FINAL

Yampa River Scorecard Project
Elk River Segment Results and Scoring

February 2026

Prepared for:

Friends of the Yampa
Steamboat Springs, Colorado

Prepared by:

Alba Watershed Consulting
Boulder, Colorado

Utah State University
Logan, Utah

YAMPA RIVER SCORECARD PROJECT

TABLE OF CONTENTS

LIST OF TABLES

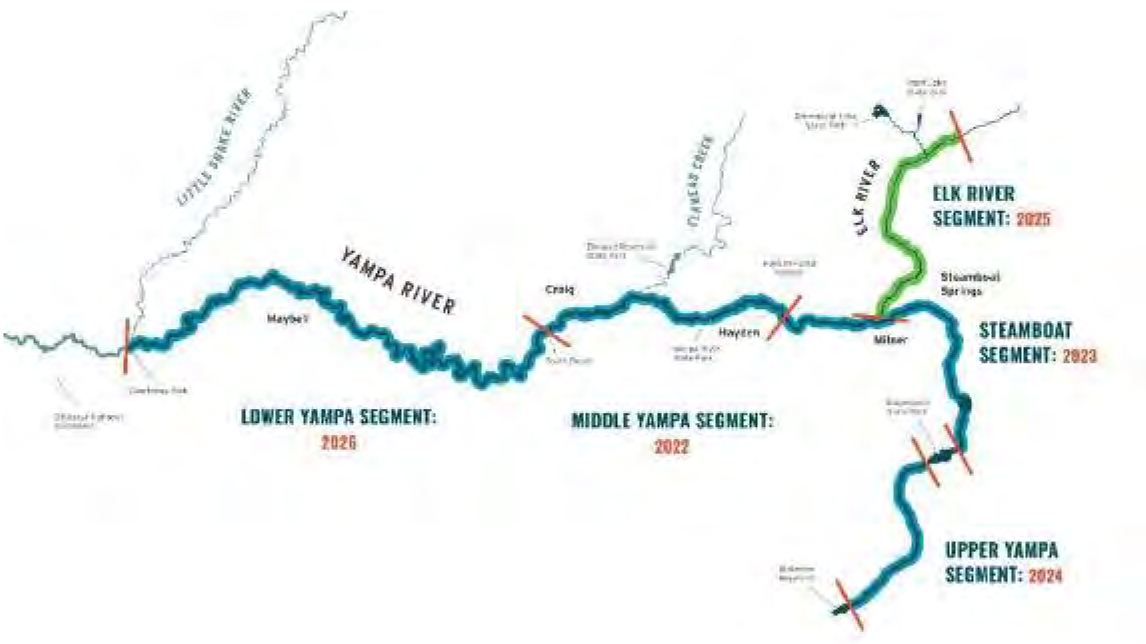
LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

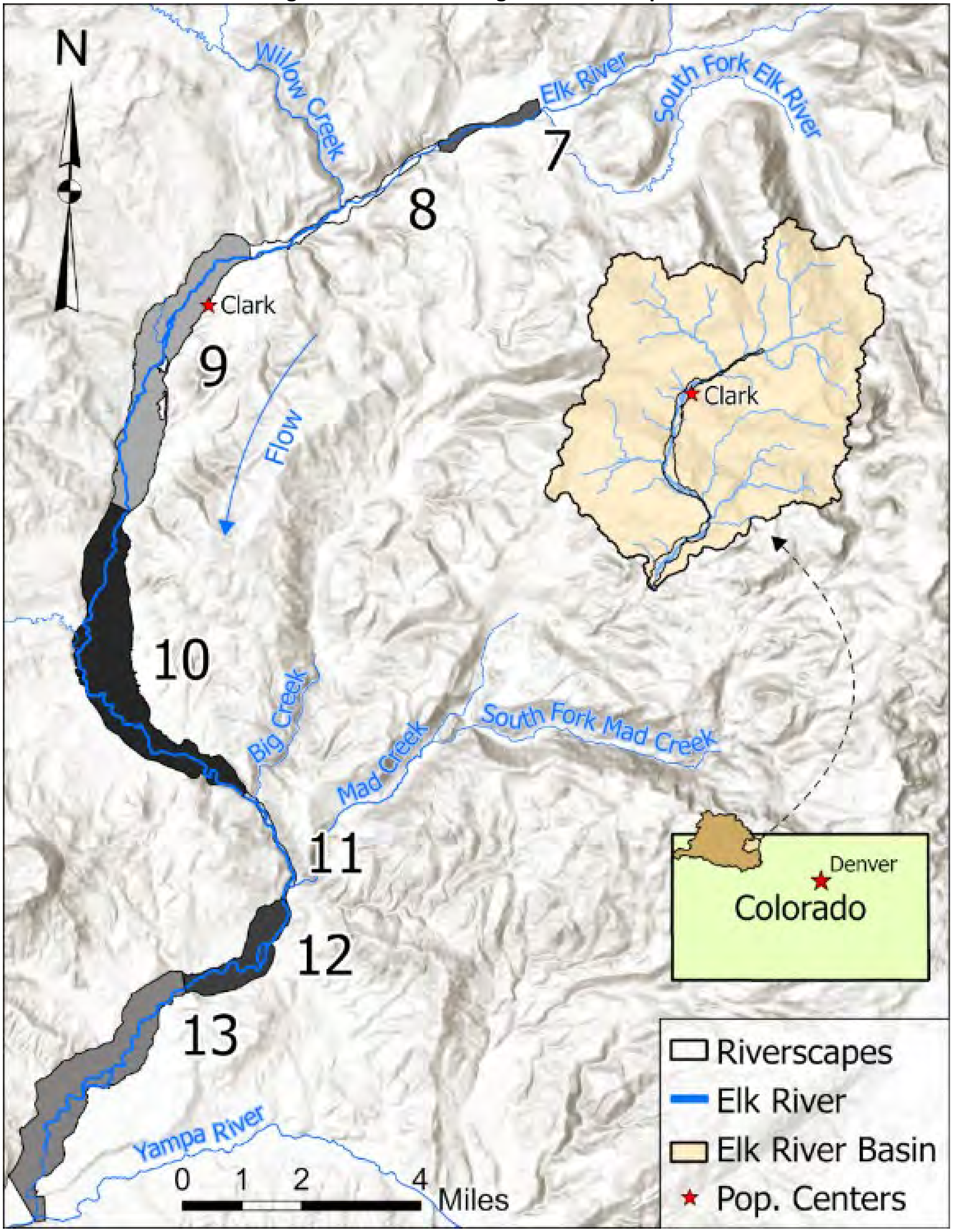
Friends of the Yampa is leading a community-based process to implement a long-term river health monitoring and evaluation program for the Yampa Basin that rates the overall condition of different segments of the Yampa and Elk Rivers and articulates results through a *Yampa River Scorecard*. This fourth iteration of the Yampa River Scorecard Project (YRSP) is focused on the Elk River segment of the Yampa River basin, a 32-mile segment of the main stem Elk River from its confluence with the South Fork Elk River to its confluence with the Yampa River. Figure 1-1 shows all five segments of the Yampa River Scorecard Project, as well as the schedule for completing assessments for each segment (Middle Yampa, 2022; Steamboat, 2023; Upper Yampa, 2024; Elk River, 2025; Lower Yampa, 2026). The Elk River segment begins at the confluence with the South Fork Elk River downstream of the Mount Zirkel Wilderness and ends at the confluence with the Yampa River just east of Milner. The segment follows the Elk River through a mixture of private property and the Medicine Bow-Routt National Forest, past the small hamlets of Glen Eden and Clark, and through a combination of large working ranches and small private developments. The Elk River segment also passes through the Christina State Wildlife Area (a Colorado Parks and Wildlife fishing easement) before it connects with the main stem Yampa River about 3 miles east of Milner.

Figure 1-1. Yampa River Scorecard Project Segments and Timeline



The Elk River segment includes 7 riverscapes, all of which were identified in the Yampa Integrated Water Management Plan (IWMP) remote assessment (Yampa IWMP 2021, Figure 1-2). A score for each indicator is developed for each riverscape and then averaged for an overall riverscape score (refer to Section 11 for more information). A weighted average across the seven riverscapes is then calculated to generate an overall ecological health and function score for the Elk River segment.

Figure 1-2. Elk River Segment Riverscapes



More information about the Yampa River Scorecard Project goals; background on determination of the five study segments and their planned timeframes; information related to the three stakeholder-identified attribute areas that are evaluated as part of the Scorecard effort (river uses and management, people and community benefits, and ecological health and function); and details specific to the categories, indicators, monitoring methods, and scoring criteria used to assess the ecological health and function attribute area are provided in the Yampa River Scorecard Project Indicators and Methods Report (FOTY/Alba Watershed Consulting 2021). To encourage community-wide engagement and contribution to tracking river health, the monitoring and evaluation process is communicated using concise, clear, and visually appealing methods; visit https://yampascorecard.org/ for the YRSP public interface.

This document details the results and rationale behind scoring of the ecological health and function attribute area for the Scorecard's Elk River segment. The YRSP Technical Committee agreed on a set of categories to evaluate river health and function, largely based on the Functional Assessment of Colorado Streams (FACStream, Beardsley et al. 2015), a reach-scale assessment tool developed for the US EPA and State of Colorado that rates stream health according to the degree of impairment of several ecological variables, and the Colorado Stream Health Assessment Framework (COSHAF), a stream health assessment framework based on the FACStream variables used in many stream management plans (SMP) across Colorado, including an SMP completed by the City of Steamboat Springs covering a 12-mile section of the Yampa River through the City (City of Steamboat Springs 2018). COSHAF uses 11 variables to: evaluate the key factors that determine the health and resilience of a stream reach, ensure that all relevant aspects of stream health are considered, and serve as a guide for determining which monitoring parameters are most relevant. COSHAF is now referred to as the Colorado River Health Assessment Framework (CoRHAF) by CWCB. Other river-related report card efforts, particularly the Eco Health Report Cards undertaken by the University of Maryland Center for Environmental Science and its partners, were consulted as well. Based on these existing scorecards and ongoing input from the Technical Committee, the following categories were identified for evaluation:

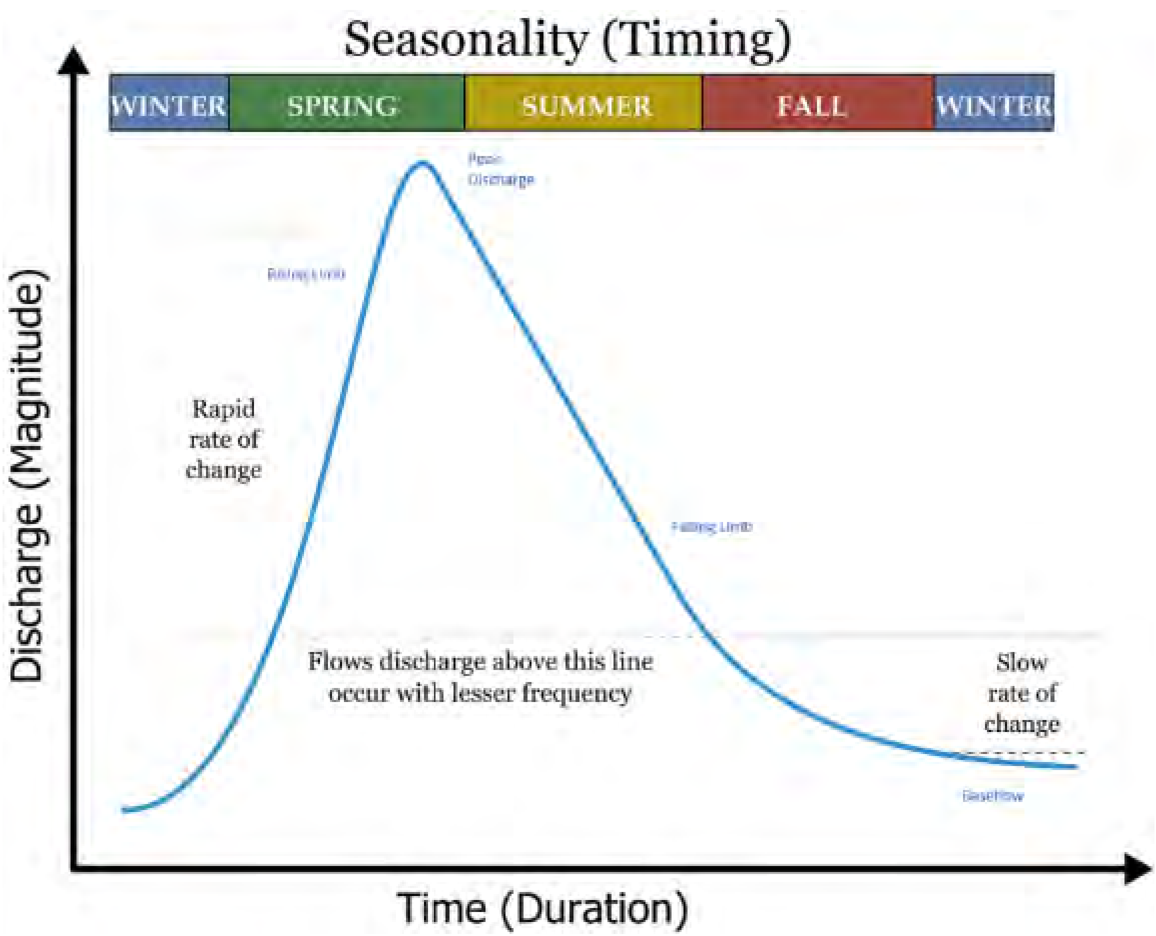
- Flow Regime (amount and timing of water supply);
- Sediment Regime (amount, timing, and type of sediment supply);
- Water Quality (physicochemical properties of water);
- Habitat Connectivity (aquatic and terrestrial habitat connectivity);
- Riverscape Connectivity (extent of riverscape/floodplain saturation or inundation);
- Riparian Condition (riparian habitat condition, including vegetation structure, diversity, and invasive species);
- River Form (channel morphology including planform, dimension, and profile);
- Structural Complexity (physical habitat including water depth, velocity, structural components, and substrate); and
- Biotic Community (community and trophic structure of the organisms in the reach).

The remainder of this document describes the suite of categories and indicators that, when evaluated, provide a comprehensive understanding of river health and function across the Elk River segment. Each sub-section discusses one of the nine categories listed above, with further subdivisions by indicator. The discussion of each indicator contains a description of the indicator, the data sources and methods used to evaluate the indicator, the scoring criteria that are applied, the results and rationale for scoring, and associated scores. Existing data are used to the extent possible, supplemented by additional data analysis and field data collection where specified. In the Elk River segment, every riverscape was visited on foot or by boat for field observations, except for minor portions of riverscapes 7 and 8, approximately 45% of riverscape 9, approximately 65% of riverscape 10, and approximately 10% of riverscape 11, mainly due to private property access considerations.

2.0 FLOW REGIME

Flow regime is defined as the characteristic pattern by which water is supplied to a river segment from its contributing watershed. It is often represented by a hydrograph, and is dictated by precipitation, inter- and intra-annual weather patterns, watershed characteristics, and human influences. Flow regime is a primary determinant of a river's structure and function. In particular, the magnitude, duration, frequency, and timing of river flow interact with the landscape to determine the functions that the river performs. The Yampa River Scorecard evaluates two indicators within the flow regime category: the overall **hydrograph** and the annual **snowpack**. Figure 2-1 provides a schematic diagram of an annual hydrograph, illustrating important concepts such as peak discharge, base flow, and rising and falling limbs. The final flow regime score is calculated as 90% hydrograph indicator score and 10% snowpack indicator score. The Technical Committee decided on this uneven split to avoid double counting and consider the fact that snowpack is a driver of flow regime and exerts a major influence on the elements of the hydrograph indicator.

Figure 2-1. Hydrograph Schematic Diagram



2.1 HYDROGRAPH INDICATOR

The hydrograph indicator considers the following components of the Yampa River's flow regime:

- Magnitude, timing, and duration of **peak flows**. Adequate peak flows are essential to river health and function. In particular, the magnitude of a high flow event controls how much of the floodplain is inundated, and for how long, and is therefore of substantial importance for maintaining riparian vegetation health, distributing sediment through and across the river corridor, building structural complexity, and enabling connectivity between in-channel and floodplain habitat. Snowmelt-driven peak flows during spring runoff are also important for numerous watershed services, such as fishery support, riparian habitat quality, sediment flushing, water quality maintenance, recreation, aesthetics, and groundwater connection and recharge.

- Magnitude, timing, and duration of **base flows**. Base flows are the low flows that occur after snowpack melt, during the dry season, usually from late summer to early spring. They provide critical support of aquatic habitat and riparian connectivity when the stream needs it most after peak flows have receded. Low flows help to maintain essential aquatic habitat, riparian vegetation, and a healthy fishery, and also influence water quality and sediment transport. Sources of base flows are rainfall events and slowly percolating groundwater, and they can be augmented by reservoir releases and irrigation return flows in managed systems.

- **Total annual flow volume**, or the amount of water delivered to the riverscape from its contributing watershed, is an important overall metric describing flow regime in the Yampa River basin both from a human use perspective and as it relates to water delivery across the riverscapes.

- Magnitude and variability of **flow rates of change**, or the rate at which flow changes (for example, how quickly flows rise during spring snowmelt), are important for various ecological aspects of the river, including habitat connectivity, aquatic habitat, riparian condition (particularly seedling establishment), and sediment transport. The speed at which flows change can be driven by rainfall, snowmelt, dam releases, diversion operations, and various other natural dynamics and human actions. Though there are some differences in their ecological and physical importance, here we evaluate both rising and falling rates together as one by considering the overall average change from natural to current conditions.

This analysis also considers timing of peak flow, which can be used as a proxy for changing climatic conditions that impact streamflow. Together, the various sub-indicators are given the following weights to determine a total score for the hydrograph indicator: 30% peak annual flow, 30% annual 7-day minimum flow, 20% annual flow volume, 15% flow rate of change, and 5% peak flow timing.

2.1.1 Data Sources and Evaluation Methods

Development of scores for this indicator relies heavily on existing USGS stream gauge data, modeled natural and existing streamflows, and local knowledge. As a holistic indicator, this variable uses expert judgement and review and analysis of available data to generate a single score for the hydrograph indicator.

The Elk River segment begins at the confluence with the South Fork of the Elk River and ends at the confluence with the Yampa River (Figure 1-2). A single stream gauge with a relatively extensive period of record exists within the Elk River segment:

- USGS 09242500 ELK RIVER NEAR MILNER, CO – This is an active USGS gauge located just above the confluence with the Yampa River (1904-present [daily]; 1990-present [continuous]).

Much of the analysis for the hydrograph indicator involves comparing existing flow conditions to modeled natural flows. A critical source for these data was hydrology modeling conducted by the Wilson Water Group (WWG) for the Basin Implementation Plan Phase 3 (WWG 2018), where stream gauge nodes within the Yampa Basin were used to explore the potential benefits and impacts of Yampa-White-Green Basin Roundtable projects under different hydrologic scenarios, including natural streamflows, baseline (existing) streamflows, and future scenario streamflows. The modeled natural flow regime is derived by removing the influence of human activities from current recorded streamflow to estimate natural, undisturbed flows at locations on the Yampa and Elk Rivers. Disturbance activities that can be accounted for include diversions, irrigated agriculture and return flows, storage and releases, and water rights administration. Existing streamflow conditions, referred to as baseline conditions, represent recorded diversions, current consumptive demands, administration, instream flow and recreational in-channel diversions (RICD), existing infrastructure, and reservoir operations, and include modifications based on water-user interviews. While the WWG modeling did not include pre-measurement changes to hydrology or paleohydrology in establishing "natural" streamflows, the authors of this report acknowledge the relative recency of the USGS and CO DWR stream gauge data.

The Yampa IWMP remote assessment's Data Synthesis Report (Yampa IWMP 2022) applied these data to percent departure of baseline conditions from natural conditions for two metrics: (1) percent departure of high flows and (2) percent departure of low flows. The two metrics were used in the remote assessment to provide a high-level, holistic indication of flow regime alteration within the Yampa basin. However, a more detailed hydrologic analysis of more than 107 metrics is presented in the Yampa River Hydrologic Review and Needs Assessment Report (Lotic 2021) and associated interactive online storyboard application (Mason 2021). Additional metrics from this report and an associated storyboard are changes in annual flow volume and rise and fall rates of the hydrograph from natural to human-altered conditions.

To rate the hydrograph indicator, streamflow data from the active USGS gauge listed above, as well as additional streamflow nodes within the 32-mile Elk River segment that are used in the detailed hydrologic analysis (Lotic 2021, Mason 2021), were used to determine the departure of existing flow regime from modeled natural flow conditions, as well as to compare the baseline hydrograph to the modeled natural hydrograph over the period of record. In particular, daily flow data for modeled baseline (modeled existing) and modeled natural flows for all gauges/nodes covering the years 1975-2013 are compared. Future iterations of the Yampa River Scorecard Project will explore acquiring similar modeled data that extends to more recent years (i.e., beyond 2013).

Riverscapes that lack modeling nodes are assumed to score similarly to the riverscape immediately upstream for metric(s) calculated from modeled data, except where significant withdrawals and/or tributaries exist within the riverscape that lacks nodes. In rare situations where riverscapes lack modeling nodes and there is no upstream riverscape, judgment is used to translate results from the next downstream riverscape. If no major tributaries or withdrawals are present, then this translation is deemed justifiable. This is done here for riverscape 7, which lacks modeling nodes and is the most upstream riverscape. Due to absence of any major tributaries between riverscapes 7 and 8, modeling nodes from riverscape 8 were considered reflective of riverscape 7.

Additional data sources used to augment this review of historical modeled hydrographs are current local knowledge of dry-up points that are not reflected in the existing stream gauge records, as well as a recent USGS publication investigating streamflow and water quality in the upper Yampa River Basin from 1992-2018 (Day 2021). This publication also conducts a streamflow trend analysis on the main stem Yampa River over a much longer time period (since 1910).

2.1.2 Scoring Criteria

The descriptive and semi-quantitative scoring criteria outlined in Table 2-1 are used to rate the hydrograph indicator. Each sub-indicator (e.g., 1-day maximum flow) is given a score and then sub-indicator scores are compiled by calculating a weighted average—30% for 1-day maximum (peak) flow, 30% for 7-day minimum (base) flow, 20% for total annual flow volume, 15% for flow rates of change, and 5% for shifting peak—to yield an overall score.

Table 2-1. Hydrograph Indicator Scoring Criteria

Grade	Description
A	Baseline hydrograph characteristics resemble the natural hydrograph. Magnitude and duration of annual discharge peaks and base flows closely resemble natural hydrograph. Percent of natural median 1-day maximum and 7-day minimum discharge estimated to be greater than or equal to 90% and lack of observable temporal downward trends in the gauge record exists. Net percent of natural flow greater than 90% of the total annual volume. Flow rates of change closely resemble natural hydrograph; average rise and fall rates greater than 90% of natural rates. No known or observed dry-up points.
B	Hydrograph has a near natural seasonal pattern, but peaks are attenuated, elevated, extended, or shortened, with 75-90% of natural median 1-day maximum flow magnitude. Seasonal 7-day minimum discharge approximately 75-90% of natural flow. One-day maximum and 7-day minimum flows lack statistically significant downward trends over time, though some observable trends may be present. Net percent of natural flow between 80-90% of total annual volume. Rate of change for flows are 80-90% of natural rates. No known or observed dry-up points.
C	Hydrograph has a natural seasonal pattern, but peaks are attenuated, elevated, extended, or shortened, with 50-75% of natural median 1-day maximum flow magnitude. Periods of biologically critical low flows occur occasionally, and seasonal 7-day minimum discharge is approximately 50-75% of natural flow. One-day maximum and 7-day minimum flows display statistically significant downward

	trends for a given time period (e.g., April flows) but not at the overall annual scale. Net percent of natural flow between 65-80% of total annual volume. Rate of change for flows are 60-80% of natural rates. Dry-up points have been observed in a few (1-3) locations.
D	Disrupted seasonal hydrograph patterns and/or similarity to natural median 1-day maximum flow magnitude less than approximately 50%. Periods of biologically critical low flows are frequent, with less than 50% of natural seasonal 7-day minimum discharge. One-day maximum and 7-day minimum flows display statistically significant downward trends for several given time periods (e.g., spring month flows) but not at the overall annual scale. Net change percent of natural flow between 50-65% of the total annual volume. Rates of change for flows are 50-60% of natural rates. Dry-up points have been observed in several (4-9) locations or comprise 1-10% of surveyed river length.
F	Disrupted seasonal hydrograph patterns and/or similarity to natural median 1-day maximum flow magnitude substantially less than approximately 50%. Frequent and extended periods of biologically critical low flows and/or periods of no flow occur, with less than 50% of natural seasonal 7-day minimum discharge. One-day maximum and 7-day minimum flows display statistically significant downward trends for a majority of given time periods (e.g., all but winter flows) and at the overall annual scale. Net percent of natural flow less than 50% of total annual flow volume. Rates of change for flows are less than 50% of natural rates. Dry-up points have been observed in many locations or comprise > 10% of surveyed river length.

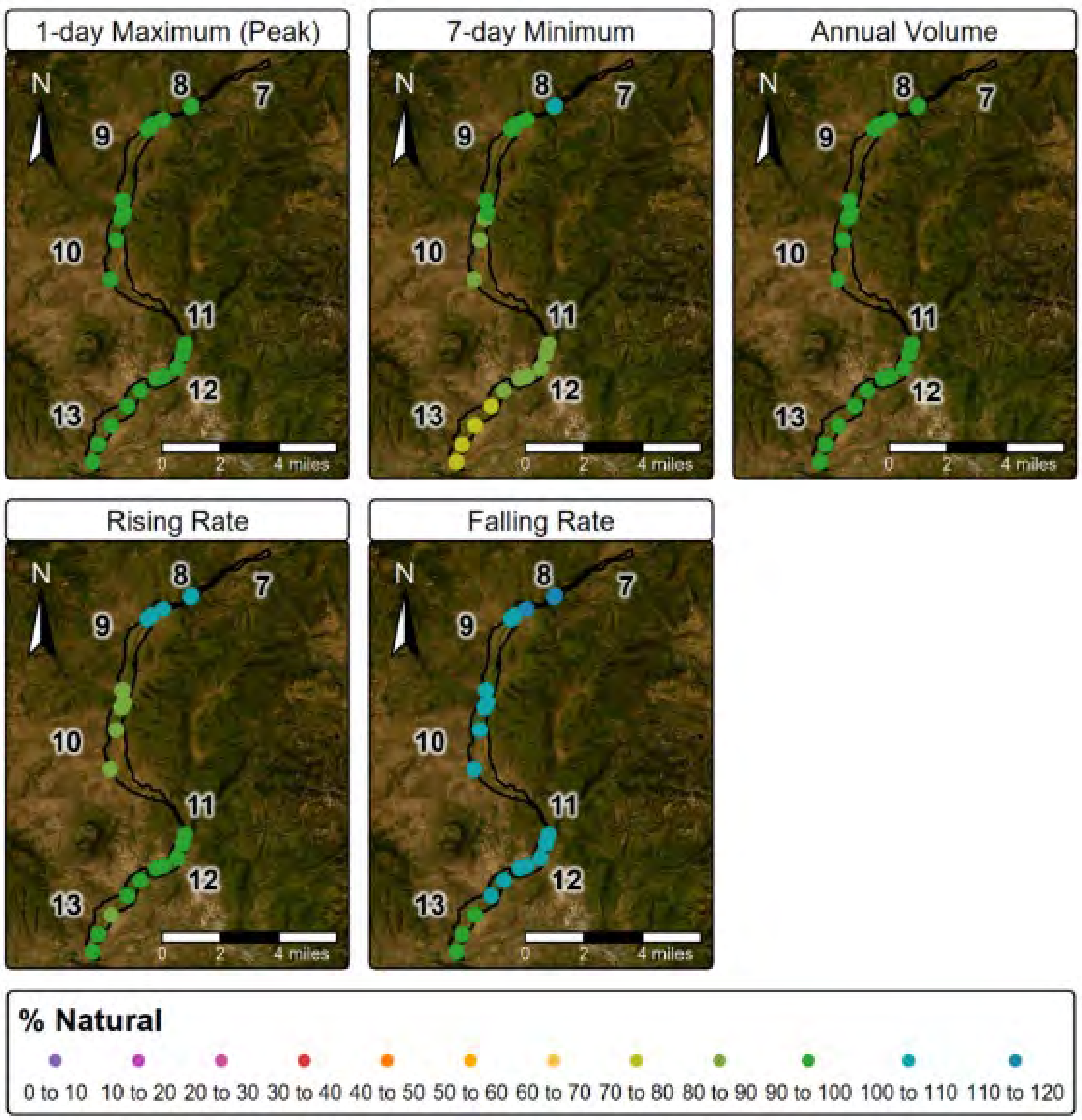
2.1.3 Results

Results and findings of previous reports regarding the health of the hydrologic regime on the Yampa River (Wilson Water Group 2018, Lotic 2021, Mason 2021) have been refined and synthesized to integrate into the Scorecard framework. Analysis focuses primarily on peak flows, minimum flows, total flow volume, and rates of flow rise and fall, as these correspond strongly with natural function. Additional consideration is given to the timing of peak flows.

Percent of natural annual 1-day maximum flows is a metric that reflects the degree to which the magnitude of high flow events has changed from modeled natural flows during the period of record studied (1975-2013) (Lotic 2021, Mason 2021). Model results indicate that average percent of natural flow conditions for the 1-day maximum flow per riverscape ranged from 97% to 100% of natural flows, suggesting very minor departures from natural conditions, if any (Figure 2-2). At USGS 09242500, Elk River at Milner, CO, located in riverscape 13, observable but not significant downward trends in 1-day maximum flow occurred in the summer months (Day 2021). Because this gauge station reflects flow conditions for all riverscapes in the watershed, this trend could potentially reduce the peak flow score slightly in each riverscape. However, evidence suggests that alterations of peak flow are minimal, and each riverscape scores an A for the peak flow component of the hydrograph indicator.

The metric assessing the percent departure in median annual 7-day minimum flow quantifies the extent to which low (base) flows are similar to modeled natural conditions. Modeling of this metric shows that departures from natural conditions are minimal in the upper Elk River riverscapes (riverscapes 7, 8, and 9), with minimum flows at 94-100% of natural flows. Altered (reduced) low flow is more observable in downstream riverscapes, ranging from 88% of natural flows in riverscape 10 to 79% of natural flows in riverscape 13 just above the confluence with the Yampa River (Figure 2-2). Similar to peak flows, downward trends in daily mean and 7-day minimum streamflow were observed in the summer months at the Elk River at Milner CO (USGS 09242500) gauge (Day 2021). Though these were not significant at the 90% confidence interval, they may continue if drivers of change in streamflow (e.g., declining snowpack and snowmelt runoff, shifts towards earlier season snowmelt peaks) persist. Downward trends in minimum streamflows may also be influenced by changes in water management and usage in the basin (Day 2021). Observed downward trends at the gauge slightly lowered baseflow scores throughout, though most substantially in the downstream-most riverscape 13, where the gauge is located. Baseflow scores were A in each of the upper riverscapes (7-9) and declined to the B range in downstream riverscapes (10-13) (Table 2-2).

Figure 2-2. Percent of Natural Flow Characteristics for Hydrograph Sub-Indicators at Elk River Modeling Nodes



Similar to peak flow, modeling of total flow volume shows that volume is minimally decreased compared to natural flows in all riverscapes of Elk River, ranging from a low of 94-95% of natural flow volume in riverscapes 10-13 to a high of 98% of natural flow volume in the upstream-most riverscapes (riverscapes 7 and 8). All riverscapes therefore received an A score for total flow volume.

Rising flow rates are approximately 90% of natural rates for riverscapes 10-13, and 97-100% of natural rates for riverscapes 7-9. Falling rates are similarly only moderately altered, with rates 104% of natural rates in riverscape 9, 100% of natural rates in riverscapes 10-12, and 95% of natural rates in riverscape 13. In the uppermost riverscapes 7 and 8, falling rates are slightly more altered (114% of natural rates). Overall, modeled flow rates of change largely resemble the natural hydrograph, and therefore each riverscape receives an A score for this metric.

Additionally, at the long-term gauge on the Yampa River (Yampa River at Steamboat Springs, CO, USGS 09239500) upstream of the Elk River confluence, a subtle yet significant shift in the date of peak flow towards earlier in the year has been identified (Day 2021), supported by a marginally significant p-value of 0.06 (Lotic 2021). Unfortunately, streamflow gauges on the Elk River lack the length of record necessary to complete a similar analysis of long-term trends. However, while the Steamboat gauge is located upstream of the Elk River confluence and therefore not technically reflective of flows in the Elk River basin, the observed trends in the Yampa River Basin, characterized by earlier peak flow events and a decline in annual streamflow, are consistent with the broader trends observed across the Colorado River Basin. They can be attributed to changing temperature patterns, particularly warming, which have led to reduced winter snowpack, reduced soil moisture, and an earlier onset of snowmelt during the spring. The impact of these changes on the riverscape is reflected in the riverscape scores for the overall hydrograph indicator using a shifting peak analysis, as detailed in Table 2-2. Overall, the available evidence suggests that changes to the natural hydrograph are minimal throughout the Elk River, and that the river retains much of its original character in this regard (Table 2-2).

Table 2-2. Hydrograph Indicator Scores by Riverscape

Riverscape	Peak Flow Score	Base Flow Score	Total Flow Volume Score	Flow Rates of Change Score	Shifting Peak Score*	Hydrograph Score
Riverscape 7	A	A	A	A		A
Riverscape 8	A	A	A	A		A
Riverscape 9	A	A	A	A		A
Riverscape 10	A	B+	A	A	C	A-
Riverscape 11	A	B	A	A		A-
Riverscape 12	A	B	A	A		A-
Riverscape 13	A	B-	A	A		A-

* Analysis of the timing of peak flow was done for USGS 09242500. The shifting peak analysis was incorporated holistically into overall scores for all riverscapes.

2.2 SNOWPACK INDICATOR

Much of the Yampa Basin is currently a snowmelt-driven system, meaning that the majority of river flows are derived from a melting snowpack in the springtime as opposed to rainfall or groundwater. In a snowmelt-driven system, snowpack characteristics have a direct effect on the basin's overall flow regime. This indicator considers maximum snowpack depth and associated maximum snow-water equivalent volume, timing of maximum snowpack, and timing from maximum snowpack to peak runoff.

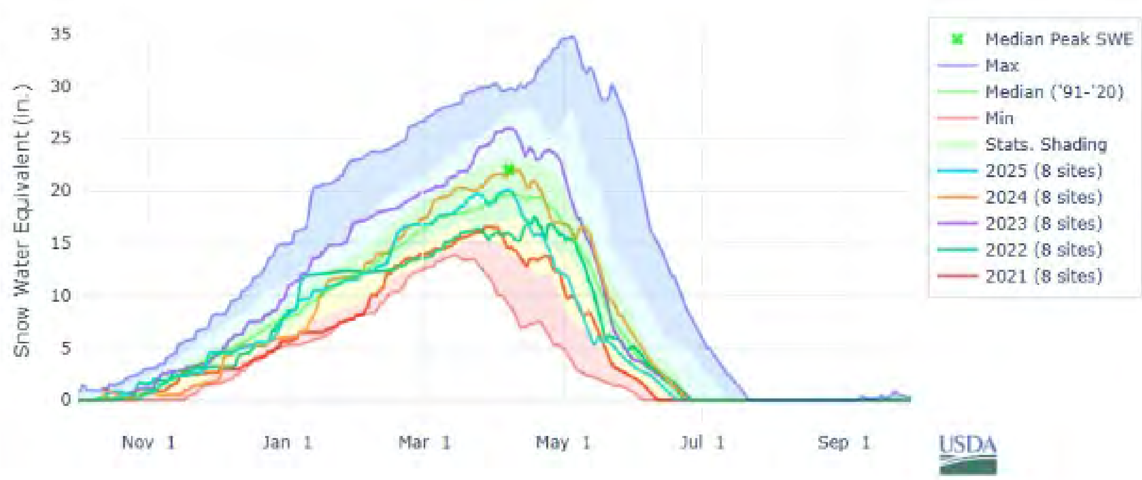
2.2.1 Data Sources and Evaluation Methods

Snowpack data (in the form of snow water equivalent, or SWE) is collected and shared by the Natural Resources Conservation Service (NRCS) collectively for the Yampa, White, and Little Snake River Basins. The NRCS typically compares SWE amounts and timing to the 30-year average and median curves (Figure 2-3). However, in using the NRCS dataset, the Yampa River Scorecard Project obtained data for the entire period of record instead of limiting the analysis to the most recent 30-year average. It also reviewed the locations of SNOTEL sites that generate the SWE data to ensure they are located in the contributing watershed for the current focal segment.

This indicator is evaluated as follows:

(1) Calculate the mean, 95% confidence interval, and standard deviation for maximum SWE (inches) for the period of record;
(2) Calculate the mean, 95% confidence interval, and standard deviation for timing of maximum snowpack (Julian date) for the period of record;
(3) Calculate the date of peak runoff for the USGS 09242500 ELK RIVER NEAR MILNER, CO stream gauge for each year in the coincident snow and streamflow record, and calculate the number of days from maximum snowpack to peak runoff;
(4) Calculate the mean, 95% confidence interval, and standard deviation for maximum snowpack to peak runoff (number of days) for the period of record; and
(5) Compare these statistics for the most recent 5-year period for which data are available (2021-2025) with statistics from the historical record to score this indicator.

Figure 2-3. Yampa Basin Snowpack Summary for the 2024-25 Water Year



2.2.2 Scoring Criteria

The semi-quantitative scoring criteria outlined in Table 2-3 are used to rate the snowpack indicator. Current conditions are considered to be the last five years of data, and the entire period of record for each SNOTEL site used in the analysis is provided in Table 2-4.

Table 2-3. Snowpack Indicator Scoring Criteria

Grade	Description
A	Current snowpack is within the range of historical conditions. Maximum snow-water equivalent (SWE) volume is within the 95% confidence interval (CI) of the period of record. Timing of maximum SWE is within the 95% CI of the period of record. Timing from maximum SWE to peak runoff is within the 95% CI of the period of record.
C	Current SWE volume is within one standard deviation of the period of record. Timing of maximum SWE is within one standard deviation of the period of record. Timing from maximum SWE to peak runoff is within one standard deviation of the period of record.
F	Current SWE volume is greater than one standard deviation from the period of record. Timing of maximum SWE is greater than one standard deviation from the period of record. Timing from maximum SWE to peak runoff is greater than one standard deviation from the period of record.

2.2.3 Results

Two SNOTEL sites, Lost Dog and Elk River, generate SWE data and are located within the contributing watershed for the Elk River segment (Figure 2-4). The periods of record at the Lost Dog and Elk River sites are 27 years and 47 years, respectively (Table 2-4).

