB STAFF INSTREAM FLOW RECOMMENDATION

UPPER TERMINUS:	Confluence South Dry Fork and North Dry Fork UTM North: 4364215.13 UTM East: 210728.25
LOWER TERMINUS:	Omundson and Frost Ditch Headgate UTM North: 4363665.66 UTM East: 213772.70
WATER DIVISION:	5
WATER DISTRICT:	70
COUNTY:	Garfield
WATERSHED:	Parachute-Roan
CWCB ID:	14/5/A-001
RECOMMENDER:	Bureau of Land Management (BLM)
LENGTH:	2.54 miles
FLOW RECOMMENDATION:	0.5 (05/01 – 08/15) 0.2 (08/16 – 04/30)

Dry Fork Roan Creek

Introduction

Colorado's General Assembly created the Instream Flow and Natural Lake Level Program in 1973, recognizing "the need to correlate the activities of mankind with some reasonable preservation of the natural environment" (see 37-92-102 (3), C.R.S.). The statute vests the Colorado Water Conservation Board (CWCB or Board) with the exclusive authority to appropriate and acquire instream flow (ISF) and natural lake level water rights (NLL). Before initiating a water right filing, the Board must determine that: 1) there is a natural environment that can be preserved to a reasonable degree with the Board's water right if granted, 2) the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made, and 3) such environment can exist without material injury to water rights.

The BLM recommended that the CWCB appropriate an ISF water right on a reach of Dry Fork Roan Creek. Dry Fork Roan Creek originates at the confluence of South Dry Fork and North Dry Fork at an elevation of approximately 5,600 ft. The creek flows in a southeasterly direction as it drops down to an elevation of approximately 5,200 ft where it joins Roan Creek. This proposed reach is located within Garfield County (See Vicinity Map) and extends from the confluence of South Dry Fork and North Dry Fork downstream to the Omundson & Frost Ditch Headgate. Thirty-seven percent of the land on the 2.54 mile proposed reach is federally owned and managed by the BLM; the remaining land is privately owned (See Land Ownership Map). The BLM recommended this reach of Dry Fork Roan Creek because it has a natural environment that can be preserved to a reasonable degree with an ISF water right.

The information contained in this report and the associated supporting data and analyses (located at: http://cwcb.state.co.us/environment/instream-flow-program/Pages/2017ProposedISFRecommendations.aspx) form the basis for staff's ISF recommendation to be considered by the Board. This report provides sufficient information to support the CWCB findings required by ISF Rule 5i on the natural environment, water availability, and material injury.

Natural Environment

CWCB staff relies on the recommending entity to provide information about the natural environment. In addition, staff reviews information and conducts site visits for each recommended ISF appropriation. This information is used to provide the Board with a basis for determining that a natural environment exists.

Dry Fork Roan Creek is a cool-water, moderate gradient stream in a stream valley that is approximately 0.5 mile wide. The stream is typically narrow, has a good width-depth ratio, and generally has small substrate. Portions of the stream that have recovered from historic overgrazing typically have good cover and a good mix of riffle and run habitat. In areas that have not fully recovered from historic overgrazing, the stream is wider, has less cover, and exhibits less bank stability.

The riparian community along Dry Fork Roan Creek is robust and recovering from historic grazing practices, providing improved cover and shading for the stream. The riparian community is comprised mainly of willow and Fremont cottonwood. BLM wildlife data collected in 2012 identified native northern leopard frogs (a State species of concern) utilizing the riparian habitats associated

with Dry Fork Roan Creek (See Table 1). In addition, BLM spot surveys have revealed a macroinvertebrate community that includes mayflies and caddisflies.

Table 1. List of species identified in Dry Fork Roan Creek.

Species Name	Scientific Name	Status
northern leopard frog	*Rana pipiens*	State - Species of Special Concern; Federal - BLM Sensitive Species.

ISF Quantification

CWCB staff relies upon the biological expertise of the recommending entity to quantify the amount of water required to preserve the natural environment to a reasonable degree. CWCB staff performs a thorough review of the quantification analyses completed by the recommending entity to ensure consistency with accepted standards.

Methodology

BLM staff used the R2Cross methodology to develop the initial ISF recommendation. The R2Cross method is based on a hydraulic model and uses field data collected in a stream riffle (Espegren, 1996). Riffles are most easily visualized as the stream habitat types that would dry up first should streamflow cease. The field data collected consists of streamflow measurements and surveys of channel geometry at a transect and of the longitudinal slope of the water surface.

The field data is used to model three hydraulic parameters: average depth, average velocity, and percent wetted perimeter. Maintaining these hydraulic parameters at adequate levels across riffle habitat types also will maintain aquatic habitat in pools and runs for most life stages of fish and aquatic macro-invertebrates (Nehring, 1979). BLM staff interprets the model results to develop an initial recommendation for summer and winter flows. The summer flow recommendation is based on meeting 3 of 3 hydraulic criteria. The winter flow recommendation is based on meeting 2 of 3 hydraulic criteria. The model's suggested accuracy range is 40% to 250% of the streamflow measured in the field. Recommendations that fall outside of the accuracy range may not give an accurate estimate of the hydraulic parameters necessary to determine an ISF rate.

The R2Cross methodology provides the biological quantification of the amount of water needed for summer and winter periods based on empirical studies of fish species preferences. The recommending entity uses the R2Cross results and its biological expertise to develop an initial ISF recommendation. CWCB staff then evaluates water availability for the reach typically based on median hydrology (see the Water Availability section below for more details). The water availability analysis may indicate less water is available than the initial recommendation. In that case, the recommending entity either modifies the magnitude and/or duration of the recommended ISF rates if the available flows will preserve the natural environment to a reasonable degree, or withdraws the recommendation.

Data Analysis

R2Cross data was collected at two transects for this proposed ISF reach (Table 2). Results obtained at more than one transect are averaged to determine the R2Cross flow rate for the reach of stream. The R2Cross model results in a winter flow of 1.07 cfs, which meets 2 of 3 criteria and is within the accuracy range of the R2Cross model. The R2Cross model results in a summer flow of 1.41 cfs, which meets 3 of 3 criteria and is within the accuracy range of the R2Cross model.

Table 2. Summary of R2Cross transect measurements and results for Dry Fork Roan Creek.

Entity	Date	Streamflow (cfs)	Accuracy Range (cfs)	Winter Rate (cfs)	Summer Rate (cfs)
BLM	05/15/2012 # 1	0.78	0.31 - 1.95	0.92	1.05
BLM	05/15/2012 # 2	0.94	0.38 - 2.35	1.22	1.78
			Mean	1.07	1.41

ISF Recommendation

BLM's analysis of this data, coordinated with Colorado Parks and Wildlife, indicates that the following flows are needed to preserve the fishery and natural environment to a reasonable degree.

0.5 cfs is recommended for the high temperature period from May 1 to August 15. This recommendation is driven by limited water availability. This creek experiences consistently low flows during late summer and fall, so it is important to protect as much physical habitat as possible during the limited time when snowmelt runoff flows are available. This flow rate should also help maintain water in the rooting zone for the extensive riparian community associated with this creek.

0.20 cfs is recommended for the base flow period between August 16 and April 30. This flow rate doesn't meet any of the instream flow criteria, but it does reflect limited water availability, as influenced by base season flows and occasional diversions. This flow rate should provide sufficient flow to prevent pools from freezing during the winter. It should also provide for connectivity between the limited physical habitat that is available during the low flow period.

Water Availability

CWCB staff conducts hydrologic analyses for each recommended ISF appropriation to provide the Board with a basis for making the determination that water is available.

Methodology

Each recommended ISF reach has a unique flow regime that depends on variables such as the timing, magnitude, and location of water inputs (such as rain, snow, and snowmelt) and water losses (such as diversions, reservoirs, evaporation and transpiration, groundwater recharge, etc). Although extensive and time-consuming investigations of all variables may be possible, staff takes a pragmatic and cost-effective approach to analyzing water availability. This approach focuses on streamflows and the influence of flow alterations, such as diversions, to understand how much water is physically available in the recommended reach.

Staff's hydrologic analysis is data-driven, meaning that staff gathers and evaluates the best available data and uses the best available analysis method for that data. Whenever possible, long-term stream gage data (period of record 20 or more years) will be used to evaluate streamflow. Other streamflow information such as short-term gages, temporary gages, spot streamflow measurements, diversion records, and StreamStats will be used when long-term gage data is not available. StreamStats, a

statistical hydrologic program, uses regression equations developed by the USGS (Capesius and Stephens, 2009) to estimate mean flows for each month based on drainage basin area and average drainage basin precipitation. Diversion records will also be used to evaluate the effect of surface water diversions when necessary. Interviews with water commissioners, landowners, and ditch or reservoir operators can provide additional information. A range of analytical techniques may be employed to extend gage records, estimate streamflow in ungaged locations, and estimate the effects of diversions. The goal is to obtain the most detailed and reliable estimate of hydrology using the most efficient analysis technique.

The final product of the hydrologic analysis used to determine water availability is a hydrograph, which shows streamflow and the proposed ISF rate over the course of one year. The hydrograph will show median daily values when daily data is available; otherwise, it will present mean-monthly streamflow values. Staff will calculate 95% confidence intervals for the median streamflow if there is sufficient data. Statistically, there is 95% confidence that the true value of the median streamflow is located within the confidence interval.

Basin Characteristics

The drainage basin of the proposed ISF on Dry Fork Roan Creek is 97.2 square miles, with an average elevation of 7,030 ft and average annual precipitation of 17.58 inches (See the Hydrologic Features Map). There are upstream irrigation uses in the drainage basin tributary to the proposed ISF on Dry Fork Roan Creek. Streamflow is altered from natural flow conditions.

Available Data

There is not a current streamflow gage on Dry Fork Roan Creek. However, a historic gage (USGS 0909533, Dry Fork at Upper Station, near de Beque, CO, 1995-1998 and 2000-2004) was located 1,400 ft downstream from the proposed lower terminus. The drainage basin of this gage is nearly identical to the proposed lower terminus, 97.4 square miles, with an average elevation of 7,030 ft and average annual precipitation of 17.58 inches. A second historic gage on Dry Fork Roan Creek (USGS 09095400 Dry Fork near de Beque, 1974 – 1982) was located approximately 3.75 miles downstream near the confluence with Roan Creek. This gage was not used in this analysis due to: (1) the distance from the proposed reach, and (2) development of new water rights and undecreed uses that are not reflected by the historic record.

In some cases, diversion records can be used to provide an indication of water availability in a stream reach. There are two diversion structures in the vicinity of the lower terminus, the Omundson and Frost Ditch (2.5 cfs, appropriation dates 1886, 1887, 1888, and 1909) and Dry Fork Ditch (2.4 cfs, appropriation dates 1886, 1887, 1888). The Omundson and Frost Ditch has intermittent records from 1975 to 2015 with many years of no data. Dry Fork Ditch has intermittent daily records from 1971 to 2014, with many years of no data. While the diversion records provide some information about streamflow, they are not a perfect measure of streamflow because years in which water is available but not taken may be recorded as zero.

BLM staff made a number of streamflow measurements on Dry Fork Roan Creek that are included in this analysis. CWCB staff made two streamflow measurements on the proposed reach of Dry Fork Roan Creek as summarized in Table 3.

Table 3. Summary of streamflow measurement visits and results for Dry Fork Roan Creek.

Visit Date	Flow (cfs)	Method	Party
6/26/2012	0.74	unknown	BLM
7/31/2012	0.74	unknown	BLM
8/15/2012	0.70	unknown	BLM
8/30/2012	0.69	unknown	BLM
10/2/2013	0.43	Wading, Marsh McBirney	CWCB
4/1/2014	0.44	unknown	BLM
5/20/2014	0.35	Wading, ADV	CWCB

Data Analysis

Due to the short period of record available at the Dry Fork Roan Creek gage, staff took additional steps to evaluate the record. Staff examined other gages in the region in an attempt to find a gage that could be used to extend the record through regression analysis. However, none of the gages evaluated produced a reasonable regression coefficient and none were found suitable for regression extension.

Staff also examined climate stations and found that the Alternbern climate station (Station ID USC00050214, downloaded 11/7/2016) has a relatively long period of record and is located about 8.9 miles north from the lower terminus. The average annual precipitation at the Alternbern climate station for years with complete records between 1947 and 2015 is 17.4 inches. During the 7 years the Dry Fork Roan Creek gage operated, this climate station recorded a range of conditions from very dry (2002) to very wet. The average precipitation for the years with climate data is similar to the long term average at the climate station. However, not all years had complete precipitation data. Moreover, the gage record may not correlate well with the precipitation record given that the year with the highest precipitation did not record the highest streamflow, and other years with similar precipitation show large differences in streamflow. Therefore, it is not clear whether the Dry Fork Roan gage operated during typical streamflow conditions.

Because of the short period of available streamflow data, a combination of data types was used to evaluate hydrology on Dry Fork Roan Creek. First, the available streamflow data from the historic Dry Fork Roan gage was adjusted by adding the diversion records from the Omundson and Frost Ditch and the Dry Fork Ditch to estimate streamflow above the diversions. Unfortunately, many of the years the gage operated were years in which there are no daily records for the diversions. The records for 2001, 2002, 2003 and 2004 all contain the water commissioner's comment: "water used in March, no information available." This analysis therefore likely underestimates total streamflow. Streamflow at the gage was not scaled to the lower terminus due to minor differences in drainage basin area. Median streamflow was calculated based on the adjusted gage data, and 95% confidence intervals were not calculated due to the short record. The second analysis summed the diversion records for the Omundson and Frost Ditch and the Dry Fork Ditch for 11/1/1975 to 10/31/2014. This time period is much longer than the available gage data and reflects when both structures have maintained diversion records in HydroBase (records accessed 11/18/2016). Median diversions and 95% confidence interval for median diversions were calculated.

Water Availability Summary
The hydrograph (See Complete Hydrograph) shows the median streamflow from the adjusted Dry Fork Roan gage, median and 95% confidence intervals for median diversions from the summed Omundson and Frost and Dry Fork Ditch records. A number of spot streamflow measurements are also included. The available data on Dry Fork Roan does not show a typical hydrology pattern with a large snow melt runoff and relatively constant baseflow. The record instead shows large differences in available streamflow on a day to day basis. This is likely because the system is highly variable year to year and day to day, but it also likely that the short period of available gage data amplifies this affect. Median streamflow over a longer period of record would likely show more uniform results.

Based on the available data, on nearly all days, the proposed ISF rates are below either the median adjusted Dry Fork Roan gage streamflow, or the median of the summed diversion records, or 95% confidence interval of the median summed diversion records. However, during the baseflow period, the ISF is higher than the streamflow or summed diversion record for a total of 5 days. On September 25th, the median streamflow is 0.17 cfs and on February 1st, it is 0.19 cfs. All days before or after those days are 0.2 cfs or higher (there are no recorded diversions during these days). In August, the proposed ISF is higher than both the median and the summed diversions on three days; these include August 18, 19, and 20th, when the median streamflow is 0.12, 0.08, and 0.14 cfs respectively. However, median streamflow, the 95% confidence interval of the median summed diversion record, and spot measurements that bracket those dates all indicate that streamflow is 0.2 cfs or higher. It is staffs opinion that a longer period of record would show water is available on those dates. Therefore, staff concludes that water is available for appropriation on Dry Fork Creek.

Material Injury
Because the proposed ISF on Dry Fork Roan Creek is a new junior water right, the ISF can exist without material injury to other water rights. Under the provisions of section 37-92-102(3)(b), C.R.S. (2016), the CWCB will recognize any uses or exchanges of water in existence on the date this ISF water right is appropriated.

Citations
Capesius, J.P. and V.C. Stephens, 2009, Regional regression equations for estimation of natural streamflow statistics in Colorado, Scientific Investigations Report 2009-5136.

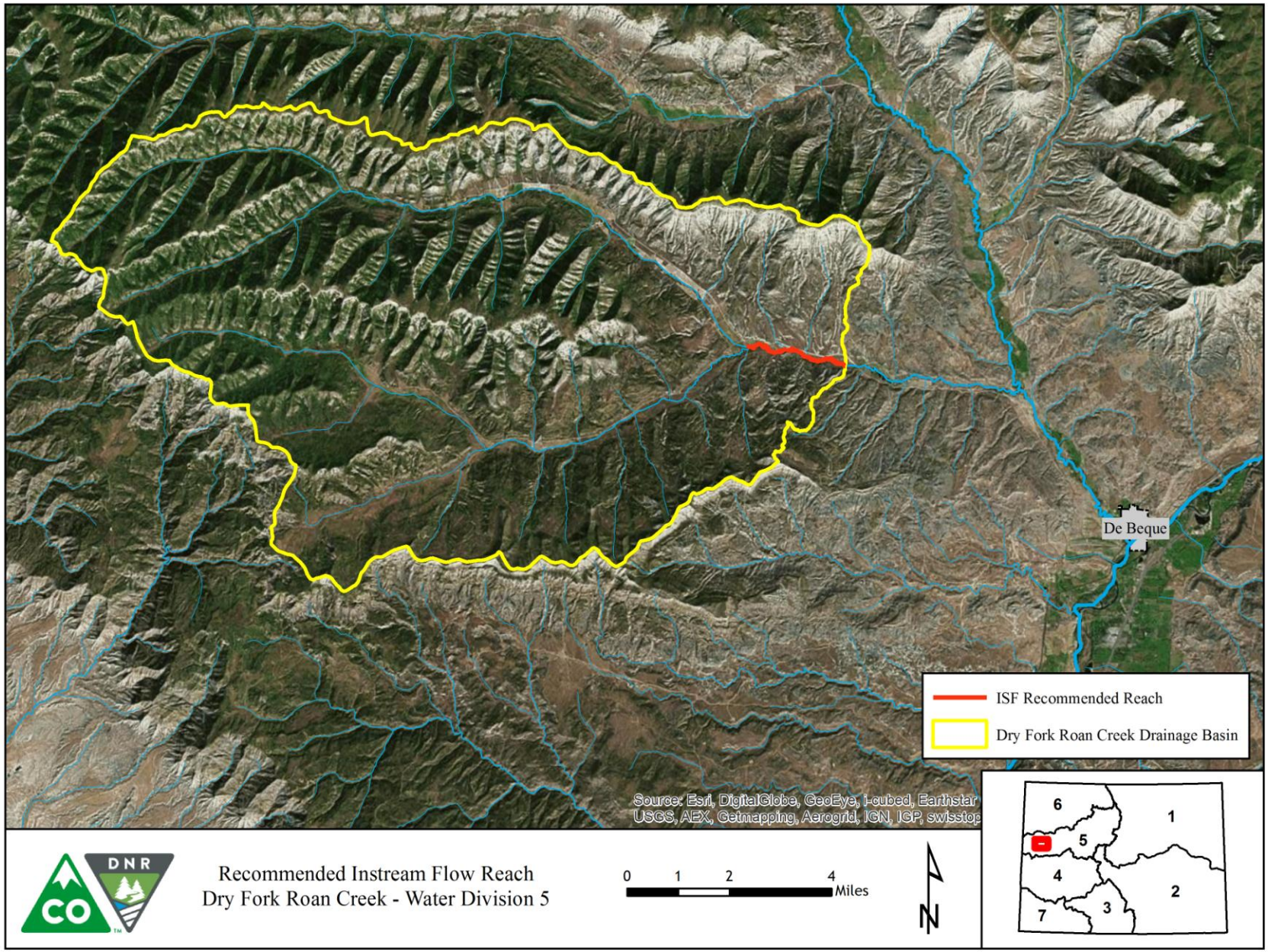
Espegren, G.D., 1996, Development of Instream Flow Recommendations in Colorado Using R2CROSS, Colorado Water Conservation Board.

Nehring, B.R., 1979, Evaluation of Instream Flow Methods and Determination of Water Quantity Needs for Streams in the State of Colorado, Colorado Division of Wildlife.

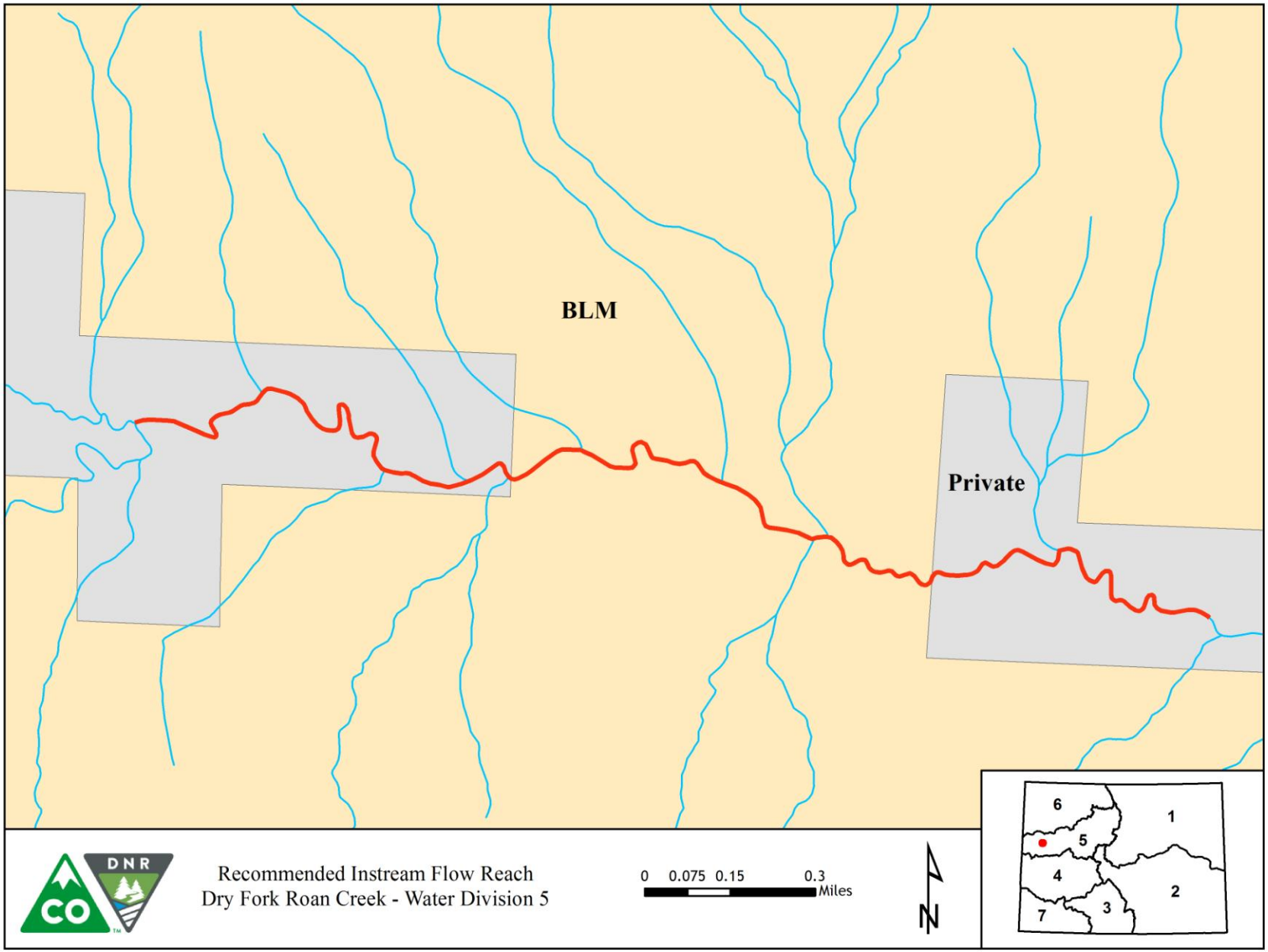
Metadata Descriptions
The UTM locations for the upstream and downstream termini were derived from CWCB GIS using the National Hydrography Dataset (NHD).

Projected Coordinate System: NAD 1983 UTM Zone 13N.

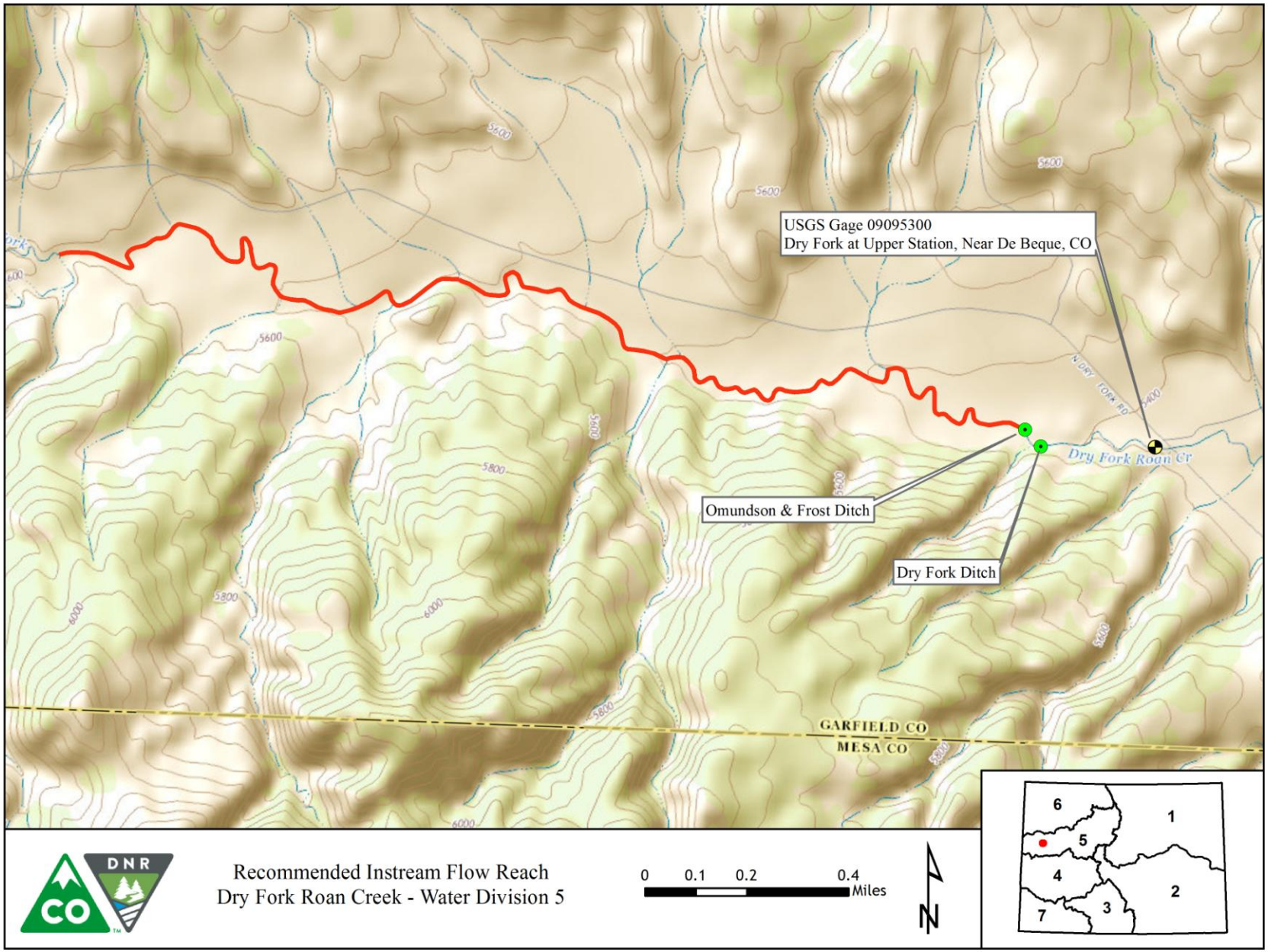
VICINITY MAP



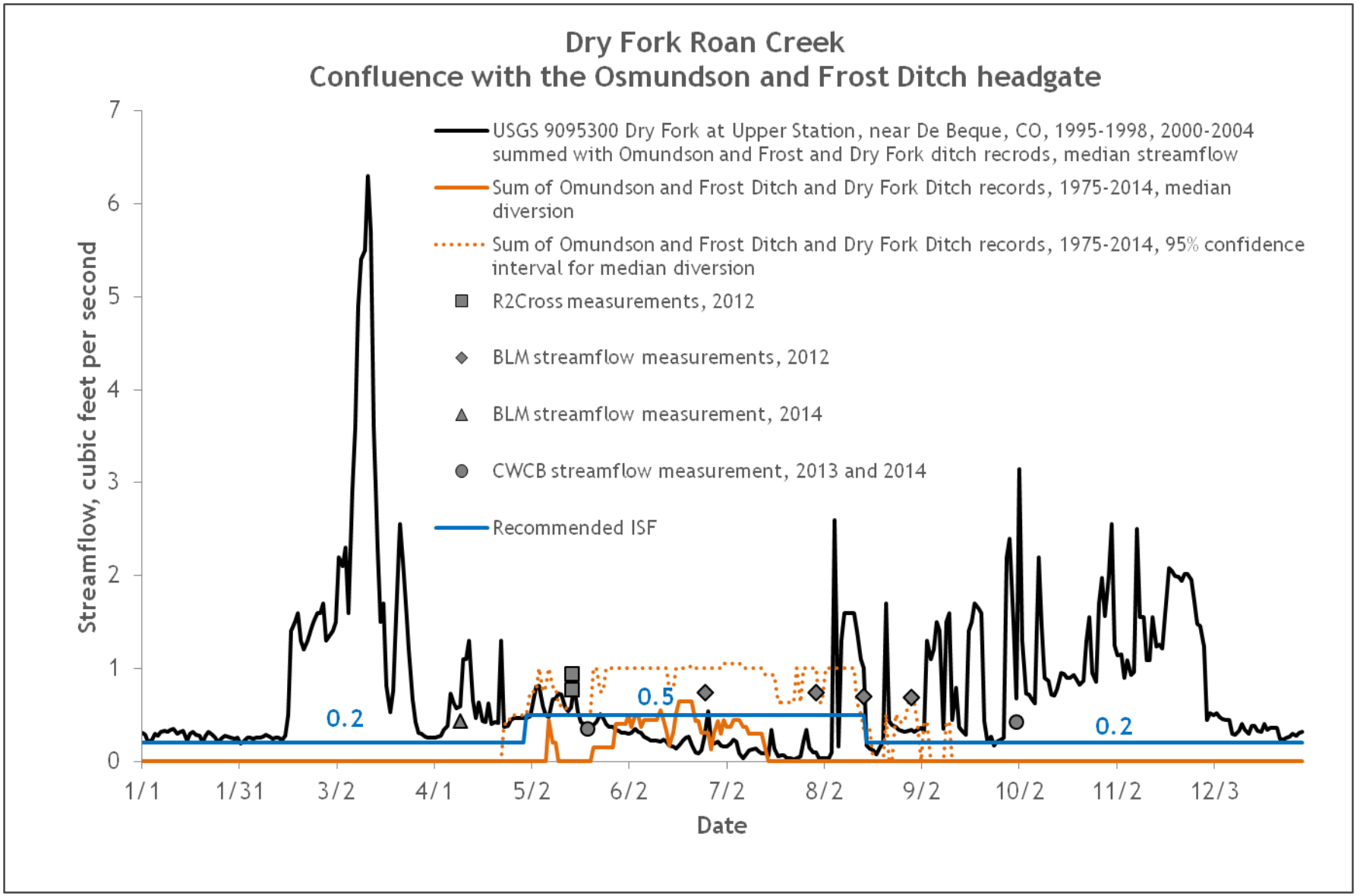
LAND OWNERSHIP MAP



HYDROLOGIC FEATURES MAP



COMPLETE HYDROGRAPH



COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Piney River
EXECUTIVE SUMMARY