Table 2-4. Elk River Segment Contributing Watershed SNOTEL Site Details

Station	Start Year*	End Year	Elevation (ft)
Lost Dog	1998	2025	9,340
Elk River	1978	2025	8,710

*Data begins with first snow of the denoted start year (generally in October).

Figure 2-5a compares the maximum annual SWE volume for the past 5 years of data (2021-2025) to the long-term mean (dashed line), 95% confidence interval (dark gray), and standard deviation (medium gray) generated from the period of record data. Maximum SWE volume over the last five years is generally within (and below) a single standard deviation of the period of record mean (Figure 2-5a), except in 2023, when maximum SWE greatly exceeded the mean and single standard deviation at both the Lost Dog and Elk River sites. In water year 2024, the maximum annual SWE is near the mean value for each of the SNOTEL stations, within the 95% confidence interval (Figure 2-5a). In 2021, 2022, and 2025, SWE volume is significantly below the mean (i.e., outside the 95% confidence interval) at each SNOTEL station, though still within a single standard deviation of the mean. Substantial exceedance of the mean in 2023 (Figure 2-5a) was directly beneficial to the Yampa River. However, this boon is unlikely to have offset the substantially lesser than average snowpack seen in three of the last five years (Figure 2-5a). Scores for maximum SWE for the 5-year period of record are found in Table 2-4.

Figure 2-5b shows the timing of maximum annual SWE volume (day of year)—hereafter referred to as peak SWE—for the past five years of data compared to the long-term mean (dashed line), 95% confidence interval (dark gray), and standard deviation (medium gray) generated from the period of record data. At the Elk River site, peak SWE occurred earlier than average in three of the past five years (2021, 2022, and 2024). At Lost Dog, peak SWE occurred later than average from 2022-2025, though from 2023-2025 this difference was slight. In 2021, peak SWE occurred earlier than average. At each SNOTEL site, the timing of maximum annual SWE is within a single standard deviation of the mean for all years except 2022 at the Elk River site (Figure 2-5b). Timing is within the 95% confidence interval at both sites for years 2023-2025, indicating that differences in timing are relatively insignificant. Timing scores are reported in Table 2-5.

Figure 2-4. Locations of Elk River Segment Contributing Watershed SNOTEL Sites

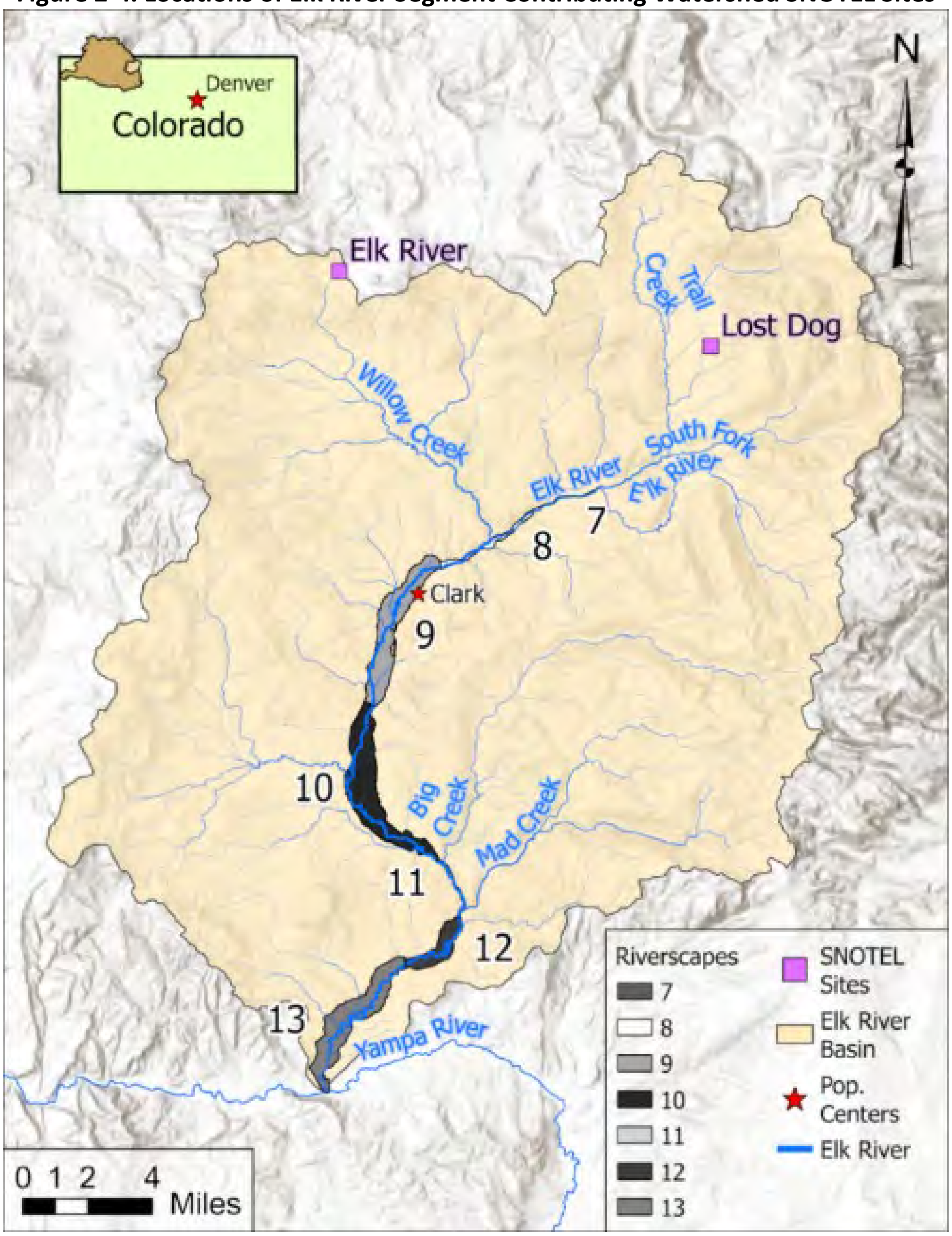
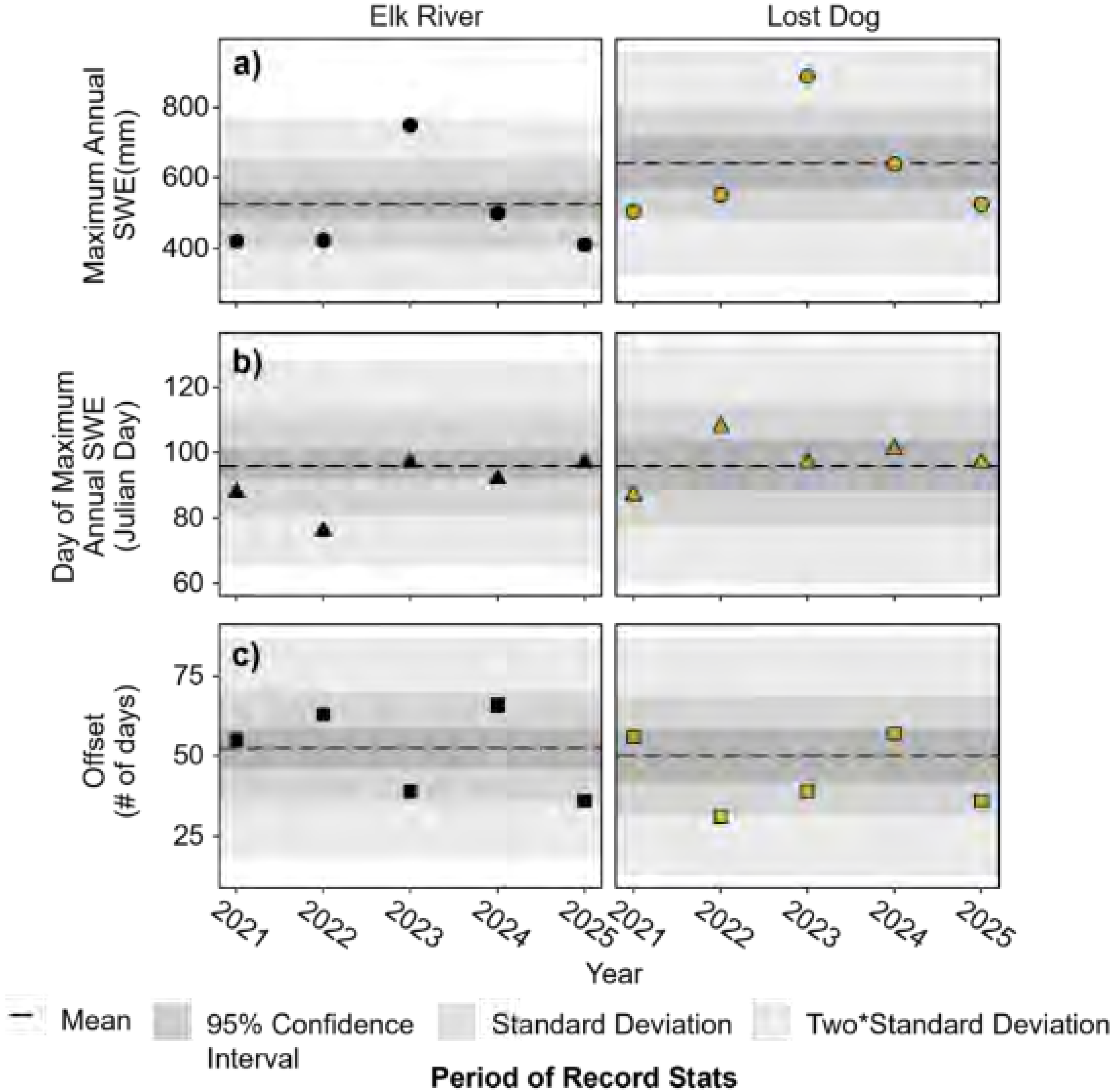


Figure 2-5. Maximum Annual SWE Volume (a), Timing of Maximum Annual SWE Volume (b), Offset of Maximum Annual SWE Volume and Peak River Discharge (c) (2021-2025) Compared to Long-Term Data



Finally, the length of time (i.e., offset) between the timing of peak SWE from the Elk River and Lost Dog SNOTEL stations and the timing of peak streamflow from the USGS Elk River near Milner, CO station are shown in Figure 2-5c. At the Elk River station, offset was longer than average in 2022 and 2024, shorter in 2023 and 2025, and roughly the same as average in 2021 (Figure 2-5c). Patterns were similar at the Lost Dog site, with an offset similar to average in 2021, shorter than average in 2023, and 2025, and longer than average in 2024. The principal difference between the two sites was seen in 2022, when offset was shorter than average at Lost Dog (Figure 2-5c). In general, offset values at Elk River are outside the 95% confidence interval but within a single standard deviation, suggesting that the relationship between streamflow and snowpack has been rather significantly different than the historical average over the last four water years. However, there is no consistent trend in offset, rendering additional interpretations difficult. Conversely, while offset values at the Lost Dog site have similarly been within the single standard deviation for three of the past five years, each of these values (years 2022, 2023, and 2025) are shorter than the historical mean. This suggests that the delay between peak snowpack volume and peak streamflow is somewhat consistently shortening, which may indicate a snowpack that is more rapidly melting (Figure 2-5c). The combined effect of reduced snowpack and early snowmelt can disrupt the usual hydrological dynamics. Offset scores are presented in Table 2-5.

The combination of the maximum annual SWE volume score, the timing score, and offset score resulted in an overall score of C+ for the Elk River SNOTEL station and B for the Lost Dog SNOTEL station. Data from both stations reflect the conditions in all riverscapes, so the average overall snowpack indicator score of B- from the two stations combined was applied to all riverscapes in the Elk River segment (Table 2-5).

Table 2-5. Snowpack Indicator Scores by SNOTEL Station

Station	Max Score	Timing Score	Offset Score	Overall Score
Elk River	B-	B-	C	C+
Lost Dog	B-	A-	B-	B
Elk River Segment (All Riverscapes)	B-			

3.0 SEDIMENT REGIME

Sediment regime is defined as the amount and timing of sediment that all sources, including land erosion in the contributing watershed and upstream channel erosion, supply to a reach, as well as patterns of sediment transport along and out of a reach. The production, transport, and deposition of sediment largely determines channel form and dynamics. Like changes to flow regime, an altered sediment regime can cause significant impacts to stream form and function, including aquatic habitat quality and long-term channel stability, and can damage infrastructure. The Yampa River Scorecard evaluates the system's sediment regime holistically, using a single indicator referred to as **sediment transport and continuity**.

3.1 SEDIMENT TRANSPORT AND CONTINUITY INDICATOR

The sediment transport and continuity indicator considers the ability of the system to maintain natural transport of sediment from its upstream and upgradient sources. Equally important components of sediment transport, erosion and deposition are natural processes critical to maintaining a healthy system. A key example of this in the Yampa Basin is cottonwood and willow riparian galleries that rely on bank erosion and its associated bar and substrate deposition to regenerate. Negative impacts from these processes tend to happen when they are severely limited or exacerbated by human land uses (e.g., bank stabilization and armoring) or natural disasters (e.g., extreme flood events). For the Yampa River Scorecard Project, this indicator is scored holistically and qualitatively by a professional geomorphologist. While sediment transport capacity is predominantly controlled by stream discharge and slope, the number and size of natural and unnatural impediments to sediment transport and the proportion of the reach and watershed from which sediment transport is limited or blocked have a significant impact.

3.1.1 Data Sources and Evaluation Methods

This indicator is scored using expert interpretation of stressors affecting sediment transport, which may be the same stresses affecting other natural processes. Scoring is based on field observations (Appendix A), aerial imagery, and GIS spatial data (e.g., calculated spacing of channel barriers). Signs of sediment aggradation or degradation outside of natural or expected patterns include disproportionate bar formation, increased bar stabilization, embeddedness by fine-grained material, disproportionate erosion, rapid meander migration, an incised channel with collapsing banks, and/or development of an inset floodplain. Field assessments are completed where appropriate to gain information about streambed substrate composition, stream power, sedimentation, embeddedness, and armoring. Review of additional documents, specifically a 2021 USGS report of water quality in the Upper Yampa Basin (Day 2021) and the Yampa River Basin Remote Assessment (Yampa IWMP 2022), was also completed to further augment the analysis.

3.1.2 Scoring Criteria

Table 3-1 includes the narrative criteria used to rate the sediment transport and continuity indicator. The criteria relate primarily to impediments to sediment transport, signs of sediment balance (or imbalance), and also to the presence of stressors and level of maintenance required to maintain functional river processes.

Table 3-1. Sediment Transport and Continuity Indicator Scoring Criteria

Grade	Description
A	The amount of sediment transported through the reach is optimized to maintain self-sustainable balance with no management or maintenance required. There are only limited, if any, impediments to sediment delivery or transport throughout the reach. Minimal signs of sediment imbalance or disequilibrium are evident.
B	Impediments to sediment transport may exist, but they are either insignificant or they impact sediment balance from only a small portion of the overall contributing area. Minor stressors are present and minimal management or maintenance is required to maintain functionality. Limited signs of sediment imbalance or disequilibrium are evident.
C	Impediments to sediment transport through the reach are notable and are impacting the sediment balance through a moderate portion of the reach. Maintenance and management are required to maintain functionality. Moderate signs of sediment imbalance or disequilibrium are evident.
D	Major impediments to sediment transport exist, yet these impediments either pass a portion of the sediment downstream or block sediment from less than half of the reach. Stressors significantly alter the natural sediment balance, and extensive or consistent active management and maintenance are required. Ample signs of sediment imbalance or disequilibrium are evident.
F	Severe impediments to sediment transport are present and impact most or all of the reach. The sediment balance through the reach is severely altered to a level that results in an inability to support functional processes. Signs of sediment imbalance or disequilibrium are ubiquitous.

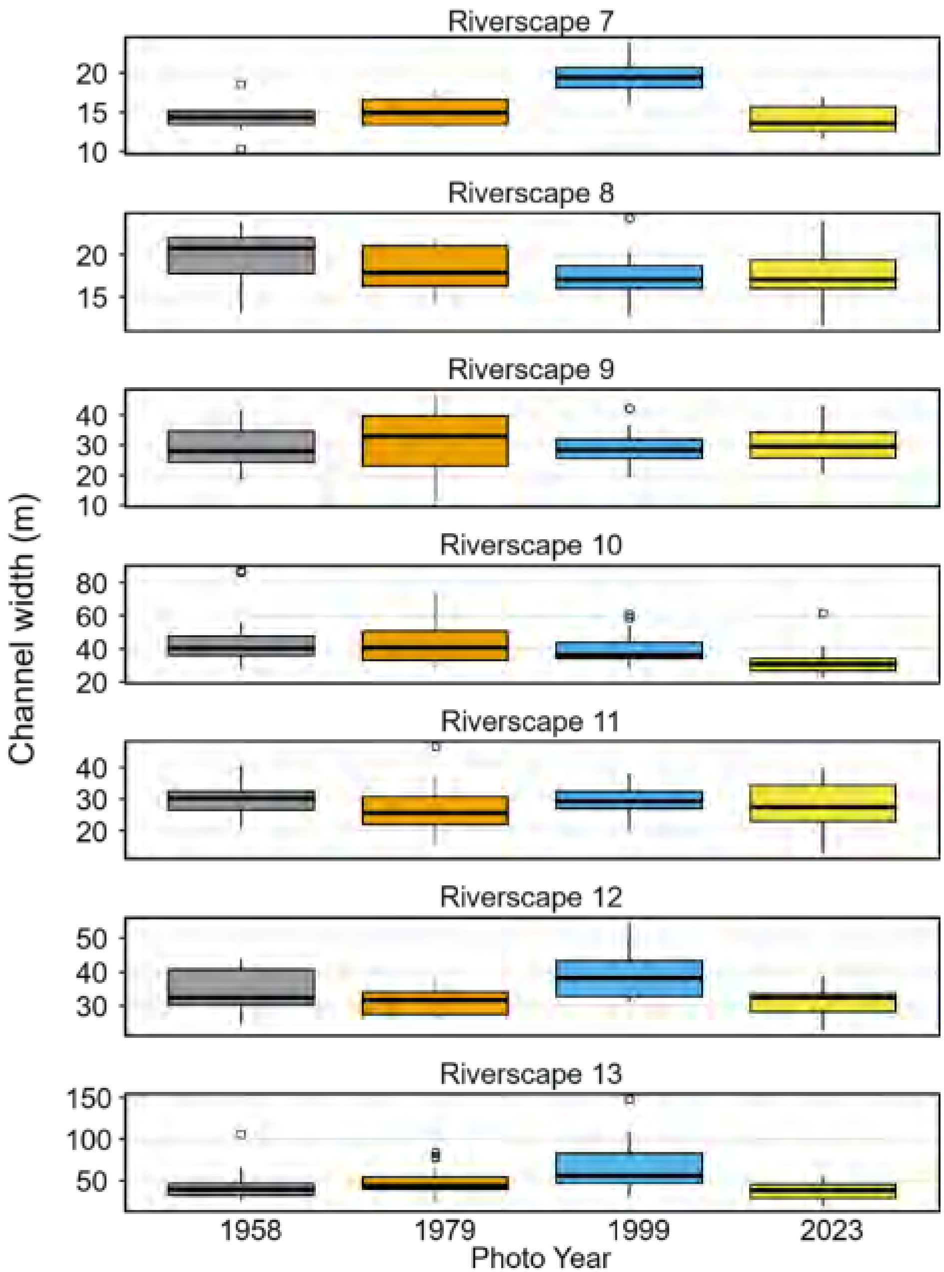
3.1.3 Results

Historical aerial imagery spaced at regular (approximately 20-25 year) intervals since the 1950s (Table 3-2) was analyzed in order to examine temporal trends in channel dimensions (Jagt et al. 2022). Because rivers are scaled to the water and sediment loads they carry, detectable trends in channel dimensions across time suggest perturbations in either component over that same time period. A significantly narrower channel today than in the past, for example, could potentially indicate a disruption in sediment supply that has resulted in observable channel adjustments as the river seeks to establish a new equilibrium. Channel widths were measured at regular spaced intervals of 0.3 miles (0.5 km) spacing; this was done for each year of historical imagery. Box plots of widths for each riverscape at each timestep were then constructed to examine temporal differences; this visual inspection was complemented by statistical tests (Welch's t-tests) to detect significant differences between years (Figure 3-1).

Table 3-2. Historical Images Used in Width Analysis

Year	Image Count	Scale/Resolution
1958	6	1:45600
1979	4	1:78000
1999	7	1:80000
2023	17	0.6 m

Figure 3-1. Box Plots of Channel Widths for Each Set of Historical Aerial Images

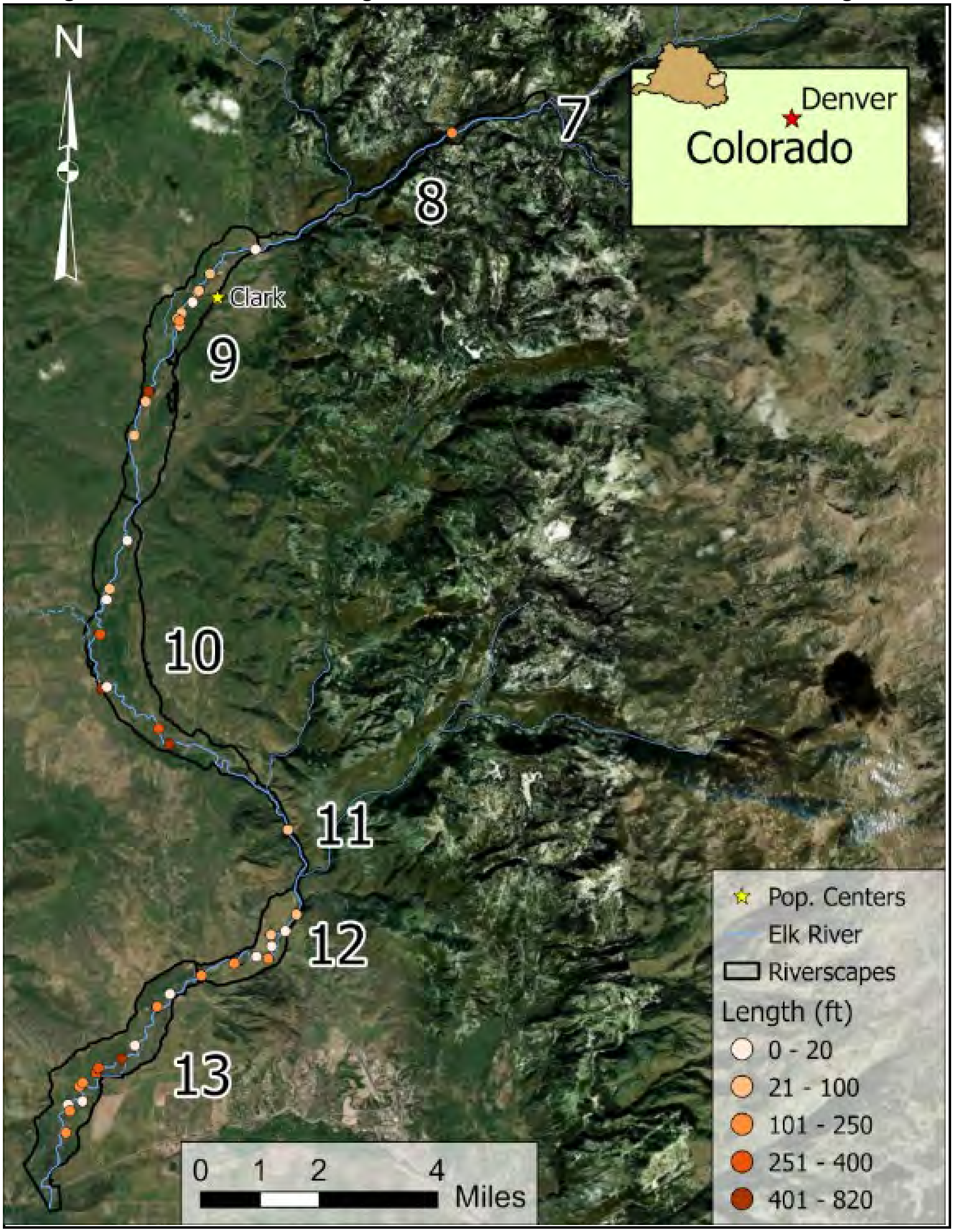


Few significant differences in width are observed across the historical aerial imagery record. Systematic widening observed in 1999 may be a relic of the relatively poorer resolution of imagery from this year, given that no large flows occurred in prior years. Narrowing may have occurred from the historical period (1959) to the present day (p-value < 0.05 for channel width in 2023 versus 1958 and 1979), though the lack of widening in upstream riverscapes suggests that this may be a localized issue related to channel modifications (e.g., bank armoring) rather than a watershed-scale change in sediment regime. Overall, the lack of significant temporal trends in channel width, especially in conjunction with the lack of observable change in peak flows (Section 2.1), suggests that the Elk River retains a healthy sediment regime.

Few other obvious indicators of sediment disequilibrium exist. Direct field observations and examination of field-collected data reveals that although the occurrence of rapid bank erosion is present in locations across the Elk River segment (Figure 3-2), it generally coincides with hayfields and armoring present in riverscapes 9, 12, and 13. Accelerated erosion is relatively minimal in riverscapes 7, 8, and 11, consistent with their confined nature, and more extensive within the wider, partially confined areas of riverscapes 9, 10, 12, and 13. Bank erosion in these riverscapes is more common because the channel here is more sinuous and meander bend cutbanks are capable of eroding. Although this could be a possible sediment imbalance in the downstream riverscapes, cutbank erosion is a natural and expected pattern in a healthy river system. The project team has taken care to only designate rapid erosion in areas where additional stressors are present (such as a lack of riparian vegetation) (Appendix A, Photo A-27). The lack of widespread, disproportionately rapid bank erosion further suggests that the sediment regime of the Elk River remains healthy.

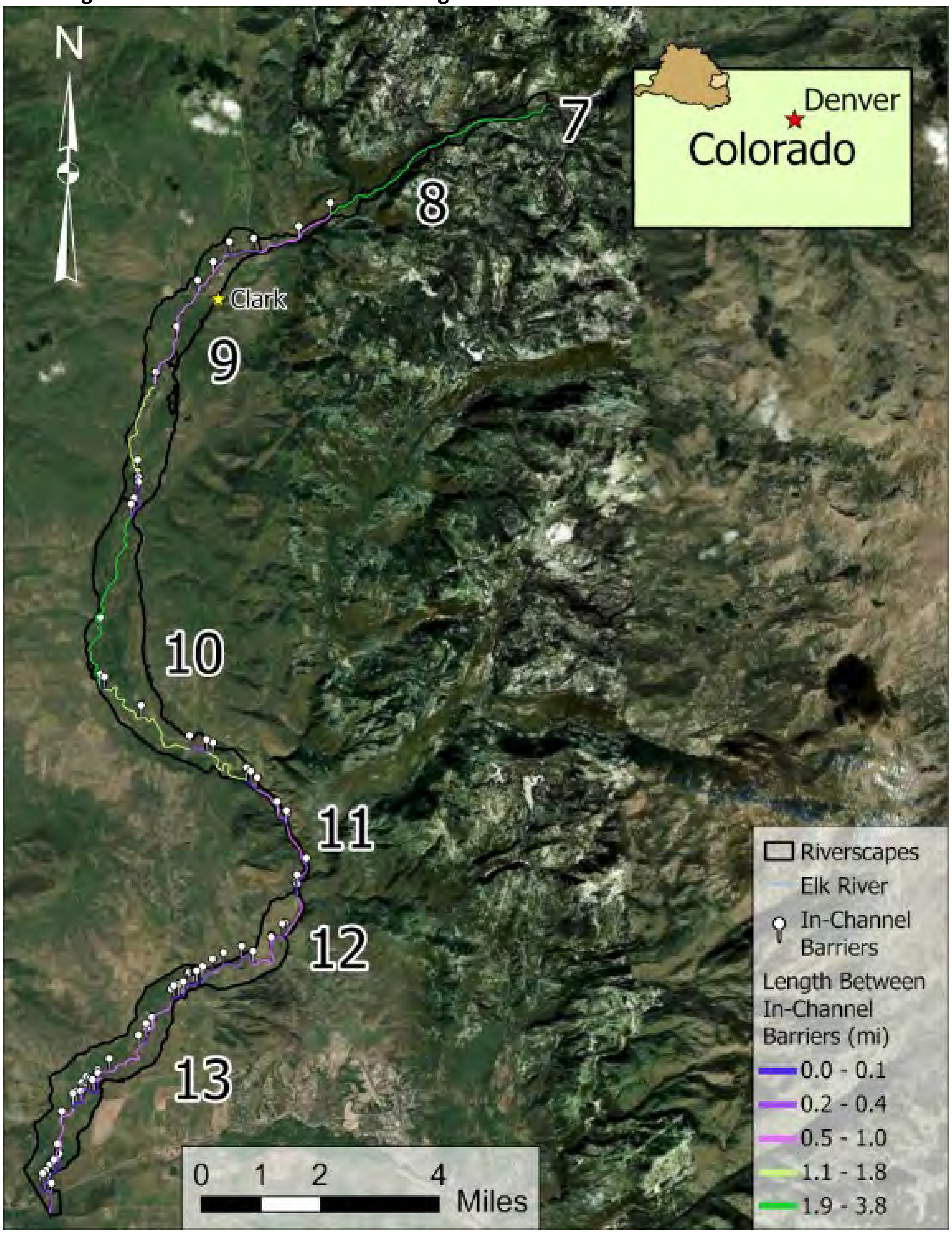
However, barriers to downstream sediment transport (in the form of channel-spanning diversions and grade control structures) (Appendix A, Photos A-1 through A-5) do exist in several locations, particularly in riverscapes 9 and 11 - 13 (Figure 3-3, see Section 5.1 for further details). These in-channel barriers may restrict the downstream movement of sediment, particularly coarser bedload sediment (gravel-sized and larger), which dominate the sediment load of the Elk River (Andrews 1978). These structures represent a stressor to the health of the sediment regime and could reduce the amount of sediment supplied to downstream riverscapes, thus detrimentally impacting channel morphology and habitat availability and quality. In-channel barriers are predominantly concentrated in riverscapes 9 and 11-13, where they generally take the form of either push-up dams, designed to direct flow into irrigation ditches or intakes, or j-hooks and cross vanes, generally designed to mitigate erosion and/or increase pool frequency by slowing flow and directing it away from the banks. Because of the prevalence of these structures in riverscapes 11, 12, and 13, these areas receive lower scores for the sediment indicator. Finally, recent modifications (extensive bank armoring along both banks) to an approximately mile-long stretch of riverscape 9 (Figure 7-1) have likely substantially disrupted sediment transport, production, and deposition within that reach of river, but the project team was not able to access the area on foot due to landowner permissions. Impacts of these modifications on the sediment regime are thus difficult to assess, partially due to lack of access but mostly due to the very recent nature of their emplacement. It is likely that, as more time passes, impacts will more strongly manifest in future iterations of the Scorecard (additional details provided in Section 7.1).

Figure 3-2. Distribution and Length of Bank Erosion Observed in the Elk River Segment



* Note: Each riverscape was visited by foot or boat for field observations, except for minor portions of riverscapes 7 and 8, approximately 45% of riverscape 9, approximately 65% of riverscape 10, and approximately 10% of riverscape 11, mainly due to private property access considerations.

Figure 3-3. In-Channel Barriers to Longitudinal Movement as Observed in the Field



* Note: Each riverscape was visited by foot or boat for field observations, except for minor portions of riverscapes 7 and 8, approximately 45% of riverscape 9, approximately 65% of riverscape 10, and approximately 10% of riverscape 11, mainly due to private property access considerations.

Finally, a USGS investigation of suspended sediment data at the Elk River near Milner, CO gauge indicates the estimated median annual concentration from 2010 to 2018 generally ranged from 1 to 25 mg/L (Day 2021). Sediment concentrations were generally highest during spring runoff (May and June), and lowest during base flow (September through February) (Day 2021). Observed suspended sediment concentrations in the Elk River watershed were among the lowest in the Yampa Basin, likely reflective of both the heavily forested nature of the Elk River watershed as well as the general dominance of bedload in the primarily coarse-grained (predominantly cobbles), steep river (Day 2021). Though agricultural land-use (primarily hay/pasture) adjacent to the river as well as other land uses (e.g., grazing) may elevate sediment loads over natural background levels, little evidence was found to indicate increasing sediment loads over time (Day 2021). Overall, the USGS investigation (Day 2021) and the Yampa IWMP (2022) suggest that the sediment regime through the Elk River segment is relatively healthy based on the lack of any generalizable temporal trends. Scores for the sediment indicator for each riverscape are presented in Table 3-3.

Table 3-2. Sediment Transport and Continuity Indicator Scores by Riverscape

Riverscape	Sediment Transport/Continuity Score
Riverscape 7	A
Riverscape 8	A
Riverscape 9	B
Riverscape 10	A-
Riverscape 11	B
Riverscape 12	B-
Riverscape 13	B-

4.0 WATER QUALITY

Water quality is defined as the physico-chemical characteristics of water in a river segment, and it is influenced by natural geological weathering, biogeochemical processes, and human activities (upstream land and water uses). Suitable water quality in streams supports recreational uses, ensures public health, and supports wildlife and fish habitat. The Yampa River Scorecard uses several indicators to evaluate water quality. The list of indicators is based on feedback from the Technical Committee and contains parameters that are relatively easy to measure and/or for which data already exist. The six water quality indicators are **temperature, dissolved oxygen, pH, macroinvertebrates, nutrients, and metals**. The final water quality score is calculated as an average of the six indicator scores.

The Elk River segment is currently 303(d) listed for E. coli based on samples collected on the lower Elk River in 2007 as a result of reports that residents' drinking water wells were contaminated with E. coli. Since then, an insufficient number of E. coli samples in the vicinity have led CDPHE to retain that listing. While the Scorecard does not include E. coli as one of the water quality metrics that are typically scored, it may be worth collecting a series of samples for E. coli in the near future in that area to determine whether elevated E. coli levels still occur on the Elk River.

Water quality measurements that can be important for assessing stream health include parameters that fall into the following categories: (1) standard physical parameters that can be measured *in situ* with a handheld water quality instrument that provides instantaneous results (e.g., temperature, pH, conductivity, dissolved oxygen, oxidation-reduction potential, turbidity); (2) analytes that require water samples to be collected and sent to a laboratory for analysis (e.g., total and dissolved metals, nutrients); and (3) biological indicators of water quality (e.g., macroinvertebrates). Locations of surface water quality and macroinvertebrate community samples collected in the field, as well as temperature sensors and gauges used in the analysis, are summarized in Figure 4-1. Water quality data are compared to CDPHE standards for scoring criteria. If water quality samples frequently exceed these standards, the stream segment is placed on the State's 303(d) or M&E (monitoring and evaluation) list for that particular constituent. This section provides more detail on the six indicators included in the Yampa River Scorecard.

Instantaneous data from water quality sampling are considered in addition to USGS water quality data due to the lack of available USGS monitoring locations. Water quality sampling took place in riverscape 9 on private property (Glen Eden) and in riverscape 11 on CPW fishing access land (Christina). Sampling was performed at each of these locations on two occasions, during both high flow (June) and low flow (August) periods, to cover a range of flow conditions (Table 4-1). In-situ and laboratory-derived results are summarized in Table 4-1.

Table 4-1. Summary of 2025 Water Quality Sampling Results for Constituents of Interest

Constituent[A]	Sample ID[B]	Riverscape	High Flow Result[C]	Low Flow Result[C]	CDPHE Standard[D]
TKN	SW-GLENEDEN-ELK	9	<0.2	0.26	1.25
TP	SW-GLENEDEN-ELK	9	<0.01	<0.01	0.11
pH	GLENEDEN-ELK	9	7.43	7.88	6.5-9
DO	GLENEDEN-ELK	9	9.41	8.29	6

TKN	SW-CHRISTINA-ELK	11	<0.2	0.37	1.25
TP	SW-CHRISTINA-ELK	11	<0.01	<0.01	0.11
pH	CHRISTINA-ELK	11	7.29	8.53	6.5-9
DO	CHRISTINA-ELK	11	9.35	8.12	6

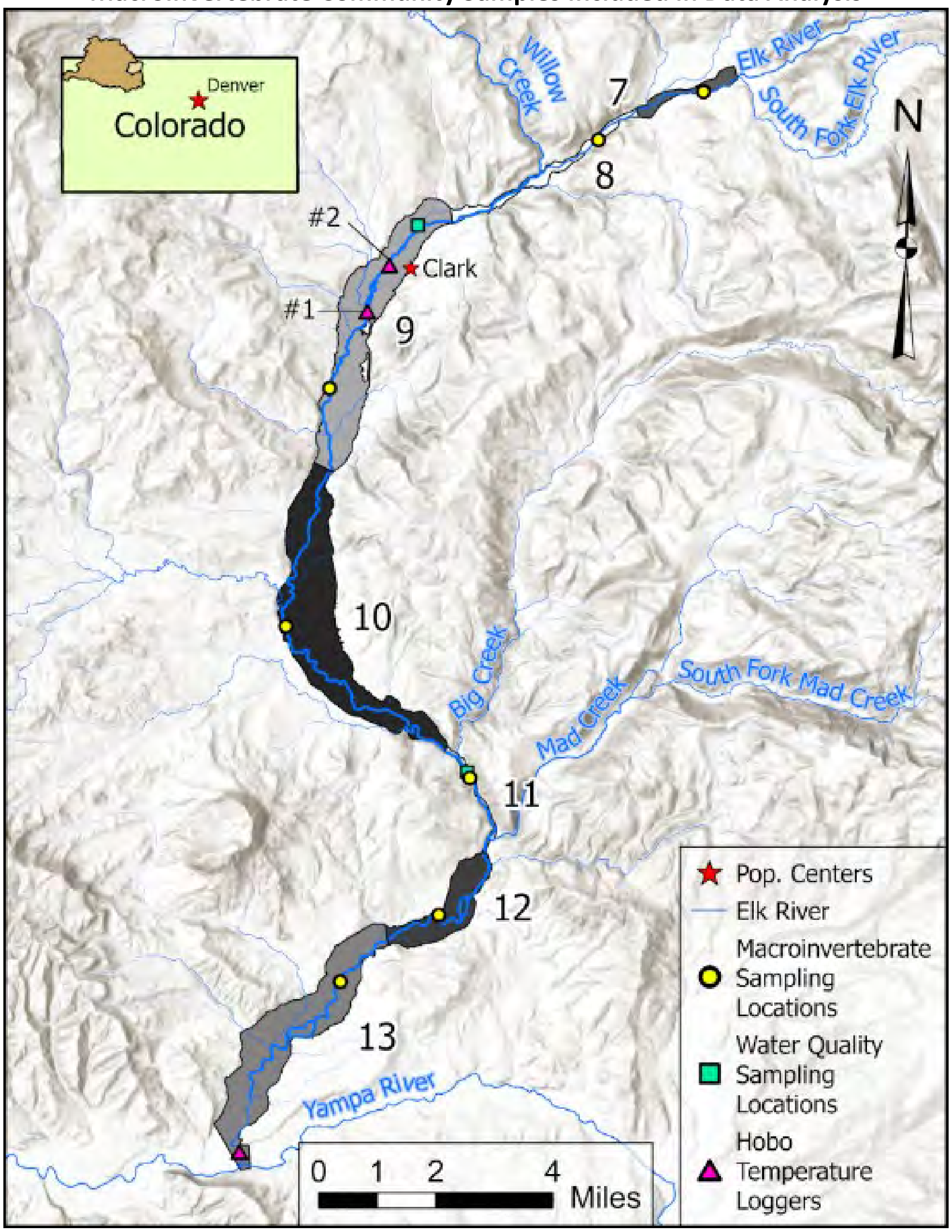
[A] TKN = Total Kjeldahl Nitrogen; TP = Total Phosphorus; DO = Dissolved Oxygen

[B] Results from surface water samples that were sent to the lab are labeled "SW." Otherwise, results are from in-situ measurements recorded in the field.