CWCB STAFF INSTREAM FLOW RECOMMENDATION

UPPER TERMINUS:	Confluence Grape Creek UTM North: 4405229.97	UTM East: 366932.04
LOWER TERMINUS:	Confluence Colorado River UTM North: 4412971.89	UTM East: 359556.85
WATER DIVISION:	5	
WATER DISTRICT:	52	
COUNTY:	Eagle	
WATERSHED:	Colorado Headwaters	
CWCB ID:	17/5/A-001	
RECOMMENDER:	Bureau of Land Management (BLM)	
LENGTH:	7.83 miles	
Existing ISF:	86CW0229; 9 cfs (1/1-12/31)	
FLOW RECOMMENDATION:	55 (5/1 - 7/15) 16 (7/16 - 8/15) 8 (8/16 - 11/30) 4 (12/1 - 3/31) 16 (4/1 - 4/30)	

Piney River

Introduction

Colorado's General Assembly created the Instream Flow and Natural Lake Level Program in 1973, recognizing "the need to correlate the activities of mankind with some reasonable preservation of the natural environment" (see 37-92-102 (3), C.R.S.). The statute vests the Colorado Water Conservation Board (CWCB or Board) with the exclusive authority to appropriate and acquire instream flow (ISF) and natural lake level water rights (NLL). Before initiating a water right filing, the Board must determine that: 1) there is a natural environment that can be preserved to a reasonable degree with the Board's water right if granted, 2) the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made, and 3) such environment can exist without material injury to water rights.

The BLM recommended that the CWCB appropriate an increase to the existing ISF water right on a reach of the Piney River. The CWCB currently holds an instream flow water right on the Piney River for 9.0 cfs (1/1-12/31), decreed in Case No. 86CW0229. The BLM does not consider the current ISF water right to be sufficiently protective of the natural environment in the Piney River, in light of CWCB's current application of R2Cross. The current instream flow water right does not meet all three instream flow criteria during the spring and summer, which is a critical growth and spawning period for the fish population.

The Piney River originates in the Eagles Nest Wilderness Area, approximately six miles northeast of Vail at an elevation of approximately 11,280 feet. The river flows in a northwesterly direction as it drops to an elevation of approximately 6,790 feet where it joins the Colorado River. The proposed reach is located within Eagle County (See Vicinity Map) and extends from the confluence with Grape Creek downstream to the confluence with the Colorado River. Thirty-three percent of the land on the 7.83 mile proposed reach is publicly owned and managed by the BLM; the remaining land is privately held. (See Land Ownership Map).

The information contained in this report and the associated supporting data and analyses (located at: http://cwcb.state.co.us/environment/instream-flow-program/Pages/2017ProposedISFRecommendations.aspx) form the basis for staff's ISF recommendation to be considered by the Board. This report provides sufficient information to support the CWCB findings required by ISF Rule 5i on the natural environment, water availability, and material injury.

Natural Environment

CWCB staff relies on the recommending entity to provide information about the natural environment. In addition, staff reviews information and conducts site visits for each recommended ISF appropriation. This information is used to provide the Board with a basis for determining that a natural environment exists.

The Piney River is a cold-water, high gradient stream. It flows through a canyon with a valley floor approximately one-fourth mile in width. The stream cuts through alluvial deposits in the narrow valley and is confined by bedrock in many locations. The stream generally has large substrate, consisting of mostly of small cobbles and boulders of up to two feet in diameter. The stream has a good mix of swift runs and riffles. Slow deep pools and sinuosity are very limited in this reach due to the channel type, but there are some pocket water pools associated with the large rock substrate.

Fisheries surveys have revealed a self-sustaining population of brown trout, rainbow trout, mountain whitefish, sculpin, and longnose sucker (See Table 1). The number of fish is likely to vary seasonally as fish move in and out of this reach from the Colorado River. Intensive macro-invertebrate surveys have not been conducted, but spot samples have revealed various species of mayfly, caddisfly, and stonefly – including the giant salmonfly (*Pteronarcys californica)*.

The riparian community is generally comprised of willow, alder, cottonwood, Douglas fir, and red osier dogwood. The riparian community is in very good condition. Given the channel width, the riparian community provides some, but not extensive, shading and cover for fish.

Table 1. List of species identified in Piney River.

Species Name	Scientific Name	Status
brown trout	*Salmo trutta*	None
rainbow trout	*Oncorhynchus mykiss*	None
mountain whitefish	*Prosopium williamsoni*	None
longnose sucker	*Catostomus catostomus*	None
mottled sculpin	*Cottus bairdii*	None

ISF Quantification

CWCB staff relies upon the biological expertise of the recommending entity to quantify the amount of water required to preserve the natural environment to a reasonable degree. CWCB staff performs a thorough review of the quantification analyses completed by the recommending entity to ensure consistency with accepted standards.

Methodology

BLM staff used the R2Cross methodology to develop the initial ISF recommendation. The R2Cross method is based on a hydraulic model and uses field data collected in a stream riffle (Espegren, 1996). Riffles are most easily visualized as the stream habitat types that would dry up first should streamflow cease. The field data collected consists of streamflow measurements and surveys of channel geometry at a transect and of the longitudinal slope of the water surface.

The field data is used to model three hydraulic parameters: average depth, average velocity, and percent wetted perimeter. Maintaining these hydraulic parameters at adequate levels across riffle habitat types also will maintain aquatic habitat in pools and runs for most life stages of fish and aquatic macro-invertebrates (Nehring, 1979). BLM staff interprets the model results to develop an initial recommendation for summer and winter flows. The summer flow recommendation is based on meeting 3 of 3 hydraulic criteria. The winter flow recommendation is based on meeting 2 of 3 hydraulic criteria. The model's suggested accuracy range is 40% to 250% of the streamflow measured in the field. Recommendations that fall outside of the accuracy range may not give an accurate estimate of the hydraulic parameters necessary to determine an ISF rate.

The R2Cross methodology provides the biological quantification of the amount of water needed for summer and winter periods based on empirical studies of fish species preferences. The recommending entity uses the R2Cross results and its biological expertise to develop an initial ISF recommendation. CWCB staff then evaluates water availability for the reach typically based on median hydrology (see the Water Availability section below for more details). The water availability

analysis may indicate less water is available than the initial recommendation. In that case, the recommending entity either modifies the magnitude and/or duration of the recommended ISF rates if the available flows will preserve the natural environment to a reasonable degree, or withdraws the recommendation.

Data Analysis

R2Cross data was collected at four transects for this proposed ISF reach (Table 2). Results obtained at more than one transect are averaged to determine the R2Cross flow rate for the reach of stream. The R2Cross model results in a winter flow of 30.99 cfs, which meets 2 of 3 criteria and is within the accuracy range of the R2Cross model. The R2Cross model results in a summer flow of 64.23 cfs, which meets 3 of 3 criteria and is within the accuracy range of the R2Cross model.

Table 2. Summary of R2Cross transect measurements and results for Piney River.

Entity	Date	Streamflow (cfs)	Accuracy Range (cfs)	Winter Rate (cfs)	Summer Rate (cfs)
BLM	07/23/2015 # 1	76.01	30.40 - 190.03	out of range	out of range
BLM	07/23/2015 # 2	75.64	30.26 - 189.1	35.85	73.80
BLM	09/16/2015 # 1	31.56	12.62 - 78.9	25.30	59.36
BLM	09/16/2015 # 2	32.22	12.89 - 80.55	31.83	59.53
			Mean	30.99	64.23

ISF Recommendation

BLM's analysis of this data, coordinated with Colorado Parks and Wildlife, indicates that the following flows are needed to preserve the fishery and natural environment to a reasonable degree.

64.0 cubic feet per second is recommended during the snow melt runoff period from May 1 to July 15. Protecting this flow rate would require an increase of 55.0 cfs to the existing instream flow water right. This recommendation is driven by the average depth criteria. This portion of the river is within a dark canyon, so it experiences significant icing during the winter months. It is important to protect a flow rate that makes most of this habitat available to the fish population while they are completing critical life history functions during the warm weather months. It is also important to make as much physical habitat as possible available to fish that enter the Piney River from the Colorado River. Finally, this flow should help recharge alluvial aquifers along the Piney River that are important for sustaining the riparian community during low flow periods.

25.0 cubic feet per second is recommended from July 16 through August 15. Protecting this flow rate would require an increase of 16 cfs to the existing instream flow water right. This is the highest water temperature period of the year, so it is important to protect sufficient flow rates to keep water temperatures stable and within the tolerance range for salmonid species. This recommendation is driven by water availability, but comes close to meeting two of the three instream flow criteria.

17.0 cubic feet per second is recommended from August 16 through November 30. This recommendation is driven by water availability. Protecting this flow rate would require an increase of 8.0 over the current instream flow water right. Even though this flow rate does not meet two instream flow criteria, it does protect substantially more habitat than the current instream flow water right during a critical period of the year for the fish population.

13.0 cubic feet per second is recommended during the period from December 1 to March 31. Protecting this flow rate would require an increase of 4.0 cfs to the existing instream flow water right. This recommendation is driven by limited water availability. This flow rate should prevent pools from freezing, allowing the fish population to successfully overwinter.

25.0 cubic feet per second is recommended from during the beginning of the snowmelt runoff period from April 1 to April 30. Protecting this flow rate would require an increase of 16 cfs to the existing instream flow water right. It is important to protect a higher flow rate when the fish population is starting to actively feed during the early portion of the growing season.

Rationale for Instream Flow Increase

The BLM believes an instream flow increase for the Piney River is warranted because of physical habitat characteristics. The R2Cross data summarized above clearly indicates that the current instream flow water right does not provide sufficient physical habitat during the warm weather portions of the year when the fish populations are feeding, growing, and spawning. When the existing instream flow rights are applied to the cross sections that were collected, the stream would exhibit between 52% to 65% wetted perimeter. However, this habitat is not highly usable by the fish population, because 9.0 cfs constrains the habitat to an average depth of 0.27 feet and average velocities ranging from 0.65 to 0.80 feet per second. An average habitat depth of 0.27 feet is not sufficient in a stream that averages 70 feet in width. During the warm weather season, the fish population needs to have access to as much of the stream channel as possible for feeding, resting, and spawning if it is to survive the pronounced cold winters in this canyon.

Water Availability

CWCB staff conducts hydrologic analyses for each recommended ISF appropriation to provide the Board with a basis for making the determination that water is available.

Methodology

Each recommended ISF reach has a unique flow regime that depends on variables such as the timing, magnitude, and location of water inputs (such as rain, snow, and snowmelt) and water losses (such as diversions, reservoirs, evaporation and transpiration, groundwater recharge, etc). Although extensive and time-consuming investigations of all variables may be possible, staff takes a pragmatic and cost-effective approach to analyzing water availability. This approach focuses on streamflows and the influence of flow alterations, such as diversions, to understand how much water is physically available in the recommended reach.

Staff's hydrologic analysis is data-driven, meaning that staff gathers and evaluates the best available data and uses the best available analysis method for that data. Whenever possible, long-term stream gage data (period of record 20 or more years) will be used to evaluate streamflow. Other streamflow

information such as short-term gages, temporary gages, spot streamflow measurements, diversion records, and StreamStats will be used when long-term gage data is not available. StreamStats, a statistical hydrologic program, uses regression equations developed by the USGS (Capesius and Stephens, 2009) to estimate mean flows for each month based on drainage basin area and average drainage basin precipitation. Diversion records will also be used to evaluate the effect of surface water diversions when necessary. Interviews with water commissioners, landowners, and ditch or reservoir operators can provide additional information. A range of analytical techniques may be employed to extend gage records, estimate streamflow in ungaged locations, and estimate the effects of diversions. The goal is to obtain the most detailed and reliable estimate of hydrology using the most efficient analysis technique.

The final product of the hydrologic analysis used to determine water availability is a hydrograph, which shows streamflow and the proposed ISF rate over the course of one year. The hydrograph will show median daily values when daily data is available; otherwise, it will present mean-monthly streamflow values. Staff will calculate 95% confidence intervals for the median streamflow if there is sufficient data. Statistically, there is 95% confidence that the true value of the median streamflow is located within the confidence interval.

Basin Characteristics

The drainage basin of the proposed ISF on Piney River is 118.00 square miles, with an average elevation of 9,490 ft and average annual precipitation of 24.42 inches (See the Vicinity Map). The Piney River basin supports agriculture, among other uses. Hydrology is altered by water use within the basin.

Available Data

The Piney River has a USGS gage located one mile downstream from the upper terminus (USGS 0959500 Piney River near State Bridge, CO). The drainage basin of the Piney Creek gage is 93 square miles, with an average elevation of 9,720 ft and average annual precipitation of 25.74 inches. Five on-channel diversions between the gage and the lower terminus were identified at the time of analysis. These diversions include; Ashlock No 2 Ditch HDG1 (3.76 cfs, appropriation date 1923), Ashlock Ditch (4.75 cfs, appropriation dates 1888, 1889, 1923, and 1938), Ashlock Ditch HDG2 (1.1 cfs appropriation date 1923), Wiltsey Ditch (2.08 cfs, appropriation date 1938), and Wiltsey Ditch HDG2 (2.08 AP, appropriation date 1938). The record for these diversions varies, but most of the diversions have records starting in 1973 or 1974. Some of the diversion records end in 1999, with others ending in 2011 and 2013. According to the water commissioner, the owner of these diversions recently upgraded to sprinkling irrigation systems (Rick Bumgardner, personal communication 5/16/2016).

CWCB staff made two streamflow measurements on the proposed reach of Piney River as summarized in Table 3.

Table 3. Summary of streamflow measurement visits and results for Piney River

Visit Date	Flow (cfs)	Method
09/21/2016	18.41	Wading ADV
08/10/2016	39.72	Wading ADV

Data Analysis
The Piney River gage and available diversion records from the five diversions located below the gage were used to estimate streamflow in the ISF reach. The effects of the diversions below the gage were accounted for by subtracting the diversion records from the gage record. This analysis was completed from 11/1/1974 to 10/31/2013 based on the availability of diversion records. The adjusted gage data was not scaled to the lower terminus due to uncertainty in the amount of flow that may accrue in the additional 24.6 square miles of contributing drainage basin below the gage. This decision not to scale the gage data likely results in underestimating streamflow at the lower terminus. Median streamflow and 95% confidence intervals for median streamflow were calculated for the adjusted Piney River gage record.

Water Availability Summary
The hydrographs (See Complete Hydrograph and Detailed Hydrograph) show median streamflow and 95% confidence intervals for the median streamflow based on the adjusted Piney River gage record. The proposed ISF rate is below the median streamflow the majority of the time. The proposed ISF rate is below the 95% confidence interval of the median at all times. Staff has concluded that water is available for appropriation.

Material Injury
Because the proposed ISF on Piney River is a new junior water right, the ISF can exist without material injury to other water rights. Under the provisions of section 37-92-102(3)(b), C.R.S. (2016), the CWCB will recognize any uses or exchanges of water in existence on the date this ISF water right is appropriated.

Citations
Capesius, J.P. and V.C. Stephens, 2009, Regional regression equations for estimation of natural streamflow statistics in Colorado, Scientific Investigations Report 2009-5136.

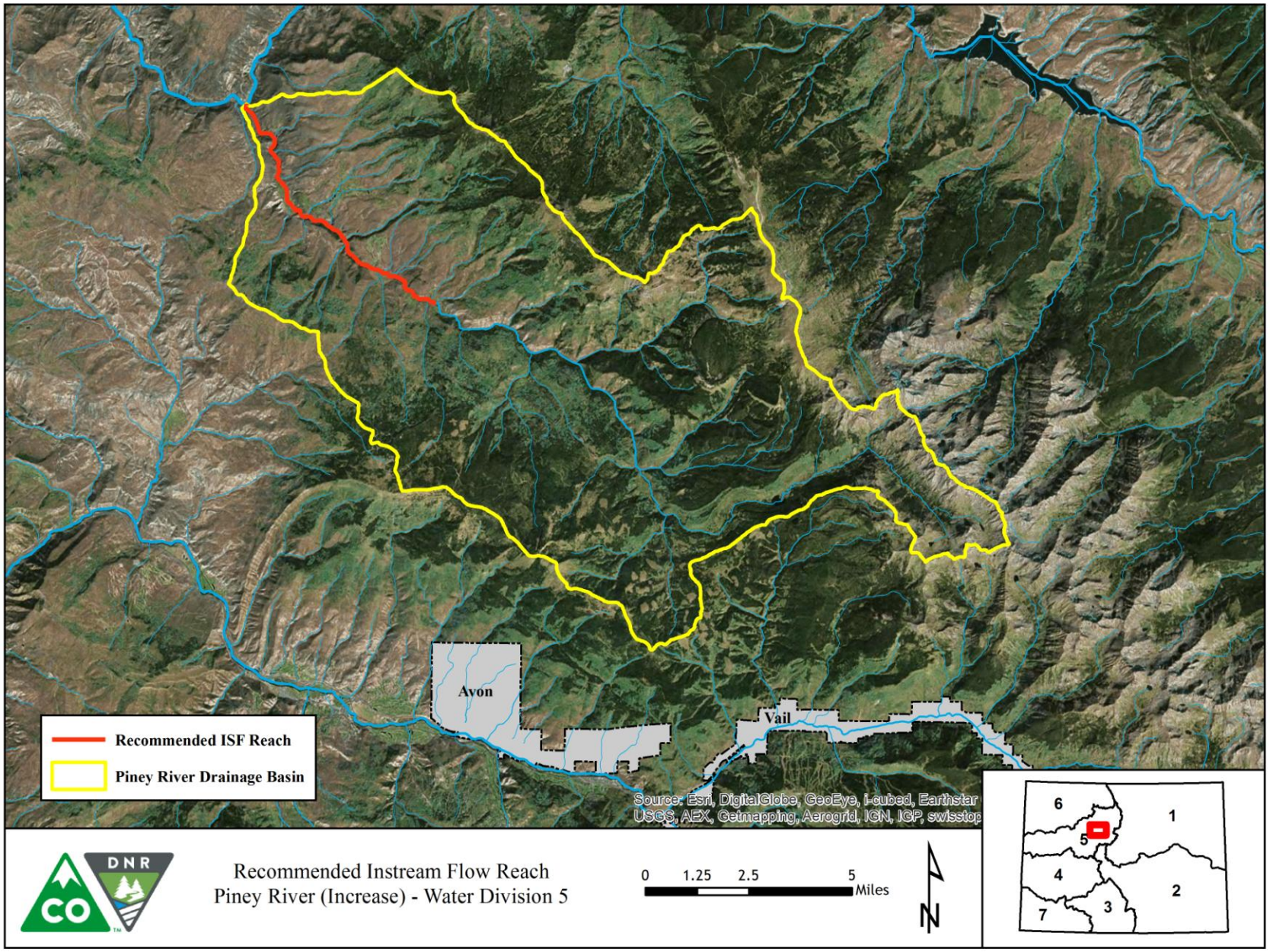
Espegren, G.D., 1996, Development of Instream Flow Recommendations in Colorado Using R2CROSS, Colorado Water Conservation Board.

Nehring, B.R., 1979, Evaluation of Instream Flow Methods and Determination of Water Quantity Needs for Streams in the State of Colorado, Colorado Division of Wildlife.

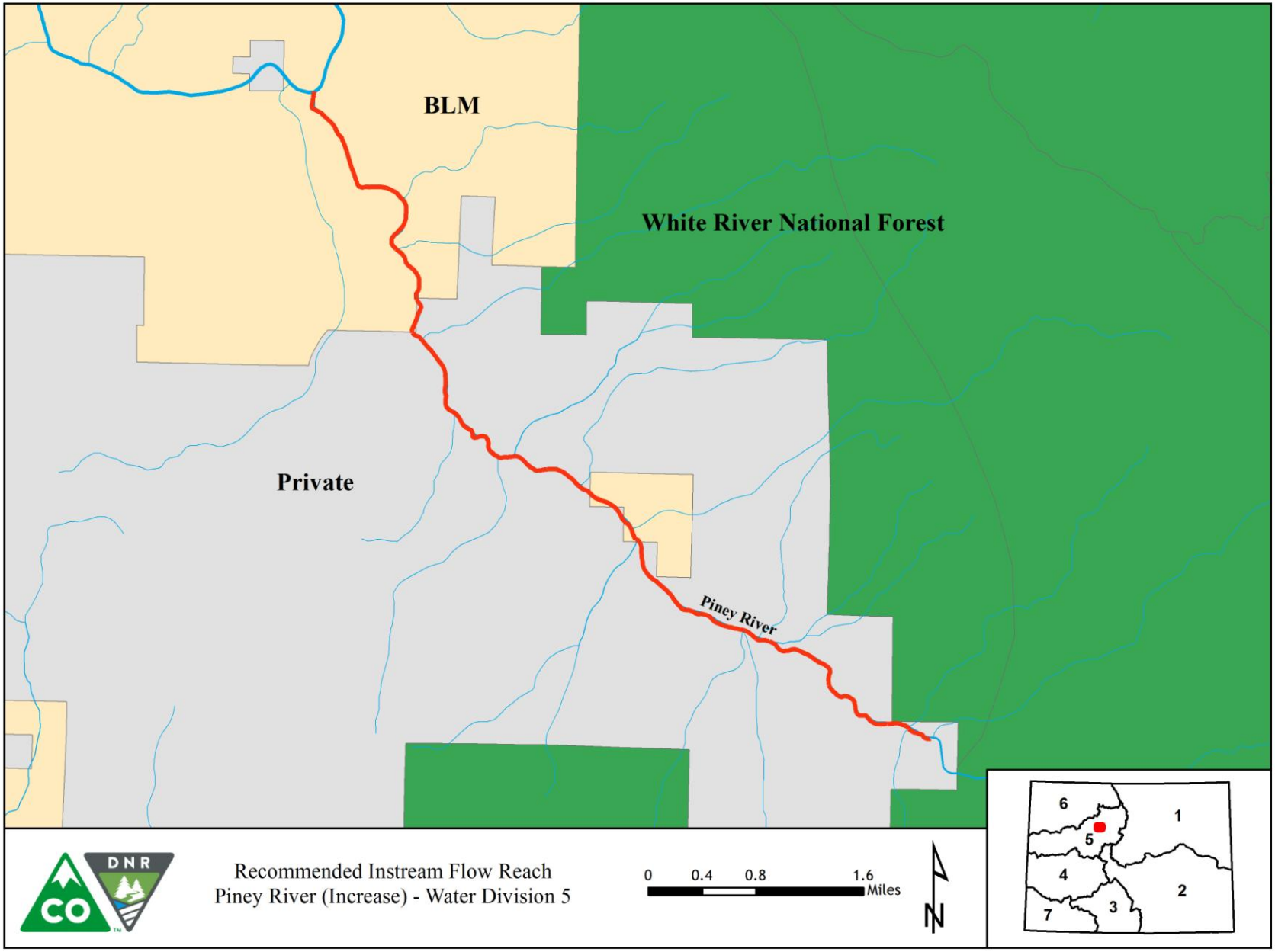
Metadata Descriptions
The UTM locations for the upstream and downstream termini were derived from CWCB GIS using the National Hydrography Dataset (NHD).

Projected Coordinate System: NAD 1983 UTM Zone 13N.