[C] High flow and low flow sampling events occurred in mid-June and late August, respectively.

[D] More information on Colorado Department of Public Health and Environment (CDPHE) standards are found in subsequent indicator sections.

Figure 4-1. Locations of Hobo Temperature Loggers, Water Quality Samples, and Macroinvertebrate Community Samples Included in Data Analysis



4.1 TEMPERATURE INDICATOR

Water temperature is measured using a standard water quality meter, a thermometer, or a HOBO temperature data logger. The ranges of many aquatic species are limited by temperature, so this parameter is an important measure of habitat quality. Shading from the riparian canopy, good hyporheic exchange, and seepage from spring-fed tributaries (in some cases) contribute to lower temperatures that support the cool- and cold-water fish species present in many Colorado streams and rivers. The CDPHE Stream Classifications for Aquatic Life with the Elk River segment are as follows:

- Elk River, from source to confluence with the Yampa (COUCYA08): Aquatic Life Cold Water 1 and Cold Stream Tier I (CS-I) temperature standards.

The Aquatic Life Cold Water 1 classification applies to all seven riverscapes in the Elk River segment. Two standards are set: one to apply to daily maximum (DM) temperature, which is akin to an "acute" standard, and one to apply to mean weekly temperature (MWAT), which is akin to a "chronic" standard. These stream segment classifications are further subject to specific water quality standards set by CDPHE, including water temperature standards (Table 4-2).

Table 4-2. Temperature Water Quality Standards in Yampa River Segment 08 (COUCYA08, Elk River)

Month	CS-I Temperature Standards	
	Acute Standard (deg C)	Chronic Standard (deg C)
January	13.0	9.0
February	13.0	9.0
March	13.0	9.0
April	13.0	9.0
May	13.0	9.0
June	21.7	17.0
July	21.7	17.0
August	21.7	17.0
September	21.7	17.0
October	13.0	9.0
November	13.0	9.0
December	13.0	9.0

4.1.1 Data Sources and Evaluation Methods

Instantaneous temperature was measured by FOTY during the collection of water quality samples in the Elk River segment (Figure 4-1). However, instantaneous measurements of water quality taken manually have limited value when considering optimal conditions for resident aquatic species. Continuous temperature data loggers that collect temperature measurements at regular intervals provide a greater understanding of the conditions impacting aquatic habitat and allow for comparison with water quality temperature standards. These are relatively inexpensive but can be tricky to install in a system like the Yampa River Basin that sees large fluctuations in flows, freezing during winter months, visitation by curious individuals or animals, and other challenging conditions for field monitoring.

Continuous temperature measurements are collected every 30 minutes at a HOBO temperature logger deployed by FOTY in two different locations: Elk River at Confluence and Elk River near Clark, CO (Figure 4-1). Data at the former span October 11, 2023 to October 15, 2025. Data at the latter are more disjointed due to construction on the Elk River that buried the originally deployed sensor; data span July 18, 2024 to October 15, 2024 at the original location (Elk Near Clark #1, Figure 4-1) and July 23, 2025 to October 15, 2025 at the new location (Elk Near Clark #2, Figure 4-1). Although data are only available for a 3-month period for each year, the months most likely to have exceedances are represented. Data from the HOBO loggers near Clark are used to score riverscapes 7, 8, and 9 for temperature, and data from the logger at the confluence are used to score riverscapes 10, 11, 12, and 13. Temperature data loggers deployed as part of the Scorecard effort follow the same protocols for equipment installation and retrieval as the City of Steamboat Springs to maintain consistency across the Yampa basin; additional details are provided in the Yampa River Scorecard Project Indicators and Methods Report (FOTY/Alba Watershed Consulting 2021).

4.1.2 Scoring Criteria

The temperature indicator scoring criteria outlined in Table 4-3 are based on regulatory standards outlined in CO Regulation 33 (CDPHE 2023). These criteria rely on consulting current regulatory standards.

Table 4-3. Temperature Indicator Scoring Criteria

Grade	Description
A	Temperature regime is natural and appropriate for a well-functioning river in its process domain.
B	Temperature regime is within the range of natural variability. Natural aquatic biota may be minimally impaired. Regulatory standards are rarely exceeded.
C	Temperature regime is altered to a degree that could significantly affect natural aquatic biota. Regulatory standards are occasionally exceeded. CDPHE Monitoring and Evaluation (M&E) listed reaches fall in this category.
D	Temperature regime is altered to a degree that is known to affect natural aquatic biota. Regulatory standards are frequently exceeded. CDPHE 303(d) listed reaches fall in this category.
F	The temperature regime is fundamentally altered. Natural biota are severely impaired. Regulatory standards are chronically exceeded.

4.1.3 Results

The temperature indicator for the Elk River segment is evaluated through analysis of the approximately two years temperature data from the HOBO logger located at the Elk River-Yampa River confluence site and the approximately six months of data from the HOBO loggers located near Clark, CO. Results were evaluated against current regulatory standards, primarily the daily maximum (DM) temperature or acute standard, which regulates the maximum temperature that can occur over a 24-hr period, and the maximum weekly average temperature (MWAT) or chronic standard, which sets the maximum allowable temperature for the rolling 7-day mean of daily average temperature (CDPHE 2023).

Temperature sensor data collected near Clark in riverscape 9 indicate the daily maximum temperature did not exceed the DM regulatory standard at any point during the monitoring period (Figure 4-2). The MWAT standard was briefly exceeded in early October in both 2024 (six days) and 2025 (seven days) (Figure 4-3, Table 4-4). No other exceedances of the MWAT standard were recorded. Though exceedances of regulatory standards do occur, they are rare and limited to several days in early October for the MWAT standard only. Additionally, no reaches within riverscapes 7, 8, and 9 are listed by CDPHE as M&E or 303(d). Temperature impairment is likely minimal and riverscapes 7, 8, and 9 therefore receive a B score.

Table 4-4. Exceedances of Temperature Regulatory Standards at Monitoring Sites Elk River Mouth and Elk River near Clark, CO (October 2023 - October 2025)

	Month	Water Year	Days DM* Exceeded	Days MWAT* Exceeded
Elk River near Clark, CO				
	Oct.	2024	—	6
Total per Year			**—**	**6**
	Oct.	2025	—	7
Total per Year			**—**	**7**
Elk River at Confluence				
	May	2024	—	—
	July		10	18
	Aug.		14	31
	Sept.		2	9
	Oct.		15	22
Total per Year			**41**	**80**
	May	2025	**—**	**2**
	July		17	28
	Aug.		14	30
	Sept.		1	3
	Oct.		5	15
Total per Year			**37**	**78**

*Months without either daily maximum (DM) or maximum average weekly temperature (MWAT) exceedances are not shown (all months except for October for the Elk River near Clark, CO station; October (2023), Nov-April (all years), and June (all years) for the Elk River at Confluence station).

For the temperature sensor located at the confluence of the Elk with the Yampa (Elk River at Confluence), data indicate that standards are far more frequently exceeded than at the monitoring location near Clark. Daily maximum temperature exceeded the standard for 41 days total in 2024 and 37 days total in 2025, with the bulk of these exceedances coming in July and August in both years, as well as in October 2024 (Figure 4-3, Table 4-4). Maximum weekly average temperature exceedances are additionally frequent, with 72 days exceeding the MWAT standard in 2024, and 78 days in 2025. The bulk of these exceedances fall within the months of July, August, and October. The MWAT standard is exceeded for the entire month of August across both years in the monitoring record (save one day in August 2025) (Figure 4-3, Table 4-4). No exceedances of either the DM or MWAT were observed. Overall, while no reach in riverscapes 10 through 13 is listed as impaired by CDPHE, regulatory standards are exceeded throughout the late summer months, suggesting the temperature regime of the river is altered to a degree that may impact biota. Riverscapes 10–13 thus receive a C score.

Figure 4-3. Temperature Data from Hobo Loggers at Elk River near Clark, CO and Elk River at Confluence

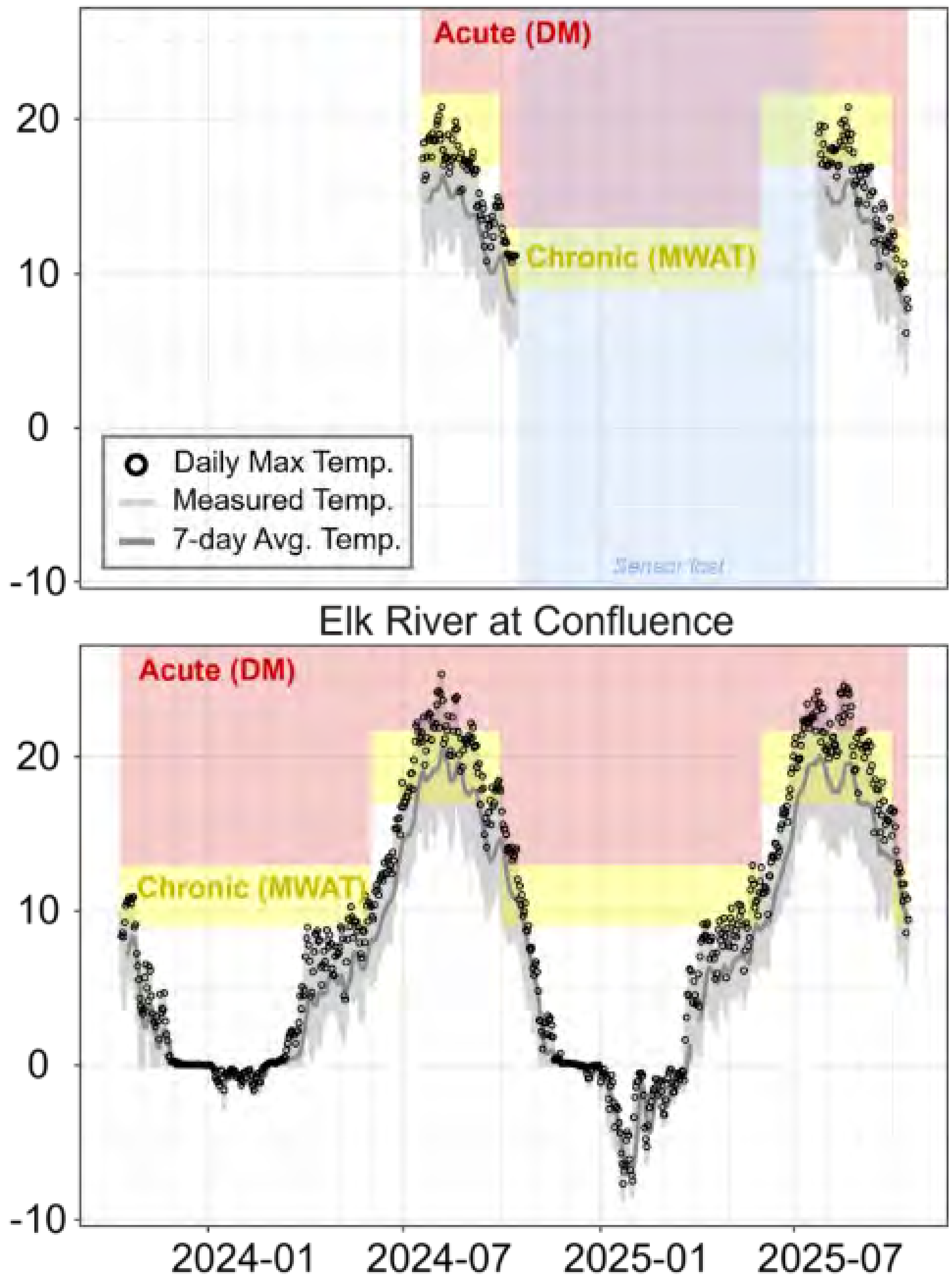


Table 4-4. Temperature Indicator Scores by Riverscape

Riverscape	Temperature Score
Riverscape 7	B
Riverscape 8	B
Riverscape 9	B
Riverscape 10	C
Riverscape 11	C
Riverscape 12	C
Riverscape 13	C

4.2 DISSOLVED OXYGEN INDICATOR

Dissolved oxygen (DO) is the amount of free oxygen present in the water column and is important for the survival of fish and other aquatic species. To ensure accurate readings when using a water quality meter to record DO, the DO probe must be suspended in the water column and out of direct contact with the stream bed, which is sometimes difficult in small, shallow streams dominated by fine substrates. Monitoring locations were selected to meet this criterion, which is not a concern on the Yampa and Elk Rivers.

4.2.1 Data Sources and Evaluation Methods

Field-based water quality parameters including dissolved oxygen are measured quarterly by USGS as part of the Upper Yampa River Basin Water Quality Monitoring Program (e.g., Day 2021). One location in this monitoring program falls within the Elk River Scorecard focal segment: Elk River near Milner, CO. Data from 2011 to 2025 were downloaded from nwis.waterdata.usgs.gov. Additionally, in-situ DO was measured by FOTY during the collection of water quality samples in the Elk River segment (Table 4-1, Figure 4-1) and considered in these analyses. FOTY measurements were made at locations in riverscapes 9 and 11.

4.2.2 Scoring Criteria

Similar to temperature, the dissolved oxygen scoring criteria outlined in Table 4-5 are based on regulatory standards. The frequency of exceedance of these standards was used to generate a score for each riverscape in the Elk River segment.

Table 4-5. Dissolved Oxygen Indicator Scoring Criteria

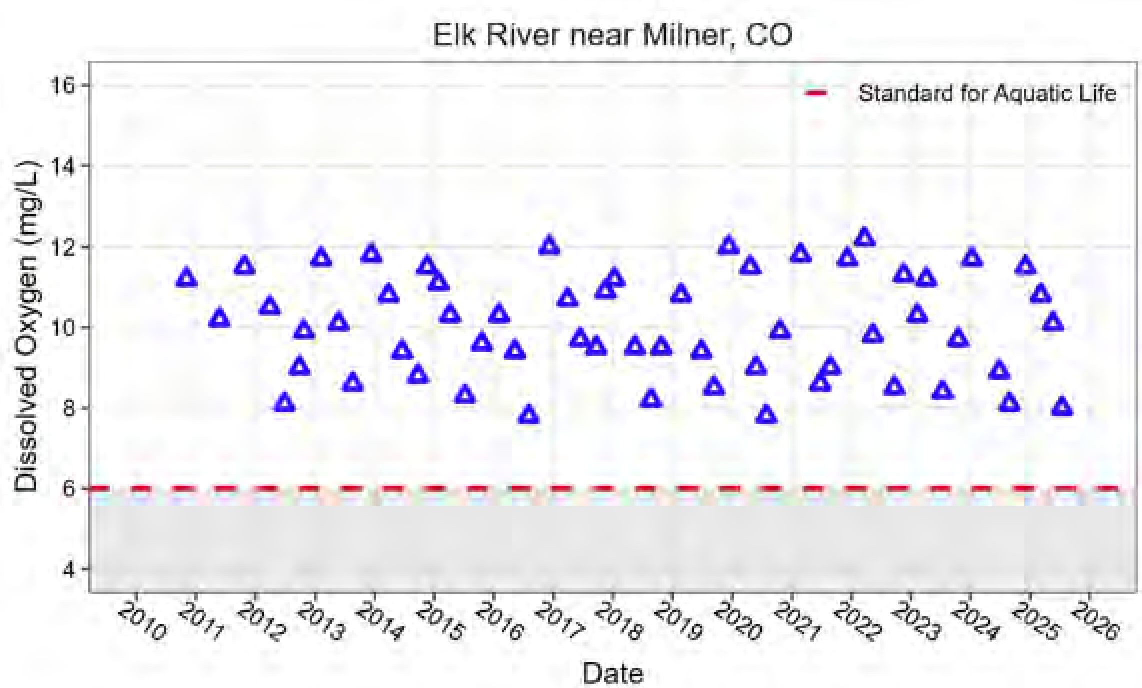
Grade	Description
A	Dissolved oxygen concentrations are natural and appropriate for a well-functioning river in its process domain.

B	Dissolved oxygen concentrations are within the range of natural variability. Natural aquatic biota may be minimally impaired. Regulatory standards are rarely exceeded.
C	Dissolved oxygen concentrations are altered to a degree that could significantly affect natural aquatic biota. Regulatory standards (6.0 mg/L or 5.0 mg/L) are occasionally exceeded. CDPHE Monitoring and Evaluation (M&E) listed reaches fall in this category.
D	Dissolved oxygen concentrations are altered to a degree that is known to affect natural aquatic biota. Regulatory standards (6.0 mg/L or 5.0 mg/L) are frequently exceeded. CDPHE 303(d) listed reaches fall in this category.
F	Dissolved oxygen concentrations are fundamentally altered. Natural biota are severely impaired. Regulatory standards are chronically exceeded.

4.2.3 Results

The dissolved oxygen indicator is evaluated through review of USGS Water Quality Monitoring Program data at the Elk River near Milner, CO gauge located in riverscape 13. Additional instantaneous data from water quality sampling are also considered due to the lack of available USGS monitoring locations. Because rivers integrate upstream inputs, data from the one USGS station in the focal segment are used to holistically score riverscapes 7-13. Data from instantaneous water quality sampling at Glen Eden, in riverscape 9, are used to further inform results for riverscapes 7-9; data from instantaneous sampling at Christiana, in riverscape 11, are used to inform results for riverscapes 10-11.

Figure 4-3. Dissolved Oxygen Concentrations from Quarterly Water Sampling at USGS Gauge Elk River near Milner, CO (2010-2025)



Dissolved oxygen concentrations at the Elk River near Milner station are well above the standard for aquatic life for each year between 2010 and 2025 (Figure 4-3). Based on these data, riverscapes 10 through 13 are within healthy standards and are functional for this parameter and receive an A score (Table 4-6). Instantaneous DO measurements from FOTY-led water quality sampling indicate a DO of 9.41 mg/L and 8.29 mg/L in riverscape 9 at high and low water, respectively, and 9.35 mg/L and 8.12 mg/L in riverscape 11. All measurements are well above the standard for aquatic life of 6 mg/L, suggesting these riverscapes support a well-functioning river for this parameter (Table 4-6). Each riverscape thus earns an A score.

Table 4-6. Dissolved Oxygen Indicator Scores by Riverscape

Riverscape	Dissolved Oxygen Score
Riverscape 7	A
Riverscape 8	A
Riverscape 9	A
Riverscape 10	A
Riverscape 11	A
Riverscape 12	A
Riverscape 13	A

4.3 pH INDICATOR

pH is a measure of water acidity that runs on a scale from 0 to 14, where lower numbers indicate high acidity, pH 7 is neutral, and higher numbers indicate water that is more basic. The ranges of many aquatic species are limited by pH. The pH of a water quality sample can be affected by biological activity in a stream, geology, precipitation, and human activities (Bauch et al. 2012).

4.3.1 Data Sources and Evaluation Methods

Field-based water quality parameters including pH are measured quarterly by USGS as part of the Upper Yampa River Basin Water Quality Monitoring Program. One location in the Elk River segment is part of this monitoring program: Elk River near Milner, CO. Data from 2011 to 2025 were downloaded from nwis.waterdata.usgs.gov. Additionally, in-situ temperature was measured by FOTY during the collection of water quality samples in the Elk River segment (Table 4-1, Figure 4-1) and considered in these analyses.

4.3.2 Scoring Criteria

Similar to temperature and dissolved oxygen, the scoring criteria for pH outlined in Table 4-7 are based on adherence to regulatory standards.

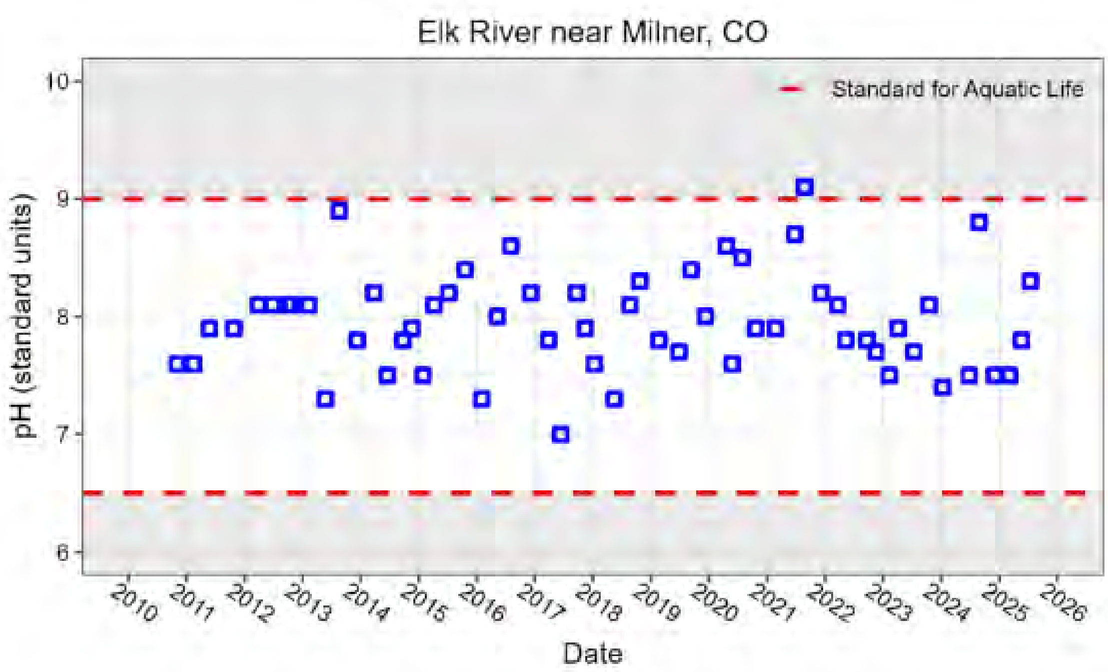
Table 4-7. pH Indicator Scoring Criteria

Grade	Description
A	pH values are natural and appropriate for a well-functioning river in its process domain.
B	pH values are within the range of natural variability. Natural aquatic biota may be minimally impaired. Regulatory standards are rarely exceeded.
C	pH is altered to a degree that could significantly affect natural aquatic biota. pH values occasionally fall outside the range of regulatory standards (6.5 - 9.0). CDPHE Monitoring and Evaluation (M&E) listed reaches fall in this category.
D	pH is altered to a degree that is known to affect natural aquatic biota. pH values frequently fall outside the range of regulatory standards (6.5 - 9.0). CDPHE 303(d) listed reaches fall in this category.
F	pH is fundamentally altered. Natural biota are severely impaired. pH values chronically fall outside the range of regulatory standards.

4.3.3 Results

The pH indicator is evaluated through review of USGS Water Quality Monitoring Program data at the Elk River near Milner, CO gage. Additional instantaneous data from FOTY-led water quality sampling in riverscapes 9 (Glen Eden site) and 11 (Christina site) are also considered due to the lack of available USGS monitoring locations. Because rivers integrate upstream inputs, data from the one USGS station in the focal segment are used to holistically score riverscapes 7-13. Data from instantaneous water quality sampling at Glen Eden, in riverscape 9, are used to further inform results for riverscapes 7-9; data from instantaneous sampling at Christiana, in riverscape 11, are used to inform results for riverscapes 10-11.

Figure 4-4. pH Values from Quarterly Water Sampling at USGS Gauge Elk River near Milner, CO (2010-2025)



pH values less than 4 and greater than 10 can lead to mortality of aquatic life if the condition persists (Bauch et al. 2012). Standards for aquatic life (6.5 - 9) set by the CDPHE were used to score the pH indicator (Table 4-7). With the exception of a single sample in summer 2021, pH values do not fall outside the range of regulatory standards for aquatic life (Figure 4-4). Regulatory standards are regularly and consistently met. Values of pH across the Elk River segment indicate slightly alkaline conditions, with pH values generally ranging from 7.5 to 9 from 2010 to 2025 (Figure 4-5). Instantaneous pH measurements taken in riverscapes 9 and 11—7.43 and 7.9 at Glen Eden in riverscape 9 at high and low water, respectively, and 7.35 and 8.5 at Christina in riverscape 11—also fall within the range of regulatory standards. All riverscapes are therefore assigned an A score (Table 4-8).

Table 4-8. pH Indicator Scores by Riverscape

Riverscape	pH Score
Riverscape 7	A
Riverscape 8	A
Riverscape 9	A
Riverscape 10	A
Riverscape 11	A
Riverscape 12	A
Riverscape 13	A

4.4 MACROINVERTEBRATES INDICATOR

Benthic macroinvertebrates are excellent indicators of the condition of lotic aquatic systems because macroinvertebrates are found in almost all freshwater environments, have a small home range, are relatively easy to sample and identify, and the different taxonomic groups show varying degrees of sensitivity to pollution and other stressors (CDPHE 2016a, Barbour et al. 1999). Benthic macroinvertebrate community monitoring is a useful tool for river health monitoring, particularly if baseline data are available.

Many comparative metrics may be used to assess the health of the benthic community, including the number of individuals; total number of taxa; total number of pollution-sensitive Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa; percentage of EPT taxa; ratios of different functional feeding groups or taxonomic groups; Shannon-Wiener Diversity Index (SDI); Hilsenhoff Biotic Index (HBI); and many others. The SDI is a mathematical measure of species diversity within a given community. For benthic macroinvertebrates, values range from 0-5, and higher values indicate higher species diversity (MacArthur 1965). The HBI reveals the relative abundance of pollution-tolerant species. Scores range from 0-10, where a higher value indicates more pollution-tolerant species are present (Hilsenhoff 1987).

The Colorado Department of Public Health and Environment (CDPHE) monitors streams throughout the state for assessment and protection of water resource quality. Their principal indicator is a multi-metric index (MMI) based on direct benthic macroinvertebrate sample data. By using seven to eight equally weighted metrics, the MMI combines measures of diversity, abundance, pollution tolerance, community structure, and other factors to generate a normalized score of 0-100 for each sample. Scores may then be compared to reference threshold scores for one of three generalized Colorado biotypes (mountains, transition, plains) that are determined by the MMI software and consider elevation, stream slope, and ecoregion of sampling locations. In “grey” areas (between impairment and attainment MMI threshold values) where the MMI alone is not sufficient, CDPHE also compares SDI and HBI results to their respective attainment and impairment threshold values.

4.4.1 Data Sources and Evaluation Methods

Historical benthic macroinvertebrate data are scarce for the Elk River segment. Given the paucity of existing data, the relative ease of collecting and analyzing macroinvertebrate data, and the useful information that can be gleaned from these data, the Scorecard project provides a prime opportunity for evaluating the macroinvertebrate community and tracking changes over time.

Seven benthic macroinvertebrate community samples were collected in the Elk River segment for the Scorecard project effort: one in each riverscape. Macroinvertebrate monitoring occurred during the low-flow period in late August 2025, and followed the SOP used by CDPHE for benthic macroinvertebrate sampling (CDPHE 2016). Detailed procedures for sample collection, processing, and preservation are provided in the SOP. Samples were collected by project partners using River Watch protocols and sent to Aquatics Associates for taxonomic identification and data analysis.

4.4.2 Scoring Criteria

The scoring criteria outlined in Table 4-9 are based on adherence to regulatory standards set by CDPHE for the relevant biotype (biotype 2/mountain for riverscapes 7 and 8, and biotype 1/ transition for riverscapes 9-13) using mainly MMI scores and CDPHE-designated attainment and impairment thresholds. Because component metrics incorporated into the MMI are designed to detect water quality impairments and are less sensitive to changes in habitat, results of other important comparative metrics such as numbers of total taxa, numbers and percentages of pollution-intolerant taxa, proportions of functional feeding groups, percentages of non-insect taxa, HBI, and SDI are also considered during the scoring process.

Table 4-9. Benthic Macroinvertebrate Indicator Scoring Criteria

Grade	Description
A	The reach is considered to be representative of the expected condition for aquatic insect communities and aquatic life use for a well-functioning river in its process domain. No management is needed other than protection of existing conditions. MMI score is 80-100 and the reach is in attainment for aquatic life use (CDPHE 2016).
B	Some detectable stressors are evident with minor alterations to aquatic insect communities. The ecological system retains its overall structure and supports a high level of function. Some management may be required to sustain or improve this condition. MMI score is in the 60-79 range, other metrics are generally

	indicative of a diverse and functional macroinvertebrate community, and the reach is in attainment for aquatic life use (CDPHE 2016).
C	The reach supports and maintains essential components of the unimpaired aquatic insect community, but exhibits measurable signs of degradation and less than optimal community parameters. Management is required (or recommended) to maintain and improve this condition. MMI score is in the 46-59 range and meets the CDPHE (2016) attainment threshold for aquatic life use, but other metrics are generally indicative of an impaired or unbalanced macroinvertebrate community.
D	Detectable alterations or degradation of aquatic life use are present, but the system still supports a fundamental aquatic insect community structure and function. Active management is required (or recommended) to maintain and improve characteristic functional support. MMI score is 34-45 and is considered to be in the “gray area” between aquatic life use attainment and impairment (CDPHE 2016).
F	Clear impairment to the aquatic insect community and aquatic life is present. This level of alteration generally results in an inability to support characteristic aquatic organisms, or makes the stream segment biologically unsuitable. MMI score is < 34 and aquatic life use is thus considered “impaired” (CDPHE 2016).

4.4.3 Results

The macroinvertebrates indicator is evaluated through analysis of data collected via the Scorecard project at benthic community monitoring locations within the Elk River segment (Figure 4-1). All samples collected within the Elk River segment exhibited healthy macroinvertebrate communities. In particular, total taxa ranged between 32-46 taxonomic groups, species diversity scores were relatively high at all locations, and all locations exhibited a well-balanced array of functional feeding groups. In addition, MMI scores ranged from 53 to 71, well above the CDPHE aquatic life use “attainment” threshold of 43 and 49 for biotype 1 (transition) and biotype 2 (mountain) samples, respectively (Table 4-10, Figure 4-5).

Table 4-10. Select Macroinvertebrate Metrics by Riverscape

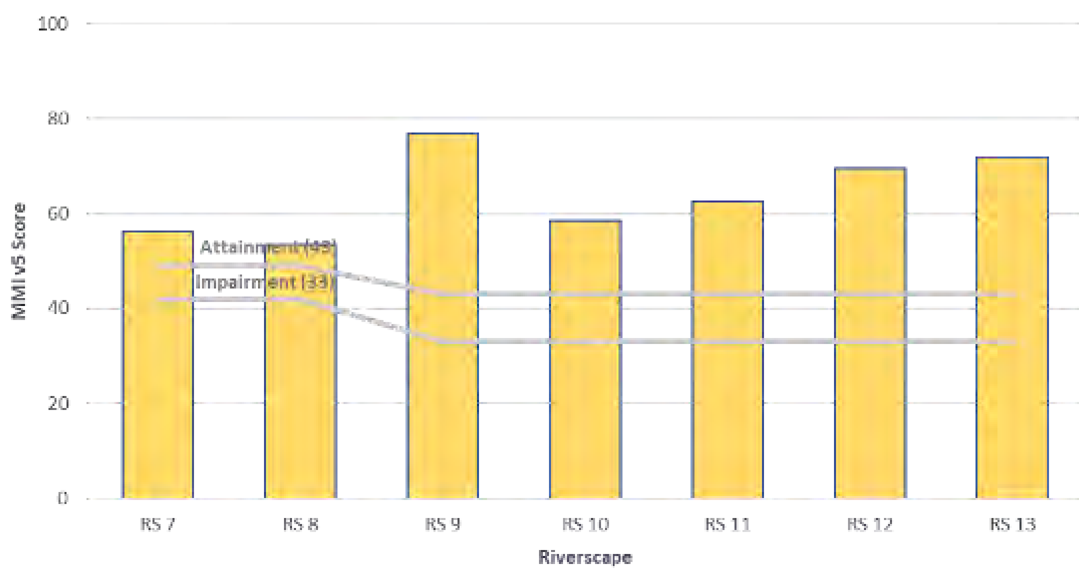
	Mountain (biotype 2)		**Transition (biotype 1)**				
Riverscape/ Metric	**RS 7**	**RS 8**	**RS 9**	**RS 10**	**RS 11**	**RS 12**	**RS 13**
MMI v5	56.3	53.5	76.9	58.6	62.7	69.5	71.9
Diversity	3.80	3.44	3.32	4.05	4.26	3.96	4.43
Evenness	0.462	0.435	0.422	0.518	0.531	0.470	0.542
HBI	4.11	3.62	2.68	4.92	4.45	4.02	3.91
EPT	16	16	17	14	19	21	24
% EPT	35.1%	45.6%	65.2%	19.5%	47.9%	50.0%	52.4%
Total Taxa	33	33	32	33	46	45	45
Non-Insect %	97.7%	99.7%	97.9%	97.6%	98.5%	100%	97.0%
% Chironomids	56.7%	47.6%	17.1%	60.7%	34.6%	33.9%	13.4%

Although riverscapes 7 and 8 had comparatively low MMI scores compared to the other sites, this difference is likely a result of their classification as mountain versus transition biotypes rather than a less well-balanced benthic macroinvertebrate community. Rather, all of the sites were very similar in terms of macroinvertebrate community health and diversity. The MMI scores were calculated using two different versions of the MMI (by biotype), which incorporate different metrics, measuring different components of the biotic community. For example, the transition biotype MMI calculation incorporates the Non-Insect Percent Individuals metric into its final MMI score, but the mountain biotype MMI calculation does not. All 7 sites had excellent scores for this metric, ranging from 97-100%, but this metric was not factored into the MMI score for riverscapes 7 and 8 while boosting all of the scores for the other riverscapes.

In general, riverscapes 7 and 8 had excellent scores for HBI (meaning a low proportion of nutrient-intolerant taxa), high numbers of total taxa (considering that fewer total taxa are expected at higher elevations), and decent percentages of pollution-intolerant taxa (EPT). In fact, the samples from riverscapes 7 and 8 had an abundance of caddisflies, which are indicative of good water quality, and several instances of the most sensitive (i.e., pollution-intolerant) taxa: *Diura knowltoni* and *Pteronarcella badia*, two of the most sensitive stoneflies found in Colorado streams and rivers.

Riverscapes 10 and 11 received the lowest relative scores based on exhibiting the highest HBI metric results. The higher the HBI metric score, the more pollution-tolerant species present in a particular sample. These sites had some localized construction and higher embeddedness scores than other locations, where an excess of fine-grained sediments could have precluded some of the more pollution-intolerant species from occupying these areas.

Figure 4-5. Macroinvertebrate MMI Scores by Riverscape



* Attainment and impairment lines refer to aquatic life use thresholds that are determined by CDPHE and vary slightly by biotype. MMI scores above the attainment threshold are deemed healthy and able to support the aquatic life use; MMI scores below the impairment threshold are considered impaired and are listed for macroinvertebrates; MMI scores in between those two thresholds are in the “grey zone” and other metrics are used to determine their level of attainment or impairment.

Overall, Elk River segment riverscapes received scores in the B range for the macroinvertebrate indicator (Table 4-11). The metrics at all sites are relatively similar, and the transition biotype sites all attain a "High Scoring Waters" designation per CDPHE (threshold of MMI >53). Scores for the benthic macroinvertebrate indicator are presented in Table 4-11.

Table 4-11. Macroinvertebrate Indicator Scores by Riverscape

Riverscape	Macroinvertebrate Score
Riverscape 7	B
Riverscape 8	B
Riverscape 9	B+
Riverscape 10	B-
Riverscape 11	B-
Riverscape 12	B+
Riverscape 13	B+

4.5 NUTRIENTS INDICATOR

Nutrients in stream water are essential for plants and animals. They occur naturally due to processes such as weathering and erosion, breakdown of organic material, and atmospheric deposition, but high nutrient levels are not good for stream health. Elevated nutrient levels in surface waters can result from human activities such as fertilizer application, runoff from agricultural and urban areas, effluent from wastewater treatment, seepage from septic systems, detergent, animal waste, and fuel combustion. Elevated nutrient levels can also cause algal blooms. In the last decade, concerns about cyanobacteria and associated cyanotoxins have been expressed by stakeholders in the Yampa Basin as algal blooms have been reported in local lakes and reservoirs, so this indicator is of public interest and therefore important to evaluate for the Scorecard.

4.5.1 Data Sources and Evaluation Methods

Nutrients, including total nitrogen and phosphorus, are measured quarterly by USGS as part of the Upper Yampa River Basin Water Quality Monitoring Program. One location in the Elk River segment is part of this monitoring program: Elk River near Milner, CO. Data from 2011 to 2025 were downloaded from nwis.waterdata.usgs.gov. Additionally, FOTY collected water quality samples at two locations in the Elk River segment (Figure 4-1) and considered those data in these analyses.

4.5.2 Scoring Criteria

The scoring criteria outlined in Table 4-12 based on adherence to interim regulatory standards set by CDPHE for nitrogen and phosphorus are used to rate the nutrients indicator.

Table 4-12. Nutrients Indicator Scoring Criteria

Grade	Description
A	Nutrient levels are natural and appropriate for a well-functioning river in its process domain.
B	Nutrient levels are within the range of natural variability. Natural aquatic biota may be minimally impaired. Interim regulatory standards are rarely exceeded.
C	Nutrient levels are altered to a degree that could significantly affect natural aquatic biota. Interim regulatory standards (0.11 mg/L (cold) and 0.17 mg/L (warm) for total phosphorus; 1.25 mg/L (cold) and 2.01 mg/L (warm) for total nitrogen) are occasionally exceeded. CDPHE Monitoring and Evaluation (M&E) listed reaches fall in this category.
D	Nutrient levels are altered to a degree that is known to affect natural aquatic biota. Interim regulatory standards (0.11 mg/L (cold) and 0.17 mg/L (warm) for total phosphorus; 1.25 mg/L (cold) and 2.01 mg/L (warm) for total nitrogen) are frequently exceeded. CDPHE 303(d) listed reaches fall in this category.
F	Unnaturally eutrophic or oligotrophic conditions clearly affect the distribution and abundance of characteristic aquatic life. Interim regulatory standards have been exceeded consistently.