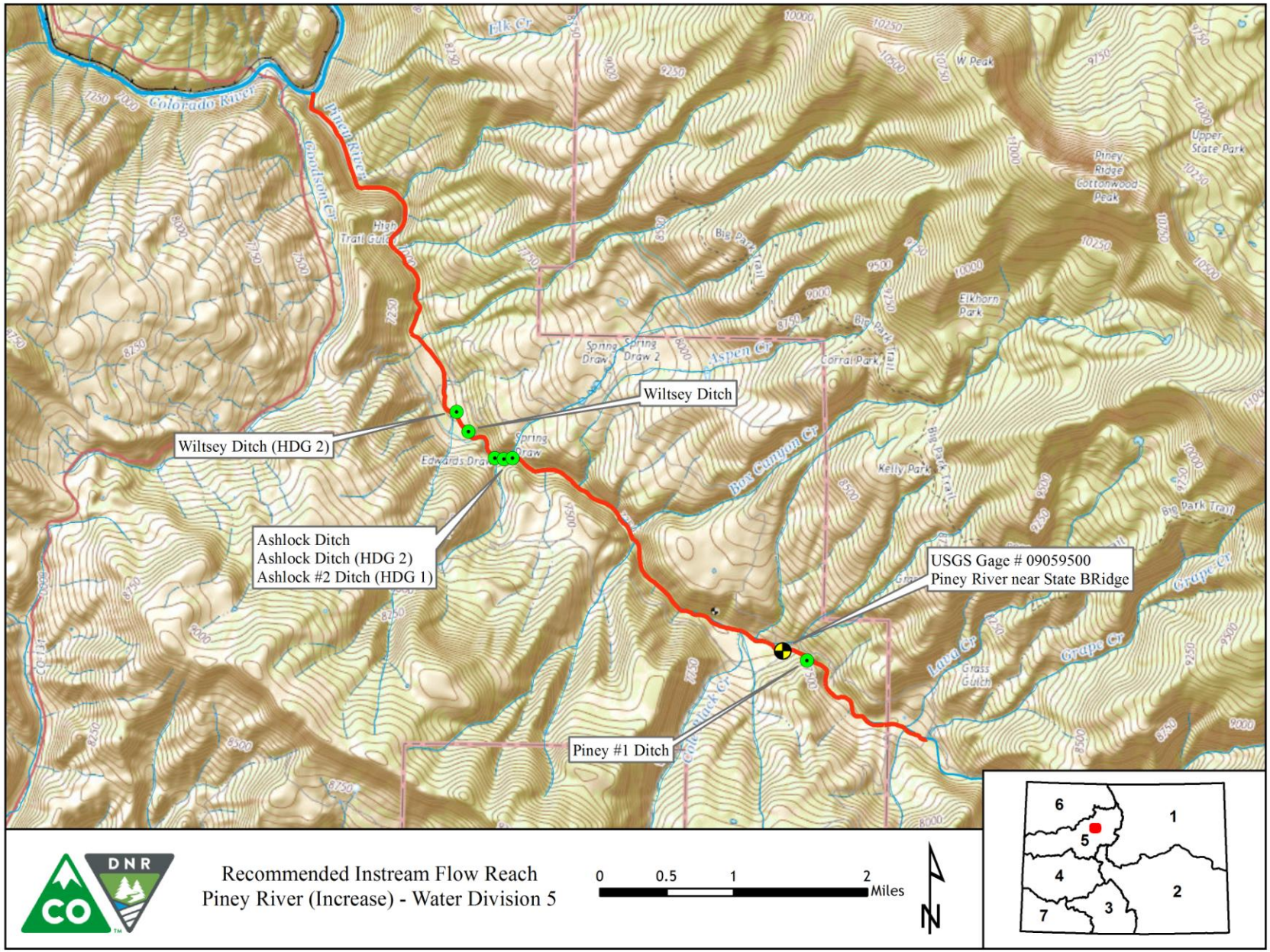
VICINITY MAP



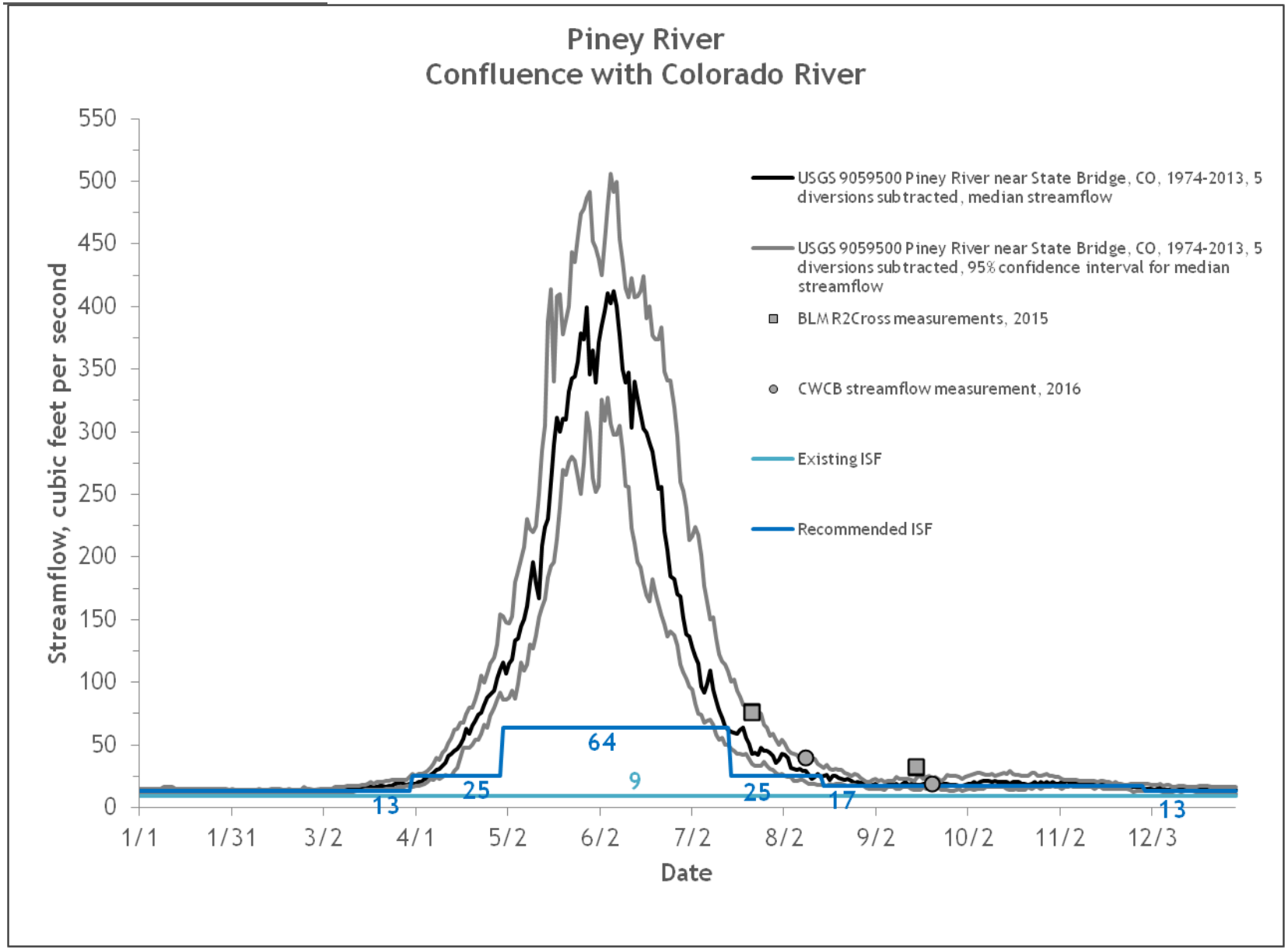
LAND OWNERSHIP MAP



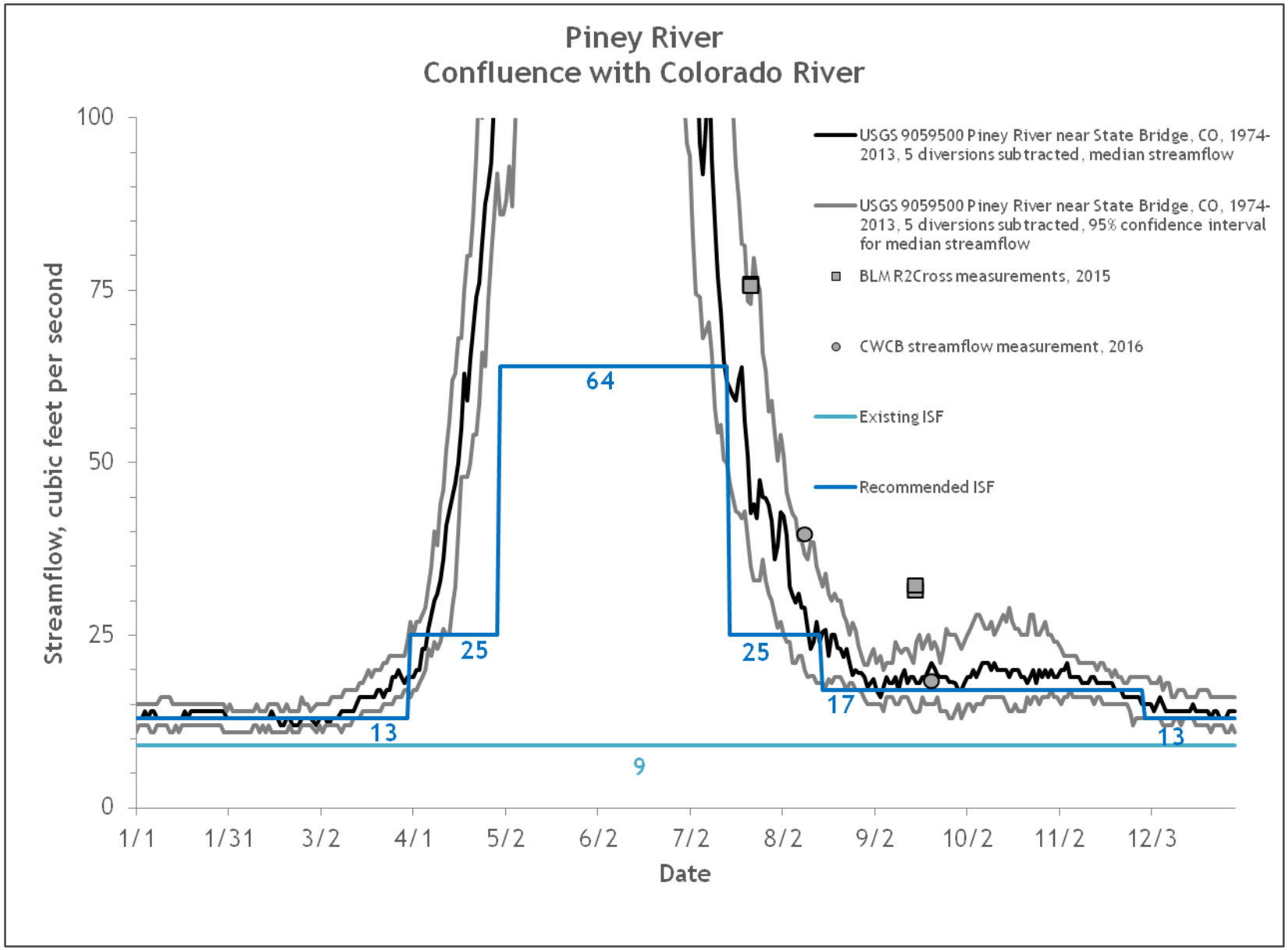
HYDROLOGIC FEATURES MAP



COMPLETE HYDROGRAPH



DETAILED HYDROGRAPH



COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Elkhead Creek (Upper)

EXECUTIVE SUMMARY

CWCB STAFF INSTREAM FLOW RECOMMENDATION

UPPER TERMINUS:	Confluence First Creek UTM North: 4511465.47 UTM East: 317014.13
LOWER TERMINUS:	Confluence North Fork Elkhead Creek UTM North: 4504451.45 UTM East: 306665.08
WATER DIVISION:	6
WATER DISTRICT:	44
COUNTY:	Routt
WATERSHED:	Upper Yampa
CWCB ID:	16/6/A-001
RECOMMENDER:	Colorado Parks and Wildlife (CPW)
LENGTH:	10.94 miles
FLOW RECOMMENDATION:	4.4 (10/16 - 03/31) 14 (04/01 - 07/15) 7 (07/16 - 07/31) 3 (08/01 - 10/15)

Elkhead Creek (Upper)

Introduction

Colorado's General Assembly created the Instream Flow and Natural Lake Level Program in 1973, recognizing "the need to correlate the activities of mankind with some reasonable preservation of the natural environment" (see 37-92-102 (3), C.R.S.). The statute vests the Colorado Water Conservation Board (CWCB or Board) with the exclusive authority to appropriate and acquire instream flow (ISF) and natural lake level water rights (NLL). Before initiating a water right filing, the Board must determine that: 1) there is a natural environment that can be preserved to a reasonable degree with the Board's water right if granted, 2) the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made, and 3) such environment can exist without material injury to water rights.

CPW recommended that the CWCB appropriate an ISF water right on a reach of Elkhead Creek. Elkhead Creek originates in the Routt National Forest at an elevation of approximately 8,900 ft and flows in a southwesterly direction as it drops to an elevation of approximately 6,200 ft where it joins the Yampa River. The proposed reach is located within Routt County (See Vicinity Map) and extends from the confluence with First Creek downstream to the confluence with North Fork Elkhead Creek. Forty-six percent of the land on the 10.94 mile proposed reach is publicly owned and managed by the U.S. Forest Service (USFS); the remaining land is privately owned (See Land Ownership Map). The CPW recommended this reach of Elkhead Creek because it has a natural environment that can be preserved to a reasonable degree with an ISF water right.

The information contained in this report and the associated supporting data and analyses (located at: http://cwcb.state.co.us/environment/instream-flow-program/Pages/2017ProposedISFRecommendations.aspx) form the basis for staff's ISF recommendation to be considered by the Board. This report provides sufficient information to support the CWCB findings required by ISF Rule 5i on the natural environment, water availability, and material injury.

Natural Environment

CWCB staff relies on the recommending entity to provide information about the natural environment. In addition, staff reviews information and conducts site visits for each recommended ISF appropriation. This information is used to provide the Board with a basis for determining that a natural environment exists.

Throughout the recommended reach, Elkhead Creek is a third order stream. The stream channel is primarily a single thread channel flowing through a variety of valley types, including both forested and open lands (meadow and pasture lands). Connection to the floodplain most likely only occurs during spring runoff, which does provide lateral connectivity to the terrestrial environment and input of terrestrial organic matter into the stream. Peak runoff likely removes the majority of the smaller sediment like sand and silt from the gravel bed. Stream banks are largely intact, with some areas of erosion present. Despite the areas of eroding banks, there is still a prominent riparian community throughout the reach. As is typical of streams of this nature, the riparian zone contributes nutrients and terrestrial insects to the aquatic environment, providing food for aquatic macro-invertebrates and fish. The riparian corridor consists of willows, alders, and cottonwoods. Throughout this reach of Elkhead Creek, there is an abundance of pool, riffle, and glide habitat. Substrate ranges from large boulders to small cobble.

The Elkhead Creek Basin has been designated both by CPW and USFS as a priority basin for native species conservation projects. The target fish species in upper Elkhead Creek basin is the Colorado River cutthroat trout (CRCT). In addition, CPW and the USFS are engaged in habitat protection projects for boreal toad (*Bufo boreas boreas*), a state endangered species in the Elkhead basin. The management of CRCT is covered by a multi-state (Colorado, Wyoming, and Utah) and federal interagency conservation agreement. The states consider CRCT to be of special concern and the federal agencies consider CRCT to be a sensitive species (CRCT Conservation Team 2006). While CRCT is the main species of concern in this basin, other native species will benefit from the conservation efforts. These species include mottled sculpin, speckled dace, and mountain sucker (See Table 1). The entire Elkhead Creek basin upstream and including the North Fork of Elkhead Creek is the subject of current and ongoing stream health management projects, and is being enhanced through a variety of interagency projects to restore both cutthroat trout and boreal toad habitat. The Elkhead CRCT is identified in conservation planning documents as a population of high genetic purity and is considered a conservation population (CRCT Conservation Team 2006).

Reducing non-native competition and hybridization is another critical aspect of CRCT conservation efforts. All non-native salmonids have been removed from the basin, and migration barriers are either put in place or planned. All brook trout (*Salvelinus fontinalis*) and rainbow trout (*Oncorhyncus mykiss*) have been removed from the system. Brook and rainbow trout are strong competitors for food and habitat, and rainbow trout also readily hybridize with cutthroat trout (NRCS 2007).

Table 1. List of species identified in Elkhead Creek.

Species Name	Scientific Name	Status
Colorado River cutthroat	*Oncorhynchus clarkii pleuriticus*	State – Species of Special Concern
mottled sculpin	*Cottus bairdii*	None
mountain sucker	*Catostomus platyrhynchus*	State – Species of Special Concern
speckled dace	*Rhinichthys osculus*	None

ISF Quantification

CWCB staff relies upon the biological expertise of the recommending entity to quantify the amount of water required to preserve the natural environment to a reasonable degree. CWCB staff performs a thorough review of the quantification analyses completed by the recommending entity to ensure consistency with accepted standards.

Methodology

CPW staff used the R2Cross methodology to develop the initial ISF recommendation. The R2Cross method is based on a hydraulic model and uses field data collected in a stream riffle (Espegren, 1996). Riffles are most easily visualized as the stream habitat types that would dry up first should streamflow cease. The field data collected consists of streamflow measurements and surveys of channel geometry at a transect and of the longitudinal slope of the water surface.

The field data is used to model three hydraulic parameters: average depth, average velocity, and percent wetted perimeter. Maintaining these hydraulic parameters at adequate levels across riffle habitat types also will maintain aquatic habitat in pools and runs for most life stages of fish and aquatic macro-invertebrates (Nehring, 1979). CPW staff interprets the model results to develop an initial recommendation for summer and winter flows. The summer flow recommendation is based on

meeting 3 of 3 hydraulic criteria. The winter flow recommendation is based on meeting 2 of 3 hydraulic criteria. The model's suggested accuracy range is 40% to 250% of the streamflow measured in the field. Recommendations that fall outside of the accuracy range may not give an accurate estimate of the hydraulic parameters necessary to determine an ISF rate.

The R2Cross methodology provides the biological quantification of the amount of water needed for summer and winter periods based on empirical studies of fish species preferences. The recommending entity uses the R2Cross results and its biological expertise to develop an initial ISF recommendation. CWCB staff then evaluates water availability for the reach typically based on median hydrology (see the Water Availability section below for more details). The water availability analysis may indicate less water is available than the initial recommendation. In that case, the recommending entity either modifies the magnitude and/or duration of the recommended ISF rates if the available flows will preserve the natural environment to a reasonable degree, or withdraws the recommendation.

Data Analysis

R2Cross data was collected at three transects for this proposed ISF reach (Table 2). Results obtained at more than one transect are averaged to determine the R2Cross flow rate for the reach of stream. The R2Cross model results in a winter flow of 4.4 cfs, which meets 2 of 3 criteria and is within the accuracy range of the R2Cross model. The R2Cross model results in a summer flow of 14.1 cfs.

Table 2. Summary of R2Cross transect measurements and results for Elkhead Creek.

Entity	Date	Streamflow (cfs)	Accuracy Range (cfs)	Winter Rate (cfs)	Summer Rate (cfs)
CPW/CWCB	10/28/2015 # 1	9.13	3.7 - 22.8	4.80	12.50
CPW/CWCB	10/28/2015 # 2	7.25	2.9 - 18.1	4.00	7.28
CPW/CWCB	09/30/2014 # 1	9.04	3.6 - 22.6	Out of range	22.60[1]
			Mean	4.4	14.1

[1] *This flow is derived from the upper limit of the R2CROSS modeling accuracy and is used in the computation of the summer flow recommendation. The flow that meets all three instream flow criteria is outside of the confidence interval for this data set.*

ISF Recommendation

CPW recommended flow rates based on R2Cross modeling analyses, biological expertise, and a preliminary water availability analysis. 14.1 cfs was recommended for the snowmelt runoff period from April 1 through June 30. This recommendation was driven by velocity criteria to provide critical spawning habitat during spring runoff. 4.4 cfs was recommended for the base flow period from July 1 to March 31. This flow was mainly driven by depth and wetted perimeter to provide overwintering habitat for the native species present in the drainage. The goal of this recommendation is to provide sufficient flows for spawning CRCT, emerging CRCT fry, and overwintering habitat for native species present.

The CPW recommendation was modified by staff as a result of water availability. The final recommendations numbers are as follows:

4.4 cfs is recommended for the period October 16 through March 31.

14 cfs is recommended for the period April 1 through July 15.

7 cfs is recommended for the period July 16 through July 31.

3 cfs is recommended for the period August 1 through October 15.

Water Availability
CWCB staff conducts hydrologic analyses for each recommended ISF appropriation to provide the Board with a basis for making the determination that water is available.

Methodology
Each recommended ISF reach has a unique flow regime that depends on variables such as the timing, magnitude, and location of water inputs (such as rain, snow, and snowmelt) and water losses (such as diversions, reservoirs, evaporation and transpiration, groundwater recharge, etc). Although extensive and time-consuming investigations of all variables may be possible, staff takes a pragmatic and cost-effective approach to analyzing water availability. This approach focuses on streamflows and the influence of flow alterations, such as diversions, to understand how much water is physically available in the recommended reach.

Staff's hydrologic analysis is data-driven, meaning that staff gathers and evaluates the best available data and uses the best available analysis method for that data. Whenever possible, long-term stream gage data (period of record 20 or more years) will be used to evaluate streamflow. Other streamflow information such as short-term gages, temporary gages, spot streamflow measurements, diversion records, and StreamStats will be used when long-term gage data is not available. StreamStats, a statistical hydrologic program, uses regression equations developed by the USGS (Capesius and Stephens, 2009) to estimate mean flows for each month based on drainage basin area and average drainage basin precipitation. Diversion records will also be used to evaluate the effect of surface water diversions when necessary. Interviews with water commissioners, landowners, and ditch or reservoir operators can provide additional information. A range of analytical techniques may be employed to extend gage records, estimate streamflow in ungaged locations, and estimate the effects of diversions. The goal is to obtain the most detailed and reliable estimate of hydrology using the most efficient analysis technique.

The final product of the hydrologic analysis used to determine water availability is a hydrograph, which shows streamflow and the proposed ISF rate over the course of one year. The hydrograph will show median daily values when daily data is available; otherwise, it will present mean-monthly streamflow values. Staff will calculate 95% confidence intervals for the median streamflow if there is sufficient data. Statistically, there is 95% confidence that the true value of the median streamflow is located within the confidence interval.

Basin Characteristics
The drainage basin of the proposed ISF on Elkhead Creek is 67.80 square miles, with an average elevation of 8,410 ft and average annual precipitation of 30.68 inches (See the Hydrologic Features Map). The drainage basin tributary to the proposed ISF reach has five known surface diversions, only one of which has diversion records, and a number of spring water rights. There is a 30 AF reservoir and a large number of small reservoirs (0.5 AF) used for USFS stock and wildlife watering. Most of the

water rights in the area are used to raise alfalfa or pasture. According to the water commissioner, Kathy Bower (contacted 9/07/2016), there is not very much irrigation use in the basin in the later part of the summer and early fall. Due to the number and volume of diversions, streamflow is somewhat altered from natural conditions.

Available Data
There is not a current streamflow gage on Elkhead Creek in the vicinity of the proposed ISF. The historic Elkhead Creek near Elkhead gage (USGS 09245000) was located approximately 740 ft upstream from the lower terminus and operated from 1953 to 1996. The drainage basin of the gage is 67.7 square miles; with average elevation of 8,410 ft and average annual precipitation of 30.69 inches. There are no known intervening diversions between the gage location and the proposed lower terminus.

CWCB staff made streamflow measurements during 2014 and 2015 site visits when R2Cross data was collected. These measurements are included in the water availability analysis.

Data Analysis
The Elkhead Creek near Elkhead gage has 43 to 44 years of record for each day of the year depending on the day. This record is relatively long, which should provide good information about the range of hydrologic conditions in the area. The gage record was not scaled to the lower terminus due to the small difference in drainage basin size between the two locations (0.1 square miles). Median streamflow and 95% confidence intervals for median streamflow were calculated using the Elkhead Creek near Elkhead gage record.

Water Availability Summary
The hydrographs (see the Complete and Detailed Hydrographs) show median streamflow and 95% confidence intervals for the median streamflow calculated from the Elkhead Creek near Elkhead gage record. The proposed ISF rate is below the median gage data during the majority of the year and below the upper 95% confidence interval from median streamflow at all times. Staff concludes that water is available for appropriation on Elkhead Creek.

Material Injury
Because the proposed ISF on Elkhead Creek is a new junior water right, the ISF can exist without material injury to other water rights. Under the provisions of section 37-92-102(3)(b), C.R.S. (2016), the CWCB will recognize any uses or exchanges of water in existence on the date this ISF water right is appropriated.

Citations
Capesius, J.P. and V.C. Stephens, 2009, Regional regression equations for estimation of natural streamflow statistics in Colorado, Scientific Investigations Report 2009-5136.

CRCT Conservation Team, 2006, Conservation agreement for Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) in the states of Colorado, Utah, and Wyoming. Colorado Division of Wildlife, Fort Collins.

CRCT Conservation Team, 2006, Conservation strategy for Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) in the states of Colorado, Utah, and Wyoming. Colorado Division of Wildlife, Fort Collins.

Espegren, G.D., 1996, Development of Instream Flow Recommendations in Colorado Using R2CROSS, Colorado Water Conservation Board.

Nehring, B.R., 1979, Evaluation of Instream Flow Methods and Determination of Water Quantity Needs for Streams in the State of Colorado, Colorado Division of Wildlife.

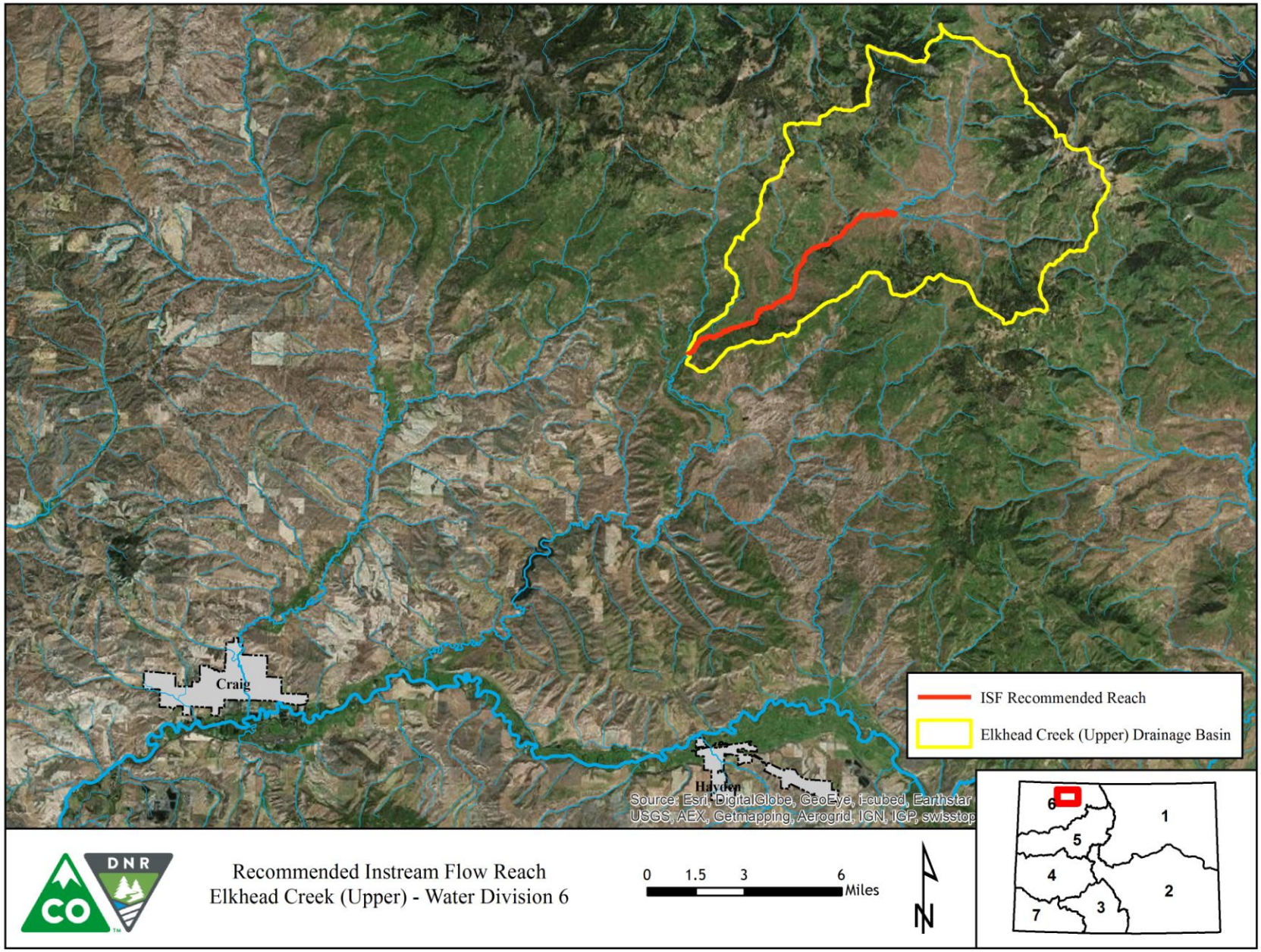
Natural Resources Conservation Services (NRCS), 2007, Cutthroat trout (*Oncorhynchus clarki*). Fish and Wildlife Habitat management Leaflet 47.

Metadata Descriptions

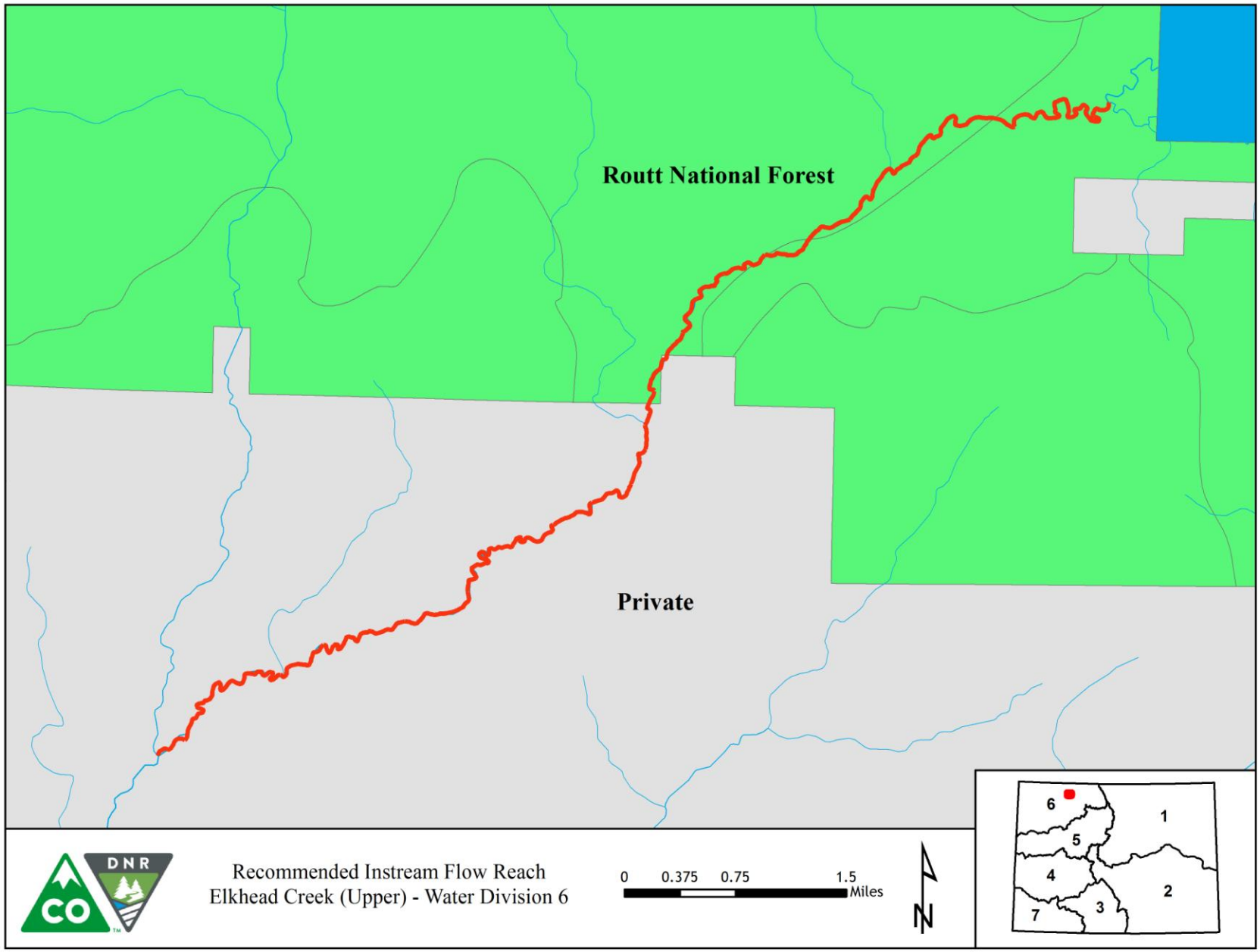
The UTM locations for the upstream and downstream termini were derived from CWCB GIS using the National Hydrography Dataset (NHD).

Projected Coordinate System: NAD 1983 UTM Zone 13N.

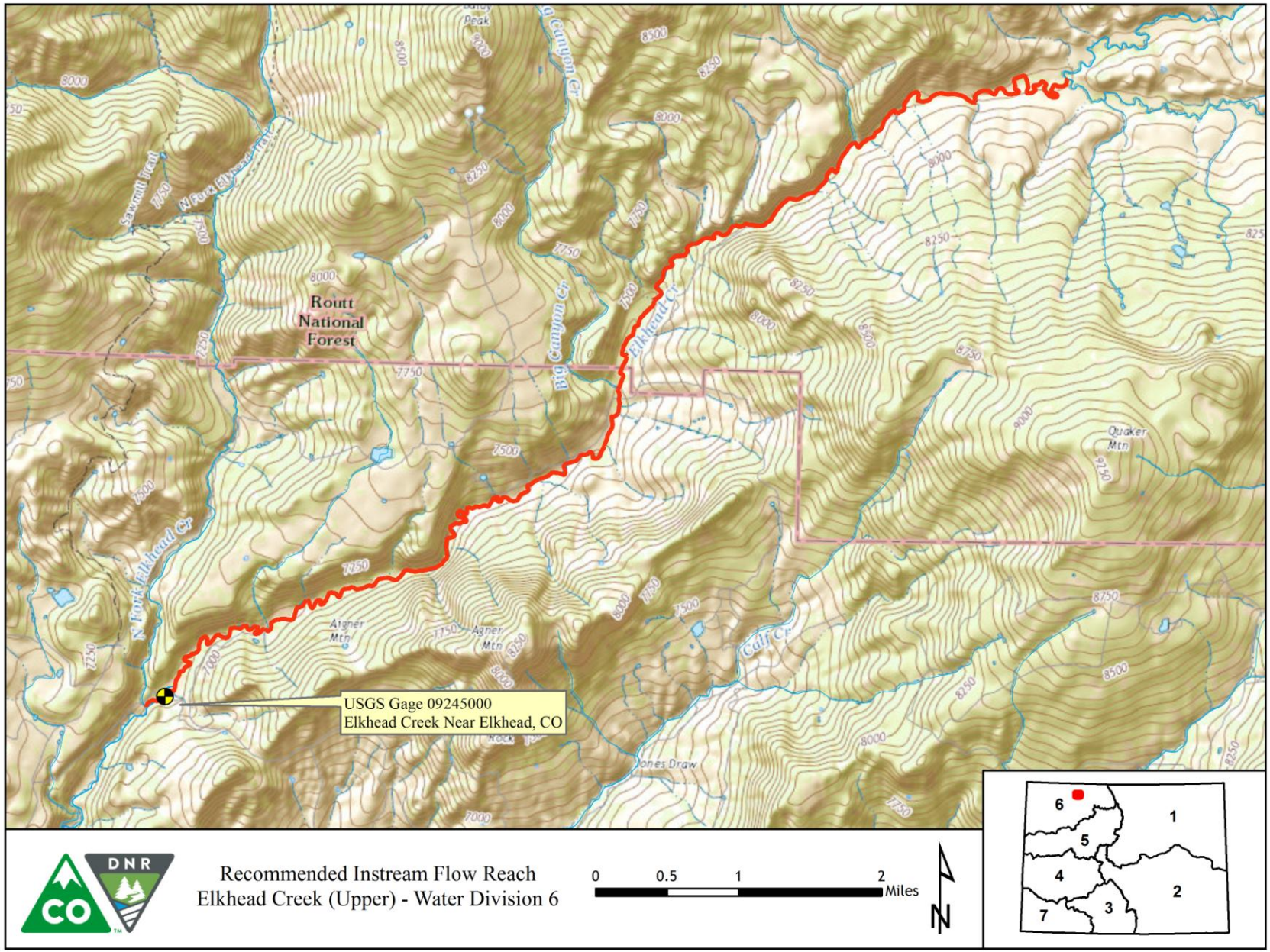
VICINITY MAP



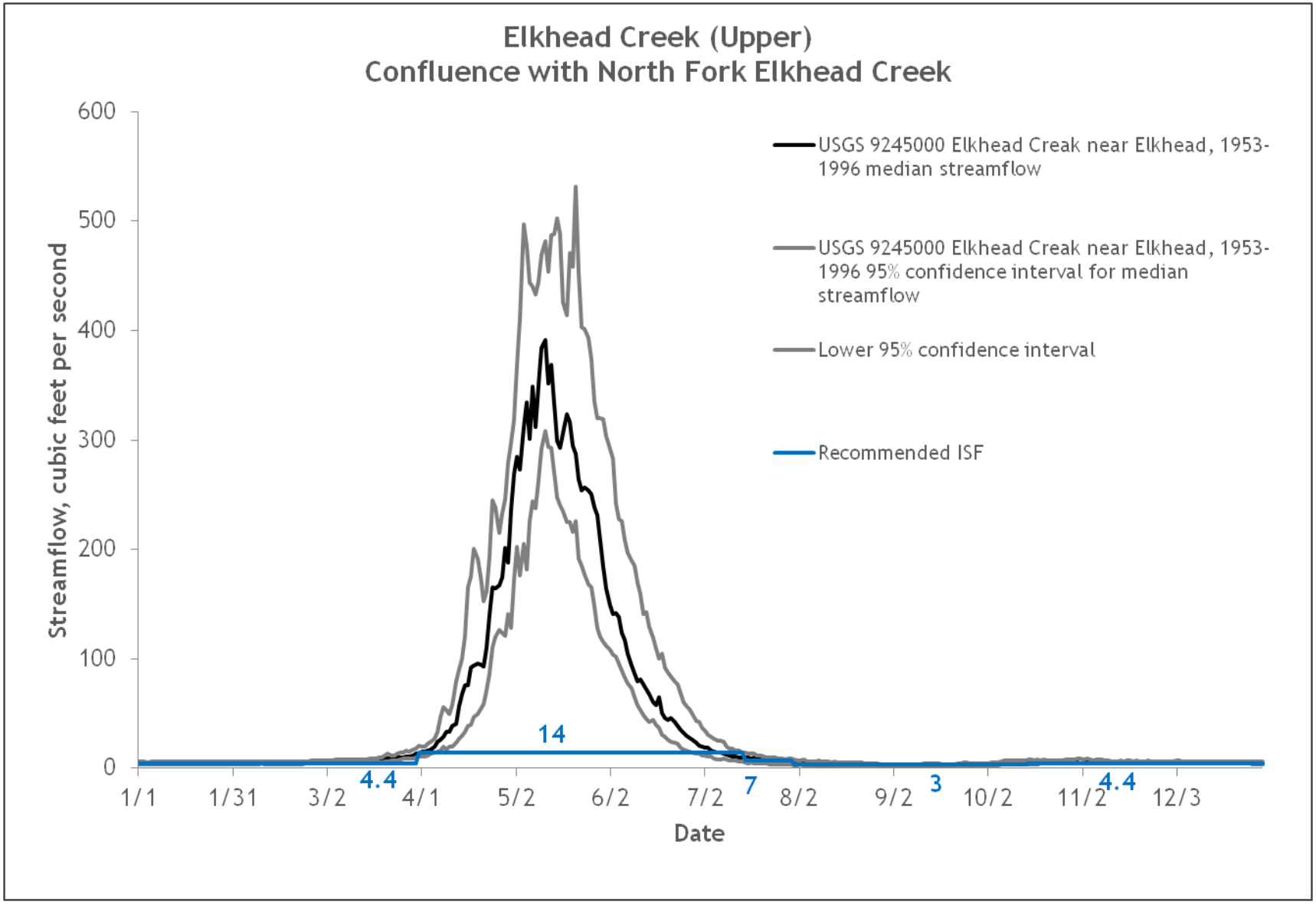
LAND OWNERSHIP MAP



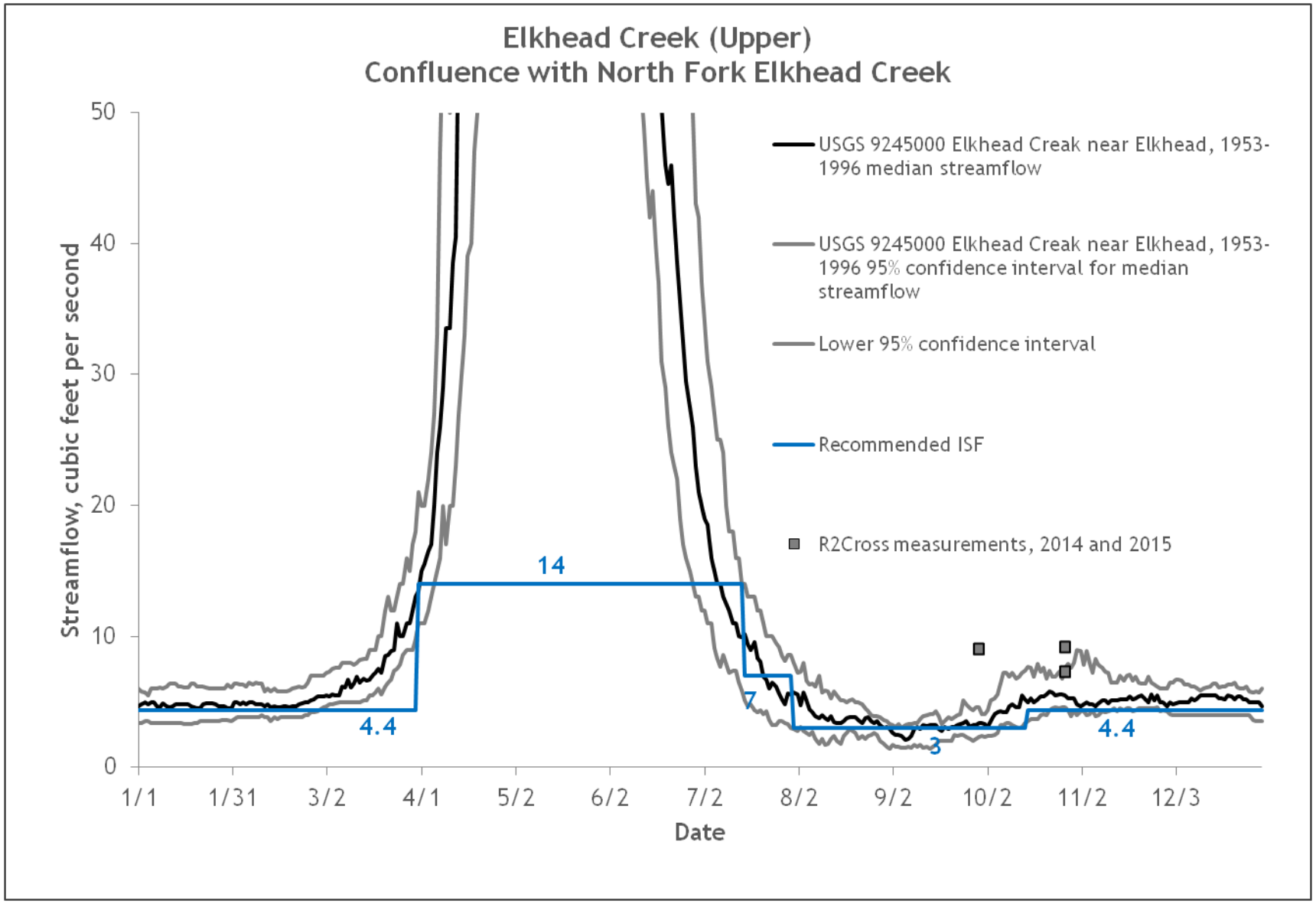
HYDROLOGIC FEATURES MAP



COMPLETE HYDROGRAPH



DETAILED HYDROGRAPH



COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Elkhead Creek (Lower)

EXECUTIVE SUMMARY

CWCB STAFF INSTREAM FLOW RECOMMENDATION

UPPER TERMINUS:	Confluence North Fork Elkhead Creek UTM North: 4504451.45 UTM East: 306665.08
LOWER TERMINUS:	USGS Gage # 09246200 UTM North: 4496025.75 UTM East: 303600.63
WATER DIVISION:	6
WATER DISTRICT:	44
COUNTY:	Routt
WATERSHED:	Upper Yampa
CWCB ID:	16/6/A-002
RECOMMENDER:	Colorado Parks and Wildlife (CPW)
LENGTH:	15.83 miles
FLOW RECOMMENDATION:	6.4 (10/01 - 02/29) 10 (03/01 - 03/15) 24 (03/16 - 06/30) 10 (07/01 - 07/15) 2.5 (07/16 - 09/30)

Elkhead Creek (Lower)

Introduction

Colorado's General Assembly created the Instream Flow and Natural Lake Level Program in 1973, recognizing "the need to correlate the activities of mankind with some reasonable preservation of the natural environment" (see 37-92-102 (3), C.R.S.). The statute vests the Colorado Water Conservation Board (CWCB or Board) with the exclusive authority to appropriate and acquire instream flow (ISF) and natural lake level water rights (NLL). Before initiating a water right filing, the Board must determine that: 1) there is a natural environment that can be preserved to a reasonable degree with the Board's water right if granted, 2) the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made, and 3) such environment can exist without material injury to water rights.

CPW recommended that the CWCB appropriate an ISF water right on a reach of Elkhead Creek. Elkhead Creek originates from Saddle Mountain at an elevation of approximately 8,900 ft and flows in a southwesterly direction as it drops to an elevation of approximately 6,200 ft where it joins the Yampa River. The proposed reach is located within Routt County (See Vicinity Map) and extends from the confluence with North Fork Elkhead Creek downstream to USGS Gage # 09246200. Nine percent of the land on the 15.83 mile proposed reach is publicly owned and managed by the State Land Board; the remaining land is privately owned (See Land Ownership Map). CPW recommended this reach of Elkhead Creek because it has a natural environment that can be preserved to a reasonable degree with an ISF water right.

The information contained in this report and the associated supporting data and analyses (located at: http://cwcb.state.co.us/environment/instream-flow-program/Pages/2017ProposedISFRecommendations.aspx) form the basis for staff's ISF recommendation to be considered by the Board. This report provides sufficient information to support the CWCB findings required by ISF Rule 5i on the natural environment, water availability, and material injury.

Natural Environment

CWCB staff relies on the recommending entity to provide information about the natural environment. In addition, staff reviews information and conducts site visits for each recommended ISF appropriation. This information is used to provide the Board with a basis for determining that a natural environment exists.

Elkhead Creek is a third order single thread stream in an unconfined valley. The land use in the Elkhead Creek valley ranges from natural habitat conditions on public lands to agricultural uses on private lands. The channel has a well connected and fairly intact floodplain with a healthy riparian corridor. The riparian community consists of cottonwood galleries and willows. Elkhead Creek is an excellent example of a transitional stream where the channel habitat changes from a substrate consisting of small cobbles and boulders in the upper reaches to sand and finer sediment in the lower reaches.

The Elkhead Creek Basin has been designated both by CPW and U.S. Forest Service (USFS) as a priority basin for native species conservation projects. The target fish species in upper Elkhead Creek basin is the Colorado River cutthroat trout (CRCT) (see Table 1). In addition, CPW and the USFS are engaged in habitat protection projects for boreal toad (*Bufo boreas boreas*), a state endangered species in the Elkhead basin. The management of CRCT is covered by a multi-state (Colorado,

Wyoming, and Utah) and federal interagency conservation agreement. The states consider CRCT to be of special concern and the federal agencies consider CRCT to be a sensitive species (CRCT Conservation Team 2006). While CRCT is the main species of concern in this basin, other native species identified in Table 1 will benefit from CRCT conservation efforts. These species include mottled sculpin, speckled dace, mountain sucker, bluehead sucker, and flannelmouth sucker (all suckers are native species of special concern). The Elkhead CRCT is identified in conservation planning documents as a population of high genetic purity and is considered a conservation population (CRCT Conservation Team 2006).

Since this reach is highly characteristic of a transition zone, the aquatic environment near the upper terminus differs from the aquatic environment near the lower terminus. Near the upper terminus, the aquatic environment is cold-water habitat, and at the lower terminus of the reach, the aquatic environment is cool-water habitat. Fish sampling records in this reach are indicative of these changes in the aquatic environment where upstream sites have cold water species and the lower sites have more cool-water species, including species that have relocated in Elkhead Creek from Elkhead Reservoir. The most upstream fish sample in CPW's records dates back to 1977 (located very close to the upstream terminus of this ISF segment), when Colorado River cutthroat trout and rainbow trout were sampled. The next sample downstream (above Routt CR 56) was sampled in 2011 and contained a large number of cutthroat trout and one black bullhead catfish. CPW also has several fish surveys from 2011 in the vicinity of "Brome Pasture" near the middle of the ISF segment, which included Colorado River cutthroat trout, bluehead sucker, creek chub, mountain sucker, fathead minnow, white sucker, mottled sculpin, redside shiner, and speckled dace. The most downstream sampling station on Elkhead Creek, in the vicinity of the lower terminus of the ISF reach, was near the CR 76 bridge crossing. In this location, CPW collected native species, including mottled sculpin, mountain sucker, and speckled dace. However, many nonnative species were also collected, such as black crappie, bluegill, creek chub, fathead minnow, largemouth bass, smallmouth bass, northern pike, white sucker, and rainbow trout. Many of these species likely came from the Elkhead Reservoir sport fishery.

Table 1. List of native species identified in Elkhead Creek.

Species Name	Scientific Name	Status
Colorado River cutthroat trout	*Oncorhynchus clarkii pleuriticus*	State – Species of Special Concern
mountain sucker	*Catostomus platyrhynchus*	State – Species of Special Concern
bluehead sucker	*Catostomus discobolus*	None
flannelmouth sucker	*Catostomus latipinnis*	None
mottled sculpin	*Cottus bairdii*	None
speckled dace	*Rhinichthys osculus*	None

ISF Quantification

CWCB staff relies upon the biological expertise of the recommending entity to quantify the amount of water required to preserve the natural environment to a reasonable degree. CWCB staff performs a thorough review of the quantification analyses completed by the recommending entity to ensure consistency with accepted standards.

Methodology
CPW staff used the R2Cross methodology to develop the initial ISF recommendation. The R2Cross method is based on a hydraulic model and uses field data collected in a stream riffle (Espegren, 1996). Riffles are most easily visualized as the stream habitat types that would dry up first should streamflow cease. The field data collected consists of streamflow measurements and surveys of channel geometry at a transect and of the longitudinal slope of the water surface.

The field data is used to model three hydraulic parameters: average depth, average velocity, and percent wetted perimeter. Maintaining these hydraulic parameters at adequate levels across riffle habitat types also will maintain aquatic habitat in pools and runs for most life stages of fish and aquatic macro-invertebrates (Nehring, 1979). CPW staff interprets the model results to develop an initial recommendation for summer and winter flows. The summer flow recommendation is based on meeting 3 of 3 hydraulic criteria. The winter flow recommendation is based on meeting 2 of 3 hydraulic criteria. The model's suggested accuracy range is 40% to 250% of the streamflow measured in the field. Recommendations that fall outside of the accuracy range may not give an accurate estimate of the hydraulic parameters necessary to determine an ISF rate.

The R2Cross methodology provides the biological quantification of the amount of water needed for summer and winter periods based on empirical studies of fish species preferences. The recommending entity uses the R2Cross results and its biological expertise to develop an initial ISF recommendation. CWCB staff then evaluates water availability for the reach typically based on median hydrology (see the Water Availability section below for more details). The water availability analysis may indicate less water is available than the initial recommendation. In that case, the recommending entity either modifies the magnitude and/or duration of the recommended ISF rates if the available flows will preserve the natural environment to a reasonable degree, or withdraws the recommendation.

Data Analysis
R2Cross data was collected at five transects for this proposed ISF reach (Table 2). Results obtained at more than one transect are averaged to determine the R2Cross flow rate for the reach of stream. The R2Cross model results in a winter flow of 15.80 cfs, which meets 2 of 3 criteria and is within the accuracy range of the R2Cross model. The R2Cross model results in a summer flow of 24.22 cfs.

Table 2. Summary of R2Cross transect measurements and results for Elkhead Creek.

Entity	Date	Streamflow (cfs)	Accuracy Range (cfs)	Winter Rate (cfs)	Summer Rate (cfs)
CPW/CWCB	10/27/2015 # 1	11.15	4.46 - 27.90	24.50	27.90[2]
CPW/CWCB[3]	10/27/2015 # 2	11.00	4.40 - 27.50	7.20	14.10
CPW/CWCB	10/27/2015 # 3	11.08	4.43 - 27.70	39.30[1]	27.70[2]
CPW/CWCB	10/27/2015 # 4	14.33	5.73 - 35.83	13.70	20.00
CPW/CWCB	10/27/2015 # 5	12.55	5.00 - 31.40	17.70	31.40[2]
			Mean	15.80	24.20

[1] This flow is above the accuracy range of the R2Cross model. This result is not used to calculate the mean R2Cross winter value.
[2] This flow is derived from the upper limit of the R2CROSS modeling accuracy and is used in the computation of the summer flow recommendation. The flow that meets all three instream flow criteria is outside of the confidence interval for this data set.
[3] Cross section located slightly downstream (approximately 700 feet) from lower terminus for this ISF recommendation; data from this cross section was used in ISF calculations because the stream channel geometry is still representative of the reach.

ISF Recommendation
CPW recommended flow rates based on R2Cross modeling analyses, biological expertise, and a preliminary water availability analysis. CPW recommended a summer rate of 24 cfs from March 16 through July 15 and a winter rate of 15.8 cfs with the knowledge that this flow rate may not be available.

The CPW recommendation was modified by staff as a result of water availability. The final recommendation flow rates are as follows:

6.4 cfs is recommended for the period October 1 to February 29.

10 cfs is recommended for the period March 1 to March 15.

24 cfs is recommended for the period March 16 to June 30.

10 cfs is recommended for the period July 1 to July 15.

2.5 cfs is recommended for the period July 16 to September 30.

Water Availability
CWCB staff conducts hydrologic analyses for each recommended ISF appropriation to provide the Board with a basis for making the determination that water is available.

Methodology
Each recommended ISF reach has a unique flow regime that depends on variables such as the timing, magnitude, and location of water inputs (such as rain, snow, and snowmelt) and water losses (such as diversions, reservoirs, evaporation and transpiration, groundwater recharge, etc). Although extensive and time-consuming investigations of all variables may be possible, staff takes a pragmatic and cost-effective approach to analyzing water availability. This approach focuses on streamflows and the influence of flow alterations, such as diversions, to understand how much water is physically available in the recommended reach.

Staff's hydrologic analysis is data-driven, meaning that staff gathers and evaluates the best available data and uses the best available analysis method for that data. Whenever possible, long-term stream gage data (period of record 20 or more years) will be used to evaluate streamflow. Other streamflow information such as short-term gages, temporary gages, spot streamflow measurements, diversion records, and StreamStats will be used when long-term gage data is not available. StreamStats, a statistical hydrologic program, uses regression equations developed by the USGS (Capesius and Stephens, 2009) to estimate mean flows for each month based on drainage basin area and average drainage basin precipitation. Diversion records will also be used to evaluate the effect of surface

water diversions when necessary. Interviews with water commissioners, landowners, and ditch or reservoir operators can provide additional information. A range of analytical techniques may be employed to extend gage records, estimate streamflow in ungaged locations, and estimate the effects of diversions. The goal is to obtain the most detailed and reliable estimate of hydrology using the most efficient analysis technique.

The final product of the hydrologic analysis used to determine water availability is a hydrograph, which shows streamflow and the proposed ISF rate over the course of one year. The hydrograph will show median daily values when daily data is available; otherwise, it will present mean-monthly streamflow values. Staff will calculate 95% confidence intervals for the median streamflow if there is sufficient data. Statistically, there is 95% confidence that the true value of the median streamflow is located within the confidence interval.

Basin Characteristics
The drainage basin of the proposed ISF on Elkhead Creek is 171 square miles, with an average elevation of 7,950 ft and average annual precipitation of 28.22 inches (See the Hydrologic Features Map). The Elkhead Creek basin supports agriculture, among other uses. According to the water commission, Kathy Bower (contacted 9/07/2016), there is not very much irrigation use in the basin in the later part of the summer and early fall. Hydrology is altered by water use within the basin.

Available Data
Elkhead Creek has a USGS gage located at the lower terminus (USGS 09246200 Elkhead Creek above Long Gulch, near Hayden, CO). The proximity of the gage to the lower terminus and relatively long period of record (1995 to present) make this gage ideally suited for water availability analysis.

CWCB staff made streamflow measurements during the 2015 site visit when R2Cross data was collected. These measurements are included in the water availability analysis.