4.5.3 Results

The nutrients indicator is evaluated through review of USGS Water Quality Monitoring Program data at the Elk River near Milner, CO monitoring location, where total phosphorus (TP), total Kjeldahl (organic) nitrogen (TKN), and total nitrogen (TN) have been measured quarterly since 2010. Because rivers integrate upstream inputs, data from the one USGS station at the downstream end of the focal segment are used to holistically score riverscapes 7-13. Data from FOTY-led instantaneous water quality sampling at Glen Eden, in riverscape 9, are used to further inform results for riverscapes 7-9; data from instantaneous sampling at Christiana, in riverscape 11, are used to inform results for riverscapes 10-11.

A USGS analysis of nutrient data (both concentrations and loads) in the Upper Yampa Basin for the 1992-2018 period was completed in 2021; more specifically, this report analyzed nutrient data at the Elk River near Milner station from 1992 - 2018 (Table 4-13). Scoring is based on that analysis, the findings of which have been synthesized for the purpose of the Scorecard and are presented below (Day 2021), as well as additional examination of the data after the period covered in the USGS report (2019-2024). Details of the methodology used in the nutrient analysis that yielded the summarized results below can be found in the body of the referenced USGS report (Day 2021).

Total nitrogen (inorganic + organic nitrogen; TN) is measured quarterly by USGS at the site mentioned above, as is Kjeldahl nitrogen (TKN). In the USGS report, daily concentrations of constituents are estimated from quarterly samples using linear regression models fit with R-LOADEST, a USGS-developed statistical program designed to calculate nutrient loads from periodic sampling data (see equation 1 of Day [2021] for mathematical explanation). Daily estimations of TN are not able to be made due to lack of the requisite number of samples; therefore, daily estimations of TKN are used as a surrogate for TN. Notably, daily estimations do not include quarterly sampling data from 2019 - 2025; only the discrete data for this latter period were analyzed for the purposes of the Scorecard.

Table 4-13. Modeled Median Kjeldahl Nitrogen and Total Phosphorous Concentrations for Each Water Year and the Overall Period of Analysis, 2010-2018 (adapted from Day [2021])

Station	2010	2011	2012	2013	2014	2015	2016	2017	2018	2010-18
Modeled Median Kjeldahl Nitrogen concentration (mg/L)										
Elk River near Milner, CO	0.21	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Modeled Median Total Phosphorous Concentration (mg/L)										
Elk River near Milner, CO	0.022	0.016	0.016	0.015	0.016	0.016	0.015	0.016	0.016	0.016

Note: All years are water year (October-September) rather than calendar year

Estimated median annual TKN was consistently well below the interim regulatory standard of 1.25 mg/L for cold water rivers for all evaluated water years at the gauging station in the focal segment (Table 4-13). Modeled monthly median concentrations for TKN were also well below the regulatory standard for all days across the analysis period at each site (Figure 4-6). TKN was typically the highest during the spring runoff months of April and May (Figure 4-6). Day (2021) mentions concentrations of water-quality constituents were typically highest in the spring months during the early snowmelt runoff period (March, April, and May). Similar to model results, discrete TKN and TN concentrations (Figure 4-7) remained below the interim regulatory standard for all quarterly samples. Lastly, results from water quality samples collected in riverscapes 9 and 11 showed TKN concentrations well below the 1.25 mg/L standard (solid points in Figure 4-7). Given the high degree of forested land within the Elk River segment and relatively low concentrations of crops or pasture, the consistently low concentrations observed are expected. Based on the available data, all riverscapes earn an A score with respect to nitrogen.

Like nitrogen, total phosphorous (TP) is measured quarterly at the Elk River near Milner, CO station, and these quarterly samples were used to estimate daily TP concentrations. Estimated median annual total phosphorous (TP) was below the interim regulatory standard of 0.11 mg/L for cold water rivers at the Elk River near Milner station for all years (Table 4-13). The same is true at the monthly and daily scale: median monthly concentrations fall well below the standard threshold, and the standard was exceeded on zero days across the entire modeling period (2010-2018). Discrete phosphorous concentrations painted a similar picture, with only one exceedance (in the spring of 2011) of the interim standard (Figure 4-7). Water quality samples collected in riverscapes 9 and 11 (solid symbols in Figure 4-7) showed very low TP concentrations, with three of the four samples having concentrations less than detection limit of 0.010 mg/L. Again, low observed and modeled concentrations are likely a result of the relatively high degree of forest cover and low concentration of pasture and cropland within the Elk River Basin. It is additionally encouraging that total phosphorus concentrations continue to fall well below the standard for aquatic life given that fires have burned significant area within the Elk River headwaters, resulting in a loss of 4.6% of the evergreen forest area from 2001-2016. Overall, each riverscape receives an A score for phosphorus. Combined nutrient indicator scores are provided in Table 4-14.

Figure 4-6. Modeled Monthly Median Kjeldahl Nitrogen and Total Phosphorus at Elk River near Milner USGS Station from 2010-2018 (Adapted from Day [2021])

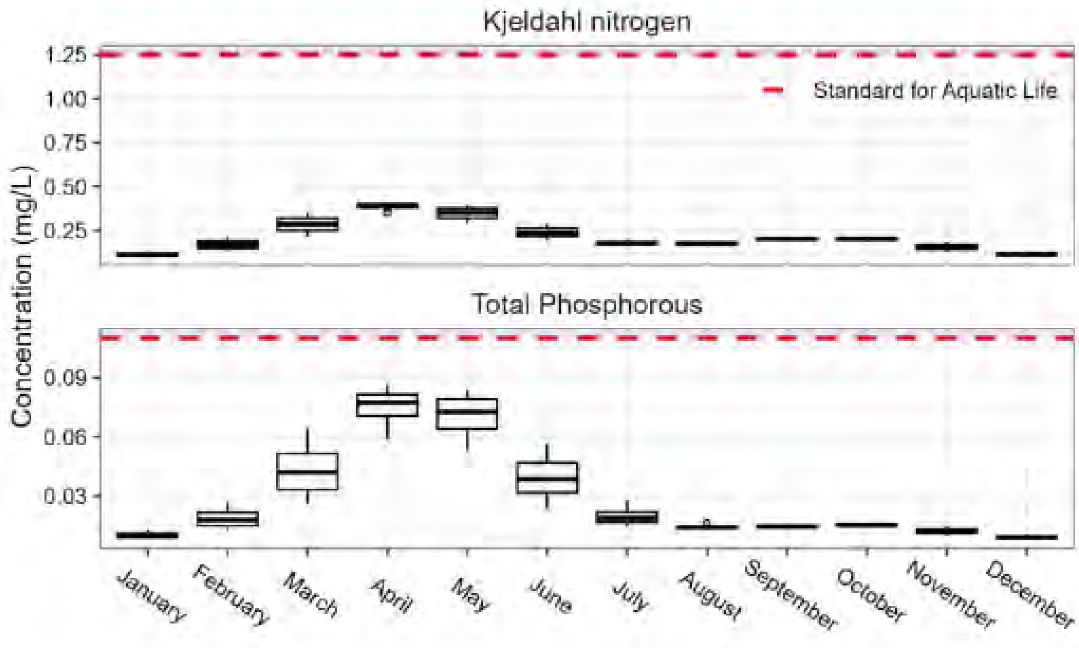


Figure 4-7. Measured (Discrete) Kjeldahl Nitrogen, Total Nitrogen, and Total Phosphorus at the Elk River near Milner USGS Station (2010-2025)

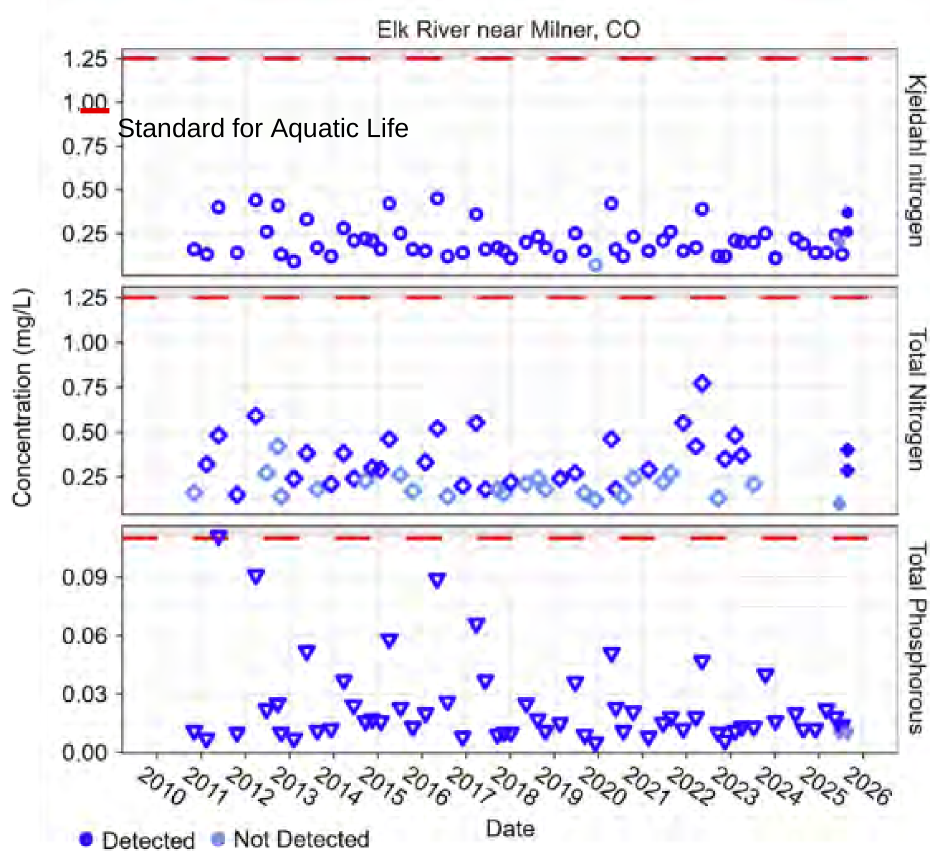


Table 4-14. Nutrients Indicator Scores by Riverscape

Riverscape	Nitrogen Score	Phosphorus Score	Nutrients Score
Riverscape 7	A	A	A
Riverscape 8	A	A	A
Riverscape 9	A	A	A
Riverscape 10	A	A	A
Riverscape 11	A	A	A
Riverscape 12	A	A	A
Riverscape 13	A	A	A

4.6 METALS INDICATOR

Metals generally occur at low concentrations in surface waters, and a number of them are essential nutrients to aquatic biota, but they are toxic at higher concentrations. CDPHE sets regulatory standards for most metals based on the uses identified for each stream segment (e.g., water supply, agriculture, recreation, aquatic life protection); if water quality samples frequently exceed these standards, the stream segment is placed on the State's 303(d) or M&E (monitoring and evaluation) list for that particular constituent.

4.6.1 Data Sources and Evaluation Methods

Select trace metals (total iron and manganese; dissolved cadmium, copper, lead, manganese, selenium, silver, and zinc) are measured quarterly by USGS as part of the Upper Yampa River Basin Water Quality Monitoring Program. One location in the Elk River segment is part of this monitoring program: Elk River near Milner, CO. Data were downloaded from nwis.waterdata.usgs.gov. Additionally, FOTY also collected water quality samples at two locations in the Elk River segment (Table 4-1, Figure 4-1) and considered the data in these analyses.

4.6.2 Scoring Criteria

The scoring criteria outlined in Table 4-15 based on adherence to regulatory standards set by CDPHE are used to rate the metals indicator.

Table 4-15. Metals Indicator Scoring Criteria

Grade	Description
A	Chemical conditions are within ranges that are natural and appropriate for a well-functioning river in its process domain.
B	Chemical conditions are within the range of natural variability. Natural aquatic biota may be minimally impaired even though background concentrations of certain metals may be elevated. Regulatory standards are rarely exceeded (except for metals with elevated background concentrations).

C	Chemical conditions are altered to a degree that could potentially limit natural aquatic biota. Stressors are present which create conditions that may warrant inclusion on State impaired waters lists. CDPHE Monitoring and Evaluation (M&E) listed reaches fall in this category.
D	Chemical conditions are altered to a degree that is known to be lethal or limiting to natural aquatic biota. Regulatory standards are frequently exceeded. CDPHE 303(d) listed reaches fall in this category.
F	The chemical environment is fundamentally altered. Natural biota are severely impaired. Regulatory standards have been exceeded consistently.

4.6.3 Results

The metals indicator is evaluated through review of USGS Water Quality Monitoring Program data at the Elk River near Milner, CO monitoring location, where total iron, total and dissolved manganese, dissolved cadmium, dissolved copper, dissolved lead, dissolved selenium, dissolved silver, and dissolved zinc are measured quarterly. Because rivers integrate upstream inputs, data from the one USGS station in the focal segment are used to holistically score riverscapes 7-13. Data from FOTY-led instantaneous water quality sampling at Glen Eden, in riverscape 9, are used to further inform results for riverscapes 7-9; data from instantaneous sampling at Christiana, in riverscape 11, are used to inform results for riverscapes 10-11. A USGS analysis of metals and other water quality data for the Upper Yampa Basin for the 1979 - 2009 period was completed in 2012; portions of this report that contain analysis and interpretation of data for the Elk River focal segment were examined for additional context (Bauch et al. 2012).

Figure 4-8 summarizes the total iron and dissolved metals concentrations from quarterly sampling at the Elk River near Milner station. Open circles indicate that concentration was below the level of the position of the point (e.g., an open circle at 1 mg/L for silver suggests that silver concentration for that sample was < 1 mg/L; Figure 4-8). Red shading corresponds to the respective metal's acute contamination standard, the yellow shading for the chronic standard, and the green shading represents the acceptable range for aquatic life (Figure 4-8). Of the metal constituents analyzed, all except iron were consistently below CDPHE regulatory standards (though the detection limit of the method used to calculate silver concentrations post-2015 precludes stating this with certainty; Figure 4-8). Elevated iron levels that occur occasionally throughout the monitoring record are likely lithologically driven; the igneous and metamorphic rocks that comprise much of the Elk River basin contain iron and iron-bearing minerals in relatively high concentrations (Bauch et al. 2012). Exceedances may also be related to the low natural hardness levels of the Elk River, which results in a lower standard for aquatic health. Low iron levels (<0.3 mg/L) were also seen in FOTY-led water quality sampling results at both sampling locations for both high (mid-June) and low (late August) flows. Overall, the relatively low concentrations of metals in the analyzed riverscapes aligns with the recent cessation or overall lack of activities that generally enhance in-stream concentrations of metallic species (e.g., industrial production, mining of precious metals). Every riverscape therefore receives an A score for the metals indicator (Table 4-16).

Figure 4-8. Total (Iron) and Dissolved Metals Concentrations from Quarterly Water Sampling at Elk River near Milner USGS Station (2010-2025)

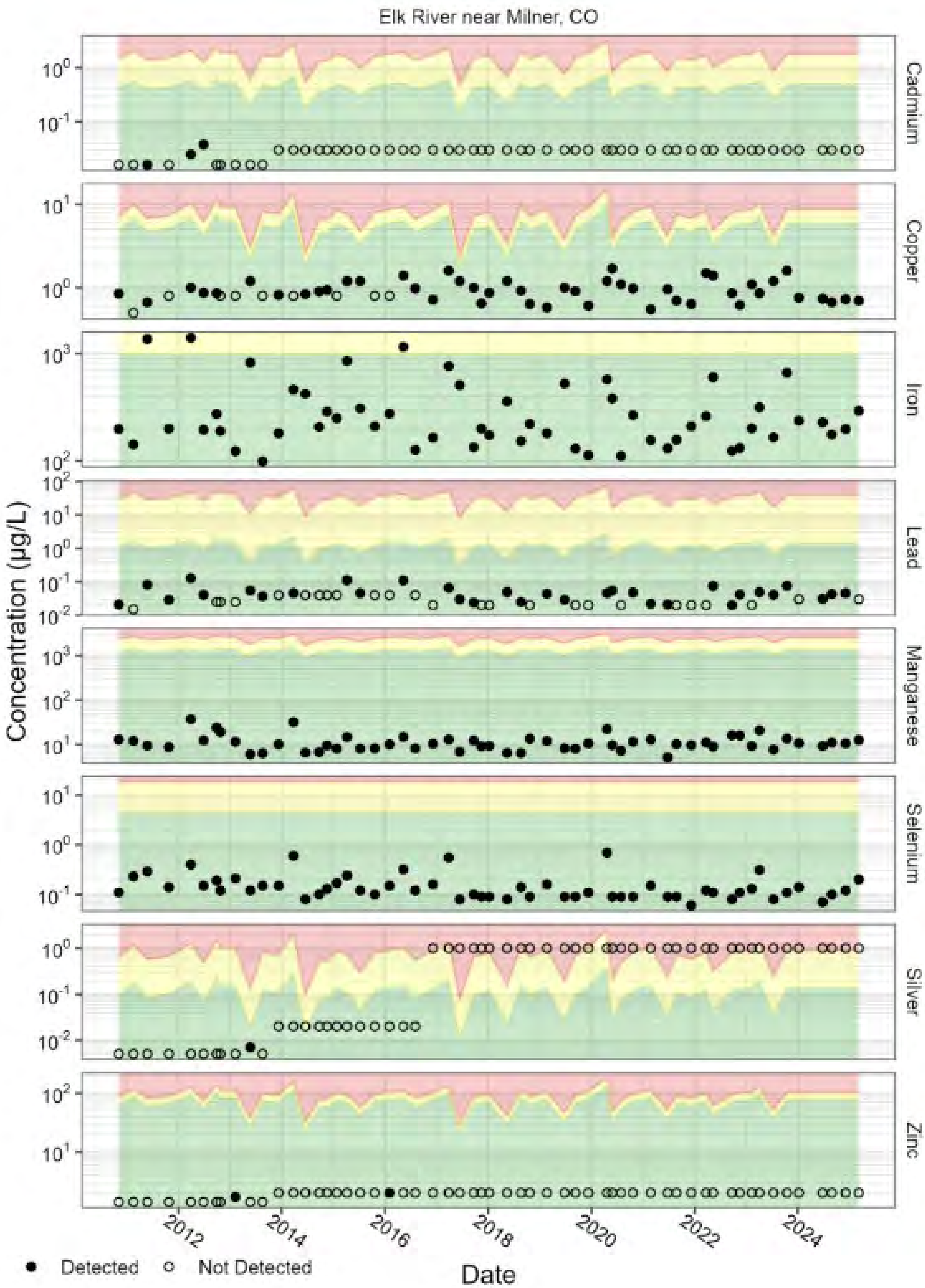


Table 4-16. Metals Indicator Scores by Riverscape

Riverscape	Metals Score
Riverscape 7	A
Riverscape 8	A
Riverscape 9	A
Riverscape 10	A
Riverscape 11	A
Riverscape 12	A
Riverscape 13	A

5.0 HABITAT CONNECTIVITY

Habitat connectivity is defined as the interaction and interconnectedness between a river segment and its surrounding landscape, including pathways for movement of biological organisms and organic matter through the riparian corridor. This category includes connectivity of both terrestrial and aquatic communities and considers both longitudinal (upstream/downstream) and lateral (channel/floodplain/upland) directions. The Yampa River Scorecard evaluates two indicators within the habitat connectivity category: **aquatic connectivity** and **terrestrial connectivity**. The final habitat connectivity score is calculated as an average of the aquatic connectivity and terrestrial connectivity indicator scores.

5.1 AQUATIC CONNECTIVITY INDICATOR

The aquatic connectivity indicator addresses the ability for aquatic organisms to migrate and disperse in both longitudinal (upstream/downstream) and lateral (between the channel and floodplain, e.g., side channels) directions. This indicator looks at the presence or absence of barriers to aquatic movement, as well as the presence and relative abundance of connected lateral aquatic habitats.

5.1.1 Data Sources and Evaluation Methods

Data used to score this indicator are collected by floating the lower riverscapes of 11, 12, and 13, and hiking as much of the upper riverscapes (7, 8, 9, and 10) as possible given private property and accessibility constraints. In the field, the team identified any in-channel structures and barriers to aquatic species movement, as well as connected lateral aquatic habitats. Locations of these structures and features were marked with a GPS to determine the spatial frequency of their occurrence within each riverscape. This fieldwork was completed in summer 2025 in coordinated partnership with local landowners (Appendix A).

Fieldwork during summer 2025 also identified the following features that are important to aquatic species migrating laterally for spawning and cover:

- Permanently inundated side channels;
- Seasonally inundated side channels;
- Backwater areas; and
- Split flows (i.e., two narrow channels versus one wide channel).

Fieldwork is augmented by review of historical and current aerial imagery to reflect the complexity and evolution of the riverscapes in terms of aquatic connectivity. The aerial imagery referenced was 2023 National Agricultural Inventory Program (NAIP) imagery, which is publicly available via the US Geological Survey online database (https://earthexplorer.usgs.gov/) and 2025 Airbus Satellite Imagery, which is accessible via Google Earth. Features evaluated to score the aquatic connectivity indicator (listed above) are, for the most part, readily observable from aerial and remotely-sensed imagery. Therefore, riverscapes where large portions were not accessible by boat or foot could still be fully scored through augmentation of field visits with remotely-sensed data.

5.1.2 Scoring Criteria

The scoring criteria outlined in Table 5-1 based on presence and extent of barriers to aquatic species movement and abundance of connected lateral aquatic habitats are used to rate the aquatic habitat connectivity indicator. Scoring thresholds are specific to the Yampa Basin and were established by an expert in the fluvial geomorphology of the Yampa River basin.

Table 5-1. Aquatic Connectivity Indicator Scoring Criteria

Grade	Description
A	No significant manmade barriers exist that prevent migration or dispersal of aquatic organisms within the entire ecoregion and upstream headwaters.
B	Impermeable migration/dispersal barriers are at least 10 miles apart and/or there are minor migration/dispersal impediments on the reach or adjacent reaches. Minimal loss of side channel and/or backwater area access may impact spawning and cover for certain species.
C	Impermeable migration/dispersal barriers are approximately 5 miles apart and/or there are multiple migration/dispersal impediments on the reach or adjacent reaches. Moderate loss of side channel and/or backwater area access may impact spawning and cover for certain species.
D	Impermeable migration/dispersal barriers are approximately 2 miles apart and/or migration/dispersal is severely impeded on the reach or adjacent reaches. Substantial loss of side channel and/or backwater area access may impact spawning and cover for certain species.
F	The reach is effectively isolated. Impermeable migration/dispersal barriers are approximately 1 mile apart or less and/or migration/dispersal is completely impeded on the reach or adjacent reaches. Access to side channel and/or backwater areas for spawning and cover is unavailable.

5.1.3 Results

The results of aquatic connectivity scoring are composed of two parts that together yield an overall score for this indicator: barriers to longitudinal connectivity (e.g., channel-spanning structures such as dams and cross vanes) and pathways for lateral connectivity (e.g., side channels and backwaters).

In terms of barriers to longitudinal connectivity, the lower riverscapes within the Elk River segment have a relatively dense concentration of structures (Figure 3-3). The majority of these structures take the form of "push-up" style structures designed to direct flow into diversion ditches (Appendix A, Photos A-4 and A-5) and channel stabilization and grade control features such as j-hooks and cross vanes designed to dissipate energy and prevent erosion (Appendix A, Photos A-1 through A-3). On average, channel spanning (but passable/permeable) structures are separated by only 0.28, 0.25, and 0.13 miles, respectively, within the downstream riverscapes of 11, 12, and 13, reflecting the relatively high agricultural use of these riverscapes as well as the greater relative frequency of homes, residential neighborhoods, and associated structures in proximity to the river. Channel stabilization structures are likely more common here because of these factors, which may lead to a greater desire to mitigate erosion and lateral migration to protect assets (structures, arable acreage, etc.). Diversion structures are also likely a direct function of relatively greater agricultural land use. The Yampa IWMP similarly identified the Elk River segment as having the second highest density of diversion structures (3.6 per mile) in the entire Yampa Basin, second to the Upper Yampa segment (Yampa IWMP 2021). Though channel stabilization features have been found to interrupt natural sediment, flood, and habitat-development processes, it is unclear if they significantly hinder aquatic organism passage at a full range of flows. Importantly, because of their relatively passable nature, especially at high flow, structures here are considered impediments to dispersal rather than fully impermeable barriers capable of isolating individual river reaches. However, because of the extremely high density of these structures within riverscape 13, that riverscape is assigned a D score for barriers to habitat connectivity. The slightly lesser density of in-channel structures within riverscapes 11 and 12 result in a C- score for habitat barriers. Notably, though in-channel barriers are common, no completely impermeable structures (e.g., impoundment dams) exist.

The further upstream riverscapes of 9 and 10 have relatively fewer in-channel structures (Figure 5-1), though such structures are still fairly common, particularly in riverscape 9 (Figure 5-1). Barriers here generally take the form of “push-up” dams, j-hooks, and cross vanes (Appendix A, Photo A-5). A few bridges associated with county road crossings are present as well, but they generally have bottom chords relatively high above river surface and lack additional modifications or features that might inhibit passage (e.g., concrete slab or other grade control features, in-channel abutments) (Appendix A, Photo A-6). Average length between barriers ranges from 0.3 miles in riverscape 9 to 0.6 miles in riverscape 10. In riverscape 10, structures are generally concentrated in the lower portion, and a long stretch of river in the upper portion of the riverscape lacks observable barriers. Notably, an approximately 1-mile length of river in riverscape 9 has been very recently altered via the addition of erosion control features for bank stabilization (Figure 7-1; Appendix A, Photos A-7 through A-8), but this stretch was not visited for fieldwork due to access permissions. Though some in-channel structures are visible from remote imagery, without field visitation, it is difficult to assess the prevalence of such features or determine the degree to which the features visible on the banks from aerial imagery intersect the channel. Scores here and in other areas without field access are based on the best available information but may not accurately reflect the exact number of structures. Given the occurrence of multiple of in-channel structures, riverscape 9 receives a C+ score for the barriers component of the aquatic connectivity indicator. Riverscape 10, which has a relatively low occurrence of passable structures for its length (9 total in approximately 8 miles), earns a B- score. As in riverscapes 11 through 13, no completely impermeable in-channel structures were observed.

In contrast to downstream riverscapes, the uppermost riverscapes 7 and 8 have relatively few in-channel structures (Figure 5-1). Riverscape 8 has two such structures located in the more downstream portion and associated with water intakes, but otherwise lacks any structures in the upper 2.5 miles of the riverscape. Riverscape 7 lacks in-channel structures completely. The relative dearth of these structures results in a barrier score of A for riverscapes 7 and 8 (Table 5-2).

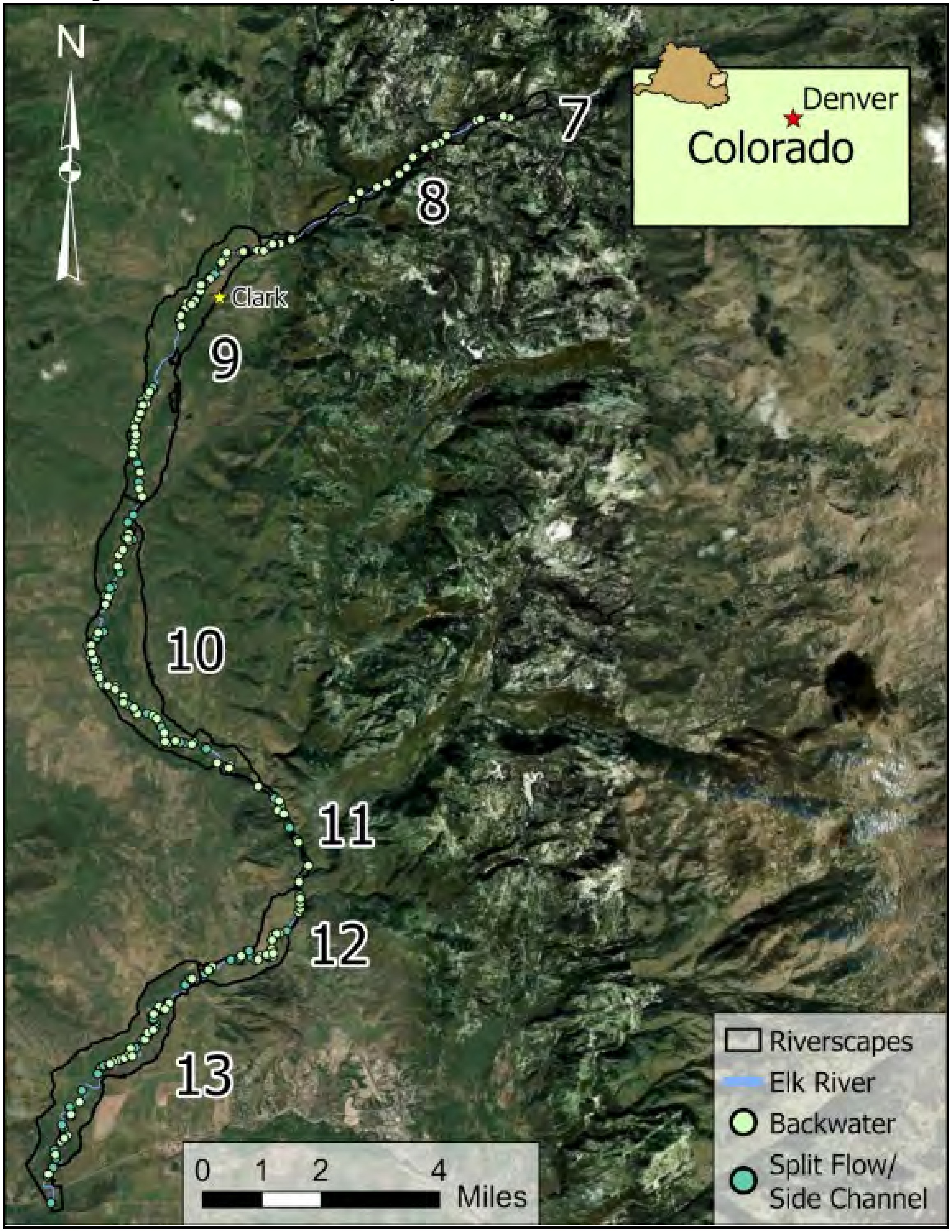
Pathways for lateral movement (e.g., side channels) are commonly found along the Elk River throughout the study area (Figure 5-1), particularly in the more unconfined riverscapes (riverscapes 9, 10, 12, and 13). The presence of such features enables aquatic organisms to extricate themselves from the higher energy of the main channel into relatively sheltered and quiescent waters (Appendix A, Photos A-9 and A-10). Lateral connectivity pathways are important for spawning and rearing of several species of fish, as well as for other organisms that may move frequently between the main river channel and the neighboring floodplain (e.g., beaver) (Appendix A, Photo A-9). Lateral pathways scores were determined by (1) calculating the number of such features observed in the field and on imagery per river mile, and then (2) evaluating that number relative to what may be expected of a natural river in its process domain using the following rubric, which dovetails with the scoring criteria described in Section 5.1.2: for unconfined reaches (riverscapes 9, 10, 12, and 13), no loss of side channel access (>4/mile); minimal loss of side channel access (3-4/mile); moderate loss of side channel access (2-3/mile); substantial loss of side channel access (1-2/mile); and full loss of side channel access (<1/mile). For partially to fully confined reaches, side channels are likely relatively rare due to the small alluvial area over which the river may flow (i.e., small to no floodplains), particularly in steep reaches such as those found in the upper Elk. In these riverscape types, no loss of side channel access is considered at >1/mile and mild loss of side channel access is quantified at <1/mile. Field-based estimates of lateral pathways represent minimum values, as all pathways in certain areas could not be measured due to lack of access.

Lateral pathways were most frequent and widespread in the unconfined riverscapes 9, 10, and 13 (approximately 11-14/mile) (Figure 5-1). This is reflective of both the wide, unconfined nature of these riverscapes as well as management that has given the river relatively free reign to form islands and split flows. Notably, a large reach within riverscape 9 has recently been modified to remove all split flows, side channels, and additional complexity (Figure 7-1), though the relatively complex reaches upstream and downstream modulate the impact of this area at the full riverscape scale. In riverscape 12, which is similar in nature in many ways to riverscapes 10 and 13, though lateral pathways are still common (approximately 9/mile), there is a relative dearth compared to these other riverscapes, perhaps reflective of the more extensive bank armoring and erosion control structures within this riverscape. Overall, riverscapes 9, 10, and 13 receive an A score for lateral pathways, while riverscape 12 receives an A- score.

In the confined reaches of riverscapes 7 and 8 (where confinement is due to glacial relic terraces), split flows and side channels are rare (Figure 5-1). This is a function of the extremely steep and confined nature of these riverscapes, which promote efficient transport of sediment and other material and thus have relatively minimal opportunities for deposition and the formation of channel complexity. Backwaters are more common here, though it should be noted that they are generally relatively small features (Appendix A, Photo A-26) Riverscape 8 has approximately 8 features/mile, suggesting that there has been little to no loss of natural channel complexity and lateral pathways. Riverscape 7, on the other hand, has only 3 features/mile (solely backwaters) and a complete lack of side channels and split flows. This is likely due to the even more substantial confinement of the river in this riverscape, which allows for little room for side channels and split flows to form. Because confinement here is natural and caused by relic glacial terraces, it is likely that the lack of features is to be expected for a river within this process domain and not a result of human modifications. Riverscapes 7 and 8 both therefore earn A scores for lateral pathways.

Finally, in riverscape 11, where the river is confined by bedrock throughout but relatively less steep than upstream confined sections, 3 features/mile were observed (Figure 5-1). This relative abundance suggests that there has been little loss of lateral pathways in this riverscape and is likely reflective of the lack of modification of the small floodplain areas that are found in the middle reaches of riverscape 11 (proximal to the Christina SWA Fishing Easement access). Riverscape 11 earns an A score for lateral pathways.

Figure 5-1. Locations of Pathways for Lateral Movement as Observed in the Field



* Note: Each riverscape was visited by foot or boat for field observations, except for minor portions of riverscapes 7 and 8, approximately 45% of riverscape 9, approximately 65% of riverscape 10, and approximately 10% of riverscape 11, mainly due to private property access considerations.

Table 5-2. Aquatic Connectivity Indicator Scores by Riverscape

Riverscape	Barriers Score	Lateral Pathways Score	Aquatic Connectivity Score
Riverscape 7	A	A	A
Riverscape 8	A	A	A
Riverscape 9	C+	A	B
Riverscape 10	B-	A	B+
Riverscape 11	C-	A	B
Riverscape 12	C-	A-	B-
Riverscape 13	D	A	B-

5.2 TERRESTRIAL CONNECTIVITY INDICATOR

The terrestrial connectivity indicator addresses the ability of terrestrial organisms to move both longitudinally (upstream/downstream) and laterally (between the channel and riparian zone, between riparian zone and upland areas). This indicator considers habitat fragmentation, including barriers created by roads, railroads, trails, bridges, fences, and other impediments.

5.2.1 Data Sources and Evaluation Methods

The Scorecard relies on floodplain fragmentation metric results from the Yampa IWMP remote assessment that was conducted as part of the riparian condition evaluation (Yampa IWMP 2021). For context, the Yampa IWMP remote assessment evaluated riparian condition across the basin using the Riparian Condition Assessment Tool (RCAT) developed by Utah State University (MacFarlane et al. 2018). RCAT provides a holistic proxy measure of riparian condition by assessing and integrating three key metrics of riparian functions: (1) riparian vegetation departure from historical conditions, (2) land use intensity within valley bottoms, and (3) floodplain fragmentation by infrastructure (roads, railroads, levees, etc.). The floodplain fragmentation metric calculates the proportion of accessible versus inaccessible floodplain within a reach due to roads, railroads, levees, or other infrastructure. Scores range from 100% (fully accessible) to zero (inaccessible). See Section 6.2.1.1.3 in the Yampa River Remote Assessment Data Synthesis Report for further details on the methodology (Yampa IWMP 2021). The floodplain fragmentation statistic calculated for each riverscape (encompassing the lateral extent of the entire valley bottom) is coupled with review of and confirmation from aerial imagery to rate the terrestrial connectivity indicator.

5.2.2 Scoring Criteria

The terrestrial connectivity indicator scoring criteria outlined in Table 5-3 are based on floodplain fragmentation and severity and proximity of migration barriers to terrestrial species movement.

Table 5-3. Terrestrial Connectivity Indicator Scoring Criteria

Grade	Description
A	Negligible fragmentation of the floodplain by infrastructure and development, with a floodplain fragmentation score of > 91%. No significant barriers to migration or dispersal of terrestrial organisms.
B	Minor fragmentation of the floodplain by infrastructure and development, with a floodplain fragmentation score between 71-90%. Impermeable barriers affect a minor portion of surrounding habitat, but permeable barriers such as gravel roads, minor berms, ditches, or barbed wire fences may be present.
C	Moderate fragmentation of the floodplain by infrastructure and development, with a floodplain fragmentation score between 41-70%. Impermeable barriers affect a moderate portion of surrounding habitat, and semi-permeable barriers such as two-lane paved roads, rail lines, or widely scattered residential development may be present.
D	Significant fragmentation of the floodplain by infrastructure and development, with a floodplain fragmentation score between 21-40%. Impermeable barriers and/or permeable barriers affect a substantial portion of surrounding habitat.
F	Severe fragmentation of the floodplain by infrastructure and development, with a floodplain fragmentation score of < 20%. Impermeable barriers and/or permeable barriers affect almost all of the surrounding habitat.

5.2.3 Results

Terrestrial habitat fragmentation is relatively negligible in riverscapes 10 and 13 where the floodplain largely consists of open agricultural fields that lack extensive infrastructure such as roads, and in riverscape 11, where the river is confined and the relatively small floodplain is similarly bereft of infrastructure (Table 5-4, Figure 5-2). Moderate fragmentation occurs in the remainder of the riverscapes except for riverscape 9, where fragmentation is minor (Table 5-4, Figure 5-2). In the uppermost riverscapes of 7 and 8, fragmentation is largely a result of Seedhouse Road, which impinges on the river in several locations (Table 5-4, Figure 5-2). In riverscapes 9 and 12, fragmentation is also a function of infrastructure associated with roads. Here, several county roads are located relatively proximal to the river in many areas, particularly in riverscape 12. Features associated with development and agricultural production (such as berms) may also fragment the floodplain in these riverscapes. Scores for the terrestrial connectivity indicator are presented in Table 5-5.

Table 5-4. Floodplain Fragmentation Percent by Riverscape

Riverscape	Floodplain Fragmentation
Riverscape 7	59%
Riverscape 8	69%
Riverscape 9	73%
Riverscape 10	95%
Riverscape 11	96%
Riverscape 12	68%
Riverscape 13	94%

* Adapted from the Yampa River Remote Assessment Data Synthesis Report (Yampa IWMP 2021); higher percentages correspond to minimal fragmentation and lower percentages correspond to greater fragmentation of the landscape.

Figure 5-2. Floodplain Fragmentation (Representing Terrestrial Connectivity) by Riverscape

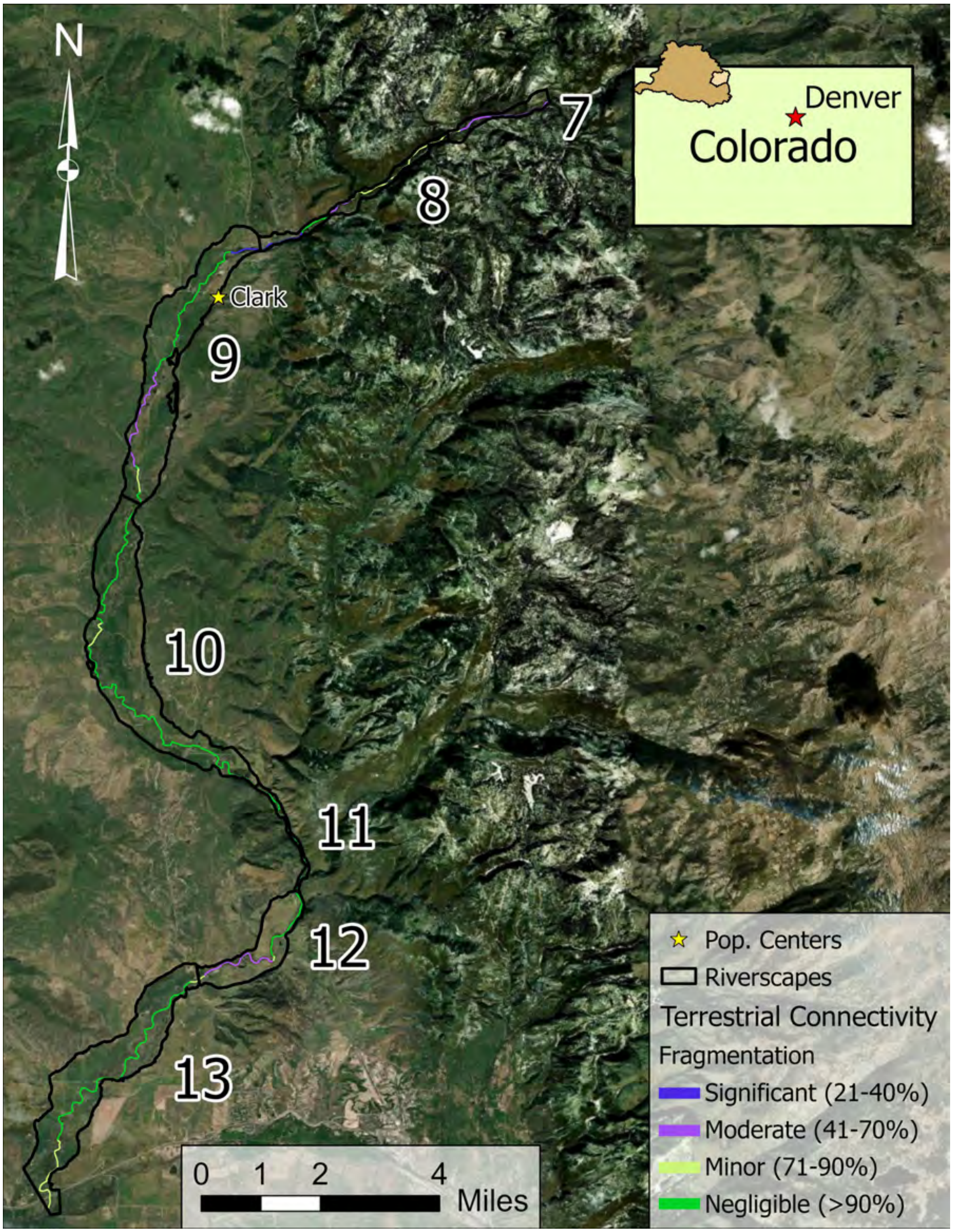


Table 5-5. Terrestrial Indicator Scores by Riverscape

Riverscape	Terrestrial Connectivity Score
Riverscape 7	C
Riverscape 8	C+
Riverscape 9	B-
Riverscape 10	A
Riverscape 11	A
Riverscape 12	C+
Riverscape 13	A

6.0 RIVERSCAPE CONNECTIVITY

Riverscape connectivity is defined as the degree to which water can access and hydrate the surrounding riverscape (channel and floodplain). In particular, riverscape connectivity reflects the ability of the valley bottom to be actively and routinely engaged by fluvial processes. Connectivity varies naturally based on geology, topography, and hydrology. It also reflects impediments due to hydromodifications, channel modifications (e.g., enlargement, entrenchment, channelization/ stabilization), and/or anthropogenic land uses within the floodplain (e.g., levees, drainage ditches, development, fill), which limit hydrogeomorphic processes, dynamism of channel/floodplain interaction, and biological interactions between the channel and its floodplain. The Yampa River Scorecard evaluates riverscape connectivity using a single indicator referred to as **riverscape connectivity**.

6.1 RIVERSCAPE CONNECTIVITY

Riverscape connectivity for the Scorecard project is defined as the ratio of the active floodplain to the maximum possible floodplain extent, as was done for the Yampa IWMP remote assessment. The Yampa IWMP remotely evaluated a Floodplain Connectivity indicator across the entire basin, described as the ratio of the accessible extent of the active floodplain to the maximum potential accessible floodplain (Yampa IWMP 2021). The floodplain connectivity ratio is a proxy measure of the extent and frequency with which flows interact with the channel and adjacent floodplain. This interaction is critical for soil health, maintaining an adequately high water table, and creating and supporting a healthy stream corridor by helping establish and maintain riparian vegetation throughout the floodplain, which in turn extends inundation residence times by attenuating and slowing flows through the system.

For the Yampa IWMP remote assessment, floodplain connectivity was assessed across the entire basin, and reassessed using higher resolution data in 6 priority riverscapes, to characterize the capacity of water to inundate and activate the adjacent riparian corridor. The higher resolution data used for a portion of the Middle Yampa and Elk River segments allowed for better identifying and mapping fluvial features and more accurately delineating floodplain extents, and those analyses yielded the generation of a set of multipliers to better approximate floodplain connectivity for riverscapes with moderate resolution data. It is important to note that a critical component of accurate floodplain and geomorphic delineations is field verification. While the remote assessment provides a good foundation, the Scorecard effort provides ground-truthing, field verification, and refinement of those results to the extent possible using all available information (described more in Section 6.1.3).

The active floodplain is defined as the extent to which flows can access the land adjacent to the river over <u>frequent to moderate</u> recurrence intervals. The active floodplain delineates the areas where inundation duration and frequency can maintain riparian vegetation and active fluvial processes. To determine the area occupied by active floodplain via remote sensing, two lines of evidence were used: (1) floodplain fragmentation by development and transportation infrastructure, which have disconnected low-lying areas from the active floodplain, and (2) topographic datasets to identify low-lying areas that have the potential to be inundated at frequent to moderate recurrence intervals. Integration of the floodplain fragmentation and the potentially active floodplain layers were used to delineate the active floodplain. The active floodplain is defined as land that is within the potentially active floodplain that has not been disconnected by development or transportation networks. Figure 6-1 shows some of the steps taken to determine the floodplain connectivity ratios for the Yampa IWMP remote assessment from an example riverscape in the Middle Yampa segment (Yampa IWMP 2021).

Figure 6-1. Yampa IWMP Remote Assessment Floodplain Connectivity Metrics Example

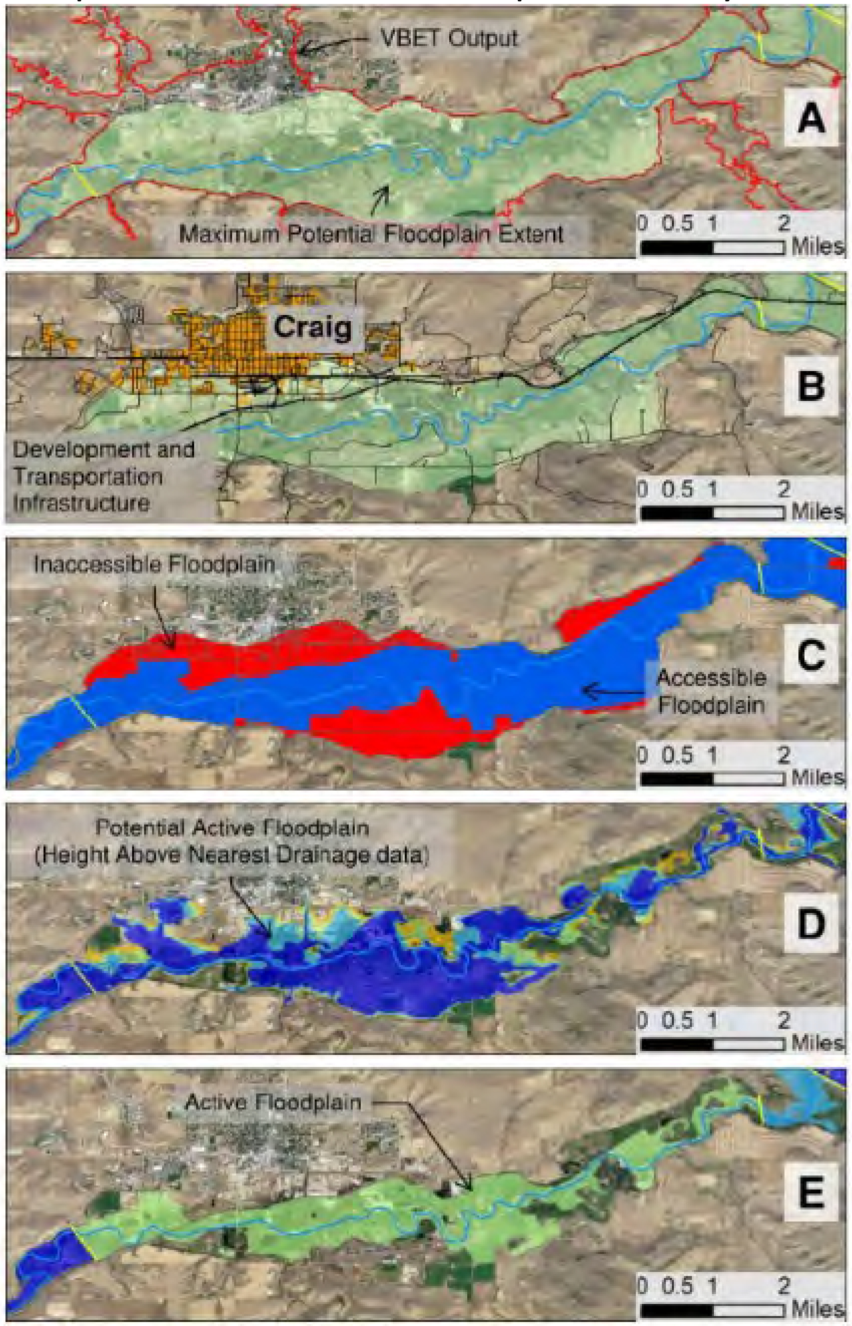


Figure 6-1. Example floodplain connectivity metrics for Riverscape 23 (see Figure 2-4 for context). A) VBET outputs and manually modified valley bottom representing the maximum potential floodplain extent. B) Development and transportation infrastructure overlain on valley bottom polygon. C) Floodplain fragmentation by development and transportation network. D) Potential active floodplain based on Height Above Nearest Drainage. E) Active floodplain.

6.1.1 Data Sources and Evaluation Methods

The Scorecard uses the results of the Yampa IWMP remote assessment floodplain connectivity evaluation (Yampa IWMP 2021) to score the riverscape connectivity indicator. However, the remote assessments did not include a field verification component. For the Scorecard, the floodplain connectivity ratios for the seven riverscapes in the Elk River segment were ground-truthed to the extent possible, particularly in terrace-confined reaches where remote assessment may have overestimated the maximum potential extent, through site visits in areas with landowner access permissions. Select sites were visited for field verification in September 2025 following review of available aerial imagery and topography data. Where discrepancies were identified, the Scorecard altered the IWMP evaluation based on the field verification exercise and used an updated score for evaluation per the scoring criteria described in Section 6.1.2.

6.1.2 Scoring Criteria

The scoring criteria outlined in Table 6-1 based on Yampa IWMP remote assessment floodplain connectivity ratios are used to rate the riverscape connectivity indicator.

Table 6-1. Riverscape Connectivity Scoring Criteria

Grade	Description
A	Natural pattern of floodplain activation over frequent to moderate recurrence intervals, with a floodplain connectivity ratio of > 90%.
B	Majority of riverscape extent is available for activation over frequent to moderate recurrence intervals, with a floodplain connectivity ratio of 75-90%.
C	Moderate amount of riverscape extent is available for activation over frequent to moderate recurrence intervals, with a floodplain connectivity ratio of 50-74%.
D	Small amount of riverscape extent is available for activation over frequent to moderate recurrence intervals, with a floodplain connectivity ratio of 25-49%.
F	Riverscape activation over frequent to moderate recurrence intervals is extremely limited, with a floodplain connectivity ratio of < 25%.

6.1.3 Results

This indicator is scored using a combination of review of IWMP remote assessment results and data collected during site visits with Scorecard partners. Edits to the active and maximum floodplain polygon generated by the IWMP were made using ground truthing, 1-m topographic data, and aerial photograph inspection for all riverscapes. Active floodplain extents were edited in riverscapes 7, 12, and 13; riverscapes 8-11 remained unchanged. The maximum floodplain extent was adjusted for riverscape 7, but remained the same as those delineated in the IWMP report for all other riverscapes. Edits to the maximum floodplain extent within riverscape 7 mainly reduced the area of this feature, as the approach taken in the IWMP overestimated the area due to the presence of relic glacial formations. Riverscapes 8-10 were priority riverscapes for the IWMP remote assessment, and results for active and maximum floodplain areas were derived using higher-resolution (1-m) elevation data than for riverscapes 7 and 11-13 (10-m resolution data). Adjustments to riverscape 7 for the Scorecard project were made using the same high-resolution imagery as the IWM used for riverscapes 8-10. Those priority riverscape scores are directly adopted for this analysis (see Yampa IWMP 2021, Appendix C). Additionally, floodplain connectivity multipliers determined by the IWMP assessment were used to adjust values for riverscapes 11-13. Briefly, multipliers were developed by the IWMP by comparing floodplain mapping results in priority riverscapes when high-resolution data were used to results in the same riverscapes when moderate resolution elevation (10-m) data were used. Multiplier values roughly represent the ratio of the calculated floodplain area using the former procedure to that calculated using the latter. They can be thought of as an empirical adjustment necessary to account for lower-resolution data. The floodplain connectivity percentage reported in Table 6-2 is a ratio of the active floodplain extent and the maximum potential floodplain extent, and the adjusted connectivity percentage is determined using the edited Scorecard floodplain polygon data.

Table 6-2. Confinement and Floodplain Connectivity Percentages by Riverscape

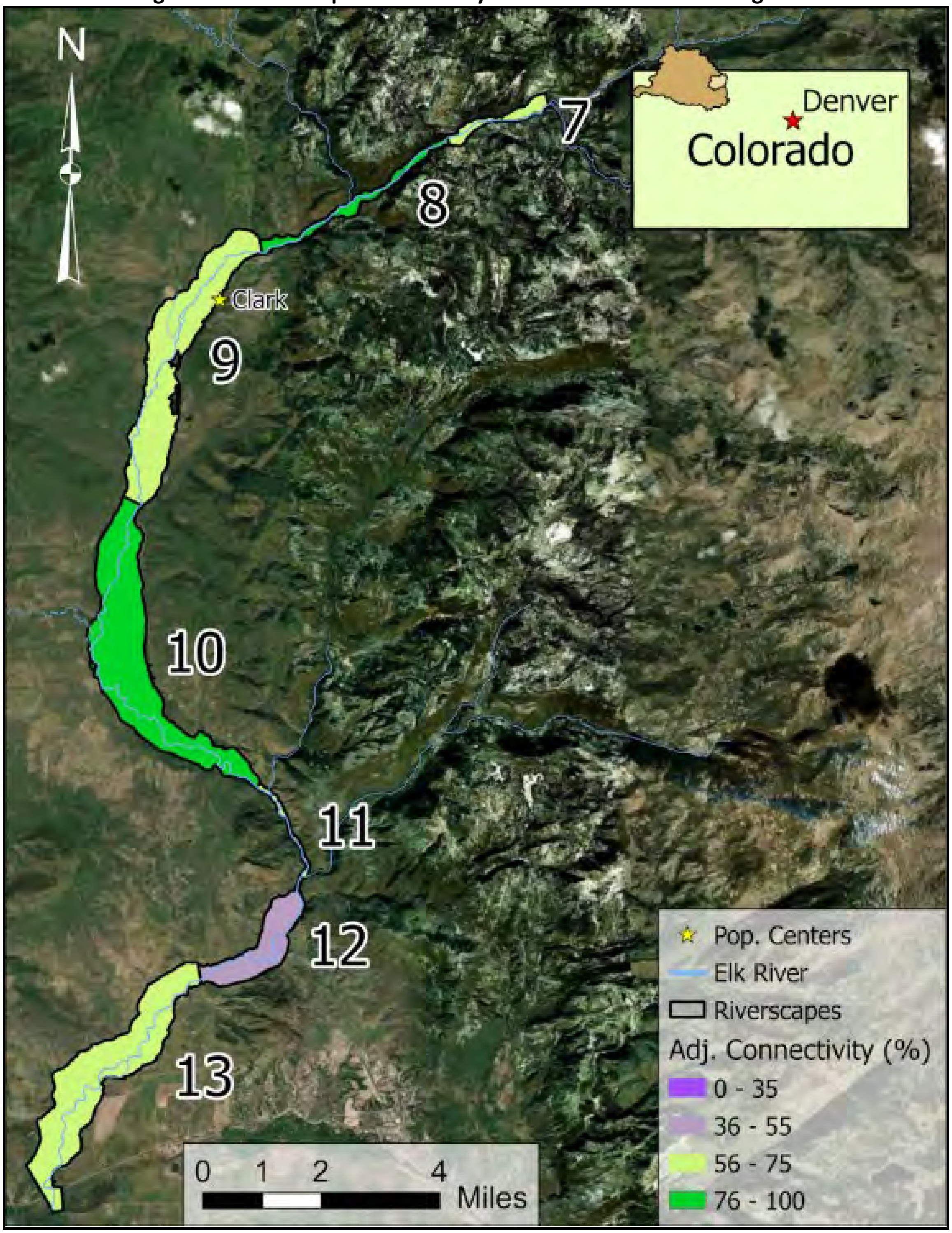
River-scape	Confinement	Max. Potential Floodplain (mi^2)	Active Floodplain IWMP (mi^2)	Active Floodplain YRSP (mi^2)	Floodplain Connectivity	Multi-plier*	Adjusted Floodplain Connectivity (%)
7	Confined	0.064**	0.08	0.047	74%	-	74%
8	Confined	0.13	0.10	0.10	80%	-	80%
9	P. Confined	1.00	0.64	0.64	64%	-	64%
10	P. Confined	2.98	2.56	2.56	86%	-	86%
11	Confined	0.15	0.09	0.09	64%	1.0	64%
12	P. Confined	1.07	0.21	0.34	21%	2.5	54%
13	Unconfined	3.07	1.41	1.50	48%	1.3	64%

* The floodplain connectivity multiplier calculated by the Yampa IWMP (2021) was not applied to riverscapes where high-resolution, 1-m elevation data was used to delineate the maximum and active floodplain area (riverscapes 7-10).

** Maximum potential floodplain area in riverscape 7 was updated by the project team based on field verification and remote assessment of high-resolution (1-m) elevation data.

Overall, adjusted floodplain connectivity scores were moderate for the majority of riverscapes in the Elk River segment (riverscapes 9, 11-13) (Figure 6-2, Table 6-2). Connectivity in these moderate-scoring areas ranges from 54-64%. In riverscape 9, floodplain connectivity is likely reduced by the presence of features such as bank armoring, which is relatively extensive throughout that riverscape (Table 9-2, Figure 9-1), as well as other infrastructure (such as roads) located proximal to the channel that inhibits the ability of the river to access its floodplain. Berms constructed on the riverbanks and the floodplain in several areas of riverscape 9 likely also reduce floodplain connectivity. Notably, very recent (spring 2025) modifications over an approximately 1-mile stretch that further increased bank armoring within riverscape 9 (Figure 7-1; Appendix A, Photos A-7 and A-8) are likely to influence floodplain connectivity calculations in the future (e.g., by causing incision). However, the potential impact of these actions have not yet been felt due to the recency of their implementation. In the lower riverscapes of 11, 12, and 13, the floodplain is fragmented by human infrastructure, including ditches, fence lines, bank protection, and development. Here, relatively low scores are reflective of this heightened degree of fragmentation. The river in riverscape 11, though confined by bedrock, is additionally confined by Elk River Road throughout much of its length. The road and associated structures (such as bank reinforcement) prevent access to the full extent of the floodplain, resulting in a connectivity score of 64%. The same is true in the upper reaches of riverscape 12. In the lower reaches of this riverscape, floodplain connectivity is additionally interrupted by development and associated bank armoring to protect structures built on the floodplain. Infrastructure in riverscape 13, a relatively wide and unconfined floodplain compared to those upstream, generally takes the form of fencing, ditches, and roads, which fragment the otherwise wide floodplain and prevent access, resulting in a score of 64%. This is especially true on the northern and western banks of the Elk.

Figure 6-2. Riverscape Connectivity Scores for the Elk River Segment



The highest connectivity scores occurred in riverscape 10 (86%), where high scores are reflective of the relatively intact degree of the floodplain cottonwood forest, which remains extensive in several locations. Relatively higher connectivity in riverscapes 7 and 8 also reflects the minimal development on the floodplain in these upper riverscapes. This is likely a result of the nature of the river here, which is confined by high terraces that are a relic of glaciation in the Zirkel Mountains and subsequently has (very) small, largely intact floodplains formed within the inset valley. Development, however, has occurred in some areas, particularly at the lower end of riverscape 7 where several houses are built within the floodplain, and in a few areas in riverscape 8 where housing developments along Seedhouse Road encroach on floodplain surfaces. Reductions in connectivity are likely also caused by the impingement of the road and associated bank armoring in several areas within these upper riverscapes. Scores for the riverscape connectivity indicator are presented in Table 6-3.

Table 6-3. Riverscape Connectivity Indicator Scores by Riverscape

Riverscape	Riverscape Connectivity Score
Riverscape 7	B-
Riverscape 8	B
Riverscape 9	C
Riverscape 10	B+
Riverscape 11	C
Riverscape 12	C-
Riverscape 13	C

7.0 RIPARIAN CONDITION

Riparian areas, or lands that occur along and are influenced by watercourses, are a critical part of a healthy and resilient stream ecosystem, providing physical roughness that slows water velocities and mitigates the impacts of flood flows; bank stability through root system cohesiveness; habitat for a diversity of riparian plants, animals, and microbes; water quality improvement; shade for the stream corridor to maintain a healthy thermal regime; large wood to stream channels, which creates beneficial habitat complexity; organic matter to the water column; cover and food for fish; and off-channel habitats like backwaters, wetlands, and side channels that act as refugia for fish and other aquatic species. Well-established and connected riparian areas also link stream corridor and upland ecological processes. Riparian condition is defined as the degree to which riparian areas support river health and critical functions. The Yampa River Scorecard evaluates two indicators within the riparian condition category: **vegetation structure and complexity** and **invasive species**. The final riparian condition score is calculated as 90% vegetation structure and complexity indicator score and 10% invasive species indicator score.

7.1 VEGETATION STRUCTURE AND COMPLEXITY INDICATOR

The vegetation structure and complexity indicator describes riparian vegetation and its ability to support characteristic riparian functions. Healthy riparian zones are characterized by a high level of vertical and horizontal complexity, including a mosaic of habitat types and multiple vegetation layers. Included in these considerations are structure, height, cover, species diversity, complexity, age, and patchiness/interspersion of riparian vegetation. The character and complexity of riparian vegetation are primarily driven by above ground saturation and the associated disturbance caused by seasonal flooding, alluvial groundwater, and erosional and depositional changes that create bars and distribute overbank fine sediment. Complex riparian corridors in turn influence a spectrum of physical functions in the river ecosystem while providing critical wildlife habitat.

Riparian condition is evaluated within a limited portion of the maximum potential floodplain as defined in the riverscape connectivity category. In particular, it is evaluated out to a maximum of 100 meters from each channel bank. The maximum potential floodplain – and therefore potential extent of riparian vegetation – is sometimes considerably wider than 200 meters on the Yampa and Elk Rivers, which is the case for several of the riverscapes within the Elk River segment. The limited scope of the riparian condition category represents a compromise between data acquisition and available resources. The condition and extent of riparian vegetation is evaluated near the channel where it exerts the greatest control on river health, but the condition of riparian vegetation in the wider riverscape is not assessed. Future assessments will seek to expand the breadth of riparian vegetation mapping within the maximum potential floodplain in order to chart riverscape-scale changes in land cover and land use.

7.1.1 Data Sources and Evaluation Methods

Vegetation structure and complexity are evaluated using the same remote polygon methodology applied in the City of Steamboat Springs SMP's river health assessment (City of Steamboat Springs 2018), with the lateral extent of the riparian zone defined as the edge of the natural floodplain or 100 meters from each river bank (200 meters total terrestrial width), whichever is narrower. This methodology was applied to riparian condition assessments of the three previous iterations of the Yampa River Scorecard Project evaluations: the Middle Yampa segment in 2022, the Steamboat segment in 2023, and the Upper Yampa segment in 2024. The approach entails the following steps:

(1) Create and classify polygons within the riparian zone by land cover (e.g., cottonwood/canopy forest, sub-canopy forest, montane forest, scrub-shrub, herbaceous, wetland, developed, bare ground, open water) and land use (e.g., ranch lands, light agriculture, wildlands, rural development, residential, transportation corridor);
(2) conduct initial desktop grading on polygons created in step 1;
(3) field verify and refine initial polygons, particularly for polygons with natural-looking riparian vegetation;
(4) perform a calibrated grading based on information from field verification step 3;
(5) grade each cover type polygon based on Table 7-1, below; and
(6) calculate an area-weighted average of all polygon scores within each riverscape to produce a single vegetation structure and complexity indicator score for each riverscape.

More details regarding the methodology for this approach are provided in Appendix B. It is worth noting that the most recent available National Agriculture Imagery Program (NAIP) imagery (September 2023) was used to delineate the Elk River main channel and create polygons based on land use and land cover. Mapping and condition assessment were further informed by higher resolution October 2022 and August 2025 aerial imagery from Google Earth where available. Google Earth imagery was being updated during the course of this study, but for consistency the 2023 condition was reported. More information on the implications of this decision is provided in the results section (Section 7.1.3).

7.1.2 Scoring Criteria

The scoring criteria outlined in Table 7-1 based on the ability of the riparian corridor to support river health functional attributes are used to rate the vegetation structure and complexity indicator.

Table 7-1. Vegetation Structure and Complexity Indicator Scoring Criteria

Grade	Description
A	Native riparian conditions exist that appear natural and appropriate for the Yampa River. Woody vegetation is present and commonly dominant, but patches and ribbons of meadow are typical. Vegetation is characteristically patchy, with strong interspersion of patches and overall good vertical structure driven by connection to the river. No evident effects of stressors – many stressors ameliorated by frequent flooding. Examples include cottonwood forest on well-connected surfaces such as vegetated point bars; young, characteristically willow-dominated, vegetation on recently formed surfaces; low, in-channel benches protected from human manipulation, typically scrub-shrub. Full support of river health.
B	Riparian habitat resembles native conditions but with detectable changes or mild, evident stressors. Vegetation appears self-sustaining and requiring little or no maintenance to preserve characteristic structural diversity. Habitat maintains a high degree of patchiness and interspersion, with little homogenization or loss of vertical structure. Small habitat patches can be relatively homogenous but

	contribute to the local mosaic of habitats. Common examples include river-connected cottonwood canopy and subcanopy forest with impacts such as grazing and primitive roadways. Minor reduction in the support of river health attributes.
C	Vegetated but with substantial departure from native conditions. Most commonly, alterations result in a loss of structural complexity, and/or homogenization of vertical structure, patchiness, and/or interspersion. Examples include cleared pastures that contain scattered trees and shrubs; fallow floodplain hayfields and cottonwood forests with substantial understory alteration; and palustrine emergent wetlands associated with ditches and sloughs. Riparian condition contributes to the degradation of one or more river health processes.
D	Dramatic loss of structural complexity, and/or homogenization of vertical structure, patchiness, and interspersion. Habitat commonly isolated from the river. Bare ground or impervious surfaces commonly makes up a significant portion of land cover. Vegetation tends to be very disturbed or actively cultivated. Examples include actively cultivated hay fields, old gravel mines, primitive roadways, and golf courses. Riparian land use contributes to river dysfunction.
F	Riparian area is developed or wholly converted with predominantly bare ground, impervious surfaces, or otherwise lacking in vegetation as a result of land use and management actions. Riparian habitat function is essentially extinguished, and land use contributes substantially to river dysfunction.

7.1.3 Results

The remote polygon desktop exercise with field verification was completed in summer/fall 2025. **Refer to Appendix B for a technical memorandum describing methods and results in more detail**. A summary of the results is provided below.

The riparian zone for the Elk River segment was divided into 679 polygons based first on land cover and then land use. Of the 9 cover types designated, herbaceous cover was by far the most common, accounting for more than 900 acres, or 50% of the study area. Herbaceous areas were mostly hayfield and pasture lands. Subcanopy forest, scrub-shrub, and canopy/cottonwood forest were the three next most common cover types, which illustrates the rural nature of the landscape. The next most common cover type was montane forest, as the upper Elk River main stem riparian zone is heavily forested above approximately 7,500 feet in elevation. After the forested lands, the next most common cover type was developed areas, highlighting the rural and residential infrastructure associated with the local communities surrounding Clark, Glen Eden, Moon Valley, and other neighborhoods. The cover types with the best mean condition were those in closest association with the river, including montane forest, cottonwood forest, and scrub-shrub habitats. These areas are continually disturbed by natural processes and recover rapidly, so in most cases signs of human disturbance are quickly erased. Subcanopy forests and flowing water are next in terms of condition, and excellent examples of both land cover types still exist on features shielded from intensive human use. As expected, developed polygons were assigned the lowest scores, with an average score of 57 (F score).

Following the pattern in land cover, ranchland and agricultural land uses are the most prevalent land uses in the Elk River segment. It should be noted that there is little distinction between these two land uses, and they often overlap spatially or temporally. The agricultural land use implies that the polygon is under active cultivation, usually for hay. It is acknowledged that fields are continually taken in and out of production, and it is not always possible to determine whether an area is being actively hayed, used as pasture, or simply has abundant herbaceous cover. Rural development surrounding communities such as Clark, Glen Eden, and Moon Valley, covered the next largest area in the Elk River segment. With ranchlands encompassing several different land cover types, scores have a wide range (between A and F), as they did in the other segments evaluated (Middle Yampa, Steamboat, and Upper Yampa segments). Ranchlands hold many of the Yampa Valley's finest examples of riparian habitat, and the average score for ranchlands in the Middle Yampa and Steamboat segments was a B. However, the overall average score for these habitats in the Upper Yampa and Elk River segments is a C+. The ranchlands in the Elk, Bear, and Upper Yampa Rivers contain a high proportion of expansive, productive hayfields that help to maintain open habitat in the riparian zone, but these come at the expense of the diversity of cover types such as forest and shrubland patches that are more typical of ranchlands in the Yampa River riverscapes further downstream.

As described in Section 7.1.1, Google Earth imagery was being updated during this study. For consistency over the timeframe of the analysis, the 2023 condition was mapped and evaluated, despite substantial alterations between 2023 and 2025. These changes will be reflected in the next iteration of the YRSP's Elk River segment in 2030. Many of the changes evident in the 2025 imagery were observed on the ground during field verification. The Elk River valley is experiencing changes that include riparian land conversion and bank stabilization in several locations. One location in particular (located in riverscape 9 and not visited during field surveys due to access constraints) was subject to dramatic alteration, resulting in severe impairment of river health and an inevitable decrease in riparian condition scores in future Scorecard iterations. This extreme example of changes on the Elk is shown in Figure 7-1 below, where a significant portion of the riparian area on both sides of the channel was cleared and bed material from the channel bottom appears to have been excavated to line the channel, resulting in channel incision, loss of wetland and riparian habitat, and floodplain disconnection.

Figure 7-1. Example Elk River Segment Reach with Worsening Riparian Condition Between 2023 (left) and 2025 (right)

Riparian condition scores based on land cover and land use were weighted by area to compute an overall riparian condition score for each of the seven riverscapes in the Elk River segment. Examples of the fine-scale riparian mapping that was completed for this assessment are provided in Appendix B, and final weighted averages by riverscape are shown in Table 7-2. The riverscapes higher up in the watershed that included or abutted public lands (i.e., those in or very near to the Routt National Forest) scored in the A/B range. Moving downriver, as riverscapes transition to more rural development and agriculture, scores decrease to the C range. The D+ score for riverscape 12 can mainly be attributed to the large swaths of riparian land conversion to hayfields and pasture lands.

Table 7-2. Vegetation Structure and Complexity Scores by Riverscape

Riverscape	Riparian Condition Score
Riverscape 7	A-
Riverscape 8	B-
Riverscape 9	C+
Riverscape 10	C+
Riverscape 11	C
Riverscape 12	D+
Riverscape 13	C

7.2 INVASIVE PLANT SPECIES INDICATOR

The invasive species indicator provides a measure of the presence and relative proportion of several invasive plant species that are common in the Yampa Valley, including leafy spurge, Russian olive, and tamarisk.

Leafy spurge is a Colorado List B noxious weed species. It is a deep-rooted perennial that spreads explosively by seed and has extensive, creeping roots. Leafy spurge is adapted to a wide range of habitats and is very competitive with other plant species, crowding out nearly all other vegetation when it becomes established in rangeland, pasture, and riparian sites. Its white, milky sap is extremely toxic to cattle and horses, and damaging to sensitive human skin and eyes. The Yampa River Leafy Spurge Project (YRLSP) has been working to map and manage the infestation of leafy spurge in riparian areas in the valley since 2015.

Russian olive, another Colorado List B species, is a perennial tree or shrub that reproduces by seed or root suckers. Once thought to be a beneficial windbreak tree, Russian olive is detrimental to riparian zones because it outcompetes native plants, interferes with natural plant succession and nutrient cycling, and disadvantages several native animal species relative to native vegetation.

Tamarisk, or saltcedar, is also a Colorado List B noxious weed. It was introduced for ornamental purposes and streambank stabilization but is now widespread in the US and crowds out native stands of riparian and wetland vegetation. Tamarisk increases the salinity of surface soils, rendering them inhospitable to native plant species.

7.2.1 Data Sources and Evaluation Methods

The Yampa River Leafy Spurge Project (YRLSP) conducted field mapping of leafy spurge along the Yampa River from Hayden, CO, to Cross Mountain in 2019-2021. This field data was used by a University of Wyoming graduate student to build a remote sensing model of current leafy spurge infestation in the Yampa Valley. Based on identified attributes of highly infested areas, a predictive model was developed to identify areas at risk for future invasion as well. A presentation describing this project and explaining modeling results is available on the YRLSP website at (https://www.yampariverleafyspurgeproject.com/chloemattilio). The remote sensing project yielded > 83% confidence that leafy spurge is correctly detected by remote sensing methods, and the final remote sensing maps and risk model have been used as a primary data source for scoring the invasive species indicator.

Data to score this indicator are also collected by floating and walking a large majority of the Elk River segment and noting instances of Russian olive and tamarisk. These observations are documented via photographs and notes, and observations of Russian olive and tamarisk are scored based on presence/absence of either species. In particular, a score of 0 is assigned if no Russian olive or tamarisk is observed on either bank within a riverscape, and 1 point is assigned if at least one individual is observed on either the left or right bank for either species. For example, if Russian olive is observed on one of the two banks in a riverscape, but tamarisk is not observed, the score is 1. If both Russian olive and tamarisk are observed on one bank, the score is 2. If both species are observed on both banks, the score is 4. Scores for these invasives range from 0 to 4 points.

7.2.2 Scoring Criteria

The scoring criteria outlined in Table 7-3 based on YRLSP leafy spurge mapping and qualitative field observations of Russian olive and tamarisk are used to rate the invasive species indicator. Scoring is mainly driven by leafy spurge data.

Table 7-3. Invasive Plant Species Indicator Scoring Criteria

Grade	Description
A	No or only trace amounts (<1%) of leafy spurge present in the riparian area. No observations of Russian olive and/or tamarisk noted (invasives score of 0).
B	Low coverage (1-5%) of leafy spurge present in the riparian area. Infrequent observations of Russian olive and/or tamarisk noted (invasives score of 0-1).
C	Moderate coverage (6-25%) of leafy spurge present in the riparian area. Moderate number of observations of Russian olive and/or tamarisk noted (invasives score of 0-3).
D	High coverage (26-50%) of leafy spurge present in the riparian area. Frequent observations of Russian olive and/or tamarisk noted (invasives score of 2-4).

F	Very high coverage (51-100%) of leafy spurge present in the riparian area. Consistent to constant observations of Russian olive and/or tamarisk noted (invasives score of 4).

7.2.3 Results

Field observations did not reveal the presence of target invasive plant species, including tamarisk, Russian olive, or leafy spurge, throughout the entirety of the accessible portion of the Elk River segment. All riverscapes therefore receive an A score for both invasive species sub-indicators. However, future risk for leafy spurge invasion is not distributed equally across the Elk River segment; risks in the upper Elk are relatively minimal, while those in the lower Elk are more notable (though still overall minor). Risks of future establishment potential are as follows: in riverscapes 7-9, the YRLSP identified the majority of that area as falling within the “least risk” category, indicating very low potential for future invasion (Table 7-4, Figure 7-2). In riverscapes 10 and 11, the majority of area falls within the “lower risk” category, with much of the remainder falling within the “least risk” category (Table 7-4, Figure 7-2). Higher potential for future establishment was found within the downstream riverscapes of 12 and 13, where roughly 15-20% of the area was deemed “higher risk.” However, the large majority (80-85%) of area within these two riverscapes still fell within the least or lower risk categories (Table 7-4, Figure 7-2). Overall, greater vigilance should be exercised for leafy spurge establishment in the downstream-most riverscapes (12-13). Invasive species indicator scores by riverscape are summarized in Table 7-5.