Data Analysis
The Elkhead Creek gage was analyzed from 9/1/1995 to 8/9/2016 based on USGS approved data available through HydroBase on 12/20/2016. Median streamflow and 95% confidence intervals for median streamflow were calculated for the Elkhead Creek gage record.

Water Availability Summary
The hydrographs (See Complete Hydrograph and Detailed Hydrograph) show median streamflow and 95% confidence intervals for the median streamflow based on the Elkhead Creek gage record. The proposed ISF rate is below the median streamflow the majority of the time. The proposed ISF rate is below the 95% confidence interval of the median at all times. Staff has concluded that water is available for appropriation.

Material Injury
Because the proposed ISF on Elkhead Creek is a new junior water right, the ISF can exist without material injury to other water rights. Under the provisions of section 37-92-102(3)(b), C.R.S. (2016), the CWCB will recognize any uses or exchanges of water in existence on the date this ISF water right is appropriated.

Citations

Capesius, J.P. and V.C. Stephens, 2009, Regional regression equations for estimation of natural streamflow statistics in Colorado, Scientific Investigations Report 2009-5136.

CRCT Conservation Team, 2006, Conservation agreement for Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) in the states of Colorado, Utah, and Wyoming. Colorado Division of Wildlife, Fort Collins.

CRCT Conservation Team, 2006, Conservation strategy for Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) in the states of Colorado, Utah, and Wyoming. Colorado Division of Wildlife, Fort Collins.

Espegren, G.D., 1996, Development of Instream Flow Recommendations in Colorado Using R2CROSS, Colorado Water Conservation Board.

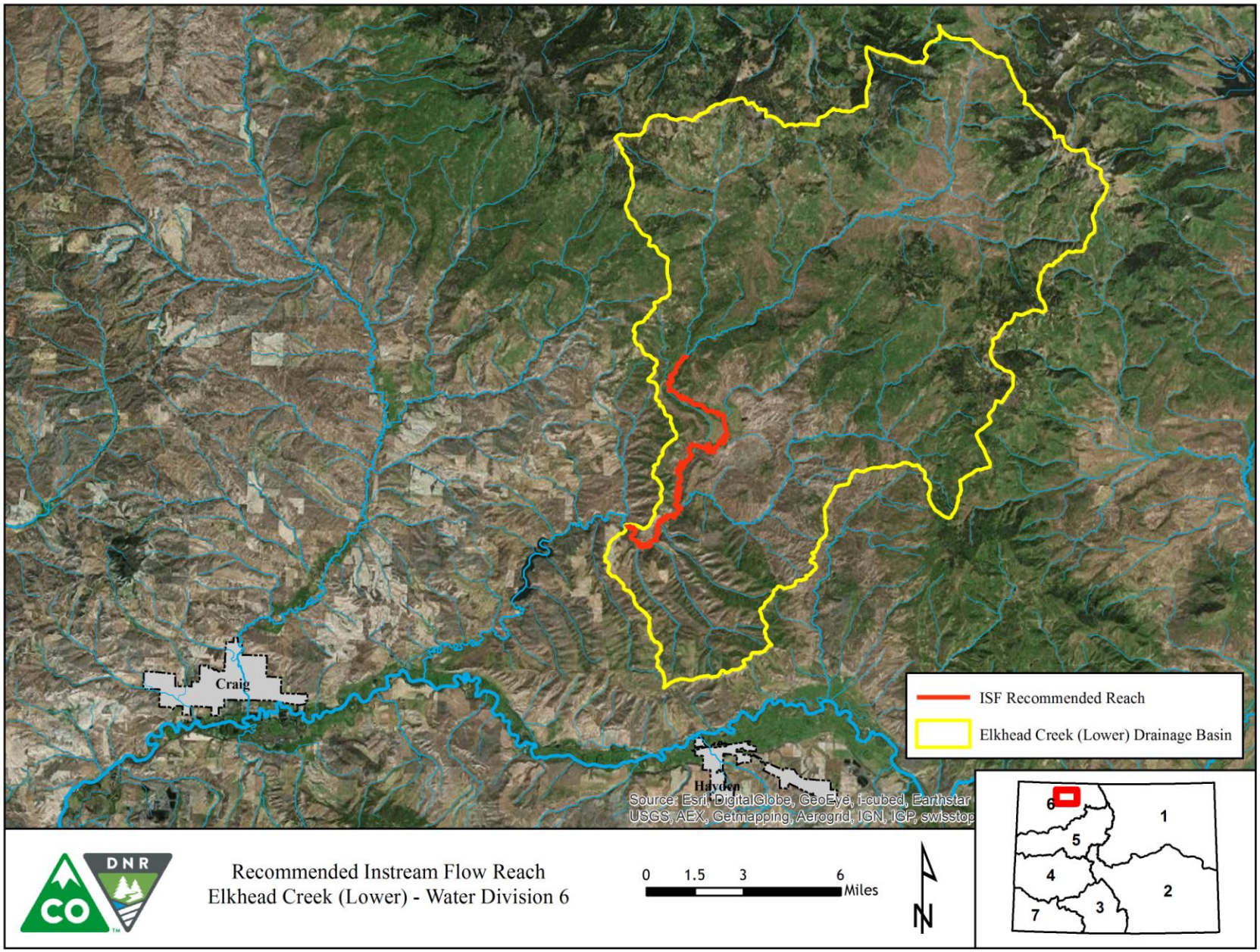
Nehring, B.R., 1979, Evaluation of Instream Flow Methods and Determination of Water Quantity Needs for Streams in the State of Colorado, Colorado Division of Wildlife.

Metadata Descriptions

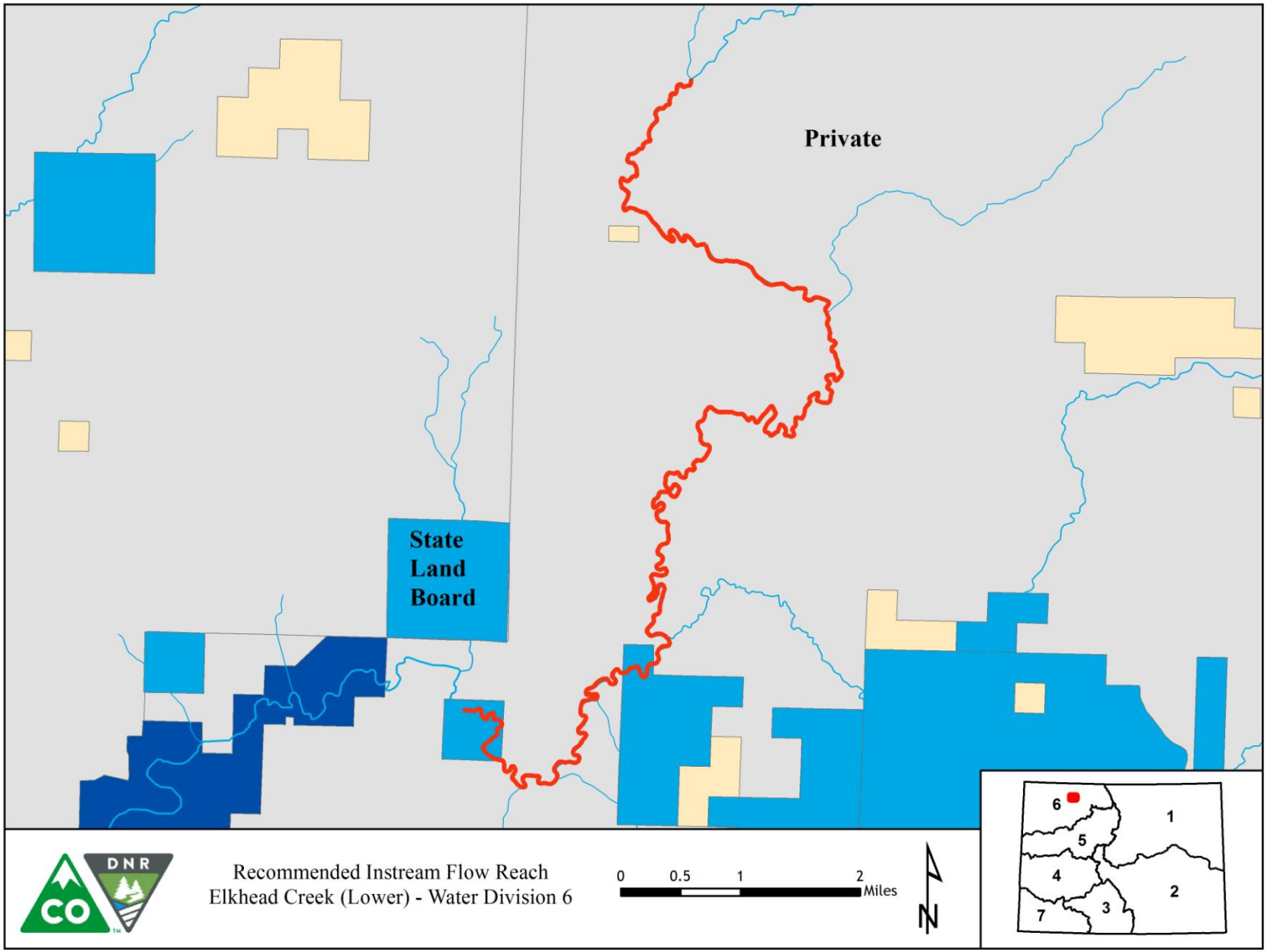
The UTM locations for the upstream and downstream termini were derived from CWCB GIS using the National Hydrography Dataset (NHD).

Projected Coordinate System: NAD 1983 UTM Zone 13N.

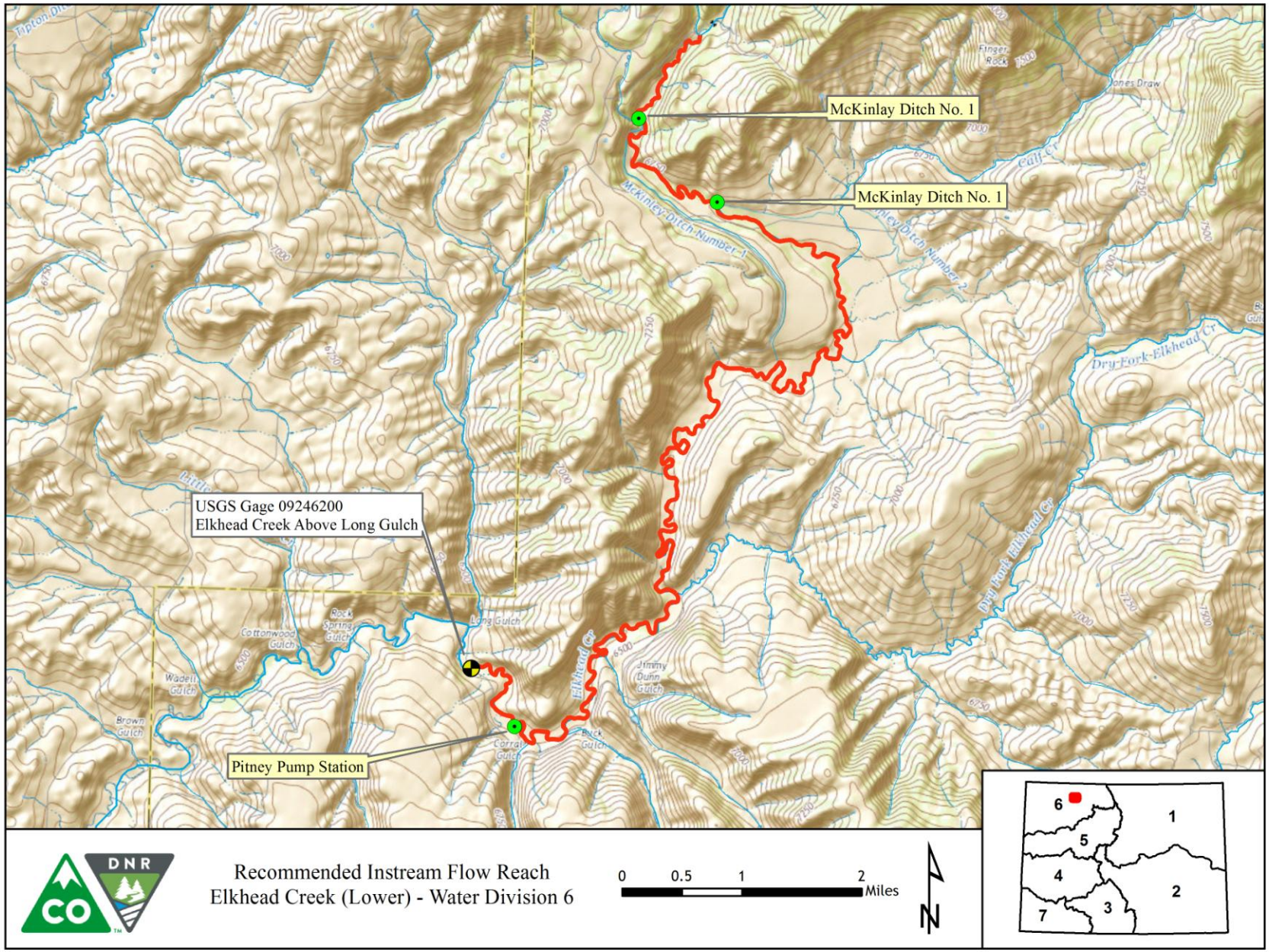
VICINITY MAP



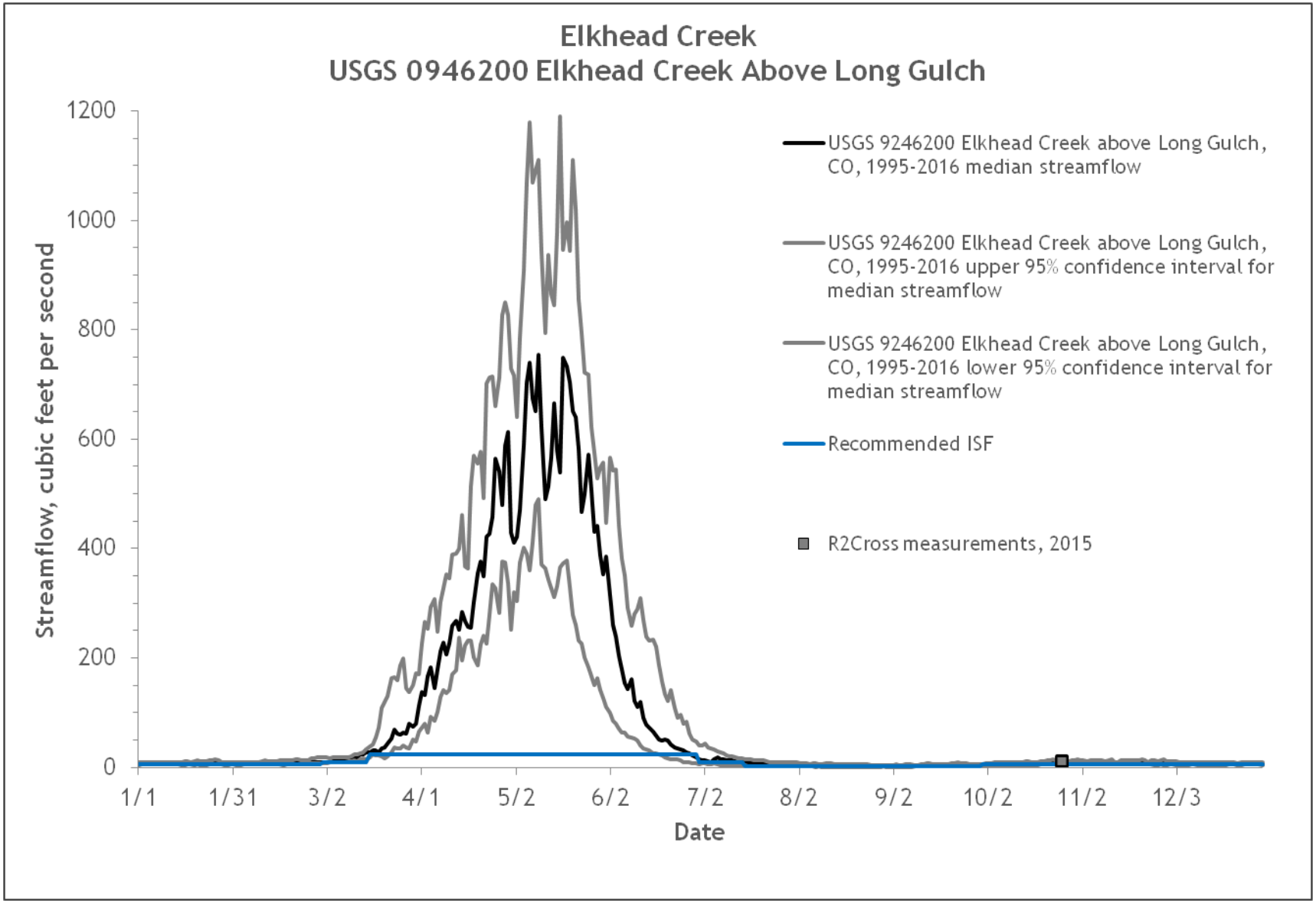
LAND OWNERSHIP MAP



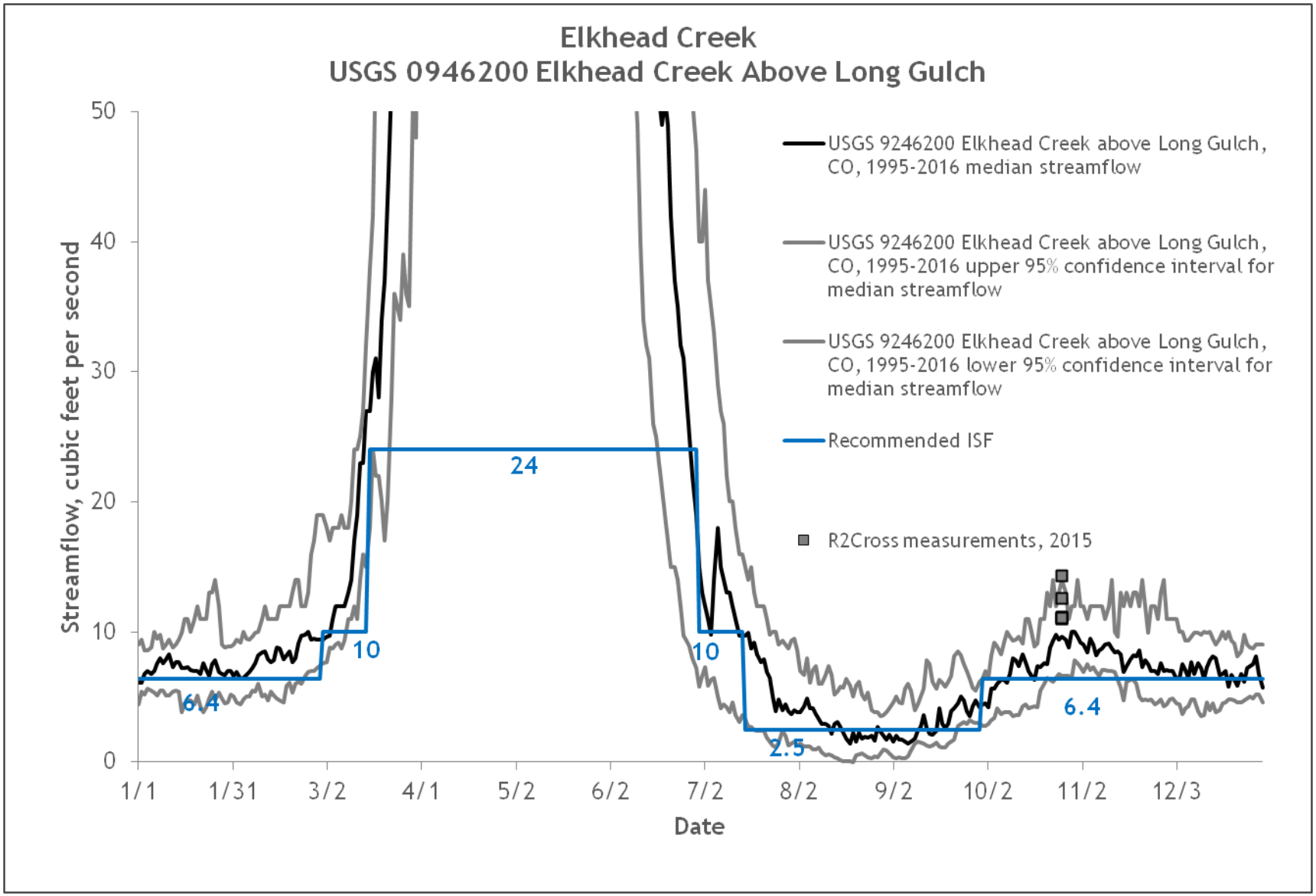
HYDROLOGIC FEATURES MAP



COMPLETE HYDROGRAPH



DETAILED HYDROGRAPH



COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Fourmile Creek
EXECUTIVE SUMMARY

CWCB STAFF INSTREAM FLOW RECOMMENDATION

UPPER TERMINUS:	Headwaters in the vicinity of UTM North: 4520769.45	UTM East: 296207.17
LOWER TERMINUS:	Norma Ryan Ditch headgate UTM North: 4523918.74	UTM East: 292918.30
WATER DIVISION:	6	
WATER DISTRICT:	54	
COUNTY:	Moffat	
WATERSHED:	Little Snake	
CWCB ID:	17/6/A-003	
RECOMMENDER:	Bureau of Land Management (BLM)	
LENGTH:	3.13 miles	
FLOW RECOMMENDATION:	3.8 (5/1 - 6/30) 0.97 (7/1 - 7/31) 0.41 (8/1 - 3/31) 1.3 (4/1 - 4/30)	

Fourmile Creek

Introduction

Colorado's General Assembly created the Instream Flow and Natural Lake Level Program in 1973, recognizing "the need to correlate the activities of mankind with some reasonable preservation of the natural environment" (see 37-92-102 (3), C.R.S.). The statute vests the Colorado Water Conservation Board (CWCB or Board) with the exclusive authority to appropriate and acquire instream flow (ISF) and natural lake level water rights (NLL). Before initiating a water right filing, the Board must determine that: 1) there is a natural environment that can be preserved to a reasonable degree with the Board's water right if granted, 2) the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made, and 3) such environment can exist without material injury to water rights.

The BLM recommended that the CWCB appropriate an ISF water right on a reach of Fourmile Creek. Fourmile Creek originates on the western flank of Mount Oliphant in the Elkhead Mountains, about 24 miles northeast of Craig at an elevation of approximately 9,600 ft. The creek flows in a northwesterly direction as it drops to an elevation of approximately 6,240 where it joins the Little Snake River. The recommended reach is located within Moffat County (See Vicinity Map) and extends from Fourmile Creek's headwaters downstream to the Norma Ryan Ditch headgate. Forty-eight percent of the land on the 3.13 mile proposed reach is publicly owned and managed by the BLM and U.S. Forest Service; the remaining land is privately held (See Land Use Map). The BLM recommended this reach of Fourmile Creek because it has a natural environment that can be preserved to a reasonable degree with an ISF water right.

The information contained in this report and the associated supporting data and analyses (located at: http://cwcb.state.co.us/environment/instream-flow-program/Pages/2017ProposedISFRecommendations.aspx) form the basis for staff's ISF recommendation to be considered by the Board. This report provides sufficient information to support the CWCB findings required by ISF Rule 5i on the natural environment, water availability, and material injury.

Natural Environment

CWCB staff relies on the recommending entity to provide information about the natural environment. In addition, staff reviews information and conducts site visits for each recommended ISF appropriation. This information is used to provide the Board with a basis for determining that a natural environment exists.

Fourmile Creek is a cold-water, high gradient stream in a densely forested environment. The stream is confined by bedrock in most locations. The stream generally has medium to large-sized substrate, consisting of cobbles and small boulders. The stream consists mostly of a series of pools broken by short drops and waterfalls. As such, the creek has abundant pool habitat for overwintering fish, but runs and riffle habitat are very limited, which limits reproduction. Abundant beaver ponds also assist in maintaining pool habitat for the fish population.

Fisheries surveys have revealed a self-sustaining population of native cutthroat trout (See Table 1). Genetic testing revealed that the population is a genetically pure population of Yampa River lineage. Colorado Parks and Wildlife has designated the fish in this creek as a core conservation population. Intensive macro-invertebrate surveys have not been conducted, but spot samples have revealed various species of mayfly, caddisfly, and stonefly.

The riparian community is generally comprised of spruce and alder at higher elevation and willow and aspen at lower elevation. The riparian community is in excellent condition, and provides abundant shading and cover for fish habitat.

Table 1. List of species identified in Fourmile Creek.

Species Name	Scientific Name	Status
Colorado River cutthroat trout	*Oncorhynchus clarkii pleuriticus*	State – Species of Special Concern; BLM - Sensitive Species

ISF Quantification

CWCB staff relies upon the biological expertise of the recommending entity to quantify the amount of water required to preserve the natural environment to a reasonable degree. CWCB staff performs a thorough review of the quantification analyses completed by the recommending entity to ensure consistency with accepted standards.

Methodology

BLM staff used the R2Cross methodology to develop the initial ISF recommendation. The R2Cross method is based on a hydraulic model and uses field data collected in a stream riffle (Espegren, 1996). Riffles are most easily visualized as the stream habitat types that would dry up first should streamflow cease. The field data collected consists of streamflow measurements and surveys of channel geometry at a transect and of the longitudinal slope of the water surface.

The field data is used to model three hydraulic parameters: average depth, average velocity, and percent wetted perimeter. Maintaining these hydraulic parameters at adequate levels across riffle habitat types also will maintain aquatic habitat in pools and runs for most life stages of fish and aquatic macro-invertebrates (Nehring, 1979). BLM staff interprets the model results to develop an initial recommendation for summer and winter flows. The summer flow recommendation is based on meeting 3 of 3 hydraulic criteria. The winter flow recommendation is based on meeting 2 of 3 hydraulic criteria. The model's suggested accuracy range is 40% to 250% of the streamflow measured in the field. Recommendations that fall outside of the accuracy range may not give an accurate estimate of the hydraulic parameters necessary to determine an ISF rate.

The R2Cross methodology provides the biological quantification of the amount of water needed for summer and winter periods based on empirical studies of fish species preferences. The recommending entity uses the R2Cross results and its biological expertise to develop an initial ISF recommendation. CWCB staff then evaluates water availability for the reach typically based on median hydrology (see the Water Availability section below for more details). The water availability analysis may indicate less water is available than the initial recommendation. In that case, the recommending entity either modifies the magnitude and/or duration of the recommended ISF rates if the available flows will preserve the natural environment to a reasonable degree, or withdraws the recommendation.

Data Analysis

R2Cross data was collected at two transects for this proposed ISF reach (Table 2). Results obtained at more than one transect are averaged to determine the R2Cross flow rate for the reach of stream. The R2Cross model results in a winter flow of 2.32 cfs, which meets 2 of 3 criteria and is within the accuracy range of the R2Cross model. The R2Cross model results in a summer flow of 3.76 cfs, which meets 3 of 3 criteria and is within the accuracy range of the R2Cross model.

Table 2. Summary of R2Cross transect measurements and results for Fourmile Creek.

Entity	Date	Streamflow (cfs)	Accuracy Range (cfs)	Winter Rate (cfs)	Summer Rate (cfs)
BLM	06/16/2015	4.78	1.91 - 11.95	2.42	3.76
BLM	07/08/2015	1.19	0.48 - 2.98	2.21	Out of range
			Mean	2.32	3.76

ISF Recommendation

BLM's analysis of this data, coordinated with Colorado Parks and Wildlife, indicates that the following flows are needed to preserve the fishery and natural environment to a reasonable degree. BLM's recommendation was modified slightly by staff to conform to a standard number of significant digits in ISF water court applications. The final recommendations numbers are as follows:

> 3.8 cubic feet per second (cfs) is recommended during the snowmelt runoff period from May 1 to June 30. This recommendation is driven by the average velocity criteria. This portion of the creek is at high altitude and the fish growth and recruitment season is short. It is important to protect a flow rate that makes most of this habitat available to the fish population while they are completing critical life history functions during the warm weather months.
>
> 0.97 cfs is recommended from July 1 to July 31. This recommendation is driven by water availability. While this flow rate does not meet at least two instream flow criteria, it provides substantially more habitat than is available during base flow periods.
>
> 0.41 cfs is recommended from August 1 to March 31. This recommendation is driven by very limited water availability. 0.4 cubic feet per second should keep pools well oxygenated and at an acceptable temperature during late summer, and it should prevent pools from freezing, allowing the fish population to successfully overwinter. Even though the base flow in this creek is small, it is extremely consistent, allowing the fishery to persist.
>
> 1.3 cfs is recommended during the initial part of the snowmelt period, from April 1 to April 30. This recommendation is driven by limited water availability. Depending upon variations in stream temperatures, the fish population may start spawning in April, and protecting sufficient spawning habitat is important.