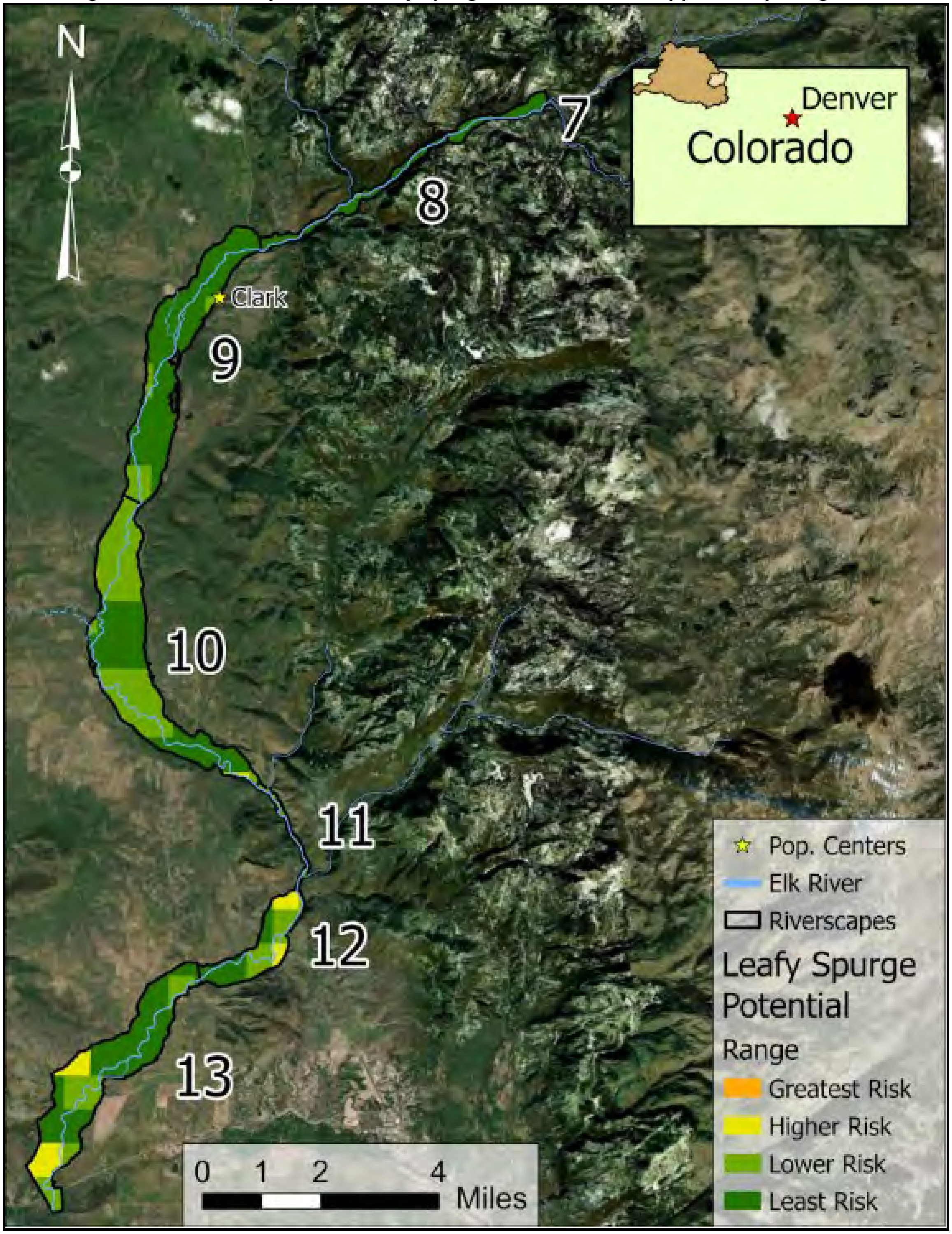
Table 7-4. Leafy Spurge Risk by Riverscape in the Elk River Segment

Riverscape	Leafy Spurge Risk Category by Area (%)			
	Least Risk	Lower Risk	Higher Risk	Greatest Risk
Riverscape 7	100	0	0	0
Riverscape 8	97.9	2.1	0	0
Riverscape 9	87.5	12.5	0.1	0
Riverscape 10	43.7	55	1.2	0
Riverscape 11	0	94	6	0
Riverscape 12	39.1	42.2	18.7	0
Riverscape 13	60.7	25	14.3	0

Table 7-5. Invasive Plant Species Indicator Scores by Riverscape

Riverscape	Tamarisk/Russian Olive Score	Leafy Spurge Score	Invasive Species Score
Riverscape 7	A	A	A
Riverscape 8	A	A	A
Riverscape 9	A	A	A
Riverscape 10	A	A	A
Riverscape 11	A	A	A
Riverscape 12	A	A	A
Riverscape 13	A	A	A

Figure 7-2. Remotely-Sensed Leafy Spurge Risk Across the Upper Yampa Segment



8.0 RIVER FORM

River form is defined as the river channel shape and geometry. It is directly influenced by the physical attributes of the watershed (e.g., geology, topography, hydrology), channel hydraulics, sediment transport, and local hillslope and floodplain uses (e.g., adjacent roadways, grazing). Biological drivers (e.g., riparian vegetation, large woody material, beaver activity, aquatic vegetation) influence river form as well, by altering hydraulics and erosional patterns. The Yampa River Scorecard evaluates river form holistically, using a single indicator referred to as **channel morphology**.

8.1 CHANNEL MORPHOLOGY INDICATOR

The channel morphology indicator is scored holistically and qualitatively considering planform shape (aerial shape), dimension (cross-sectional shape/size), and profile (slope). In some cases, quantitative measurements are used to inform qualitative scoring.

8.1.1 Data Sources and Evaluation Methods

A combination of remote sensing, quantitative measurements, and field observations are used to score the channel morphology indicator. Planform shape can be evaluated through remote measurement of valley confinement and parameters such as sinuosity. Comparison of historical and current aerial imagery can also be helpful. A stressor-based approach is also employed to evaluate channel morphology, with a component of the fieldwork that includes taking note of low-head dams, diversions, and bank- and in-channel treatments that may impact grade (Appendix A).

The Scorecard effort acknowledges that channel morphology assessments that employ traditional metrics have been conducted on river systems that have been impacted by controls that reduce complexity, leading to the narrow view of rivers as channels having easily measured forms. For the Scorecard, these metrics are used in the context of a progression from the past to the present, as well as evaluating where they fall on a continuum of stability. In this manner, the channel form that falls outside of the natural continuum to be expected of a healthy river can be evaluated as indicative of a river that may be impacted by unnatural influences. The Scorecard public interface explains these differences.

This indicator is scored using best professional judgement by a professional geomorphologist supported by the observations and measurements described above. Expert opinion is based on data collected and observed in the field, aerial imagery, and GIS spatial data to generate a single score for the channel morphology indicator.

8.1.2 Scoring Criteria

The descriptive, qualitative scoring criteria outlined in Table 8-1 are used to rate the channel morphology indicator. The criteria relate primarily to the presence of stressors and level of maintenance required to maintain functional river processes.

Table 8-1. Channel Morphology Indicator Scoring Criteria

Grade	Description
A	Planform, sinuosity, meander-wavelength to bankfull-width ratios, and variations are appropriate for a well-functioning river of this flow/sediment regime and landscape setting. There are no significant constraints to river planform or significant artificial changes in slope (e.g., dams, channelization, grade control structures). Channel geometry is within a range that is natural and appropriate for a well-functioning river in its process domain. The channel geometry is self-sustaining under natural channel processes and requires no maintenance.
B	Planform, sinuosity, meander-wavelength to bankfull-width ratios, and variations are within a range that is natural and suitable for a river of this flow/sediment regime and landscape position. Stressors are detectable but minimal management is needed to maintain functionality. Minor localized impacts exist that minimally affect channel entrenchment, capacity, or width-depth ratios.
C	Stressors on the river planform and/or sinuosity and/or wavelength-width ratios impact localized portions of the channel. Examples include reaches with short lengths of bank armoring (decreased sinuosity) or reaches that have been slightly straightened (decreased wavelength-to-width ratios). Stressors are common along the reach and management is likely required to maintain functionality. Moderate impacts exist that significantly affect channel entrenchment, capacity, or ratios.
D	Widespread stressors impact the river planform, such as floodplain encroachment, hardened banks, or planform straightening. Major bank armoring and/or significant changes to sinuosity or meander wavelength are present, such as reaches with large (>3 feet) grade control structures and moderate planform changes. Active management and maintenance are required to maintain functionality. Widespread impacts exist that severely affect channel entrenchment, capacity, or width-depth ratios.
F	Widespread stressors cause severe impacts or changes to the planform and slope. Examples include anastomosed or meandering streams that were straightened or channelized, rivers with severe floodplain encroachment or armoring of banks, and streams with very large (>6 ft) grade control structures. Stressors are extensive throughout the reach and the level of impairment results in an inability to maintain characteristic function. Profound impacts exist with near-complete alteration of channel entrenchment, capacity, or width-depth ratios. Intensive or consistent active management and maintenance are required. Severe changes to slope are evident.

8.1.3 Results

The channel morphology indicator is evaluated through remote sensing analysis using aerial imagery and GIS spatial data, as well as qualitative field observations. Various morphological calculations were made to evaluate planform in the context of what would be expected for a river in the process domain of the Elk River segment, including sinuosity (the ratio of channel length to valley length) and meander wavelength to channel width ratios (l/w) (Table 8-2). Fieldwork completed for the Scorecard project also included stressor-based observations that are relevant for channel morphology.

The Elk River is largely a bedload-dominated river throughout the entire segment, with bed load comprising approximately 70% of the mean annual sediment load as measured at stations on the Elk River near Clark and Milner (Andrews 1978). The Elk River is also primarily a confined or partly confined river, meaning that it is laterally bound (in full or in part) by natural features such as glacial terraces or bedrock hillslopes that influence its form. Riverscape 13 is the only unconfined area in the Elk River segment (Table 8-2), meaning that the river through this riverscape is unrestricted by natural, non-fluvial features and has the potential to freely form its own morphology.

Table 8-2. Confinement, Sinuosity, and Meander Wavelength to Bankfull Width Ratios (l/w) by Riverscape

Riverscape	Confinement	Sinuosity	l/w
Riverscape 7	Confined/Canyon	1.02	21.1
Riverscape 8	Confined/Canyon	1.01	18.6
Riverscape 9	Partly Confined	1.14	11.3
Riverscape 10	Partly Confined	1.27	11.7
Riverscape 11	Confined/Canyon	1.02	16.0
Riverscape 12	Partly Confined	1.19	16.6
Riverscape 13	Unconfined	1.21	13.0

The highest scores for the channel morphology indicator in the Elk River segment are in riverscapes 7 and 8, where the river is largely confined by high glacial terraces (Table 8-3). Here sinuosity is low given the restrictive nature of the terraces, which are a legacy of Pleistocene glaciation in the Zirkel mountains and incapable of being reworked by the modern river. Manmade features that prevent channel reworking are minimal, and the river is largely capable of accessing the relatively small, inset natural floodplain formed within the modern inset valley. Length-to-width (l/w) ratios largely reflect the nature of the inset valley rather than the river itself, and are within the range of a steep, bedload-dominated river (Schumm 1985). These riverscapes receive an A for channel morphology (Table 8-3).

In riverscapes 9 and 10, where the river is confined in part by terraces (in the upper reaches of riverscape 9 and the lower reaches of riverscape 10) or hillslopes, sinuosity is observably higher than the upstream riverscapes and meander/wavelength ratio is lower. The l/w ratios are within the range of natural variability for freely meandering, unconfined channels, though on the low end of what might be expected for confined/partly confined channels (Nicoll and Hickin 2010). This suggests that meander cutoffs due to bend overtightening may be more frequent in these riverscapes than might otherwise be expected, perhaps reflective of the fact that river reaches in these riverscapes likely sit near the braided/straight-meandering threshold and may behave as a hybrid of these morphological endmembers (Leopold and Wolman 1957). Sinuosity in riverscapes 9 and 10 is within the range of natural variability for a bedload-dominated river (Schumm 1985). These riverscapes are generally well-connected to the available floodplain, despite moderate terrestrial habitat fragmentation (Table 5-4) and relatively heavy bank armoring in riverscape 9 (Table 9-2, Figure 9-1). Evidence of possible straightening of the channel in the upper portions of riverscape 10–from the vicinity of the County Road 56 bridge to just downstream of the current Moon Valley development–is observable in historical aerial photographs; conversations with local landowners have similarly suggested straightening may have been undertaken by old-time ranchers within the Elk River valley. However, the river in this area has largely regained a more natural, sinuous planform. Notably, the recent extensive modifications to riverscape 9 in terms of armoring (Figure 7-1) will likely preclude additional morphologic change and dynamism, potentially leading to decreased scores in future iterations of the Scorecard. Riverscapes 9 and 10 have a straight to low-sinuosity meandering planform expected from the stream evolution triangle (Castro and Thorne 2019). Riverscapes 9 and 10 therefore earn a channel morphology score of B and A-, respectively (Table 8-3).

Riverscape 11, similar to riverscapes 7 and 8, has a low sinuosity and high l/w ratio expected of a confined river (Nicoll and Hickin 2010, Schumm 1985). Though bank armoring is relatively extensive here due to proximity to County Road 129, this likely does not substantially alter the expected morphology - relative long-wavelength meanders and narrow channel widths - of this confined river reach. Riverscape 11 thus receives an A- for channel morphology. Riverscape 12, which is partly confined throughout its length by hillslopes (to the east) and glacial terraces (to the west), has a similarly high l/w ratio reflective of this partial confinement, which generally prohibits the development of tight meander bends due to the control exerted by confining features that inhibit the outward (lateral) growth of meanders. The observed l/w ratio is within the range of that observed for confined rivers (Nicoll and Hickin 2010). Sinuosity is similarly within the expected range for a relatively steep, bedload-dominated river (Schumm, 1985). However, the relatively frequent occurrence of stressors such as in-channel barriers (Figure 5-1) and bank armoring (Figure 9-1, Table 9-2), in concert with the subsequent lack of channel complexity features (such as bars, Figure 9-12), suggest that morphology here may be altered by human activity. Riverscape 12 thus receives a B score for channel morphology.

Lastly, riverscape 13 is the only unconfined riverscape in the Elk River segment. Here, l/w ratios are within the ranges of an unconfined, freely meandering river (Nicoll and Hickin 2010. Sinuosity, meanwhile, is reflective of and within the natural range of variability for a bedload-dominated river (Schumm 1985). However, inspection of historical aerial photography suggests that the channel here historically exhibited a fairly complex morphology of multiple channels perhaps suggestive of braiding and indicative of the location of the channel above the braided-meandering threshold (Leopold and Wolman 1957). This multi-channel morphology also reflects the fact that the Elk in this riverscape is flowing across a delta or alluvial fan environment formed by the junction of the steep Elk River with the relatively lower gradient Yampa River. Multiple channels here thus may be technically classified as “distributaries,” which commonly occur in delta and fan environments as the main channel splits into multiple flow paths. Compared to historical evidence, the river here has been largely simplified into two distinct channels–the main channel of the Elk and a distributary known as the West Fork Elk River–particularly in the lower reaches where bank armoring is common. Riverscape 13 receives a B+ score for channel morphology.

Table 8-3. Channel Morphology Indicator Scores by Riverscape

Riverscape	Channel Morphology Score
Riverscape 7	A
Riverscape 8	A
Riverscape 9	B
Riverscape 10	A-
Riverscape 11	A-
Riverscape 12	B
Riverscape 13	B+

9.0 STRUCTURAL COMPLEXITY

Structural complexity is defined as the degree of heterogeneity and physical composition of a stream that results from interactions between flow regime, sediment dynamics, biological influences such as beaver activity, and other factors. The more complex and heterogeneous the physical structure of a stream, the more enhanced the habitat for resident aquatic species. Structural complexity considers hydraulic characteristics (water depth and velocity patterns) as expressed through the occurrence of features that create complexity in this regard (e.g., backwaters, split flows, side channels), bed and bank features, and substrate material. In scoring the indicators in this category, a concerted effort is made to integrate quantifiable records and observations from fieldwork conducted by educational partners. Two indicators are included in the structural complexity category: **macrohabitat** and **microhabitat**. The final structural complexity score is calculated as 75% macrohabitat and 25% microhabitat indicator scores.

9.1 MACROHABITAT INDICATOR

The macrohabitat indicator considers physical habitat relevant to fish and larger animals, including distribution and diversity of water depth, velocity, and physical cover, shape of bed and bank features, heterogeneity of habitat, and other large physical structure provided by rock, wood, vegetation, etc. Macrohabitat includes cobble/gravel/sand bars, undercut banks, presence/absence of secondary channels/backwaters, and presence of large wood. The presence of beaver in a riverscape is considered to increase macrohabitat structural complexity. The presence of bank armoring is considered to decrease macrohabitat structural complexity.

9.1.1 Data Sources and Evaluation Methods

The following features that are important for heterogeneity and complexity within the channel are evaluated in the field, usually from a boat:

- Bedforms including riffles, runs, pools, and glides;
- Split flows (i.e., two narrow channels versus one wide channel);
- Secondary channels (i.e., narrow side channels that may or may not flow);
- Point bars (vegetated, cobble, gravel, sand; size);
- Signs of beaver activity (chews, dams, side channel dams, bank dens);
- Presence of large wood;
- Reinforced bank length and type (material could be concrete, car bodies, riprap, etc.);
- Undercut bank length; and
- Backwater areas.

Fieldwork to inform this indicator was completed during the summer of 2025, in partnership with local landowners. Data was collected by boat and foot and supplemented with aerial imagery. To the extent possible, these features were enumerated, representative photos taken, and measurements quantified and marked with a GPS device (Appendix A). These quantitative measurements feed into the scoring described in detail in Table 9-1.

9.1.2 Scoring Criteria

The scoring criteria outlined in Table 9-1 for the macrohabitat indicator is based on the presence of complexity features and physical structure of the reach, estimates of diversity of depth/velocity combinations (e.g., presence/absence of backwater areas, split flows, and side channels), and topographic complexity of beds and banks (e.g., presence/absence of homogenizing features like bank armoring).

Table 9-1. Macrohabitat Indicator Scoring Criteria

Grade	Description
A	Macro-scale structural heterogeneity is natural and appropriate for a well-functioning river in its process-domain. All velocity-depth combinations and structural components (features formed by wood, rock, vegetation, debris dams/jams, and beaver activity) are present in characteristic distribution.
B	Most typical velocity-depth combinations are present, but distribution of structural components (features formed by wood, rock, vegetation, debris dams/jams, and beaver activity) is slightly skewed due to dispersed stressors or minimal direct impacts. Pools provide adequate cover for fish and other aquatic organisms.
C	Some typical velocity-depth combinations or characteristic structural elements (features formed by wood, rock, vegetation, debris dams/jams, and beaver activity) are absent or limited. Pools provide some cover for fish and other aquatic organisms. Examples include reaches with increased pool/run habitat, lack of off-channel habitat, or skewed riffle-pool ratio. Reaches with artificial structure or hardened/revetted banks also fall into this category.
D	Some typical velocity-depth combinations or characteristic structural elements (features formed by wood, rock, vegetation, debris dams/jams, and beaver activity) are absent, making the reach uncharacteristically homogeneous. Pools may provide minimal cover for fish and other aquatic organisms. Examples include reaches with graded or heavily armored banks, or with features that are frequently limited by inundation or low flow.
F	Homogeneous form with uniform velocity-depth pattern, lack of physical structure, and lack of pools. Examples include reaches with severely homogenized physical characteristics such as unnatural plane-bed morphology.

9.1.3 Results

Macrohabitat was scored by the consideration of the variables outlined in the scoring scheme above, several of which comprise criteria considered for additional indicators already evaluated. Rather than an indicator of redundancy, this instead illustrates the broad, integrative nature of the river landscape in setting the habitat template. Data evaluated here were gathered from field floats and hikes of the riverscapes in consideration and informed by review of current and historical aerial imagery.

Bank armoring contributes to reach homogenization and increased resistance to the drivers of river complexity, mainly channel migration and the formation of secondary channels. Therefore, bank armoring (e.g., Figure 9-1; Appendix A, Photos A-11 through A-17) is likely the most consistently detrimental factor regarding relatively diminished structural heterogeneity and thus macrohabitat. Diversion structures, or hard points such as cross vane anchors and bridge pilings (Appendix A, Photos A-1 through A-2, A-5 through A-6, and A-18), also decrease levels of complexity and potential for channel migration, although their impact is minimal compared to traditional armoring due to shear differences in length/impacted area.

Moderate bank armoring (>20%) exists in all riverscapes except riverscapes 7, 8, and 10 (Figure 9-1, Table 9-2). Riverscape 7 is located at the upstream end of the Elk River segment, partially on USFS land, and so bank armoring is essentially nonexistent aside from a few hard points associated with bridge crossings and irrigation infrastructure. Just downstream, riverscape 8 has observably more armoring, generally due to the need to protect Seedhouse Road at several points where it impinges on the river channel. Here, bank hardening structures (e.g., rip-rap embankments) have been put in place to prevent erosion from undermining the road (Appendix A, Photos A-13 through A-14). Though a larger percentage of the channel is armored within riverscape 8 (approximately 13%), this amount is relatively minor compared to the downstream riverscapes. Riverscape 10 also has relatively minimal armoring (5%), though this low number may be due in part to the fact that the project team was unable to access relatively large portions of this riverscape. Though field observation was augmented by examination of aerial and satellite imagery, it is often difficult to see bank hardening structures in these images unless they are especially large and/or extensive, and so this number may be considered as more of a minimum.

In contrast, riverscapes 9, 11, 12, and 13 have substantially more armoring (Figure 9-1, Table 9-2). Riverscapes 9 and 11 are particularly heavily armored, with bank hardening placed on more than 40% of the river (by length). In the former, this number is driven in part by the recent armoring of both riverbanks with large boulders and cobbles along a stretch over a mile in length (Figure 7-1); in the latter, this is a function of several heavily armored stretches where the river flows at close proximity to County Road 129. Similarly, extensive armoring in riverscape 12 (34%) is generally placed to protect roads and other infrastructure such as houses. Armoring to protect local and/or private roads is also relatively prevalent in riverscape 13, though here fewer of these structures are located directly adjacent to the river, leading to a slightly lower percentage of armoring (22%). Armoring is also used to prevent erosion of pasture/hay fields in several locations within the unconfined, relatively more agricultural riverscapes of 9, 10, 12, and 13. These actions taken to stabilize riverbanks often utilize boulders to create hardened banks but in turn limit lateral mobility (Appendix A, Photos A11-A12, A15-A16).

Table 9-2. Bank Reinforcement as Percent of Channel Length

Riverscape	Percent Channel Length Reinforced*
Riverscape 7	0.3%
Riverscape 8	13.2%
Riverscape 9	40.7%
Riverscape 10	5.1%
Riverscape 11	42.4%
Riverscape 12	33.5%
Riverscape 13	21.7%

***** These percentages represent a minimum of armoring that exists in each riverscape, as the project team was unable to observe all armoring, especially in riverscapes 9 and 10, where large sections of the river were inaccessible to the team and field observations had to be augmented by remotely sensed data.

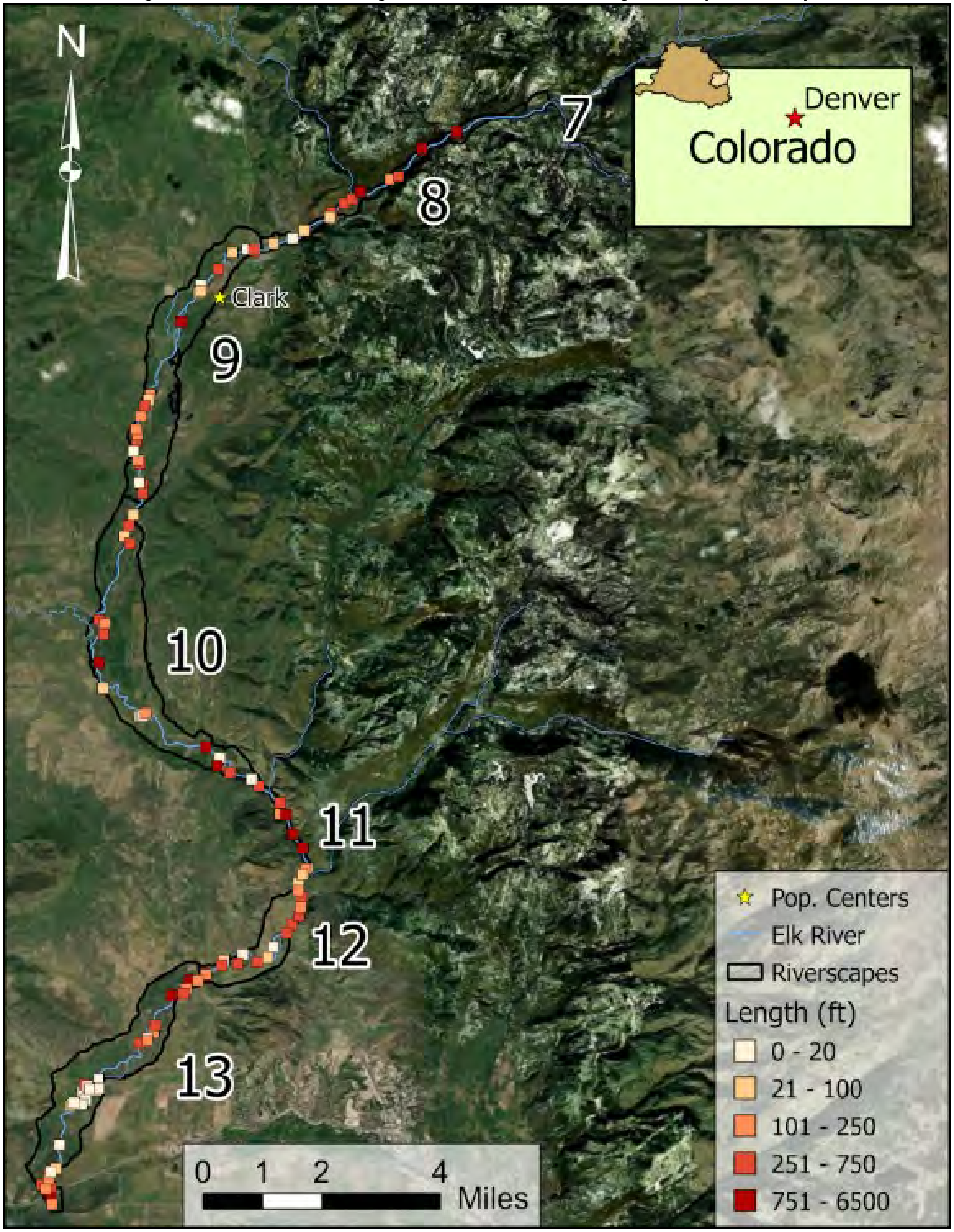
Conversely, although riverscapes 9 and 12 have a relatively high prevalence of bank armoring, they also have extensive occurrences of features indicative of complexity such as backwater areas and side channels/split flows (Figure 3-3). This may result from the occurrence and frequency of large wood, which generally creates or enhances river complexity (Figure 9-2). Of all riverscapes, wood is most prevalent, in terms of pieces/jams per river length, in riverscape 9, as is beaver sign (in terms of observations/length) (Figure 9-3).

Riverscape 9 is also located immediately downstream from more confined sections of the river, which may lead to the deposition of sediment and the formation of point bars and mid-channel bars/islands as the river loses the ability to transport sediment due to the additional “room” for the river to expand, spread out, and slow flow. Bars are particularly prevalent throughout riverscapes 9, 10, and 13 (Figure 9-4), likely reflective of the relatively unconfined nature of the river in these areas. Bars are more limited in riverscapes 11 and 12, though limitation in riverscape 11 is likely due its confined nature and canyon setting. The relatively extensive occurrence of armoring and other artificial features (such as cross vanes) in riverscape 12 may explain the lack of bars observed. However, the prevalence of cross vane structures here likely leads to a relatively high occurrence of backwaters and slower flow areas, which are beneficial habitat features.

Large wood, as mentioned previously, contributes to channel and floodplain heterogeneity and complexity that is important for aquatic habitat (Appendix A, Photos A-19 through A-23). In addition to its prevalence in riverscape 9 and 12, wood is found extensively throughout riverscapes 8, 10, and 13 (Figure 9-2). Wood is relatively less widespread in riverscapes 7 and 11, likely due to the confinement (by terraces and the road, respectively) of each of these riverscapes, which can increase the transport capacity for wood as well as limit the number of features (such as bars) that may slow flow and encourage wood deposition. The relative paucity of wood in riverscape 7 may also be attributed to the steep nature of this channel, which enables increased transport of wood through and out of that riverscape. Riverscape 7 is also frequently rafted by commercial outfitters and private rafters, who have an interest in keeping this section clear of wood where possible.

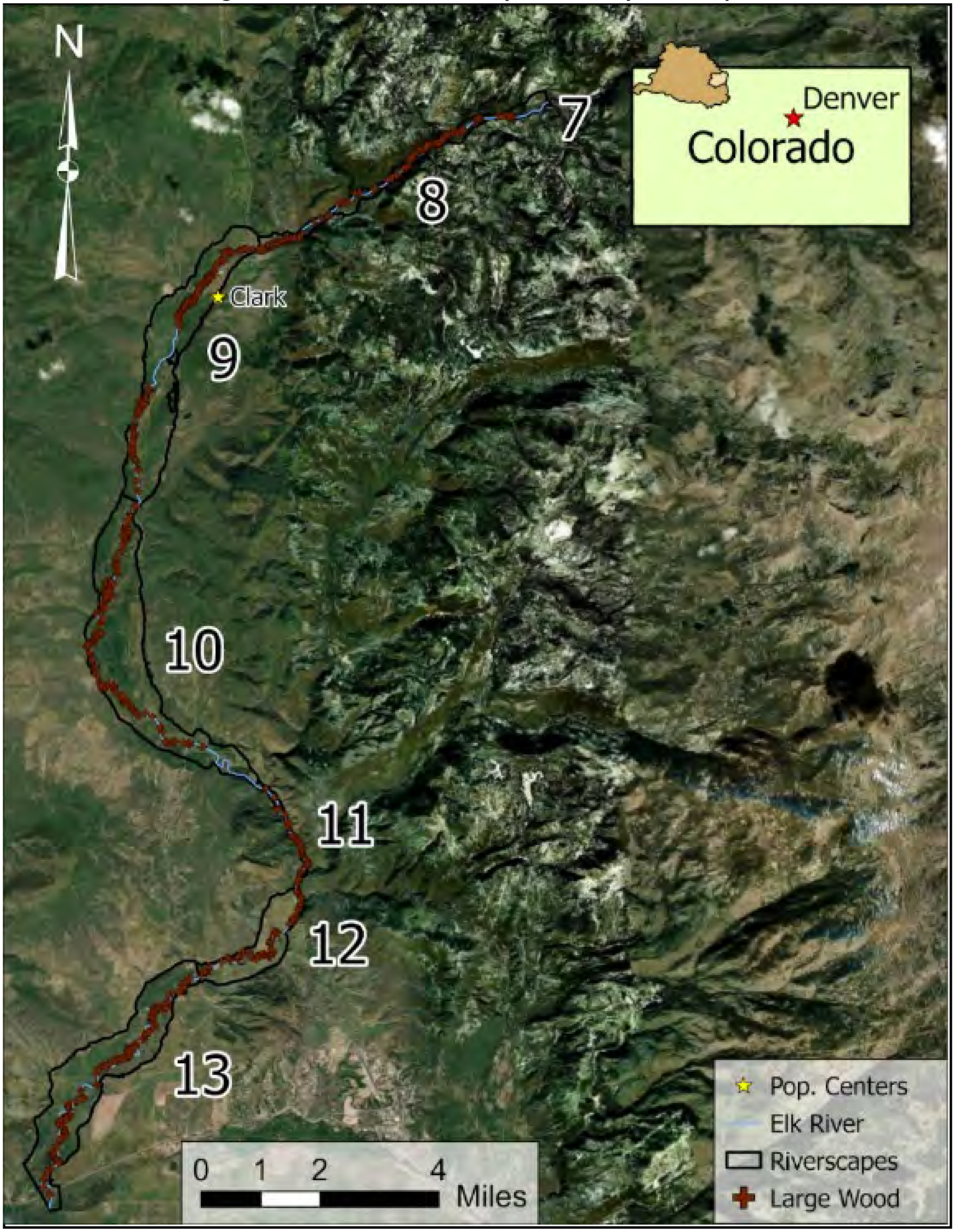
Signs of beaver activity are frequently found throughout all of the lower riverscapes (9-13) but are absent along the main channel of the Elk River in riverscapes 7 and 8, likely due to the relatively confined, fast-flowing, and higher elevation nature of these areas (Figure 9-3). Beaver activity has been observed in many of the upper tributaries (e.g., Hinman Creek, Coalton Creek, Willow Creek) that enter the upper Elk in riverscapes 7 and 8. Signs of beaver activity on the main stem ranged from beaver chew on the floodplain to beaver dams in side channels and backwaters as well as lodges and slides on the banks (Appendix A, Photos A-9, A-24 through A-25). Beaver activity in riverscapes 9, 10, and 13 in particular may be a critical driver for pool creation, increased complexity and floodplain connectivity, sediment and nutrient retention, support for riparian vegetation, and increased biodiversity. This is especially true given the relatively altered nature of riparian vegetation in these riverscapes, which may limit the supply of complexity-creating features like large wood. Riverscapes with more frequent signs of beaver activity therefore score better than others.

Figure 9-1. Bank Armoring Across the Elk River Segment by Riverscape



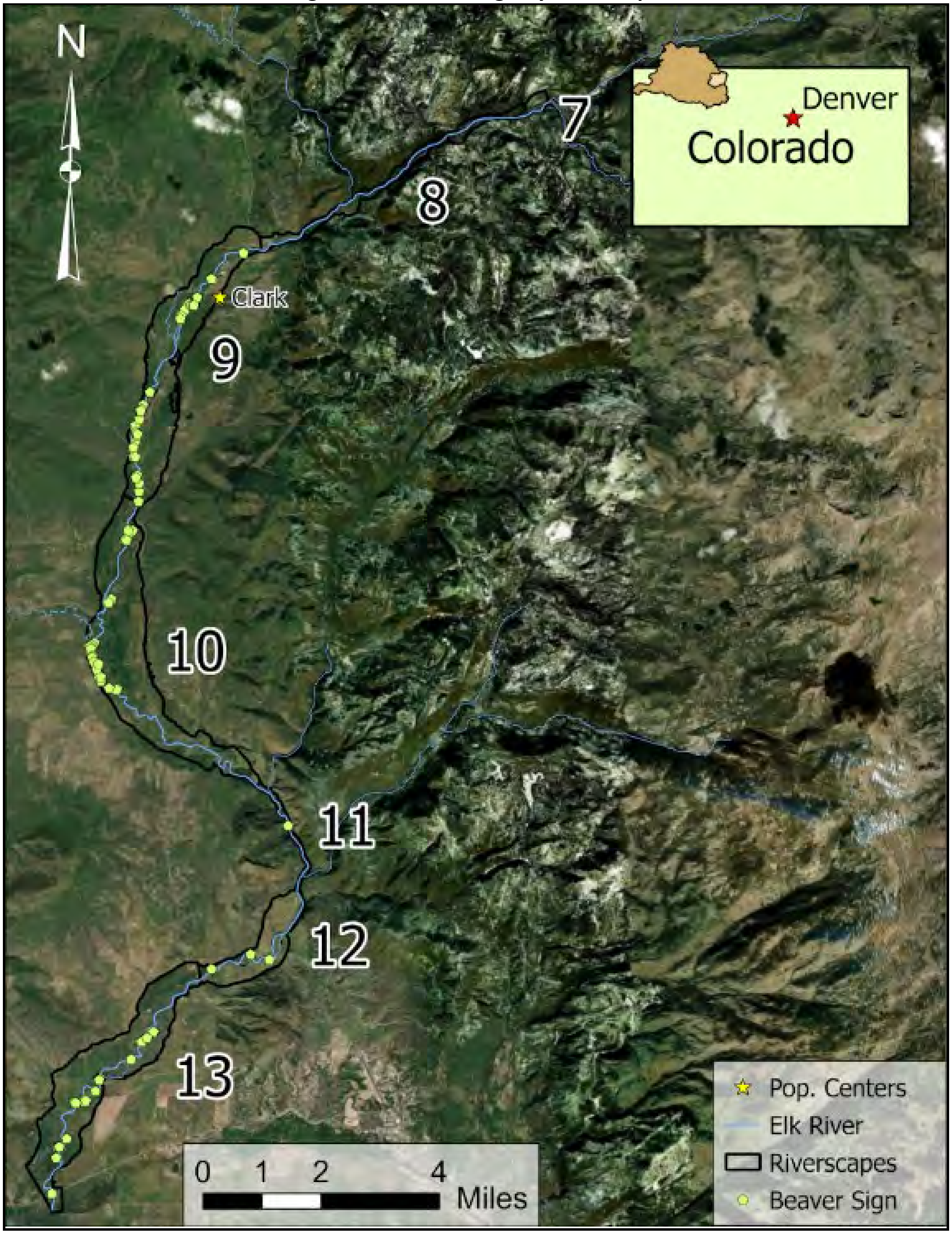
* Note: Each riverscape was visited by foot or boat for field observations, except for minor portions of riverscapes 7 and 8, approximately 45% of riverscape 9, approximately 65% of riverscape 10, and approximately 10% of riverscape 11, mainly due to private property access considerations.