Water Availability

CWCB staff conducts hydrologic analyses for each recommended ISF appropriation to provide the Board with a basis for making the determination that water is available.

Methodology

Each recommended ISF reach has a unique flow regime that depends on variables such as the timing, magnitude, and location of water inputs (such as rain, snow, and snowmelt) and water losses (such as diversions, reservoirs, evaporation and transpiration, groundwater recharge, etc). Although extensive

and time-consuming investigations of all variables may be possible, staff takes a pragmatic and cost-effective approach to analyzing water availability. This approach focuses on streamflows and the influence of flow alterations, such as diversions, to understand how much water is physically available in the recommended reach.

Staff's hydrologic analysis is data-driven, meaning that staff gathers and evaluates the best available data and uses the best available analysis method for that data. Whenever possible, long-term stream gage data (period of record 20 or more years) will be used to evaluate streamflow. Other streamflow information such as short-term gages, temporary gages, spot streamflow measurements, diversion records, and StreamStats will be used when long-term gage data is not available. StreamStats, a statistical hydrologic program, uses regression equations developed by the USGS (Capesius and Stephens, 2009) to estimate mean flows for each month based on drainage basin area and average drainage basin precipitation. Diversion records will also be used to evaluate the effect of surface water diversions when necessary. Interviews with water commissioners, landowners, and ditch or reservoir operators can provide additional information. A range of analytical techniques may be employed to extend gage records, estimate streamflow in ungaged locations, and estimate the effects of diversions. The goal is to obtain the most detailed and reliable estimate of hydrology using the most efficient analysis technique.

The final product of the hydrologic analysis used to determine water availability is a hydrograph, which shows streamflow and the proposed ISF rate over the course of one year. The hydrograph will show median daily values when daily data is available; otherwise, it will present mean-monthly streamflow values. Staff will calculate 95% confidence intervals for the median streamflow if there is sufficient data. Statistically, there is 95% confidence that the true value of the median streamflow is located within the confidence interval.

Basin Characteristics

The drainage basin of the proposed ISF on Fourmile Creek is 3.42 square miles, with an average elevation of 9,100 ft and average annual precipitation of 38.17 inches (See the Vicinity Map). There are no known surface water diversions in the drainage basin tributary to the proposed ISF on Fourmile Creek.

Available Data

There is not a current or historic daily streamflow gage on Fourmile Creek. There was a historic gage, but it only measured peak flows and therefore is not particularly useful for this analysis. A number of gages were examined to determine if there was a representative gage in the area. The closest gage is Willow Creek near Dixon, CO (USGS 09258000) which was located in the adjacent drainage basin to the north, roughly 6.2 miles northwest from the proposed lower terminus of Fourmile Creek. The period of record for this gage is 10/1/1953 to 9/30/1993 (downloaded from HydroBase on 11/9/2016). The drainage basin of the Willow Creek gage is 24.8 square miles with an average elevation of 8,060 ft and average annual precipitation of 28.11 inches. This results in a proration factor of 0.187 using the area-precipitation method. The area-precipitation method estimates streamflow based on the ratio of the precipitation weighted drainage area at the lower terminus location to that of the gage location. There are a number of relatively small active diversions on Willow Creek, but diversion records are not maintained. The largest water right is the Perkins Fox Ditch (WDID 5400554, 10 cfs absolute, appropriation dates 1889, 1891, 1896). This diversion structure appears to divert upstream from the gage for use on lands downstream from the gage. There are fairly consistent diversion records from the late 1950s through about 2005 with additional years of records both before and after that time period. Casey Fawcett (District 54 Water

Commissioner) estimated that ditch loss is approximately 40% to 50% due to the length of the ditch, construction materials, and issues with animals undermining the ditch.

The Norma Ryan Ditch (3 cfs, appropriation date 1919) is located at the lower terminus of the proposed Fourmile Creek ISF reach. This structure has diversion records between 1936 and the present; however, not all years have records.

BLM staff made a number of streamflow measurements on Fourmile Creek. The best available access point is located approximate 1.5 miles upstream from the lower terminus. A total of 3 measurements were available for inclusion in this analysis. CWCB staff made one streamflow measurement on the proposed reach of Fourmile Creek. All known measurements are summarized in Table 3.

Table 3. Summary of streamflow measurement visits and results for Fourmile Creek.

Visit Date	Flow (cfs)	Method	Party
07/20/2016	1.19	Wading, Marsh McBirney	CWCB
08/22/2016	0.72	unknown	BLM
09/26/2016	1.02	unknown	BLM
10/28/2016	0.76	unknown	BLM

Data Analysis

The Willow Creek near Dixon gage represents the best available streamflow data to estimate streamflow on Fourmile Creek. Natural streamflow on Willow Creek was estimated by adding 50% of the recorded diversions from the Perkins Fox Ditch to the Willow Creek gage data. The adjusted Willow Creek gage data was then scaled by 0.187 to the lower terminus of Fourmile Creek. Median streamflow and 95% confidence intervals for media streamflow were calculated.

The median diversion and 95% confidence intervals for the median diversion for the Norma Ryan Ditch were calculated based on the available record, 1936 to 2015 (downloaded from HydroBase on 10/7/2016). The diversion rates from that structure are typically less than the proposed ISF; however, the timing of ditch use confirms that Fourmile and Willow Creek have similar runoff periods.

Measurements made by the BLM staff on Fourmile Creek suggest that significantly more water may be available than indicated by the Willow Creek analysis; however, this cannot be confirmed without making substantially more measurements.

Water Availability Summary

The hydrographs (See Complete and Detailed Hydrographs) show the median streamflow and 95% confidence intervals for the median streamflow calculated from the scaled Willow Creek near Dixon gage and the available streamflow measurements on Fourmile Creek. The proposed ISF rate is below median streamflow the majority of the time and below the upper 95% confidence interval at all times. The median and 95% confidence intervals of the median diversion of the Norma Ryan Ditch are included to provide additional information. Staff concludes that water is available for appropriation on Fourmile Creek.

Material Injury
Because the proposed ISF on Fourmile Creek is a new junior water right, the ISF can exist without material injury to other water rights. Under the provisions of section 37-92-102(3)(b), C.R.S. (2016), the CWCB will recognize any uses or exchanges of water in existence on the date this ISF water right is appropriated.

Citations
Capesius, J.P. and V.C. Stephens, 2009, Regional regression equations for estimation of natural streamflow statistics in Colorado, Scientific Investigations Report 2009-5136.

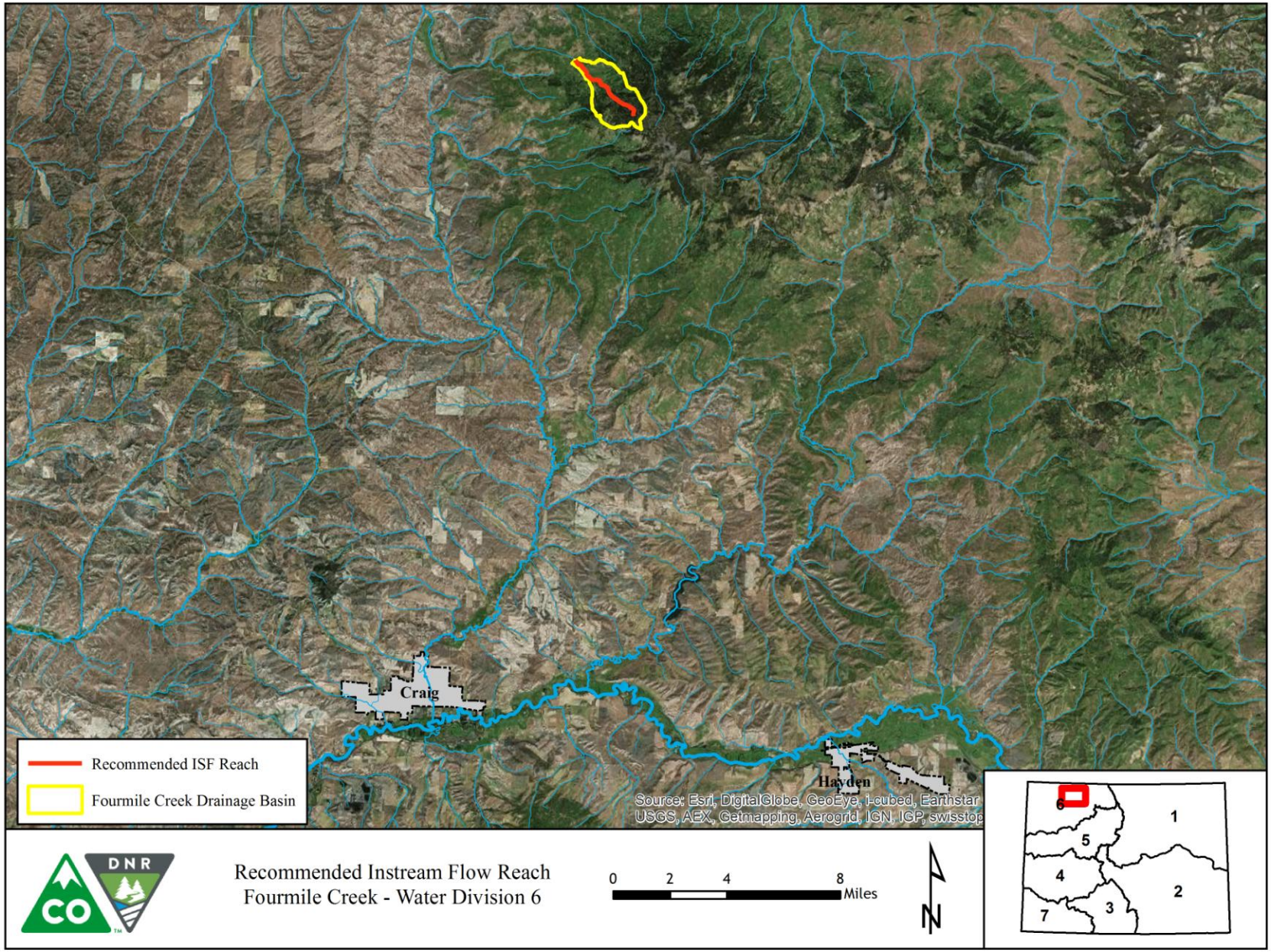
Espegren, G.D., 1996, Development of Instream Flow Recommendations in Colorado Using R2CROSS, Colorado Water Conservation Board.

Nehring, B.R., 1979, Evaluation of Instream Flow Methods and Determination of Water Quantity Needs for Streams in the State of Colorado, Colorado Division of Wildlife.

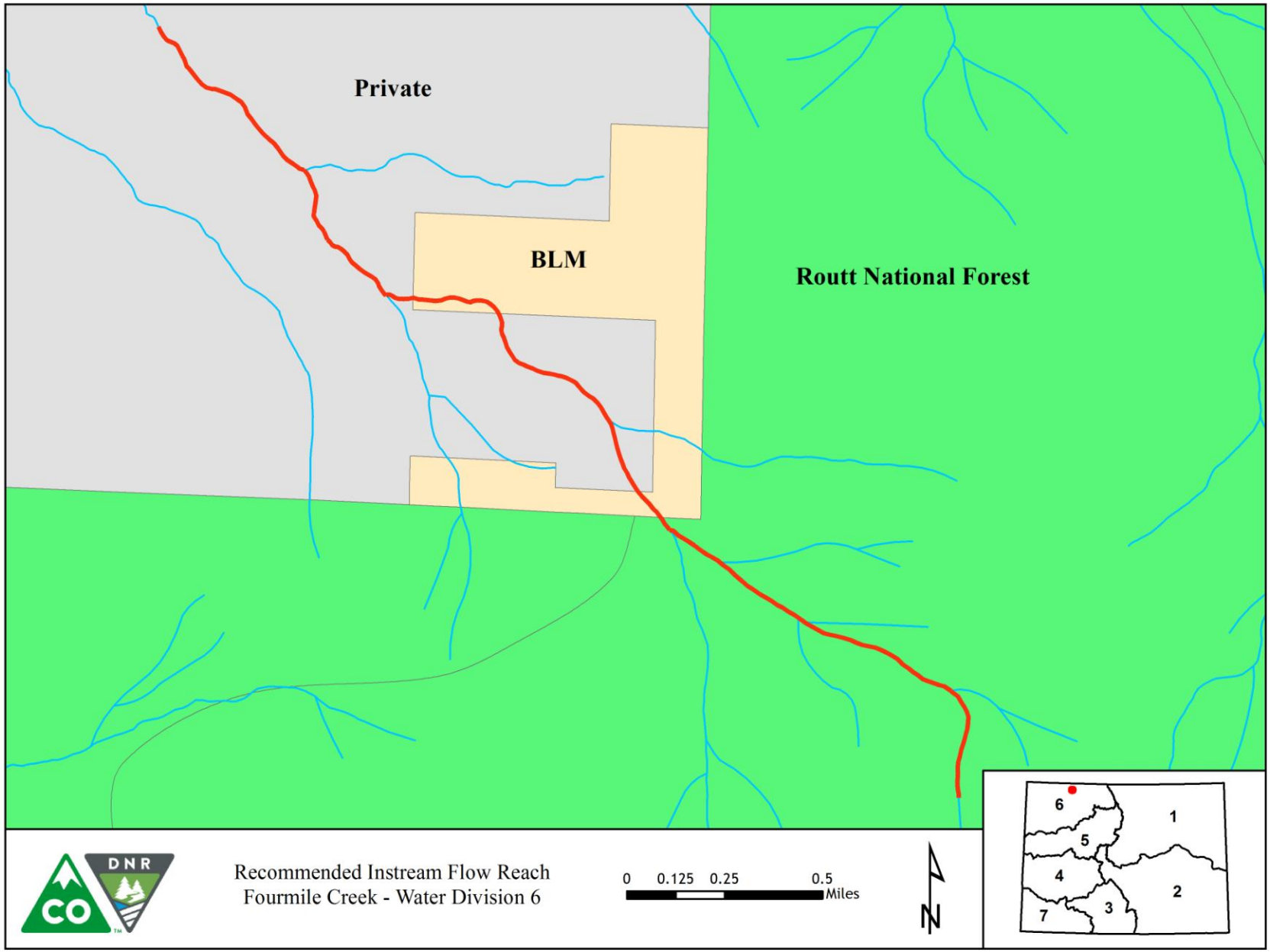
Metadata Descriptions
The UTM locations for the upstream and downstream termini were derived from CWCB GIS using the National Hydrography Dataset (NHD).

Projected Coordinate System: NAD 1983 UTM Zone 13N.

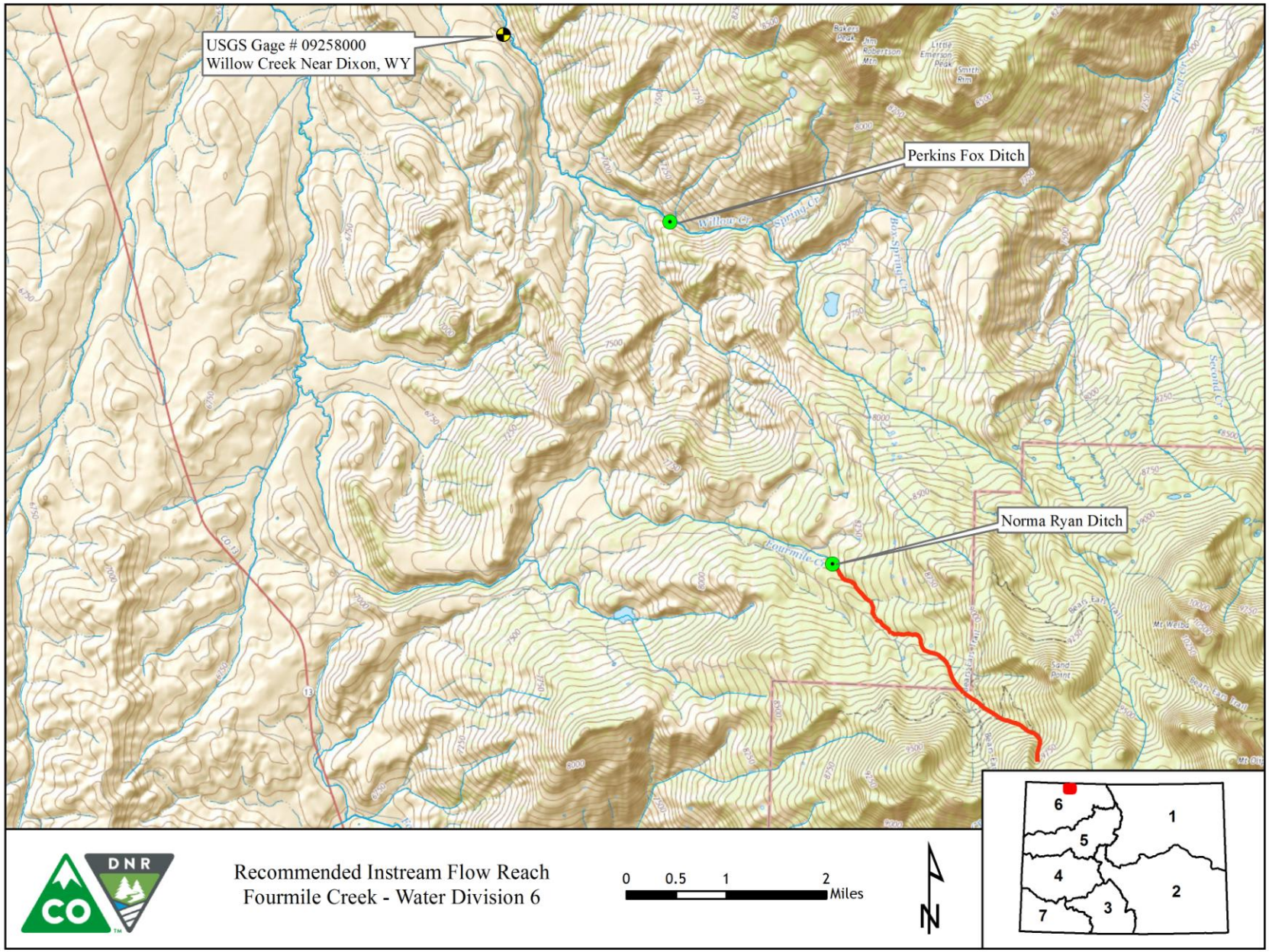
VICINITY MAP



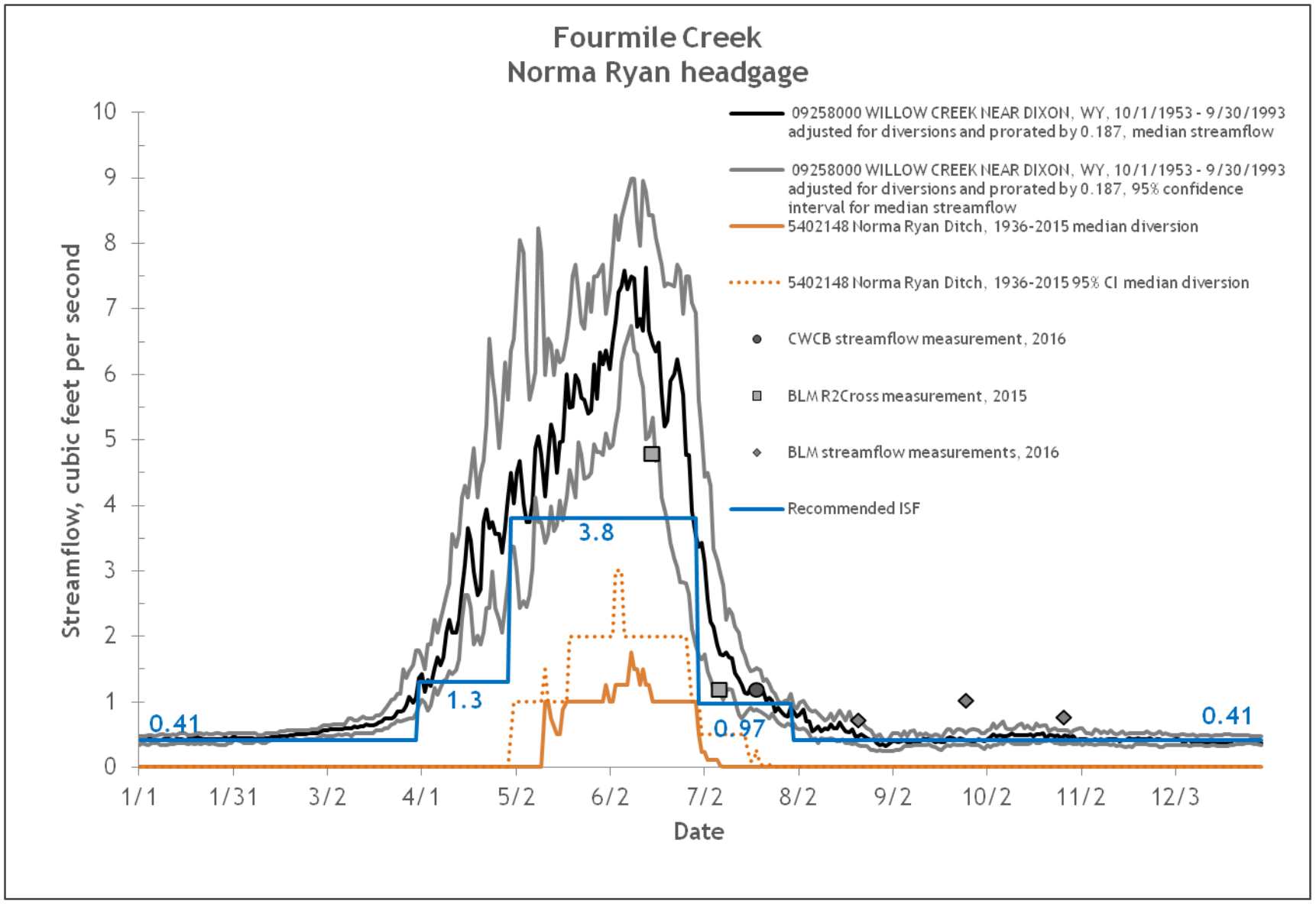
LAND OWNERSHIP MAP



HYDROLOGIC FEATURES MAP



COMPLETE HYDROGRAPH



COLORADO
Colorado Water Conservation Board
Department of Natural Resources

North Fork Elkhead Creek

EXECUTIVE SUMMARY

CWCB STAFF INSTREAM FLOW RECOMMENDATION

UPPER TERMINUS:	Headwaters in the Vicinity of UTM North: 4515748.48	UTM East: 310855.20
LOWER TERMINUS:	Confluence Elkhead Creek UTM North: 4504451.45	UTM East: 306665.08
WATER DIVISION:	6	
WATER DISTRICT:	44	
COUNTY:	Routt	
WATERSHED:	Upper Yampa	
CWCB ID:	15/6/A-008	
RECOMMENDER:	Colorado Parks and Wildlife (CPW)	
LENGTH:	9.39 miles	
FLOW RECOMMENDATION:	1.8 (12/01 - 03/31) 5.4 (04/01 - 06/30) 1.2 (07/01 - 07/31) 0.57 (08/01 - 09/17) 1.4 (09/18 - 11/30)	

North Fork Elkhead Creek

Introduction

Colorado's General Assembly created the Instream Flow and Natural Lake Level Program in 1973, recognizing "the need to correlate the activities of mankind with some reasonable preservation of the natural environment" (see 37-92-102 (3), C.R.S.). The statute vests the Colorado Water Conservation Board (CWCB or Board) with the exclusive authority to appropriate and acquire instream flow (ISF) and natural lake level water rights (NLL). Before initiating a water right filing, the Board must determine that: 1) there is a natural environment that can be preserved to a reasonable degree with the Board's water right if granted, 2) the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made, and 3) such environment can exist without material injury to water rights.

CPW recommended that the CWCB appropriate an ISF water right on a reach of North Fork Elkhead Creek. North Fork Elkhead Creek originates from the southeast flank of Bears Ears Peak at an elevation of approximately 10,000 ft. The creek flows in a southwesterly direction as it drops to an elevation of approximately 6,800 ft where it joins Elkhead Creek. The proposed reach is located within Routt County (See Vicinity Map) and extends from its headwaters downstream to the confluence with Elkhead Creek. Sixty-four percent of the land on the 9.39 mile proposed reach is publicly owned and managed by the U.S. Forest Service (USFS) (See Land Ownership Map). The CPW recommended this reach of North Fork Elkhead Creek because it has a natural environment that can be preserved to a reasonable degree with an ISF water right.

The information contained in this report and the associated supporting data and analyses (located at: http://cwcb.state.co.us/environment/instream-flow-program/Pages/2017ProposedISFRecommendations.aspx) form the basis for staff's ISF recommendation to be considered by the Board. This report provides sufficient information to support the CWCB findings required by ISF Rule 5i on the natural environment, water availability, and material injury.

Natural Environment

CWCB staff relies on the recommending entity to provide information about the natural environment. In addition, staff reviews information and conducts site visits for each recommended ISF appropriation. This information is used to provide the Board with a basis for determining that a natural environment exists.

The North Fork Elkhead Creek starts as a first order stream and then is a second order stream for the lower 6 miles. This recommended reach drops about 2,250 ft over 9.4 miles, so that much of the creek is fairly high gradient. Because the North Fork valley is fairly confined, the stream is relatively straight for much of its course and most of the channel is a single thread channel. Any hydrologic connection to the floodplain most likely occurs only during spring runoff or high precipitation events. The stream's banks are mostly intact and stable, although some areas have been impacted by beaver activity. A prominent and healthy riparian corridor exists throughout this segment and plays a significant role in the energy and food web dynamics of and for the aquatic environment, providing food for both the aquatic macro-invertebrates and fish. The riparian community is primarily composed of willows, alders, and cottonwoods. Stream cover is variable, but is mostly forested with a few openings in the riparian canopy. The health of the riparian canopy is a major factor in protecting this small stream from solar radiation and heating during times of low flow during the late

summer months. Due to the stream's relative steepness, a majority of the habitat is small pool and short riffle sections. The stream's substrate is predominantly boulders and large cobble.

The Elkhead Creek Basin has been designated both by CPW and the USFS as a priority basin for native species conservation projects. The target fish species is the Colorado River cutthroat trout (CRCT) (see Table 1). In addition, CPW and the USFS are involved in habitat protection projects for boreal toad (*Bufo boreas boreas*), a state endangered species in the Elkhead basin. The management of CRCT is covered by a multi-state (Colorado, Wyoming, and Utah) and federal interagency conservation agreement. The states consider CRCT to be of special concern and the federal agencies consider CRCT to be a sensitive species (CRCT Conservation Team 2006). While CRCT is the main species of concern in this basin, other native species identified in Table 1 will benefit from CRCT conservation efforts. These species include mottled sculpin (*Cottus bairdi*), speckled dace (*Rhinichthys osculus*), and the mountain sucker (*Catostomus playtrhynchus*), which is also a state species of special concern (CRCT Conservation Team 2006). The entire Elkhead Creek basin upstream and including the North Fork of Elkhead Creek is the subject of current and ongoing stream health management projects, and is being enhanced through a variety of interagency projects to restore both cutthroat trout and boreal toad habitat. The Elkhead CRCT is identified in conservation planning documents as a population of high genetic purity and is considered a core conservation population (CRCT Conservation Team 2006).

Reducing non-native competition and hybridization is another critical aspect of CRCT conservation efforts. All non-native salmonids have been removed from the basin, and migration barriers are either in place or planned. All brook trout (*Salvelinus fontinalis*) and rainbow trout (*Oncorrhynchus mykiss*) have been removed from the system. Brook and rainbow trout are strong competitors for food and habitat, and rainbow trout also readily hybridize with cutthroat trout (NRCS 2007).

Table 1. List of species identified in North Fork Elkhead Creek.

Species Name	Scientific Name	Status
Colorado River cutthroat	*Oncorhynchus clarkii pleuriticus*	State - Species of Special Concern
mottled sculpin	*Cottus bairdii*	None
mountain sucker	*Catostomus platyrhynchus*	State - Species of Special Concern
speckled dace	*Rhinichthys osculus*	None

ISF Quantification

CWCB staff relies upon the biological expertise of the recommending entity to quantify the amount of water required to preserve the natural environment to a reasonable degree. CWCB staff performs a thorough review of the quantification analyses completed by the recommending entity to ensure consistency with accepted standards.

Methodology

CPW staff used the R2Cross methodology to develop the initial ISF recommendation. The R2Cross method is based on a hydraulic model and uses field data collected in a stream riffle (Espegren, 1996). Riffles are most easily visualized as the stream habitat types that would dry up first should streamflow cease. The field data collected consists of streamflow measurements and surveys of channel geometry at a transect and of the longitudinal slope of the water surface.

The field data is used to model three hydraulic parameters: average depth, average velocity, and percent wetted perimeter. Maintaining these hydraulic parameters at adequate levels across riffle habitat types also will maintain aquatic habitat in pools and runs for most life stages of fish and aquatic macro-invertebrates (Nehring, 1979). CPW staff interprets the model results to develop an initial recommendation for summer and winter flows. The summer flow recommendation is based on meeting 3 of 3 hydraulic criteria. The winter flow recommendation is based on meeting 2 of 3 hydraulic criteria. The model's suggested accuracy range is 40% to 250% of the streamflow measured in the field. Recommendations that fall outside of the accuracy range may not give an accurate estimate of the hydraulic parameters necessary to determine an ISF rate.

The R2Cross methodology provides the biological quantification of the amount of water needed for summer and winter periods based on empirical studies of fish species preferences. The recommending entity uses the R2Cross results and its biological expertise to develop an initial ISF recommendation. CWCB staff then evaluates water availability for the reach typically based on median hydrology (see the Water Availability section below for more details). The water availability analysis may indicate less water is available than the initial recommendation. In that case, the recommending entity either modifies the magnitude and/or duration of the recommended ISF rates if the available flows will preserve the natural environment to a reasonable degree, or withdraws the recommendation.

Data Analysis

R2Cross data was collected at two transects for this proposed ISF reach (See Table 2). Results obtained at more than one transect are averaged to determine the R2Cross flow rate for the reach of stream. The R2Cross model results in a winter flow of 2.5 cfs, which meets 2 of 3 criteria and is within the accuracy range of the R2Cross model. The R2Cross model results in a summer flow of 5.40 cfs.

Table 2. Summary of R2Cross transect measurements and results for North Fork Elkhead Creek.

Entity	Date	Streamflow (cfs)	Accuracy Range (cfs)	Winter Rate (cfs)	Summer Rate (cfs)
CPW/CWCB	10/28/2015 # 1	2.21	0.88 - 5.53	4.00	5.50[1]
CPW/CWCB	10/28/2015 # 2	2.12	0.85 - 5.30	0.89	5.30[1]
			Mean	2.50	5.40

[1] *This flow is derived from the upper limit of the R2CROSS modeling accuracy and is used in the computation of the summer flow recommendation. The flow that meets all three instream flow criteria is outside of the confidence interval for this data set.*

ISF Recommendation

CPW recommended flow rates were based on R2Cross modeling analyses, biological expertise, and a preliminary water availability analysis. 5.4 cfs was recommended for the snowmelt runoff period from April 1 through June 30. This recommendation was driven by velocity criteria to provide critical habitat for the aquatic environment. 2.5 cfs was recommended for the base flow period from July 1 to March 30. This flow was mainly driven by depth and wetted perimeter. The goal of this

recommendation is to provide spawning habitat and overwintering habitat for the native species present.

The CPW recommendation was modified by staff as a result of water availability. The final recommendations numbers are as follows:

1.8 cfs is recommended for the period December 1 to March 31.

5.4 cfs is recommended for the snowmelt runoff period from April 1 to June 30.

1.2 cfs is recommended for the period July 1 to July 31.

0.57 cfs is recommended for the period August 1 to September 17.

1.4 cfs is recommended for the period September 18 to November 30.

Water Availability
CWCB staff conducts hydrologic analyses for each recommended ISF appropriation to provide the Board with a basis for making the determination that water is available.

Methodology
Each recommended ISF reach has a unique flow regime that depends on variables such as the timing, magnitude, and location of water inputs (such as rain, snow, and snowmelt) and water losses (such as diversions, reservoirs, evaporation and transpiration, groundwater recharge, etc). Although extensive and time-consuming investigations of all variables may be possible, staff takes a pragmatic and cost-effective approach to analyzing water availability. This approach focuses on streamflows and the influence of flow alterations, such as diversions, to understand how much water is physically available in the recommended reach.

Staff's hydrologic analysis is data-driven, meaning that staff gathers and evaluates the best available data and uses the best available analysis method for that data. Whenever possible, long-term stream gage data (period of record 20 or more years) will be used to evaluate streamflow. Other streamflow information such as short-term gages, temporary gages, spot streamflow measurements, diversion records, and StreamStats will be used when long-term gage data is not available. StreamStats, a statistical hydrologic program, uses regression equations developed by the USGS (Capesius and Stephens, 2009) to estimate mean flows for each month based on drainage basin area and average drainage basin precipitation. Diversion records will also be used to evaluate the effect of surface water diversions when necessary. Interviews with water commissioners, landowners, and ditch or reservoir operators can provide additional information. A range of analytical techniques may be employed to extend gage records, estimate streamflow in ungaged locations, and estimate the effects of diversions. The goal is to obtain the most detailed and reliable estimate of hydrology using the most efficient analysis technique.

The final product of the hydrologic analysis used to determine water availability is a hydrograph, which shows streamflow and the proposed ISF rate over the course of one year. The hydrograph will show median daily values when daily data is available; otherwise, it will present mean-monthly streamflow values. Staff will calculate 95% confidence intervals for the median streamflow if there is

sufficient data. Statistically, there is 95% confidence that the true value of the median streamflow is located within the confidence interval.

Basin Characteristics
The drainage basin of the proposed ISF on North Fork Elkhead Creek is 22.5 square miles, with an average elevation of 8,400 ft and average annual precipitation of 31.25 inches (See the Hydrologic Features Map). The drainage basin tributary to the proposed ISF reach has one known surface diversion (Ellis and Kitchens Ditch, appropriation date 1903 for 1.66 cfs and appropriation date 1966, 6.0 cfs for a total of 7.66 cfs). There are a small number of spring water rights, one 10 AF reservoir, and other small reservoirs (0.5 – 2 AF). Most of the water rights in the area are used to raise alfalfa or pasture. According to the water commissioner, Kathy Bower (contacted 9/7/2016), there is not very much irrigation use in the basin in the later part of the summer and early fall. Due to the number and amount of diversions, streamflow is somewhat altered from natural conditions.

Available Data
There is not a current streamflow gage on the proposed reach of North Fork Elkhead Creek. There was a historic gage, North Fork Elkhead Creek near Elkhead (USGS 09245500), located approximately 1 mile upstream from the proposed lower terminus at the confluence with Elkhead Creek. The gage operated from 1958 to 1973 and is no longer in use. The drainage basin of the gage is 21.4 square miles, with an average elevation of 8,460 ft and average annual precipitation of 31.51 inches. The Ellis and Kitchens Ditch is located upstream from the gage location. The effects of this diversion structure are partially included in the available gage data. According to the water commissioner, this structure does not sweep the stream. There are no known intervening diversions between the gage location and the proposed lower terminus.

CWCB staff made streamflow measurements during the 2015 site visit when R2Cross data was collected. These measurements are included in the water availability analysis.

Data Analysis
The Elkhead Creek near Elkhead gage has 15 years of record. This record is relatively long, which should provide good information about the range of hydrologic conditions in the area. The gage record was not scaled to the lower terminus because it would only result in a small increase in streamflow. Median streamflow and 95% confidence intervals for median streamflow were calculated using the North Fork Elkhead Creek near Elkhead gage record.

Water Availability Summary
The hydrographs (see the Complete and Detailed Hydrographs) show median streamflow and 95% confidence intervals for the median streamflow calculated from the North Fork Elkhead Creek near Elkhead gage record. The proposed ISF rate is below the median gage data during the majority of the year and below the upper 95% confidence interval from median streamflow at all times. Staff concludes that water is available for appropriation on North Fork Elkhead Creek.

Material Injury
Because the proposed ISF on North Fork Elkhead Creek is a new junior water right, the ISF can exist without material injury to other water rights. Under the provisions of section 37-92-102(3)(b), C.R.S. (2016), the CWCB will recognize any uses or exchanges of water in existence on the date this ISF water right is appropriated.

Citations

Capesius, J.P. and V.C. Stephens, 2009, Regional regression equations for estimation of natural streamflow statistics in Colorado, Scientific Investigations Report 2009-5136.

CRCT Conservation Team, 2006, Conservation agreement for Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) in the states of Colorado, Utah, and Wyoming. Colorado Division of Wildlife, Fort Collins.

CRCT Conservation Team, 2006, Conservation strategy for Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) in the states of Colorado, Utah, and Wyoming. Colorado Division of Wildlife, Fort Collins.

Espegren, G.D., 1996, Development of Instream Flow Recommendations in Colorado Using R2CROSS, Colorado Water Conservation Board.

Nehring, B.R., 1979, Evaluation of Instream Flow Methods and Determination of Water Quantity Needs for Streams in the State of Colorado, Colorado Division of Wildlife.

Metadata Descriptions

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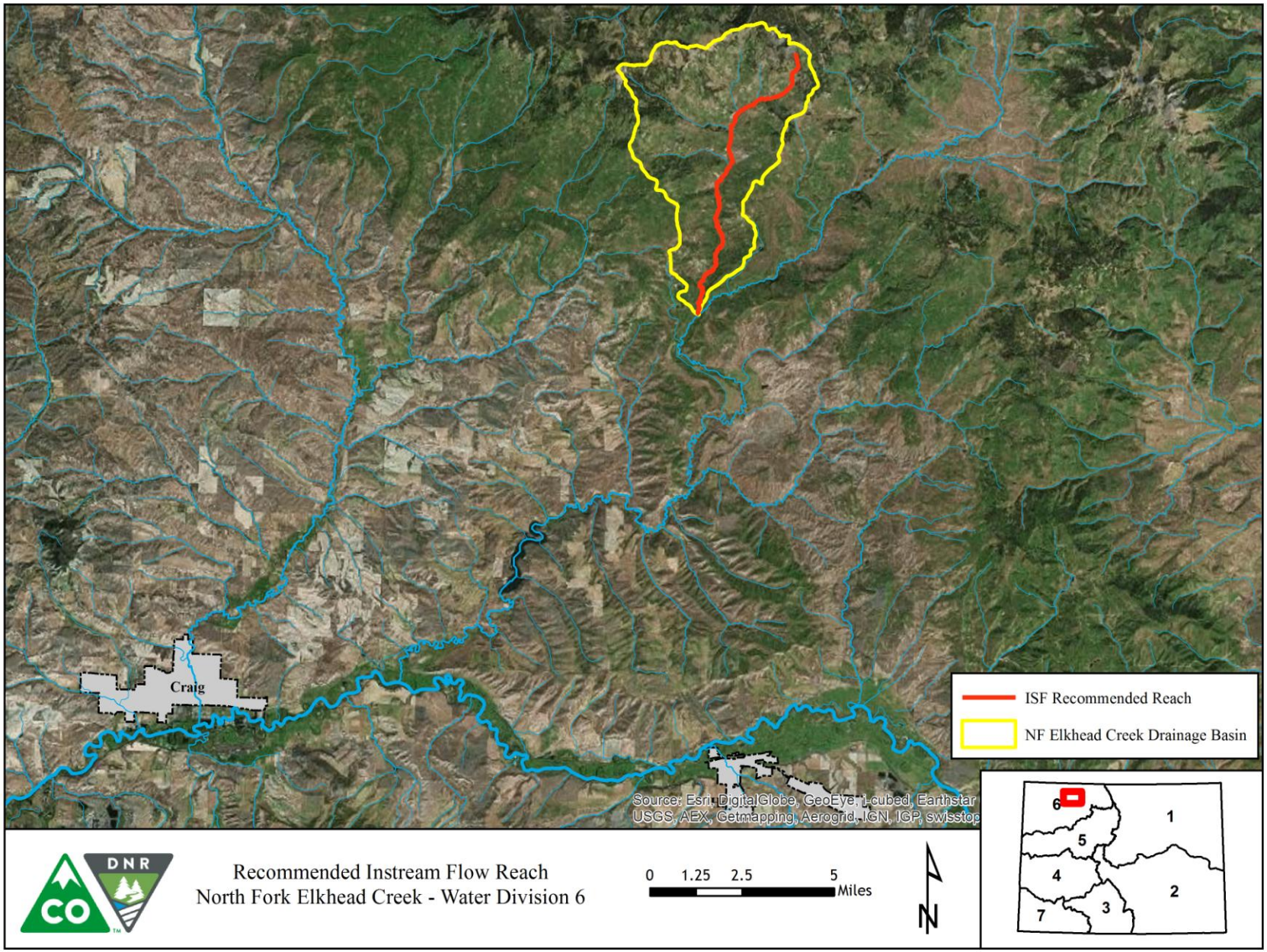
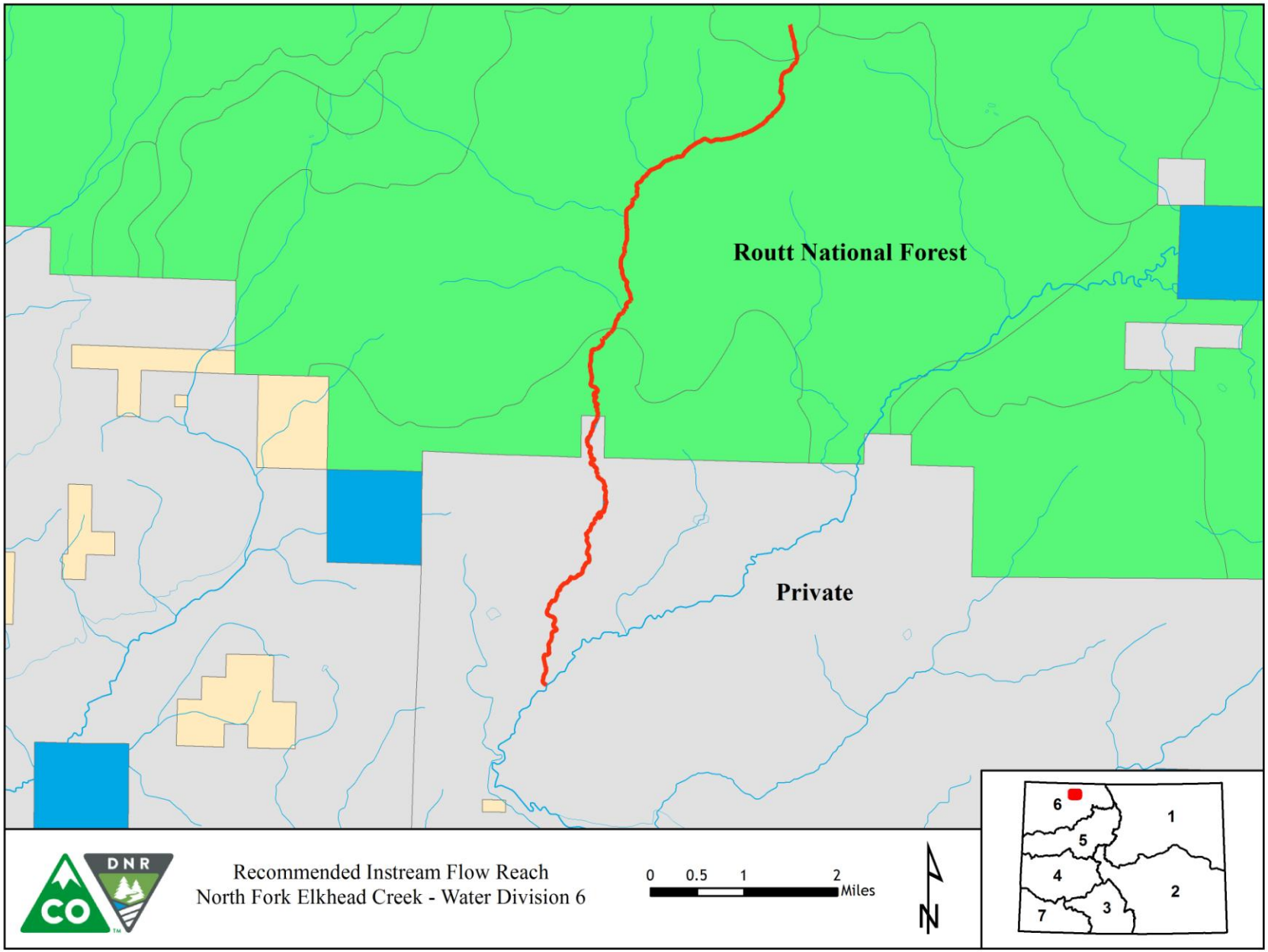
Projected Coordinate System: NAD 1983 UTM Zone 13N.

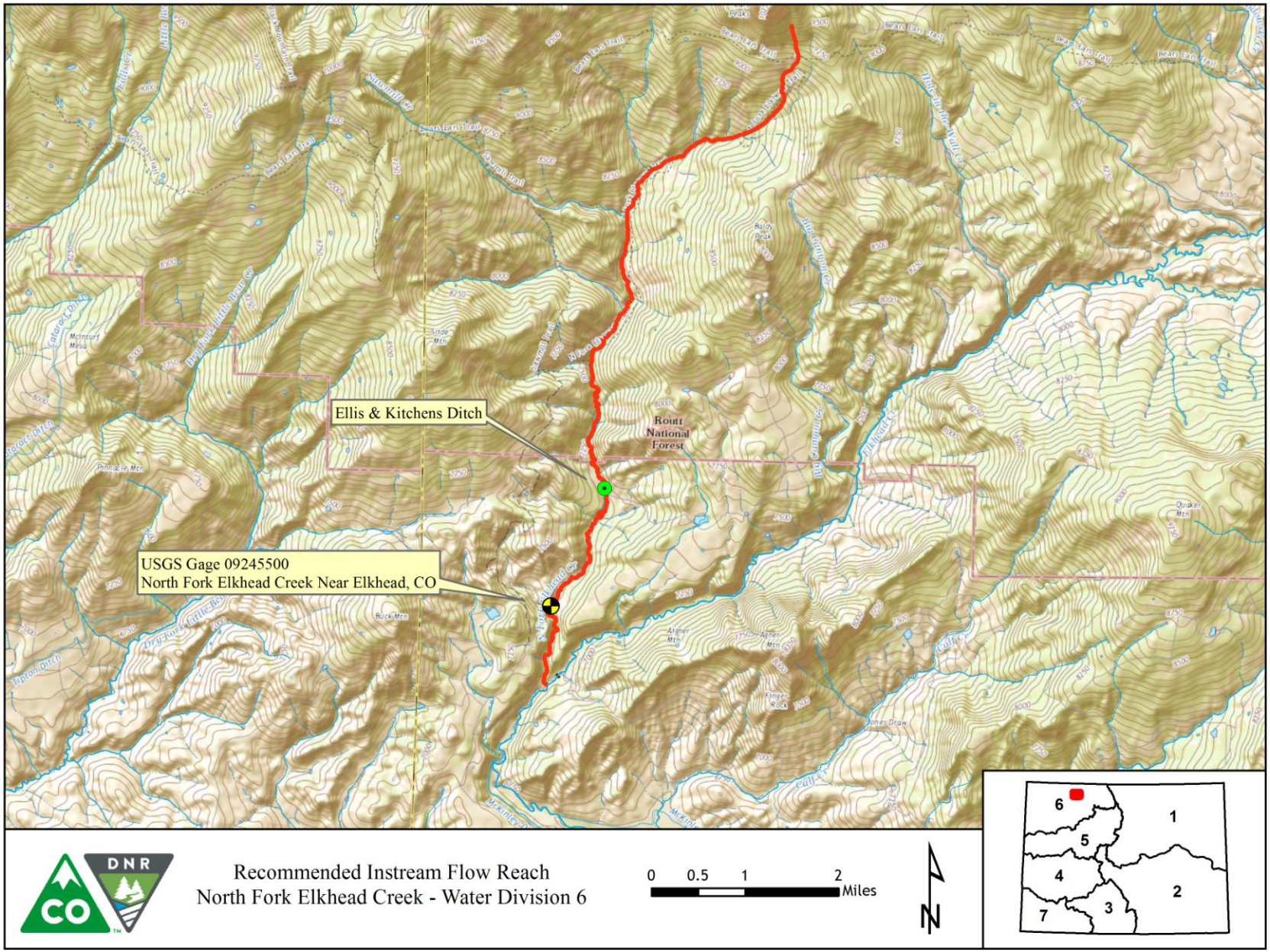
VICINITY MAP



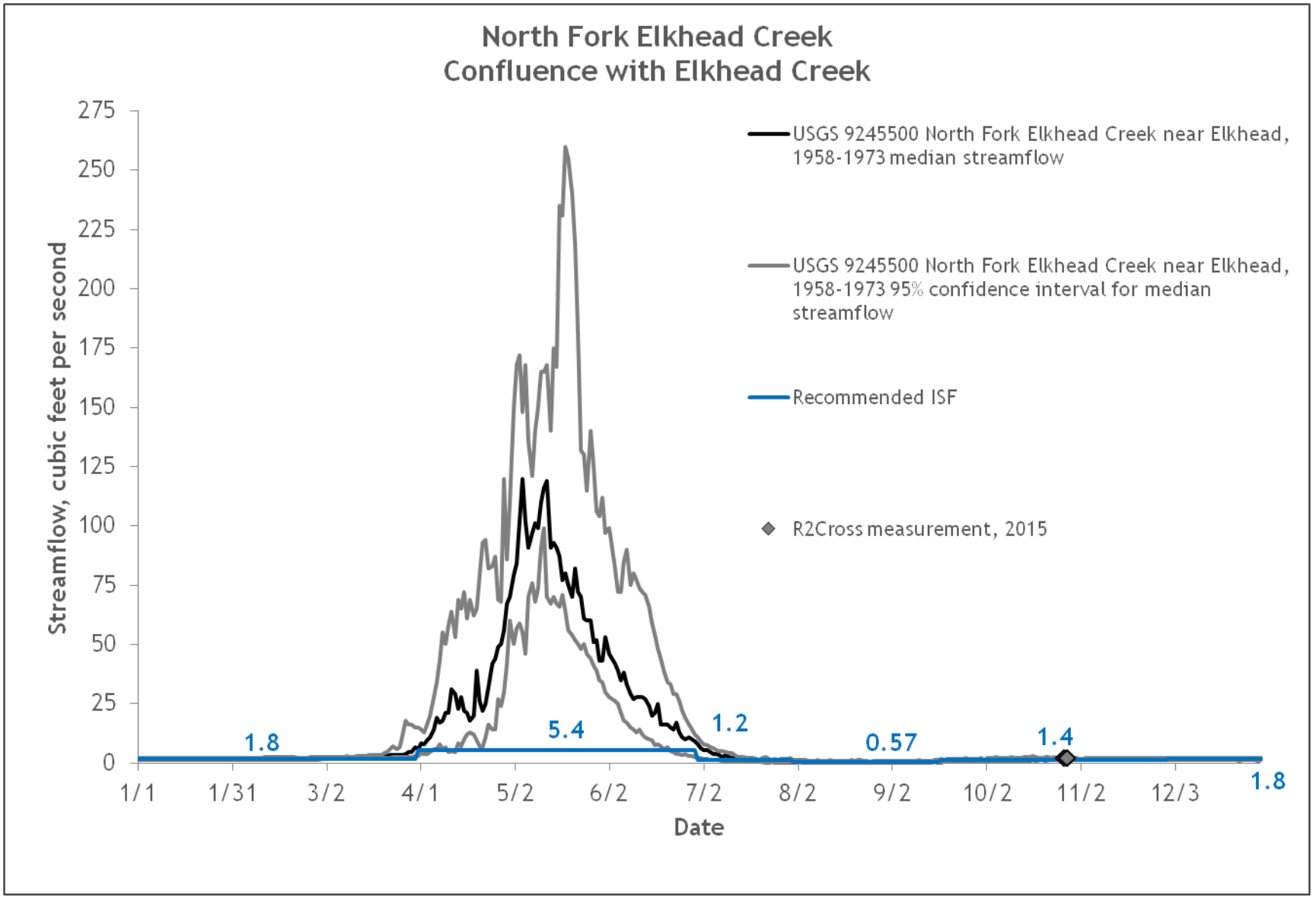
LAND OWNERSHIP MAP



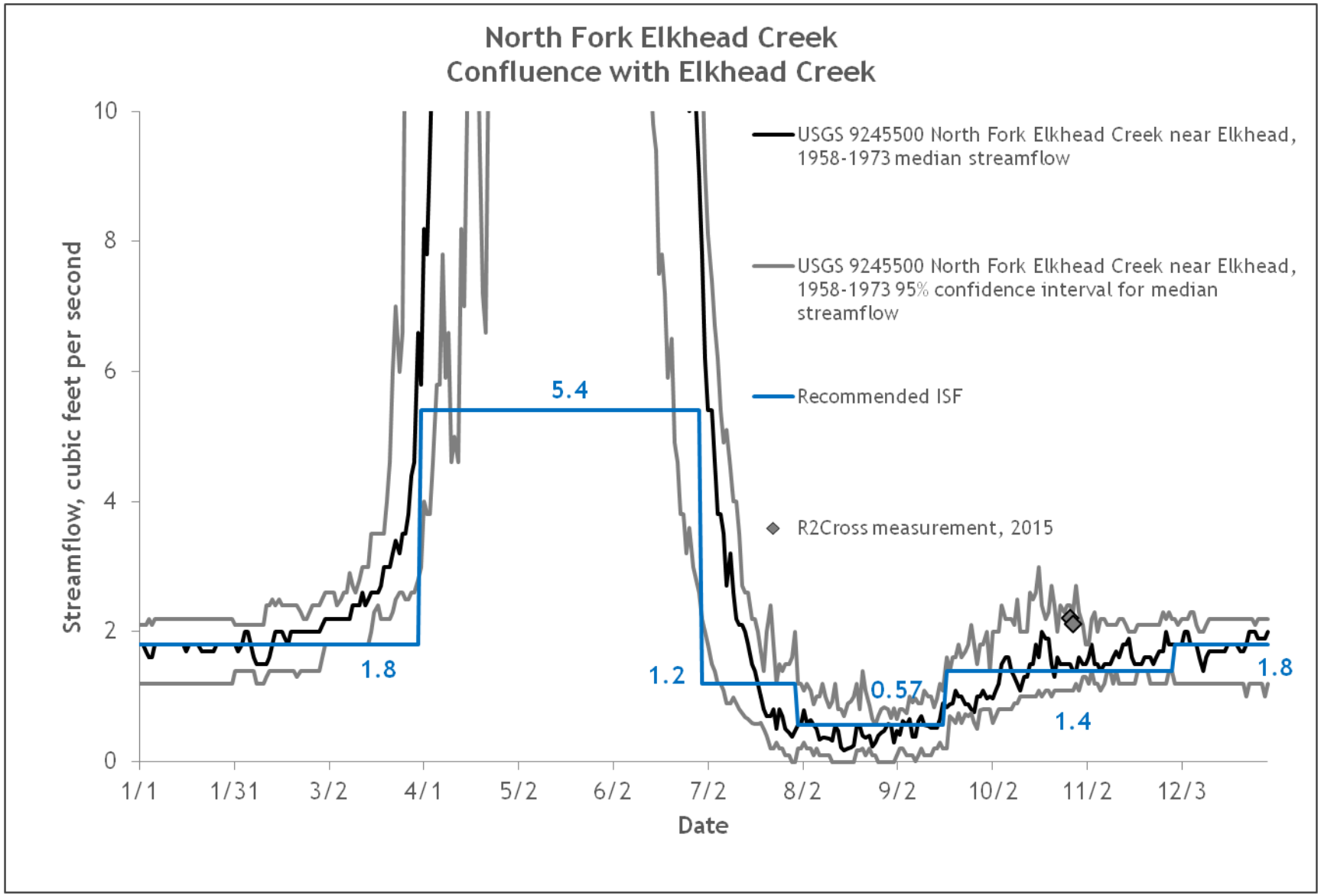
HYDROLOGIC FEATURES MAP



COMPLETE HYDROGRAPH



DETAILED HYDROGRAPH



COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Slater Creek

EXECUTIVE SUMMARY

CWCB STAFF INSTREAM FLOW RECOMMENDATION

UPPER TERMINUS:	Confluence Beaver Creek UTM North: 4529487.44	UTM East: 303385.46
LOWER TERMINUS:	USGS Gage # 09255000 UTM North: 4539540.79	UTM East: 299527.79
WATER DIVISION:	6	
WATER DISTRICT:	54	
COUNTY:	Moffat	
WATERSHED:	Little Snake	
CWCB ID:	17/6/A-004	
RECOMMENDER:	Bureau of Land Management (BLM)	
LENGTH:	12.58 miles	
FLOW RECOMMENDATION:	25 (03/16 – 04/15) 74 (04/16 - 06/30) 25 (07/01 - 07/15) 10 (07/16 - 07/31) 6.5 (08/01 - 09/15) 8.5 (09/16 - 10/15) 16 (10/16 - 03/15)	

Slater Creek

Introduction

Colorado's General Assembly created the Instream Flow and Natural Lake Level Program in 1973, recognizing "the need to correlate the activities of mankind with some reasonable preservation of the natural environment" (see 37-92-102 (3), C.R.S.). The statute vests the Colorado Water Conservation Board (CWCB or Board) with the exclusive authority to appropriate and acquire instream flow (ISF) and natural lake level water rights (NLL). Before initiating a water right filing, the Board must determine that: 1) there is a natural environment that can be preserved to a reasonable degree with the Board's water right if granted, 2) the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made, and 3) such environment can exist without material injury to water rights.