Figure 9-2. Locations of Woody Material by Riverscape



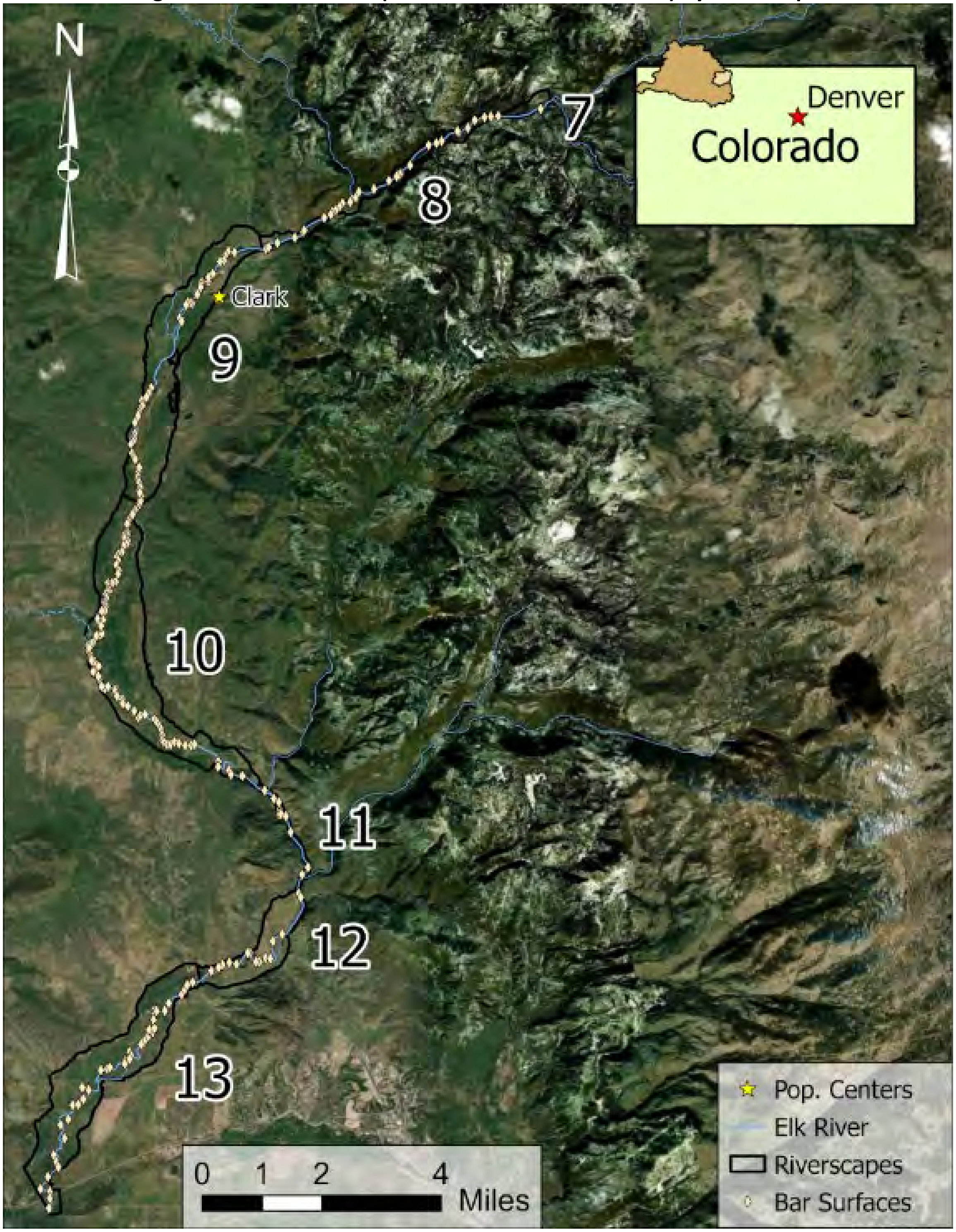
* Note: Each riverscape was visited by foot or boat for field observations, except for minor portions of riverscapes 7 and 8, approximately 45% of riverscape 9, approximately 65% of riverscape 10, and approximately 10% of riverscape 11, mainly due to private property access considerations.

Figure 9-3. Beaver Sign by Riverscape



* Note: Each riverscape was visited by foot or boat for field observations, except for minor portions of riverscapes 7 and 8, approximately 45% of riverscape 9, approximately 65% of riverscape 10, and approximately 10% of riverscape 11, mainly due to private property access considerations.

Figure 9-4. Bar Features (Mid-Channel and Point Bars) by Riverscape



* Note: Each riverscape was visited by foot or boat for field observations, except for minor portions of riverscapes 7 and 8, approximately 45% of riverscape 9, approximately 65% of riverscape 10, and approximately 10% of riverscape 11, mainly due to private property access considerations.

Overall, riverscapes 7 and 8 receive an A score (Table 9-3) due to the low frequency of bank armoring (especially in the former) and the prevalence of beneficial habitat features such as bars, large wood, and backwaters (especially in the latter). Riverscape 10 similarly receives an A score for the relative lack of armoring and frequent beneficial habitat features such as split flows and bars. Conversely, riverscapes 11 and 12 earn a C score due to fairly extensive armoring and related lack of complexity and beneficial habitat features. Riverscape 13 scores better than its downstream counterparts (riverscapes 11 and 12) due to the lesser extent of armoring and more frequent occurrence of bar features, large wood, and beaver sign. The relatively intact riparian forest in this riverscape likely both drives and is reflective of the high quality of macrohabitat in this riverscape, though armoring is more extensive than ideal and lowers the score to a B+. Finally, riverscape 9 is the most difficult to score, as it is extensively armored but also has a high density of beneficial geomorphic features (bars, split flows, and backwaters) and prevalence of large wood and beaver sign. Placing a higher weight on the observed complexity as it is a more direct reflection of the actual habitat conditions (as opposed to armoring, which is more a (potentially negative) driver of those conditions), this riverscape earns a B score. Importantly, due to the recent extensive armoring of a mile-plus-long reach within riverscape 9, habitat may degrade in the future as bank stabilization and floodplain disconnection increasingly impact habitat conditions.

Table 9-3. Macrohabitat Scores by Riverscape

Riverscape	Macrohabitat Score
Riverscape 7	A
Riverscape 8	A
Riverscape 9	B
Riverscape 10	A
Riverscape 11	C
Riverscape 12	C
Riverscape 13	B

9.2 MICROHABITAT INDICATOR

The microhabitat indicator considers physical habitat relevant to small aquatic species such as benthic macroinvertebrates and larval fish, particularly the availability of interstitial spaces among the river bed substrate, degree of embeddedness, armoring, proportion of fine sediment, algae cover, and patches of organic material or detritus accumulations.

9.2.1 Data Sources and Evaluation Methods

The microhabitat indicator is scored in the field through measurements of embeddedness and visual observations of presence/absence of algae cover. Embeddedness measures the degree to which gravel and cobble substrates are surrounded by fine sediment. It relates directly to the suitability of the stream substrate as habitat for macroinvertebrates, fish spawning, and egg incubation. Embeddedness measurements occur in riffles only. Embeddedness is measured by picking up particles of gravel or cobble with the evaluator's fingertips at the fine sediment level. The particle is pulled out of the bed and the percent of that particle that was buried by sediment is estimated (NRCS 2017). All measures of percent embeddedness within each riverscape are averaged for a final embeddedness percentage by riverscape.

9.2.2 Scoring Criteria

The scoring criteria outlined in Table 9-3 based on field observations of interstitial space availability, bed armoring, embeddedness, and algae in riffles are used to rate the microhabitat indicator.

Table 9-3. Microhabitat Indicator Scoring Criteria

Grade	Description
A	Micro-scale structural heterogeneity is natural and appropriate for a well-functioning river in its process-domain. Interstitial spaces appropriate for natural geographic conditions.
B	All aspects of micro-scale structural diversity are present, but distribution of features is skewed due to dispersed stressors or minimal direct impacts. Examples include reaches with mild fine sediment deposition or slightly decreased interstitial space (minimal embeddedness, 10-20%) for either cobble- or gravel-bed reaches, depending on natural geographic conditions.
C	Some aspects of micro-scale structural diversity are lacking or limited. Examples include reaches with altered bed material distribution, patches of armoring, increased cover of persistent algae/aquatic vegetation, decreased detritus/organic accumulation patches, or moderate embeddedness (20-30%) for either cobble- or gravel-bed reaches, depending on natural geographic conditions.
D	Some aspects of micro-scale structural diversity are lacking or severely limited, making the reach uncharacteristically homogeneous. Examples include reaches with widespread armoring, persistent algae/aquatic vegetation in riffles, lack of any detritus/organic accumulation patches, or severe embeddedness (30-40%) for either cobble- or gravel-bed reaches, depending on natural geographic conditions.
F	Completely static or homogeneous armored micro-scale physical structure. Examples include gravel- or cobble-bed streams that are aggrading with fine material (embeddedness >40%) or choked with algae, alluvial streams unnecessarily scoured to bedrock, or grouted/hardened artificial streambeds.

9.2.3 Results

Data to score this indicator were collected via field visits to illustrative locations with reliable access in each riverscape and observing presence/absence of algae cover, as well as evaluating embeddedness at riffles co-located with macroinvertebrate monitoring locations. Embeddedness is evaluated following the methodology described above.

Embeddedness was lowest (<10%) at measured riffles in riverscape 7-9 and 13. Low embeddedness values in the upper riverscapes are consistent with the high transport capacity and steep gradient of these reaches (Figure 9-5). Low embeddedness in riverscape 13, which is a relatively lower gradient reach, is likely reflective of the overall low sediment load of the Elk River. Each of these reaches thus receives an A score (Table 9-5). Higher embeddedness (10-20%) was observed within riverscapes 10 and 12, though values are still low overall. This is again likely indicative of the relatively high transport capacity of the Elk River, which enables substantial transport of fine-grained sediments. These riverscapes earn a B score (Table 9-5). Embeddedness values are highest in riverscape 11 (>40%) (Figure 9-5), which may reflect a heightened supply of fine-grained sediment from localized erosion of bluffs in several locations immediately upstream in riverscape 10. Alternatively, it may be most reflective of recent construction of stabilization features in the vicinity of the sampling location, which necessitated heavy machinery to be present in the channel and may have compacted bed sediment and increased sedimentation. Given the absence of additional stressors such as extensive algal mats, this riverscape receives a D+ score (Table 9-5).

Figure 9-5. Embeddedness Locations and Ranges by Riverscape

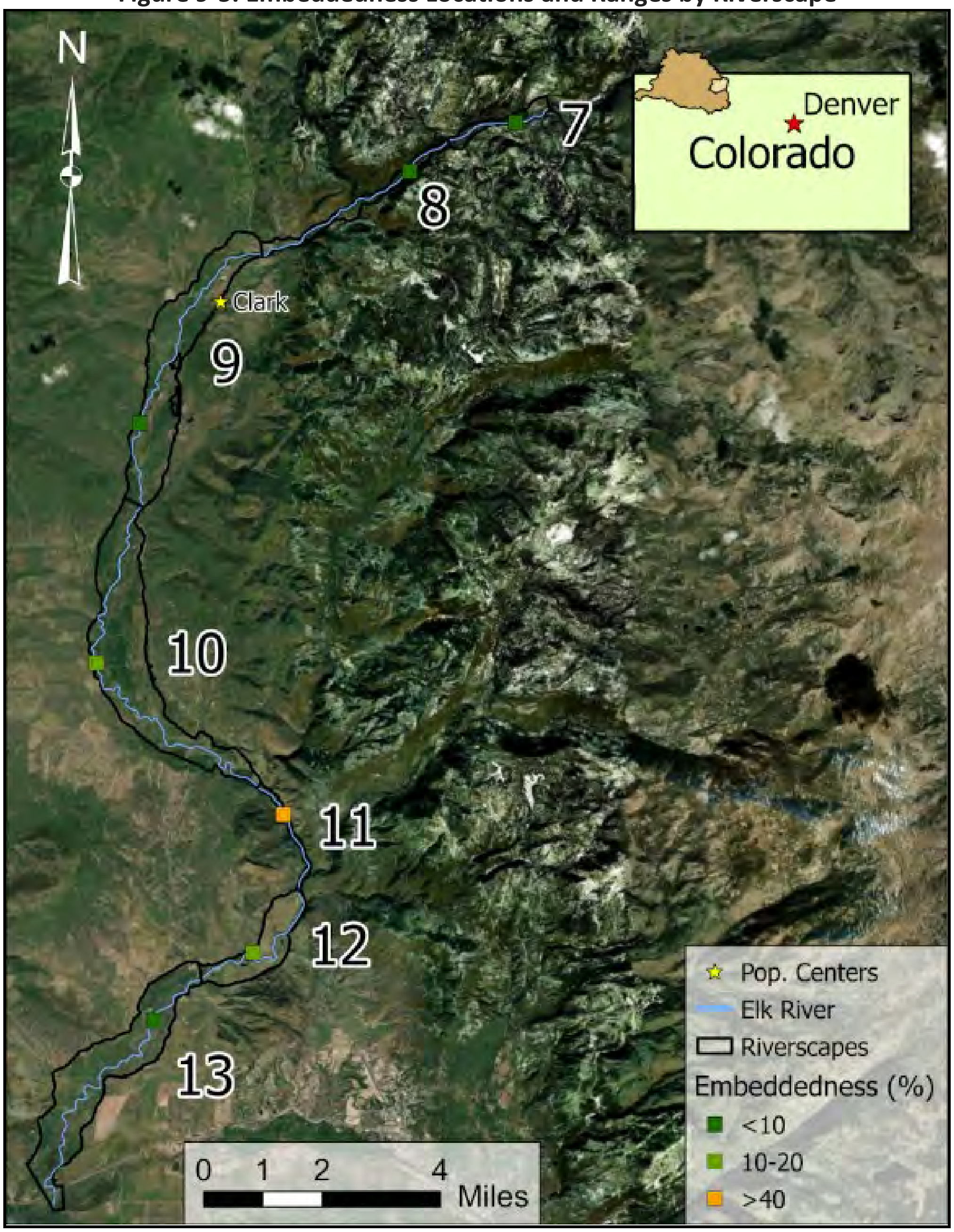


Table 9-4. Microhabitat Scores by Riverscape

Riverscape	Microhabitat Score
Riverscape 7	A
Riverscape 8	A
Riverscape 9	A
Riverscape 10	B
Riverscape 11	D+
Riverscape 12	B
Riverscape 13	A

10.0 BIOTIC COMMUNITY

Biotic community is defined as the health of resident aquatic biota including microbes, periphyton (attached algae), macrophytes (aquatic plants), macroinvertebrates (aquatic insects), fish, amphibians, and any other organism that is part of the aquatic biological community for all or part of its life history. There are two indicators within the biotic community category: **macroinvertebrates** and **native fish**. The final biotic community score is calculated as an average of the macroinvertebrates and native fish indicator scores. Information about recreational sport fishing is covered in the River Uses and Management attribute of the Scorecard.

10.1 MACROINVERTEBRATES INDICATOR

Benthic macroinvertebrates can be used as indicators of both water quality and the health of the biotic community. Refer to Section 4.4 for details and scores related to this indicator.

10.2 NATIVE FISH INDICATOR

Fish population monitoring, typically conducted via electrofishing surveys, is used to determine fish species composition (including relative abundances of species), density estimates, age or size class distribution, and other metrics related to the health of the fishery. Due to the paucity of comprehensive data in the Elk River segment, the native fish indicator is focused on percent native fish and presence of Mountain Whitefish. It is important to note that after 2000, the geographic ranges of native coldwater fishes in the Upper Yampa (including native Mountain Whitefish and Colorado River Cutthroat Trout) decreased markedly, and warmwater natives such as Bluehead Sucker and Flannelmouth Sucker were no longer present (Yampa IWMP 2021). However, invasive warmwater fishes are not common in the Elk River, presumably because of cold water temperatures (Yampa IWMP 2021). This section is completed mainly as a tool for comparison between riverscapes and to contrast with other Scorecard segments. While Friends of the Yampa is engaging in efforts to conduct fishery population monitoring in additional locations in this segment, the historical data (and even current data) are extremely limited and so any conclusions that are made based on available data in this section are associated with some uncertainty.

10.2.1 Data Sources and Evaluation Methods

According to CPW’s database of aquatic data collected across the state, fish population data have been collected at each riverscape in the Elk River segment except riverscapes 7 and 12 between one and seven times over the years 1955 to 2015. Due to the paucity of fish population data in the Elk River segment, electrofishing surveys to determine species presence/absence and relative abundance were conducted as part of the Scorecard effort at two sites on private property with landowner permission on August 26, 2025: one in riverscape 10 on an Elk River side channel, and one “spot-shocking” effort in riverscape 9 on the main stem of the Elk River. Because limited data were available for review in the entirety of the Elk River segment, some uncertainty is associated with fishery scores from all riverscapes.

10.2.2 Scoring Criteria

The scoring criteria outlined in Table 10-1 based on presence and proportions of native species are used to rate the native fish indicator. This scoring scheme is based on the fisheries evaluation conducted for the Yampa IWMP remote assessment (Yampa IWMP 2021). It acknowledges that nearly all of the Yampa and Elk's riverscapes contain impacted fisheries; any riverscapes that earn a score of A are still highly modified compared to historical conditions. However, the goal of this scoring system is to differentiate between riverscapes on a relative scale. Had the historical condition of robust, native fisheries been used for a score of A, no differentiation would be possible, because all riverscapes would have low scores. The use of an altered baseline condition allows the prioritization of riverscapes and the opportunity to select individual riverscapes for future adaptive management and research activities (Yampa IWMP 2021).

Table 10-1. Native Fish Indicator Scoring Criteria

Grade	Description
A	The reach supports all of the expected native species for the given watershed location. In coldwater riverscapes, Colorado River Cutthroat Trout, Mountain Whitefish, native Sculpin[1], and Mountain Sucker are expected. In warmwater riverscapes, The Three Species (Bluehead Sucker, Flannelmouth Sucker, and Roundtail Chub), Mountain Sucker, Colorado Pikeminnow, and Speckled Dace are expected. Nonnative species such as Northern Pike, Smallmouth Bass, and White Sucker are not common. The percentage of native species is generally greater than 50%.
B	The reach supports a majority of the expected native species for the given watershed location. In coldwater riverscapes, Colorado River Cutthroat Trout, Mountain Whitefish, native Sculpin, and Mountain Sucker could be expected. In warmwater riverscapes, The Three Species (Bluehead Sucker, Flannelmouth Sucker, and Roundtail Chub), Mountain Sucker, Colorado Pikeminnow, and Speckled Dace are expected. Nonnative species such as Northern Pike, Smallmouth Bass, and White Sucker are present but not common. The percentage of native species is generally greater than 20%.
C	The reach supports some expected native species for the given watershed location. In coldwater riverscapes, some or all of the native salmonids may have been replaced with Brook Trout, Brown Trout, and/or Rainbow Trout, but the naturalized populations are robust. Native Sculpin are expected. In warmwater riverscapes, some of the native warmwater species listed above are present. Native Sculpin and Speckled Dace are also expected. Nonnative species are common, and native species comprise 10-20% of the fish community.
D	The reach supports few or no native fish, or the fishery exhibits a highly degraded condition. In coldwater systems, salmonids are expected, but in low densities. Native Sculpin or Speckled Dace may be present. In warmwater riverscapes, The Three Species (Bluehead Sucker, Flannelmouth Sucker, and Roundtail Chub), Mountain Sucker, and Colorado Pikeminnow are largely or entirely absent. Speckled Dace may be the only native warmwater species present. Nonnative

[1] The CPW database lists native sculpin as Mottled Sculpin, but sculpin taxonomy has been updated in recent years and we refer to them in this and future Scorecard reports as "native sculpin."

	species are common and abundant. Native species comprise less than 10% of the fish community.
F	The reach does not support native fish, and/or the fishery exhibits a highly degraded condition. In coldwater systems, salmonids are absent or present in low densities, and native Sculpin and Speckled Dace are absent. In warmwater riverscapes, The Three Species (Bluehead Sucker, Flannelmouth Sucker, and Roundtail Chub), Mountain Sucker, and Colorado Pikeminnow are absent. Nonnative species dominate, and native species comprise less than 5% of the fish community.

10.2.3 Results

Results for the native fish indicator are provided in Table 10-2 and described here. Unfortunately, no data are available for riverscapes 7 and 12, so those riverscapes are not scored for the native fish indicator.

CPW stocking records show that hundreds of thousands of trout (mainly Rainbow Trout and Cutthroat Trout) have been stocked in the Elk River (primarily in riverscapes 8 and 10). These records indicate consistent stocking in these locations from the early 1970s to the present time. In addition, the database does not include stocking on private ranches, which adds even more trout to these water bodies. This widespread stocking makes it difficult to draw conclusions about the presence of self-sustaining populations of any species.

Riverscape 8 along Seedhouse Road to Glen Eden has limited data, with information available for 1993 only. More native fish than non-natives were observed in that monitoring event, with Sculpin, Mountain Sucker, and Mountain Whitefish making up 63% of the sample and Trout (Brook, Brown, and Rainbow) comprising the remainder. Based on the limited available data, riverscape 8 is assigned an A- score. Again though, this result should be interpreted with caution because it only reflects a single sampling event more than three decades ago.

In riverscape 9 between Glen Eden and the Moon Valley neighborhood, data availability is also very limited. Reports from 1955 show observations of Mountain Whitefish and Brook Trout, with native Mountain Whitefish comprising 75% of the 8 fish observed. Recent electrofishing efforts for the Scorecard project in summer 2025 were completed on the main stem of the Elk River on private property via “spot shocking” with a backpack electrofishing unit. These efforts showed observations of native Sculpin in comparatively large numbers, as well as Rainbow Trout, Brook Trout, Brown Trout, and Cutthroat Trout. No Mountain Whitefish were observed in 2025 at this location. The percent of native species observed decreased from 75% to 66% between 1955 and 2025, but the monitoring methodologies and locations were different. Although the percentage of native species was greater than 50%, based on data showing a decline in these percentages and the fact that no Mountain Whitefish were observed in 2025, riverscape 9 earns a B+ score.

Riverscape 10 extends from the Moon Valley neighborhood to the location where the valley narrows upstream of CPW’s Christina fishing easement and the Red Dirt tailhead. Historical data are limited to two monitoring events in this reach in 1955 and 2012, and supplemented by 2025 Scorecard electrofishing data. 1955 data showed 79% Mountain Whitefish and 21% Rainbow Trout. The 2012 observations appear to be more complete, with records of native Mountain Whitefish, as well as an abundance of native Sculpin and Speckled Dace (93% of total catch), along with Brook Trout, Brown Trout, White Sucker, and Creek Chub. The 2025 electroshocking effort was completed on private property in a side channel to the Elk River, where 67% native species were observed. The monitoring revealed native Sculpin and Speckled Dace, as well as a single native Mountain Sucker. The catch also included Rainbow Trout, Brown Trout, Brook Trout, a single Cutthroat Trout, and a single Brook Stickleback. After electrofishing the side channel, the field crew also clearly observed 6-8 Mountain Whitefish in the main channel. Based on these observations and the relative abundance of native species confirmed this year, riverscape 10 earns a score of A-.

Riverscape 11, encompassing a narrow canyon section of the Elk River with parts of Routt National Forest and CPW's Christina fishing easement, has the most data of any riverscape, with monitoring conducted on 7 occasions between 1985 and 2015. During this time, percent native species declined from 100% in 1985 to 59% in 2015, but intermediate years had percentages of native species between 62% and 93%. It is notable that native Flannelmouth Suckers were observed in 1985 and 1993, and native Mountain Suckers were recorded in 1993, 2003, and 2014. Native Mountain Whitefish and Speckled Dace were observed in all years. Based on these data, this riverscape earns an A- score. However, efforts should be made in the next iteration of this segment of the Scorecard to shift the electrofishing focus to this riverscape so more current fish species data are available to compare to this relatively robust long-term record.

The downstream-most portion of the Elk River segment is represented by riverscape 13. Datasets from 1955, 1976, and 2001 provide information about the fishery through this reach. Percentages of native species declined from 98% in 1955 to 79% in 2001, with observations of native Bluehead Sucker in 1976, along with other natives in all three years. Increasing numbers of non-native Creek Chub and Brook Stickleback, as well as trout, were observed in the later years. This would be another location where Scorecard electrofishing efforts would be helpful so more current fish species data are available. While FOTY is limited by backpack electrofishing equipment for a variety of reasons, it would be wise to plan a fish population monitoring effort in collaboration with CPW over the next 5 years at this and several other riverscapes to incorporate more current data into the scoring. That said, based on this limited information, riverscape 13 also earns an A- score.

Table 10-2. Native Fish Indicator Scores by Riverscape*

Riverscape	Native Fish Score
Riverscape 7	NA
Riverscape 8	A-
Riverscape 9	B+
Riverscape 10	A-
Riverscape 11	A-
Riverscape 12	NA
Riverscape 13	A-

*based on very limited data

11.0 OVERALL RIVER HEALTH AND FUNCTION SCORE

Upon assigning scores for each indicator and category to each riverscape within the Scorecard focal segment, the individual category scores are integrated to derive a final river health and function score for each of the 7 riverscapes within the 32-mile Elk River segment. The percentage contributions of each river health and function category are provided in Table 11-1. A weighted average by riverscape area is then calculated to yield a final segment score for the River Health and Function attribute area.

Table 11-1. Percent Contribution to Overall River Health and Function Score by Category

Category	Percent
Flow Regime	20
Sediment Regime	5
Water Quality	15
Habitat Connectivity	5
Riverscape Connectivity	10
Riparian Condition	20
River Form	5
Structural Complexity	15
Biotic Community	5

The final river health and function scores for the Elk River segment are provided in Table 11-2, organized by indicator and riverscape. **Weighting the cumulative scores for each riverscape by river length yields an overall ecological health and function score of B for the entire Elk River segment**.

In contrast with other Scorecard segments on the Yampa River, the flow regime in the Elk River remains largely unaltered despite human actions (such as diversions and irrigation withdrawals), contributing significantly to the Elk River segment's good final score. However, alterations to the flow regime associated with the changing climate (earlier and more rapid snowmelt and earlier arrival of peak flows) will likely continue over the coming decades and further impact the riverine ecosystem. Additionally, throughout the Elk River segment, channel morphology is largely intact, and features that add complexity and heterogeneity and consequently increase habitat quality and suitability are abundant. Invasive plant species have very limited presence, and negative impacts on the riparian zone from such species are not observed. Water quality across the segment is generally excellent.

While the Elk River segment shows compliance with most regulatory standards for water quality parameters, periodic exceedances of temperature thresholds in downstream riverscapes could stress native aquatic species. The sediment regime remains largely balanced, but downstream riverscapes in particular are frequently fragmented by in-channel barriers (such as cross vanes and push-up dams) that disrupt potential downstream sediment transport and may decrease sediment supplied to these areas. That said, the degree to which the sediment regime is altered from these structures, which are permeable and allow flow and potentially passage of finer-grained sediments (particularly at high flow), is unclear. Aquatic and terrestrial connectivity scores indicate a functioning but somewhat fragmented habitat, with barriers and infrastructure limiting connectivity, particularly in terms of aquatic connectivity in downstream riverscapes. Extensive bank armoring in these lower riverscapes negatively influences this connectivity and reduces aquatic habitat quality. Bank armoring in general prevents river mobility, especially in partially confined to unconfined reaches, often resulting in a loss of complexity and relative homogenization of the riverscape. Notably, river complexity is still high in some relatively heavily armored segments, likely due in part to the frequent occurrence of large wood, which often encourages the creation (and maintenance) of river features that increase complexity (such as mid-channel bars/islands and split flows). Similar to other segments of the Yampa, native fish data for the Elk River are extremely sparse, and stocking of non-native species is widespread and unregulated. Protection or repair of the native fishery will require that substantial resources be allocated to data collection related to native fish populations and stocking of non-native species.

With significant stretches located on public land, the upper riverscapes (riverscapes 7 and 8) benefit from less direct human alterations. Here, the channel is steep and confined by relic glacial terraces; small, inset floodplains are generally well-connected to the channel and riparian vegetation remains largely intact. Some development fragments the floodplain, but, in general, barriers to aquatic connectivity are rare, as are the presence of features/actions that reduce the ability of the river to establish a natural morphology (e.g., bank armoring). In contrast, the downstream riverscapes (riverscapes 9-13) have more built infrastructure and consequently more manipulation of the channel and banks intended to protect that infrastructure. As a result, these riverscapes have a greater degree of fragmentation (i.e., disruptions to connectivity) and alteration to natural vegetation assemblages and channel morphology. Despite these conditions, the river in these areas remains healthy, likely due to the relatively minor nature–in the grand scheme of things–of the present alterations. One reason for this is because the more extensive modifications and alterations (e.g., bank armoring, riparian vegetation removal) that occur in the Elk River segment are often located solely on one bank of the river, while the opposite bank is often less easily accessible and thus retains much of its more “wild” and natural character (Appendix A, Photos A-28 through A-31).

The overall health and vitality of the Elk River segment in general (Table 11-2) emphasizes the need to continue to protect these areas in order to maintain the Elk River as an example of a well-functioning riverine system that dually supports both a healthy and productive human community and a relatively natural ecosystem. Protecting and enhancing flow and sediment regimes, bolstering habitat connectivity, and expanding monitoring efforts to capture local and emerging climate impacts will be key to preserving the river’s ecological health. One consideration for enhanced riverscape health is to replace traditional, hardened river engineering infrastructure (such as bank armoring with large boulders or riprap) with more nature-based designs such as willow plantings or wood structures. These types of projects often result in similar protection of proximal land and assets while also improving riparian habitat and promoting connectivity, both for aquatic species in the channel and for riverscape connection across the floodplain. This and other recommendations are outlined in more detail in the Yampa River Stewardship Program, a program designed to follow the Scorecard and connect landowners and land managers with the tools and resources necessary to tackle priority projects in a way that protects river health.

Scorecard results from the Elk River segment demonstrate that the Elk River is a healthy river that retains a good deal of its natural character and processes. Taken in conjunction with the scores of prior segment assessments, the Yampa Basin is poised to serve as a potential flagship for riverine health in the western United States. The Yampa River Scorecard Project website at https://yampascorecard.org/ is a resource for understanding the nuanced strengths and challenges that make up the current state of the river. Engaging with the website and with Friends of the Yampa can provide pathways for becoming actively involved in the preservation and restoration of the Yampa and Elk Rivers.

Table 11-2. Elk River Segment Ecological Health and Function Scores by Indicator and Riverscape

			Elk River Segment							
	Segment									
	Riverscape		7	8	9	10	11	12	13	Overall
	Length (miles)		1.91	3.99	5.98	8.11	2.24	3.13	6.26	31.6
	Riverscape Area (square miles)		1.20	0.42	3.04	4.86	0.15	1.02	3.07	13.8
Category	**Indicator**	**Scoring Weight**								
Flow Regime	Hydrograph		A	A	A	A-	A-	A-	A-	A
	Snowpack		B-	B-	B-	B-	B-	B-	B-	B-
	Flow Regime	**20%**	A	A	A	A-	A-	A-	A-	A-
Sediment Regime	**Sediment Transport and Continuity**	**5%**	A	A	B	A-	B	B-	B-	B+
Water Quality	Temperature		B	B-	B	C	C	C	C	C+
	Dissolved Oxygen		A	A	A	A	A	A	A	A
	pH		A	A	A	A	A	A	A	A
	Macroinvertebrates		B	B-	B+	B-	B-	B+	B+	B
	Nutrients		A	A	A	A	A	A	A	A
	Metals		A	A	A	A	A	A	A	A
	Water Quality	**15%**	A-	A-	A-	A-	A-	A-	A-	A-
Habitat Connectivity	Aquatic Habitat Connectivity		A	A	B	B+	B	B-	B-	B+
	Terrestrial Habitat Connectivity		C	C+	B-	A	A	C+	A	B+
	Habitat Connectivity	**5%**	B	B+	B	A-	A-	C+	B+	B+
Riverscape Connectivity	**Riverscape Connectivity**	**10%**	B-	B	C	B+	C	C-	C	C+
Riparian Condition	Vegetation Structure and Complexity		A-	B-	C+	C+	C	D+	C	C+
	Invasive Species		A	A	A	A	A	A	A	A
	Riparian Condition	**20%**	A-	B	C+	C+	C	C-	C	C+
River Form	**Channel Morphology**	**5%**	A	A	B	A-	A-	B	B+	A-
Structural Complexity	Macrohabitat		A	A	B	A	C	C	B+	B+
	Microhabitat		A	A	A	B	D+	B	A	B+
	Structural Complexity	**15%**	A	A	B+	A	C	C+	A-	B+
Biotic Community	Macroinvertebrates		B	B-	B+	B-	B-	B+	B+	B
	Native Fish		N/A	A-	B+	A-	A-	N/A	A-	A-
	Biotic Community	**5%**	C+	B	B+	B	B+	B	B+	B
	Weighted River Health Score	**100%**	A-	A-	B	B+	B	B-	B	B

12.0 REFERENCES

Andrews, ED. 1978. Present and potential sediment yields in the Yampa River Basin, Colorado and Wyoming. US Geological Survey. Water Resources Investigations Nos. 78-105, p. 33.

Barbour, MT, J. Gerritsen, BD Snyder, and JB Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. US Environmental Protection Agency, Office of Water, Washington, DC. EPA 841-B-99-002. Available online at http://www.epa.gov/owow/monitoring/rbp/index.html.

Bauch, NJ, JL Moore, KR Schaffrath, JA Dupree. 2012. Water-quality assessment and macroinvertebrate data for the Upper Yampa River watershed, Colorado, 1975 through 2009. Scientific Investigations Report. U.S. Geological Survey, Reston, VA (USGS Numbered Series No. 2012–5214). https://doi.org/10.3133/sir20125214.

Beardsley, Mark and Brad Johnson. 2018. Flood Recovery Project Monitoring Methods. Prepared by Ecometrics and others for the Colorado Water Conservation Board. March 7, 2018.

Castro, JM and CR Thorne. 2019. The stream evolution triangle: Integrating geology, hydrology, and biology. River Research and Applications 35, 315–326. https://doi.org/10.1002/rra.3421.

CDPHE. 2023. Water Quality Control Commission. (2023). Regulation No. 33 - Classifications and Numeric Standards for Upper Colorado River Basin and North Platte River (Planning Region 12), 5 C.R.R. § 1002.33 (2023).

CDPHE. 2021. Water Quality Control Commission. (2021). Regulation No. 33 - Classifications and Numeric Standards for Upper Colorado River Basin and North Platte River (Planning Region 12), Adopted Rule: Temporary modifications 5 C.R.R. § 1002.33 (2021).

CDPHE. 2016a. Benthic Macroinvertebrate Sampling Standard Operating Procedure. Colorado Department of Public Health and Environment, Water Quality Control Division, Environmental Data Unit. Version 5.0-111716. November 17, 2016.

Colorado Water Conservation Board/Department of Natural Resources (CWCB/DWR). 2024. Colorado's Decision Support Systems structures database. Accessed at https://dwr.state.co.us/Tools/Structures.

City of Steamboat Springs/Lotic. 2023. Reducing Uncertainty in Water Temperature Modeling on the Yampa River near Steamboat Springs, prepared by Lotic Hydrological for the City of Steamboat Springs.

City of Steamboat Springs. 2018. Yampa River Health Assessment and Streamflow Management Plan. June 2018.

Day, NK. 2021. Assessment of Streamflow and Water Quality in the Upper Yampa River Basin, Colorado, 1992 – 2018. US Geological Survey Scientific Investigations Report 2021-5016. 45p. https://doi.org/10.3133/sir20215016.

Friends of the Yampa (FOTY) and Alba Watershed Consulting. 2021. Yampa River Scorecard Project Indicators and Methods Report. September 2021.

Hilsenhoff, William L. 1987. An Improved Biotic Index of Organic Stream Pollution. The Great Lakes Entomologist. Volume 20, No. 1, Article 7, pages 31-39.

Jagt, K, M Blazewicz, and M Guiney. 2022. Yampa River IWMP Fluvial Hazards and Management: Middle Yampa and Elk Rivers in Routt County, Colorado. Version 1.0. June 17, 2022. https://storymaps.arcgis.com/stories/4c156897209c4e41864adfd55902fee9.

Johnson, Brad, Mark Beardsley, and Jessica Doran. 2015. Functional Assessment of Colorado Streams (FACStream) 1.0. Prepared for US Environmental protection Agency and the Colorado Water Conservation Board.

Leopold, LB and MG Wolman. 1957. River channel patterns: Braided, meandering, and straight. US Geological Survey Professional Paper 282-B. US Government Printing Office, Washington DC. https://doi.org/10.3133/pp282B.

Lotic. 2021. Yampa River Hydrology Review and Needs Assessment, Draft Technical Report prepared by Lotic Hydrological for River Network.

MacArthur, Robert H. 1965. Patterns of Species Diversity. Biological Reviews. Volume 40, Issue 4, pages 510-533.

Mason, Seth. 2021. Yampa River Hydrology Review and E&R Needs Assessment. Interactive online storyboard available at: https://lotic.shinyapps.io/yampa-flows-storyboard/. July 2021.

Mattilio, Chloe. 2021. *Interactive map*. Yampa River Leafy Spurge Project. Available at: https://www.yampariverleafyspurgeproject.com/interactivemap

Nicoll, TJ and EJ Hickin. 2010. Planform geometry and channel migration of confined meandering rivers on the Canadian prairies. Geomorphology. Volume 116. Pages 37-47. https://doi.org/10.1016/j.geomorph.2009.10.005.

NRCS. 2017. Stream Visual Assessment Protocol (Version 2): Colorado. US Department of Agriculture, Natural Resources Conservation Service. June 2017.

Schumm, SA. 1985. Patterns of Alluvial Rivers. Annual Review of Earth and Planetary Sciences. Volume 13. Pages 5-27.

Williams, P. 2022. Personal communication between P Williams and K Lennberg via email. September 26, 2022.

Wilson Water Group (WWG). 2018. DRAFT Yampa/White/Green Basin Roundtable Basin Implementation Plan Modeling Phase 3 Final Report. March 2018.

Yampa IWMP. 2021. Physical and Biological Characterization of the Yampa River Basin Via Remote Assessment: Data Synthesis Report. Prepared for the Yampa-White-Green Basin Roundtable Integrated Water Management Plan. Prepared by Alba Watershed Consulting, Otak Inc, Anabranch Solutions, and GEI Consultants. September 2021.