The BLM recommended that the CWCB appropriate an ISF water right on a reach of Slater Creek. Slater Creek originates on the west side of Diamond Mountain in the Elkhead Mountains at an elevation of approximately 8,400 ft, about 25 miles northeast of Hayden. The Creek flows in a northerly direction as it drops to an elevation of approximately 6,600 ft where it joins the Little Snake River. The proposed reach is located within Moffat County (See Vicinity Map) and extends from the confluence with Beaver Creek downstream to USGS Gage # 09255000. Seven percent of the land on the 12.58 mile proposed reach is publicly owned and managed by the BLM; the remaining land is privately held (See Land Ownership Map). The BLM recommended this reach of Slater Creek because it has a natural environment that can be preserved to a reasonable degree with an ISF water right.

The information contained in this report and the associated supporting data and analyses (located at: (http://cwcb.state.co.us/environment/instream-flow-program/Pages/2017ProposedISFRecommendations.aspx) form the basis for staff's ISF recommendation to be considered by the Board. This report provides sufficient information to support the CWCB findings required by ISF Rule 5i on the natural environment, water availability, and material injury.

Natural Environment

CWCB staff relies on the recommending entity to provide information about the natural environment. In addition, staff reviews information and conducts site visits for each recommended ISF appropriation. This information is used to provide the Board with a basis for determining that a natural environment exists.

Slater Creek is a cold-water, moderate to high gradient stream. It flows through a canyon with a valley floor approximately one-fourth mile to one-half mile in width. The stream cuts through alluvial deposits in the valley and is confined by bedrock in some locations. The stream generally has large substrate, consisting of mostly of small cobbles and boulders of up to two feet in diameter. The stream has a good mix of swift runs, riffles, and pools in meander bends.

Fisheries surveys have revealed a self-sustaining native fish population comprised of bluehead sucker, speckled dace, and mottled sculpin. The fish population also includes fathead minnow and creek chub, which are nonnative species (See Table 1). Intensive macro-invertebrate surveys have not been conducted, but spot samples have revealed various species of mayfly, caddisfly, and stonefly.

The riparian community is generally comprised of narrowleaf cottonwood, alder, willows, sedges, and rushes. The riparian community is in generally in good condition. Given the wide channel, the riparian community provides some, but not extensive, shading and cover for fish.

Table 1. List of species identified in Slater Creek.

Species Name	Scientific Name	Status
bluehead sucker	*Catostomus discobolus*	BLM - Sensitive Species
speckled dace	*Rhinichthys osculus*	None
mottled sculpin	*Cottus bairdii*	None
fathead minnow	*Pimephales promelas*	None
creek chub	*Semotilus atromaculatus*	None

ISF Quantification

CWCB staff relies upon the biological expertise of the recommending entity to quantify the amount of water required to preserve the natural environment to a reasonable degree. CWCB staff performs a thorough review of the quantification analyses completed by the recommending entity to ensure consistency with accepted standards.

Methodology

BLM staff used the R2Cross methodology to develop the initial ISF recommendation. The R2Cross method is based on a hydraulic model and uses field data collected in a stream riffle (Espegren, 1996). Riffles are most easily visualized as the stream habitat types that would dry up first should streamflow cease. The field data collected consists of streamflow measurements and surveys of channel geometry at a transect and of the longitudinal slope of the water surface.

The field data is used to model three hydraulic parameters: average depth, average velocity, and percent wetted perimeter. Maintaining these hydraulic parameters at adequate levels across riffle habitat types also will maintain aquatic habitat in pools and runs for most life stages of fish and aquatic macro-invertebrates (Nehring, 1979). BLM staff interprets the model results to develop an initial recommendation for summer and winter flows. The summer flow recommendation is based on meeting 3 of 3 hydraulic criteria. The winter flow recommendation is based on meeting 2 of 3 hydraulic criteria. The model's suggested accuracy range is 40% to 250% of the streamflow measured in the field. Recommendations that fall outside of the accuracy range may not give an accurate estimate of the hydraulic parameters necessary to determine an ISF rate.

The R2Cross methodology provides the biological quantification of the amount of water needed for summer and winter periods based on empirical studies of fish species preferences. The recommending entity uses the R2Cross results and its biological expertise to develop an initial ISF recommendation. CWCB staff then evaluates water availability for the reach typically based on median hydrology (see the Water Availability section below for more details). The water availability analysis may indicate less water is available than the initial recommendation. In that case, the recommending entity either modifies the magnitude and/or duration of the recommended ISF rates if the available flows will preserve the natural environment to a reasonable degree, or withdraws the recommendation.

Data Analysis

R2Cross data was collected at three transects for this proposed ISF reach (Table 2). Results obtained at more than one transect are averaged to determine the R2Cross flow rate for the reach of stream. The R2Cross model results in a winter flow of 51.36 cfs, which meets 2 of 3 criteria and is within the accuracy range of the R2Cross model. The R2Cross model results in a summer flow of 73.69 cfs, which meets 3 of 3 criteria and is within the accuracy range of the R2Cross model.

Table 2. Summary of R2Cross transect measurements and results for Slater Creek.

Entity	Date	Streamflow (cfs)	Accuracy Range (cfs)	Winter Rate (cfs)	Summer Rate (cfs)
BLM	06/16/2015	123.16	49.26 - 307.90	57.50	109.27
BLM	07/08/2015 # 1	50.47	20.19 - 126.18	out of range	34.06
BLM	07/08/2015 # 2	50.93	20.37 - 127.33	45.21	77.75
			Mean	51.36	73.69

ISF Recommendation

BLM's analysis of this data, coordinated with Colorado Parks and Wildlife, indicates that the following flows are needed to preserve the fishery and natural environment to a reasonable degree.

74.0 cfs is recommended during the snow melt runoff period from April 16 to June 30. This recommendation is driven by the average depth criteria. Slater Creek experiences significant icing during the winter months and habitat is extremely limited. During ice-free periods, it is important to protect a flow rate that makes as much habitat as possible available to the fish population while it is completing critical life history functions. It is also important to make as much physical habitat as possible available to fish that enter Slater Creek from the Little Snake River. Finally, this flow rate should help recharge alluvial aquifers along Slater Creek that are important for sustaining the riparian community during annual low flow periods.

25.0 cfs is recommended from July 1 through July 15. This recommendation is driven by water availability. Protecting this intermediate flow rate on the descending limb of the hydrograph is important before fish are stressed by very low flows in mid-summer.

10.0 cfs is recommended from July 16 to July 31. This recommendation is driven by water availability. While this flow rate does not meet the instream flow criteria, it is critical in preventing significant fish kills along the creek. If additional water becomes available in the future, the BLM recommends that the CWCB increase the flow rate during this time period.

6.5 cfs is recommended from August 1 through September 15. This recommendation is driven by water availability. While this flow rate does not meet the instream flow criteria, it is critical in preventing significant fish kills along the creek. If additional water becomes available in the future, the BLM recommends that the CWCB increase the flow rate during this time period.

8.5 cfs is recommended from September 16 to October 15. This recommendation is driven by water availability. While this flow rate does not meet the instream flow criteria, it is critical in preventing significant fish kills along the creek. If additional water becomes available in the future, the BLM recommends that the CWCB increase the flow rate during this time period.

16.0 cfs is recommended during the period from October 16 to March 15. This recommendation is driven by limited water availability. This flow rate should prevent pools from freezing, allowing the fish population to successfully overwinter.

25.0 cfs is recommended from March 16 through April 15. This recommendation is driven by water availability. Protecting this intermediate flow rate on the ascending limb of the hydrograph is important because the fish population starts to actively feed and put on weight during this period, which prepares them for low flow periods that occur during mid-summer.

Water Availability

CWCB staff conducts hydrologic analyses for each recommended ISF appropriation to provide the Board with a basis for making the determination that water is available.

Methodology

Each recommended ISF reach has a unique flow regime that depends on variables such as the timing, magnitude, and location of water inputs (such as rain, snow, and snowmelt) and water losses (such as diversions, reservoirs, evaporation and transpiration, groundwater recharge, etc). Although extensive and time-consuming investigations of all variables may be possible, staff takes a pragmatic and cost-effective approach to analyzing water availability. This approach focuses on streamflows and the influence of flow alterations, such as diversions, to understand how much water is physically available in the recommended reach.

Staff's hydrologic analysis is data-driven, meaning that staff gathers and evaluates the best available data and uses the best available analysis method for that data. Whenever possible, long-term stream gage data (period of record 20 or more years) will be used to evaluate streamflow. Other streamflow information such as short-term gages, temporary gages, spot streamflow measurements, diversion records, and StreamStats will be used when long-term gage data is not available. StreamStats, a statistical hydrologic program, uses regression equations developed by the USGS (Capesius and Stephens, 2009) to estimate mean flows for each month based on drainage basin area and average drainage basin precipitation. Diversion records will also be used to evaluate the effect of surface water diversions when necessary. Interviews with water commissioners, landowners, and ditch or reservoir operators can provide additional information. A range of analytical techniques may be employed to extend gage records, estimate streamflow in ungaged locations, and estimate the effects of diversions. The goal is to obtain the most detailed and reliable estimate of hydrology using the most efficient analysis technique.

The final product of the hydrologic analysis used to determine water availability is a hydrograph, which shows streamflow and the proposed ISF rate over the course of one year. The hydrograph will show median daily values when daily data is available; otherwise, it will present mean-monthly streamflow values. Staff will calculate 95% confidence intervals for the median streamflow if there is sufficient data. Statistically, there is 95% confidence that the true value of the median streamflow is located within the confidence interval.

Basin Characteristics

The drainage basin of the proposed ISF on Slater Creek is 151 square miles, with an average elevation of 8,380 ft and average annual precipitation of 30.4 inches (See the Vicinity Map). The Slater Creek basin supports agriculture, among other uses. Hydrology is altered by water use within the basin.

Available Data
Slater Creek has a USGS gage located at the lower terminus (USGS 0255000 Slater Fork near Slater, CO). The proximity of the gage to the lower terminus and an extensive period of record (1931 to present) make this gage ideally suited for water availability analysis.

CWCB staff made one streamflow measurement on the proposed reach of Slater Creek as summarized in Table 3.

Table 3. Summary of streamflow measurement visits and results for Slater Creek

Visit Date	Flow (cfs)	Method
07/20/2016	11.93	Wading, Marsh McBirney

Data Analysis
The USGS Slater Creek gage was analyzed from 1/1/1931 to 8/8/2016 based on USGS approved data available through HydroBase on 10/14/2016. Median streamflow and 95% confidence intervals for median streamflow were calculated for the Slater Creek gage record.

Water Availability Summary
The hydrographs (See Complete Hydrograph and Detailed Hydrograph) show median streamflow and 95% confidence intervals for the median streamflow based on the Slater Creek gage record. The proposed ISF rate is below the median streamflow the majority of the time. The proposed ISF rate is below the 95% confidence interval of the median at all times. Staff has concluded that water is available for appropriation.

Material Injury
Because the proposed ISF on Slater Creek is a new junior water right, the ISF can exist without material injury to other water rights. Under the provisions of section 37-92-102(3)(b), C.R.S. (2016), the CWCB will recognize any uses or exchanges of water in existence on the date this ISF water right is appropriated.

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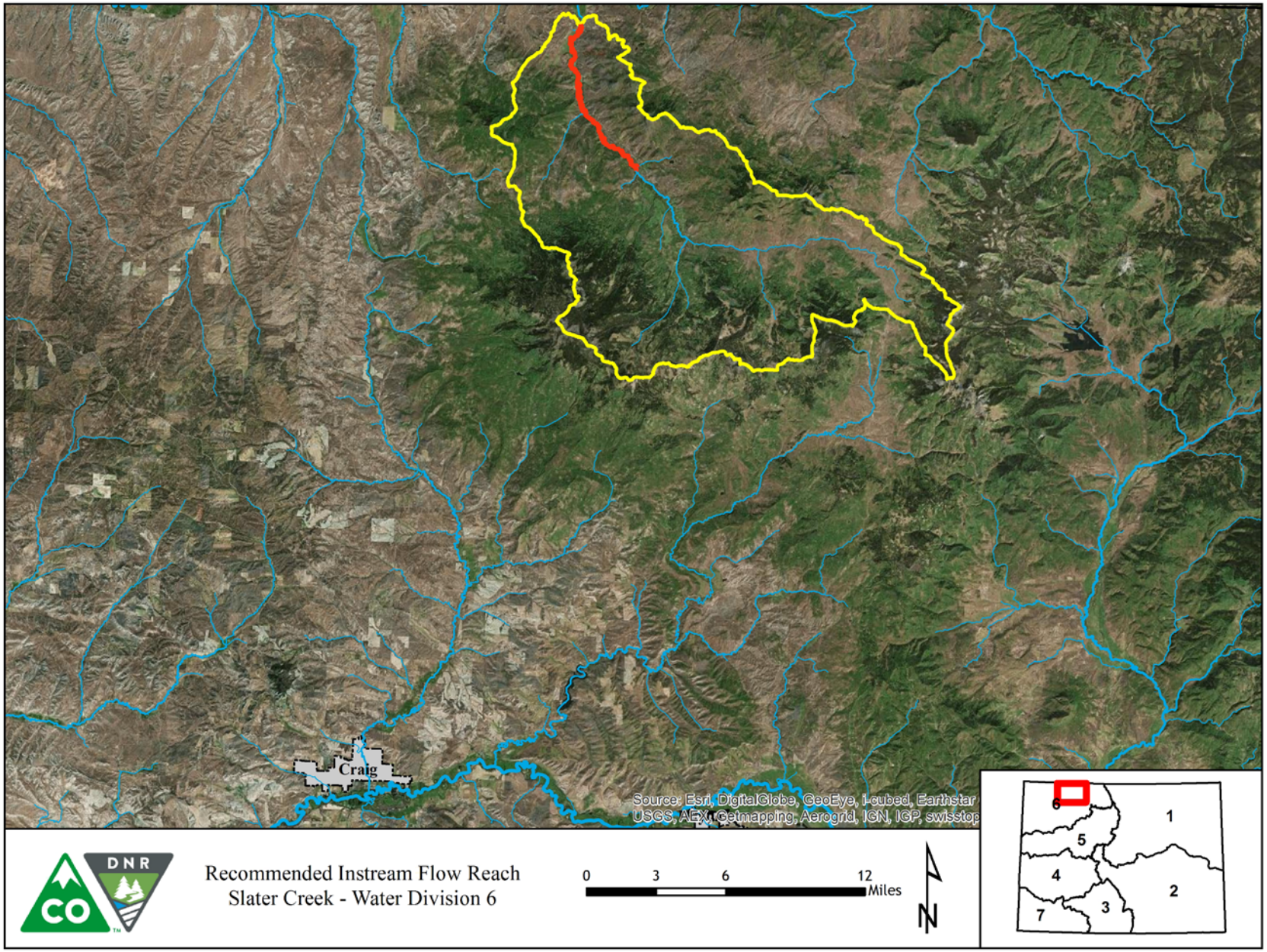
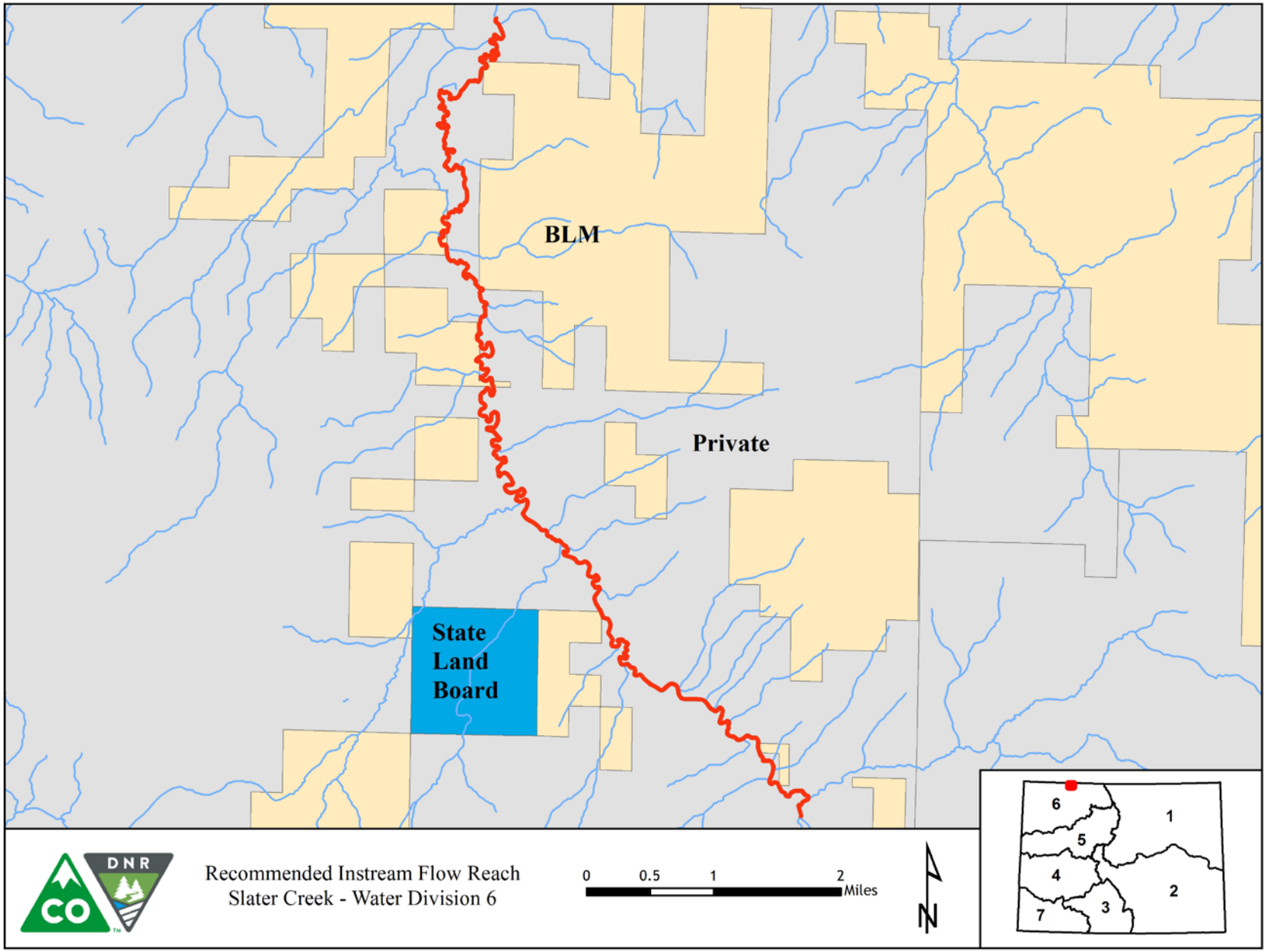


LAND OWNERSHIP MAP



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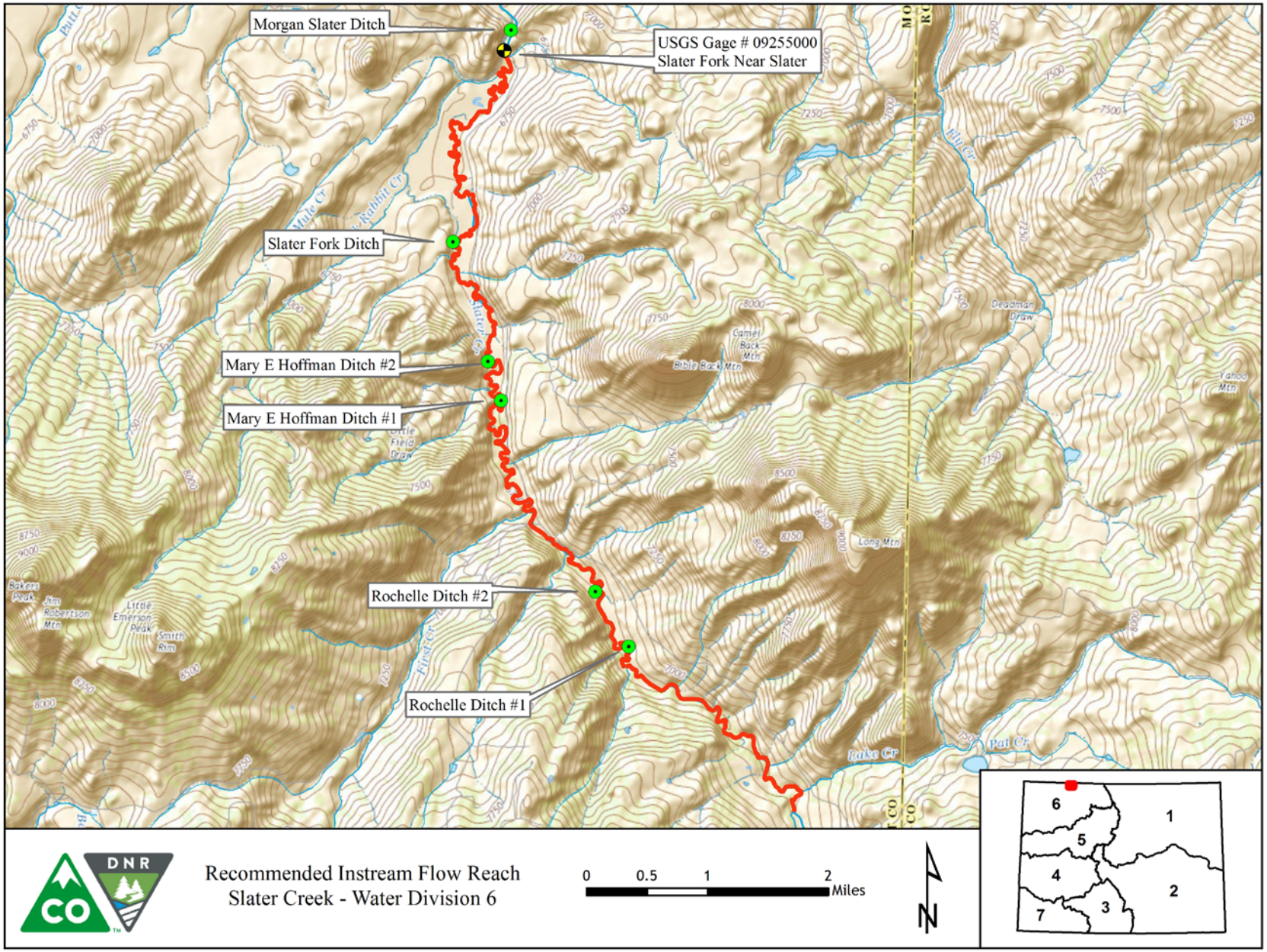
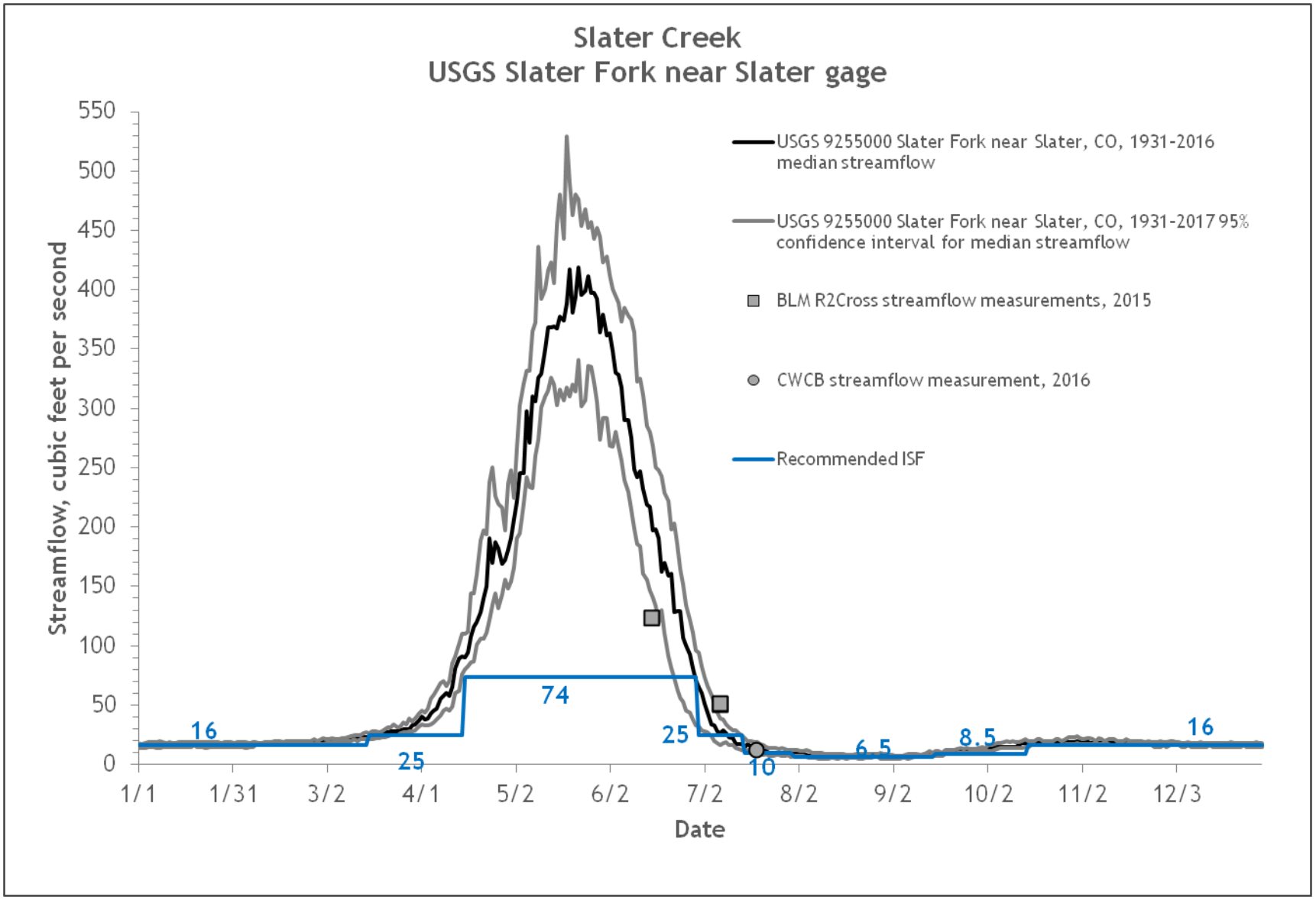


COMPLETE HYDROGRAPH



DETAILED HYDROGRAPH