APPENDIX A

PHOTO COMPILATION

Figure A-1. Large grade control structure (cross vane) in riverscape 12 (looking downstream)

Figure A-2. Several grade control structures (cross vanes) in riverscape 11 (looking downstream)

Figure A-3. Grade control structure (j-hook) in riverscape 10

Figure A-4. Diversion structure ("push-up" dam & intake/headgate) in riverscape 12

Figure A-5. Diversion structure ("push-up" dam & intake/headgate) in riverscape 9

Figure A-6. County road bridge in riverscape 9

Figure A-7. Upstream end of extensive armoring in riverscape 9 (looking downstream)

Figure A-8. Extensive armoring on both sides of the river in riverscape 9, looking downstream

Figure A-9. Side channel with beaver dam in riverscape 9

Figure A-10. Side channel typical of the partially confined and unconfined riverscapes in the Elk River segment (riverscape 9)

Figure A-11. Bank armoring in riverscape 9

Figure A-12. Bank armoring in riverscape 10

Figure A-13. Bank armoring along Seedhouse Road in riverscape 8

Figure A-14. Bank armoring along Seedhouse Road in riverscape 7

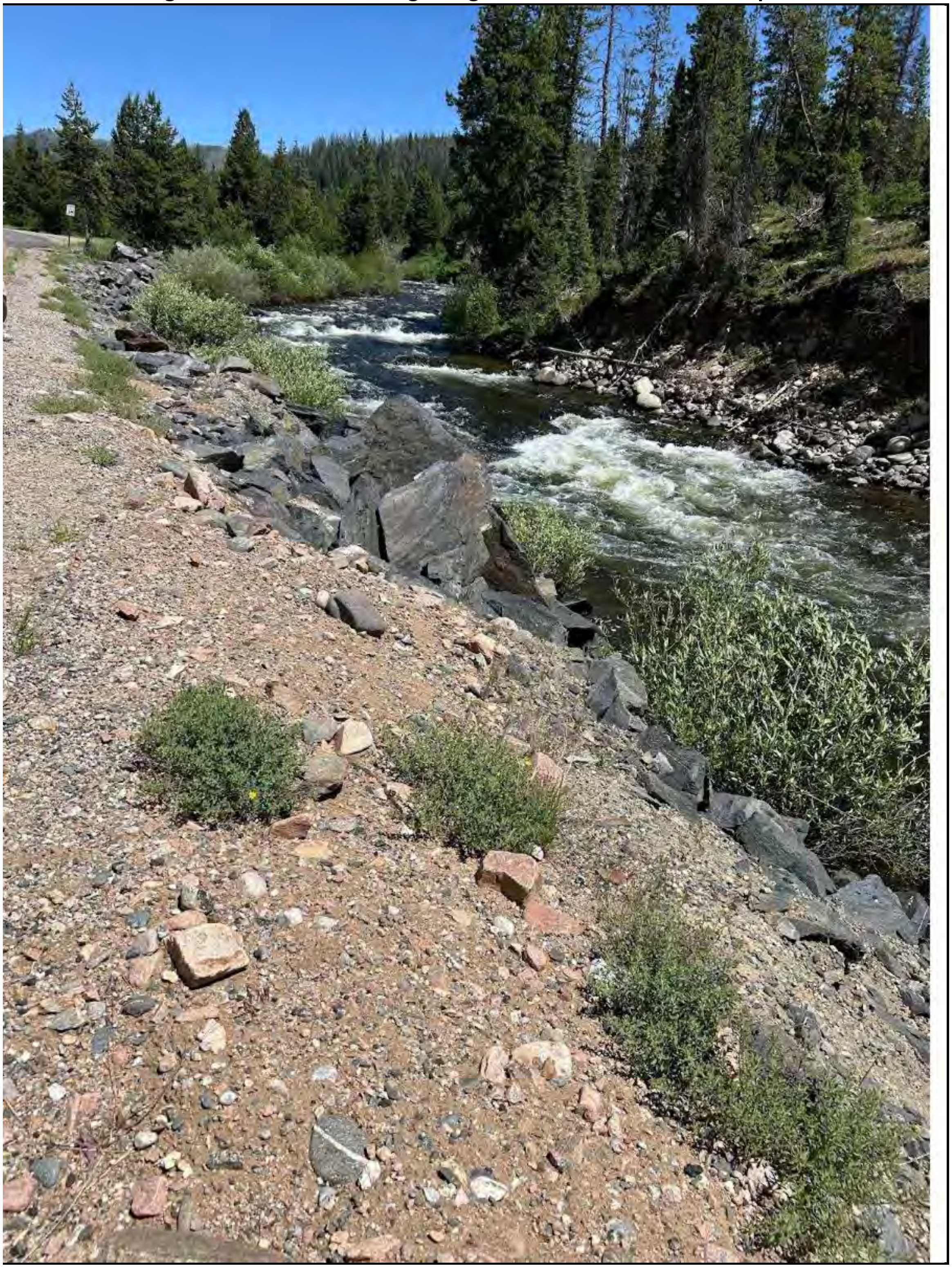


Figure A-15. Bank armoring with large boulder rip-rap in riverscape 12

Figure A-16. Bank armoring with large boulders in riverscape 12

Figure A-17. Bank armoring with concrete blocks in riverscape 12

Figure A-18. Bank armoring around/upstream of bridge abutments in riverscape 9

Figure A-19. Wood accumulation in riverscape 9

Figure A-20. Wood accumulation in lateral pool in riverscape 10

Figure A-21. Wood accumulation in middle of channel in riverscape 12

Figure A-22. Wood accumulation on mid-channel bars in riverscape 13

Figure A-23. Wood accumulation along banks in riverscape 7

Figure A-24. Beaver chew in riverscape 9

Figure A-25. Beaver chew in riverscape 10

Figure A-26. Backwater in riverscape 8, illustrative of the relatively small backwaters found throughout the upper confined riverscapes (7 and 8).

Figure A-27. Rapidly eroding banks in riverscape 10 due to riparian vegetation absence (left side), compared to the natural bank erosion where riparian vegetation remains intact (right side). This photo is illustrative of what the project team considers "rapid erosion," which takes place in the presence of stressors (here, lack of riparian vegetation and a hayfield that extends to the river edge).

Figure A-28. Example of modified riverbank and floodplain (right) opposite a relatively intact, natural channel and floodplain (left) in riverscape 10. "Pairings" like this, where one bank is extensively modified through human actions while the opposite retains a relatively natural character, are common throughout the Elk River segment.

Figure A-30. Example of modified riverbank and floodplain (left) opposite a relatively intact, natural channel and floodplain (right) in riverscape 10

Figure A-31. Example of modified riverbank and floodplain (left) opposite a relatively intact, natural channel and floodplain (right) in riverscape 10

Figure A-32. Example of modified riverbank and floodplain (top right) opposite a relatively intact, natural channel and floodplain (bottom left) in riverscape 10

APPENDIX B

TECHNICAL MEMORANDUM: YAMPA SCORECARD ELK RIVER SEGMENT RIPARIAN MAPPING METHODS AND RESULTS (OCTOBER 14, 2025)

TECHNICAL MEMORANDUM

TO: Lindsey Marlow (Friends of the Yampa)
Jenny Frithsen (Friends of the Yampa)

FROM: Kim Lennberg (Alba Watershed Consulting)
Brad Johnson (Johnson Environmental Consulting)

SUBJECT: Yampa Scorecard Elk River Segment Riparian Mapping Methods and Results

DATE: October 14, 2025

This memorandum outlines the approach and methodology used to map and evaluate existing conditions within the Elk River riparian corridor along a 30-mile segment from the confluence with the South Fork of the Elk River to the confluence with the Yampa River in north Routt County, Colorado. The segment evaluated is this year's Yampa River Scorecard Project focal segment, which encompasses seven riverscapes (RS 7-13). All riverscapes are identified in the Yampa Integrated Water Management Plan (IWMP) remote assessment (Final Physical and Biological Characterization of the Yampa River Basin Via Remote Assessment: Data Synthesis Report, September 2021). This memorandum also provides results of the mapping and a summary of major findings.

Background

This detailed mapping of a defined riparian corridor for a 30-mile segment of the Elk River main stem was completed to improve understanding of current conditions, to support identification of potential opportunities for restoration or conservation, and to score the *vegetation structure and complexity indicator* for the Yampa River Scorecard Project. The *vegetation structure and complexity indicator* describes vegetation condition and its ability to support characteristic riparian functions (i.e., river health). Healthy riparian zones are characterized by a high level of vertical and horizontal complexity, including a mosaic of habitat types and multiple vegetation layers. Included in these considerations are structure, height, cover, species diversity, complexity, age, and patchiness/interspersion of riparian vegetation. The character and complexity of riparian vegetation are primarily driven by moisture regime, the disturbance caused by seasonal flooding, alluvial groundwater, and erosional and depositional changes that create bars and distribute fine sediment. Overlaid on these natural drivers are the omnipresent effects of land use and management. Complex riparian corridors in turn influence a spectrum of physical functions in the river ecosystem while providing critical wildlife habitat.

Spatial Extent

Within the 30-mile-long Elk River segment, riparian vegetation was evaluated within a defined belt extending 100 meters from each bank or to the edge of the natural floodplain, whichever was less. This corridor is referred to as the Yampa Scorecard Riparian Zone (YSRZ). The maximum potential extent of riparian vegetation in the study reach is sometimes wider than 200 meters. The limited width of the YSRZ represents a compromise between data acquisition and available resources. The condition and extent of riparian vegetation was evaluated near the channel where it exerts the greatest control on river health, but the condition of riparian vegetation in the wider riverscape is not addressed. Future assessments could seek either to expand riparian vegetation mapping within the maximum potential floodplain in order to chart riverscape-scale changes in land cover and land use, or to conduct a separate analysis to quantify the overall extent of riparian vegetation within the maximum potential floodplain to track changes in spatial extent of riparian vegetation over time.

Methodology

Within the YSRZ, vegetation structure and complexity were evaluated using the same remote polygon methodology applied in the City of Steamboat Springs SMP's river health assessment (City of Steamboat Springs 2018). This methodology was applied to riparian condition assessments of the three previous iterations of the Yampa River Scorecard Project evaluations: the Middle Yampa segment in 2022, the Steamboat segment in 2023, and the Upper Yampa segment in 2024. This approach entailed the following steps:

(1) Aerial imagery was used to delineate the Elk River main channel for the 30-mile segment of interest.

(2) A 100-meter buffer from each bank was created using the ArcGIS buffer tool, delineating the maximum potential extent of the study area. This polygon was then trimmed to the width of the floodplain in areas where it is narrower than 100 meters. The resulting polygon is the YSRZ.

(3) The YSRZ was then cut into polygons, each holding relatively homogenous land cover and land use. Each polygon was classified according to its land cover (e.g., cottonwood/canopy forest, sub-canopy forest, montane forest, scrub-shrub, herbaceous, developed, bare ground, open water) and land use (e.g., ranch lands, light agriculture, wildlands, rural development, residential, transportation corridor).

(4) Next, a set of the polygons created in step 3 received preliminary condition scores based on the general criteria provided in **Table 1**, following the procedure detailed in the section below. Kim Lennberg (Alba Watershed Consulting) carried out the mapping and remote condition assessment and Brad Johnson (Johnson Environmental Consulting), performed a quality control check of the rated condition of each polygon. The team then visited as many locations as possible within the constraints imposed by time limitations and property access on September 24, 2025. Field verification prioritized polygons with natural-looking riparian vegetation. Field verification was also used to clear up instances of uncertainty and served to calibrate scoring by different team members.

(5) Discrepancies between evaluators' applied scores were discussed and reconciled, and polygon scores were then adjusted according to field observations and finalized. Throughout the mapping process, efforts were made to foster consistency with mapping of the Middle Yampa segment in 2022, the Steamboat segment in 2023, the Upper Yampa segment in 2024, and eventually all remaining segments.

(6) To develop overall scores for each of the seven riverscapes, an area-weighted average of polygon scores was calculated to produce a single vegetation structure and complexity indicator score for each riverscape.

Table 1. Vegetation Structure and Complexity Indicator Scoring Criteria

Score	Description
A	Native riparian conditions exist that appear natural and appropriate for the Yampa River. Woody vegetation is present and commonly dominant, but patches and ribbons of meadow are typical. Vegetation is characteristically patchy, with strong interspersion of patches and overall good vertical structure driven by connection to the river. No evident effects of stressors – many stressors ameliorated by frequent flooding. Examples include cottonwood forest on well-connected surfaces such as vegetated point bars; young, characteristically willow-dominated, vegetation on recently formed surfaces; low, in-channel benches protected from human manipulation, typically scrub-shrub. Full support of river health.
B	Riparian habitat resembles native conditions but with detectable changes or mild, evident stressors. Vegetation appears self-sustaining and requiring little or no maintenance to preserve characteristic structural diversity. Habitat maintains a high degree of patchiness and interspersion, with little homogenization or loss of vertical structure. Small habitat patches can be relatively homogenous but contribute to the local mosaic of habitats. Common examples include river-connected cottonwood canopy and subcanopy forest with impacts such as grazing and primitive roadways. Minor reduction in the support of river health attributes.
C	Vegetated but with substantial departure from native conditions. Most commonly, alterations result in a loss of structural complexity, and/or homogenization of vertical structure, patchiness, and/or interspersion. Examples include cleared pastures that contain scattered trees and shrubs; fallow floodplain hayfields and cottonwood forests with substantial understory alteration; and palustrine emergent wetlands associated with ditches and sloughs. Riparian condition contributes to the degradation of one or more river health processes.
D	Dramatic loss of structural complexity, and/or homogenization of vertical structure, patchiness, and interspersion. Habitat commonly isolated from the river. Bare ground or impervious surfaces commonly makes up a significant portion of land cover. Vegetation tends to be very disturbed or actively cultivated. Examples include actively cultivated hay fields, old gravel mines, primitive roadways, and golf courses. Riparian land use contributes to river dysfunction.
F	Riparian area is developed or wholly converted with predominantly bare ground, impervious surfaces, or otherwise lacking in vegetation as a result of land use and management actions. Riparian habitat function is essentially extinguished, and land use contributes substantially to river dysfunction.

Notes on mapping procedures and scoring

The most recent available National Agriculture Imagery Program (NAIP) imagery (September 2023) was used to delineate the Elk River main channel and create polygons based on land use and land cover. Mapping and condition assessment were further informed by higher resolution October 2022 and August 2025 aerial imagery from Google Earth where available. Google Earth imagery was being updated during the course of this study, but for consistency the 2023 condition was reported, despite the fact that several locations within the study area experienced substantial changes between 2023 and 2025. These changes will be reflected in the next iteration of the YRSP's Elk River segment in 2030.

Vegetation condition was scored based on its ability to support river health. **Table 1** provides the general criteria used to guide scoring. Vegetation condition scoring was based on apparent structural complexity, indication of clearing or similar practices, and the observed presence of anthropogenic alteration. Vegetation did not require a high degree of complexity to receive a high score. Dense, near-channel willow scrub, for example, often received a high score despite its monotony. Similarly, meadows near the channel that do not show signs of clearing and have apparently been removed from active management were assumed to be a natural vegetation type and scored accordingly. Importantly, the level of connection between riparian patches and the river influenced condition scores. That is, patches of (semi-)natural habitat isolated from the river by levees, road grades, railroads, or other infrastructure typically scored 5-10 percent lower than comparable habitat connected to the river, because such habitat has a diminished ability to support river health. For instance, isolated patches cannot receive and spread flows across the floodplain or assist with other vital functions.

Results

The 1,823-acre YSRZ was divided into 679 polygons based first on land cover and then land use. **Table 2** includes summary statistics for land cover types. **Figures 1** and **2** show the same data graphically. Of the nine cover types designated, herbaceous cover was by far the most common, accounting for more than 900 acres, or 50% of the YSRZ. Herbaceous areas were mostly hayfield and pasture lands. Subcanopy forest, scrub-shrub, and canopy/cottonwood forest were the three next most common cover types, which illustrates the rural nature of the landscape. The next most common cover type was montane forest, as the upper Elk River main stem riparian zone is heavily forested above approximately 7,500 feet in elevation. After the forested lands, the next most common cover type was developed areas, highlighting the rural and residential infrastructure associated with the local communities surrounding Clark, Glen Eden, Moon Valley, and other neighborhoods.

The cover types with the best mean condition were those in closest association with the river, including montane forest, cottonwood forest, and scrub-shrub habitats (**Table 2** and **Figure 2**). These areas are continually disturbed by natural processes and recover rapidly, so in most cases signs of human disturbance are quickly erased. Sub-canopy forests and flowing water are next in terms of condition, and excellent examples of both land cover types still exist on features shielded from intensive human use. Not surprisingly, developed polygons were assigned the lowest scores, with an average score of 57 (F score).

Table 2. Land Cover Type Statistics and Definitions

Land Cover Type Code	Land Cover Type	Number of Polygons	Minimum Score	Average Score	Maximum Score	Total Area (ac)	Notes
HRB	Herbaceous	211	55	68	92	913	Most commonly hayfields or pastureland used to various degrees for grazing.
SFO	Sub-canopy forest	88	67	78	93	311	Cottonwood forest that is less developed than the galleries of CFO. Trees and are either young, low, and relatively dense, or more widely scattered with occasional mature individuals mixed in.
SSH	Scrub-shrub	143	64	86	94	293	Typically patches or strips of shrubs dominated by sandbar willow, especially on channel banks and bars. Fairly homogeneous and species-poor but characteristic of riparian habitats and commonly observed in reference standard condition.
CFO	Cottonwood forest	66	65	83	93	158	Stands of mature trees with a generally closed canopy, also called gallery forest. Meadow and/or shrub patches commonly occur in forest openings.
MTF	Montane forest	26	72	87	93	61	Montane forest, generally found below 9,000 ft in elevation and consisting of aspen, ponderosa pine, and lodgepole pine species.
DEV	Developed	59	55	57	60	46	Usually with a high coverage of impervious surface. Roads and industrial areas are common examples.
BGR	Bare ground	57	55	59	72	30	Generally human-disturbed lands but occasionally cleared by natural disturbance.
LOW	Lentic open water	16	67	68	70	9	Any type of impounded water. Most commonly gravel ponds, but occasional oxbow ponds occur.
FOW	Lotic (flowing) water	13	65	77	94	2	Most commonly open water in sloughs or ditches, but occasional tributaries or side channels also occur.

Figure 1. Land Cover Type by Area (acres)

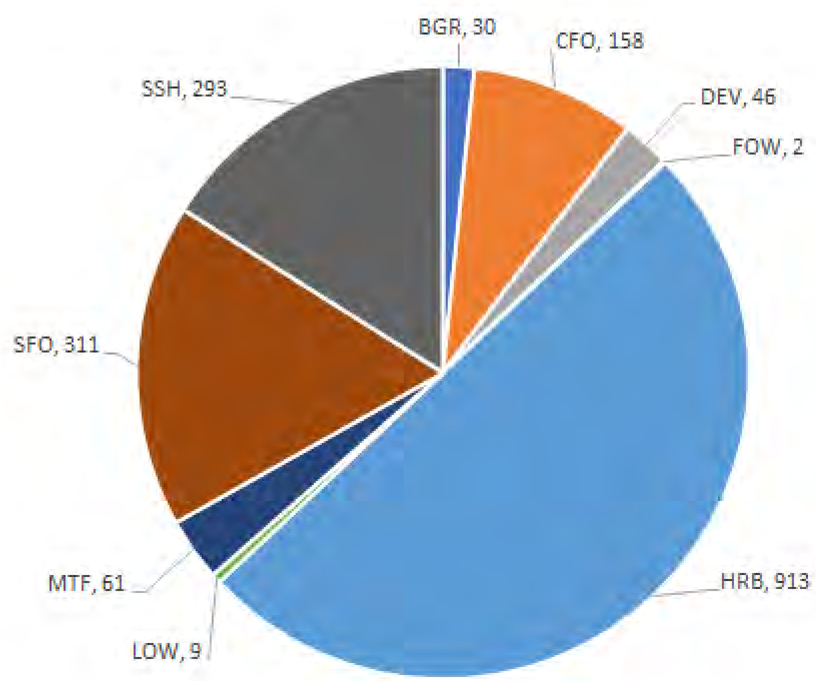
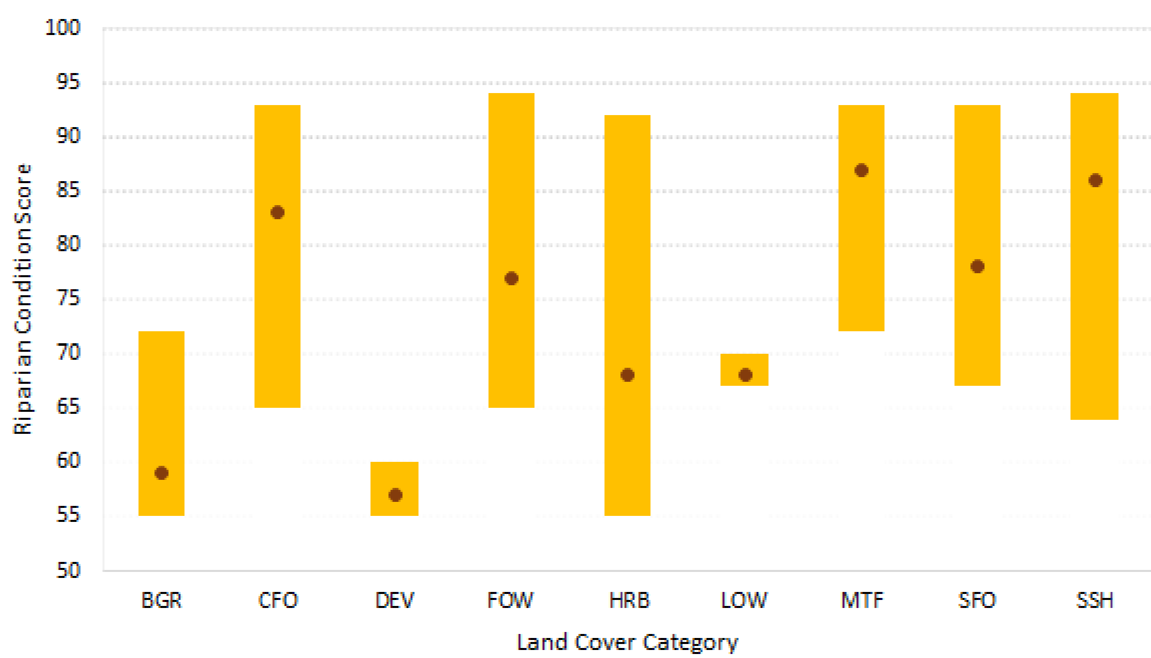


Figure 2. Land Cover Category Scoring Statistics



*Average score is represented by the maroon circle; yellow bars span the minimum to maximum scores

Land use type data are presented in **Table 3** and **Figures 3** and **4.** Following the pattern in land cover, ranchland and agricultural land uses are the most prevalent land uses in the YSRZ. It should be noted that there is little distinction between these two land uses, and they often overlap spatially or temporally. The agricultural land use implies that the polygon is under active cultivation, usually for hay. It is acknowledged that fields are continually taken in and out of production, and it is not always possible to determine whether an area is being actively hayed, used as pasture, or simply has abundant herbaceous cover. Rural development surrounding communities such as Clark, Glen Eden, and Moon Valley, covered the next largest area in the Elk River segment.

With ranchlands encompassing a number of land cover types, scores for this land use type in the Elk River segment have a wide range (between A and F), as they did in the other segments evaluated (Middle Yampa, Steamboat, and Upper Yampa segments). Ranchlands hold many of the Yampa Valley's finest examples of riparian habitat, and the average score for ranchlands in the Middle Yampa and Steamboat segments was a B. However, the overall average score for these habitats in the Upper Yampa and Elk segments is a C+. The ranchlands in the Elk, Bear, and Upper Yampa Rivers hold a high proportion of expansive, productive hayfields that help to maintain open habitat in the riparian zone, but this has come at the expense of the diversity of cover types such as forest and shrubland patches that are more typical of ranchland habitats in the Yampa River riverscapes further downstream.

Table 3. Land Use Type Statistics and Definitions

Land Use Type Code	Land Use Type	Number of Polygons	Minimum Score	Average Score	Maximum Score	Total Area (ac)	Notes
RCH	Ranchlands	465	55	78	94	1304	By far the most common land use and one encompassing a number of management regimes and cover types.
AGL	Light agriculture	52	64	68	69	357	Lands that are obviously irrigated and cropped, almost always for hay.
RUD	Rural development	69	55	66	94	85	Generally isolated dwellings, outbuildings, and ranch infrastructure.
WLD	Wildland	23	67	87	94	38	Generally public lands managed by the federal government with a "wild" character and limited human impacts.
TRC	Transportation corridor	66	55	57	60	36	Most commonly paved roads and railroad tracks.
RES	Residential	4	55	55	55	3	Developed areas for residential housing, usually with a high degree of impervious surfaces.

Figure 3. Land Use Type by Area (acres)

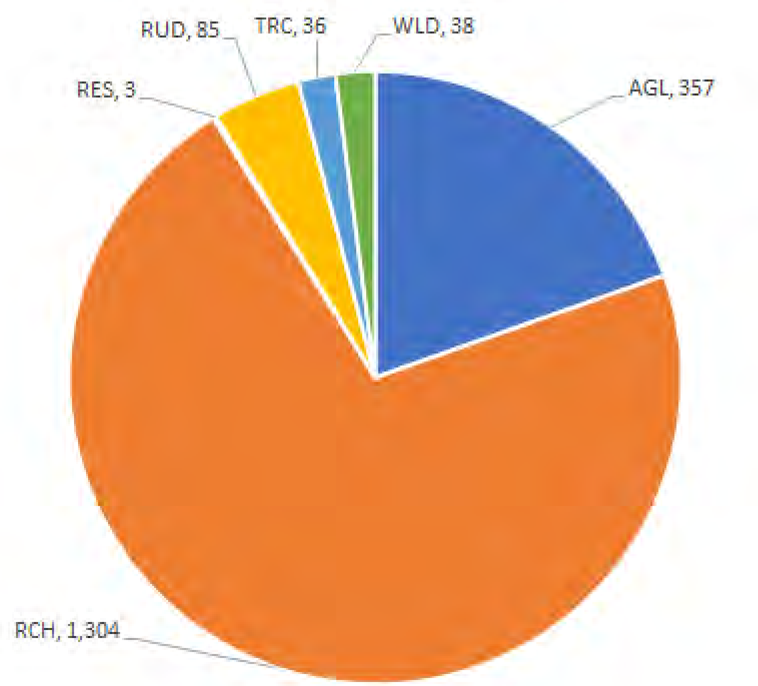
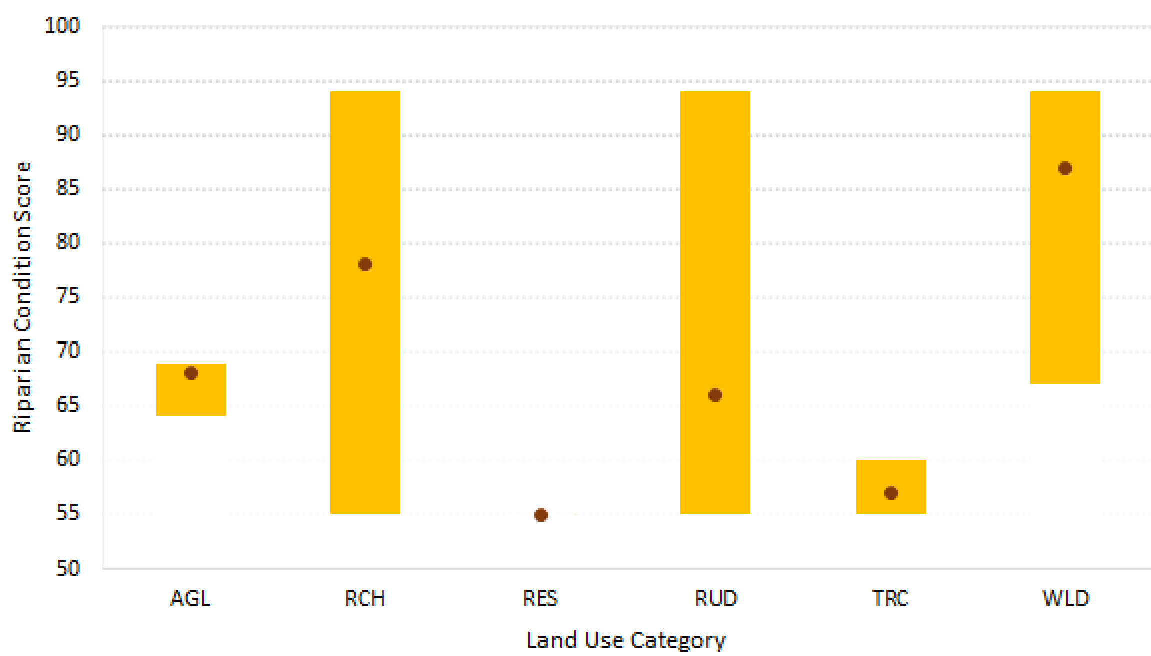


Figure 4. Land Use Category Scoring Statistics



*Average score is represented by the maroon circle; yellow bars span the minimum to maximum scores

Finally, riparian condition scores were weighted by area to compute an overall riparian condition score for each of the seven riverscapes in this study segment (**Table 4**). Examples of the fine-scale riparian mapping produced by this assessment are presented at the end of this document (**Figures A-1 through A-7**). Each polygon that was mapped includes details on land cover type, land use type, field verification, QC status, riverscape identification, numerical score, letter grade, ancillary notes, and calculated area. The polygons are color-coded by letter grade on a scale from green (A) to red (F). The riverscapes higher up in the watershed that included or abutted public lands (i.e., those in or very near to the Routt National Forest) scored in the A/B range. Moving downriver as riverscapes transitioned to more rural development and agriculture, scores decreased to the C range.

Table 4. Riparian Condition Scores by Riverscape

Riverscape	Riparian Condition Score
RS 7	90 (A-)
RS 8	82 (B-)
RS 9	77 (C+)
RS 10	77 (C+)
RS 11	74 (C)
RS 12	69 (D+)
RS 13	74 (C)

Results of Riparian Condition Mapping by Riverscape

Figure A-1. Riverscape 7 Riparian Condition Mapping

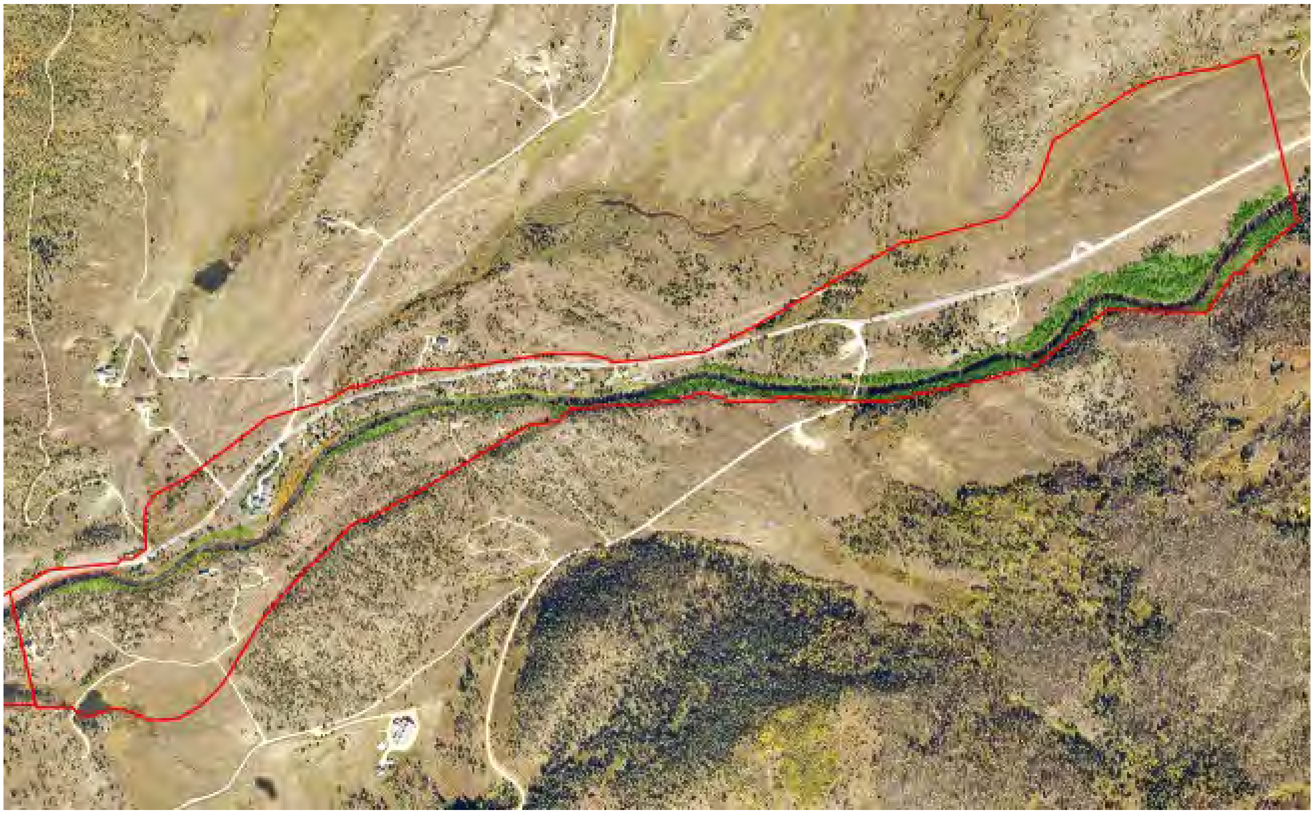


Figure A-2. Riverscape 8 Riparian Condition Mapping

Figure A-3. Riverscape 9 Riparian Condition Mapping

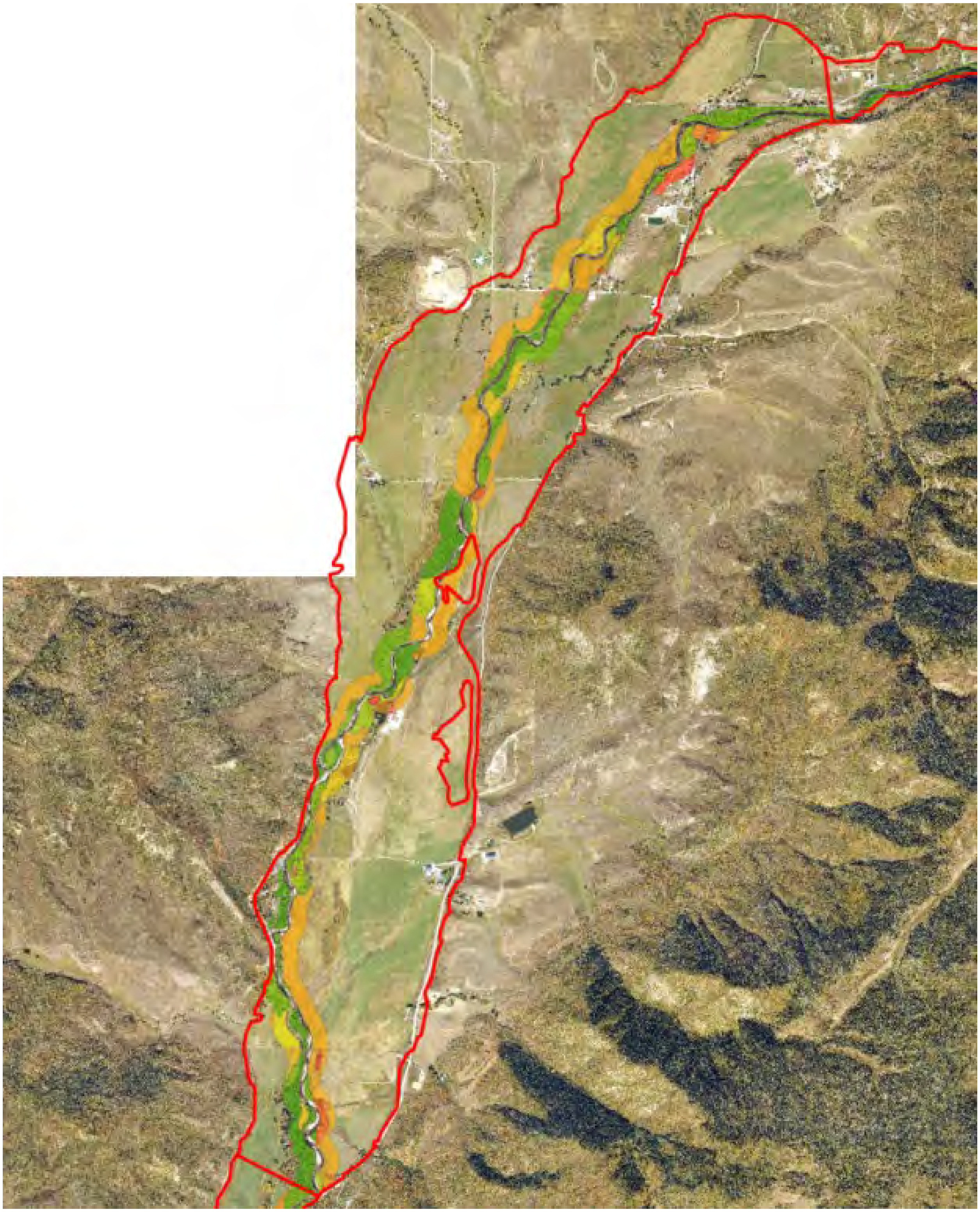


Figure A-4. Riverscape 10 Riparian Condition Mapping

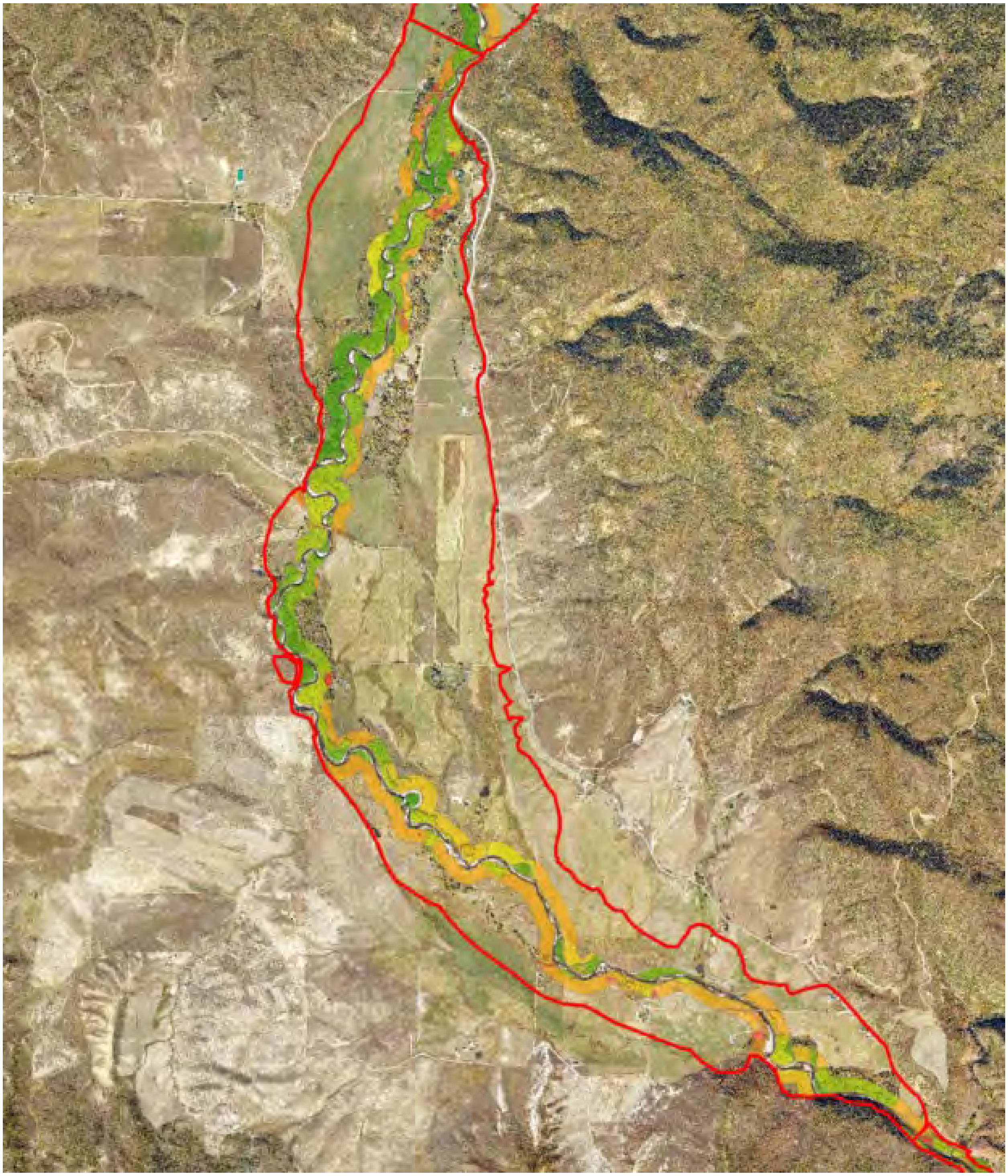


Figure A-5. Riverscape 11 Riparian Condition Mapping

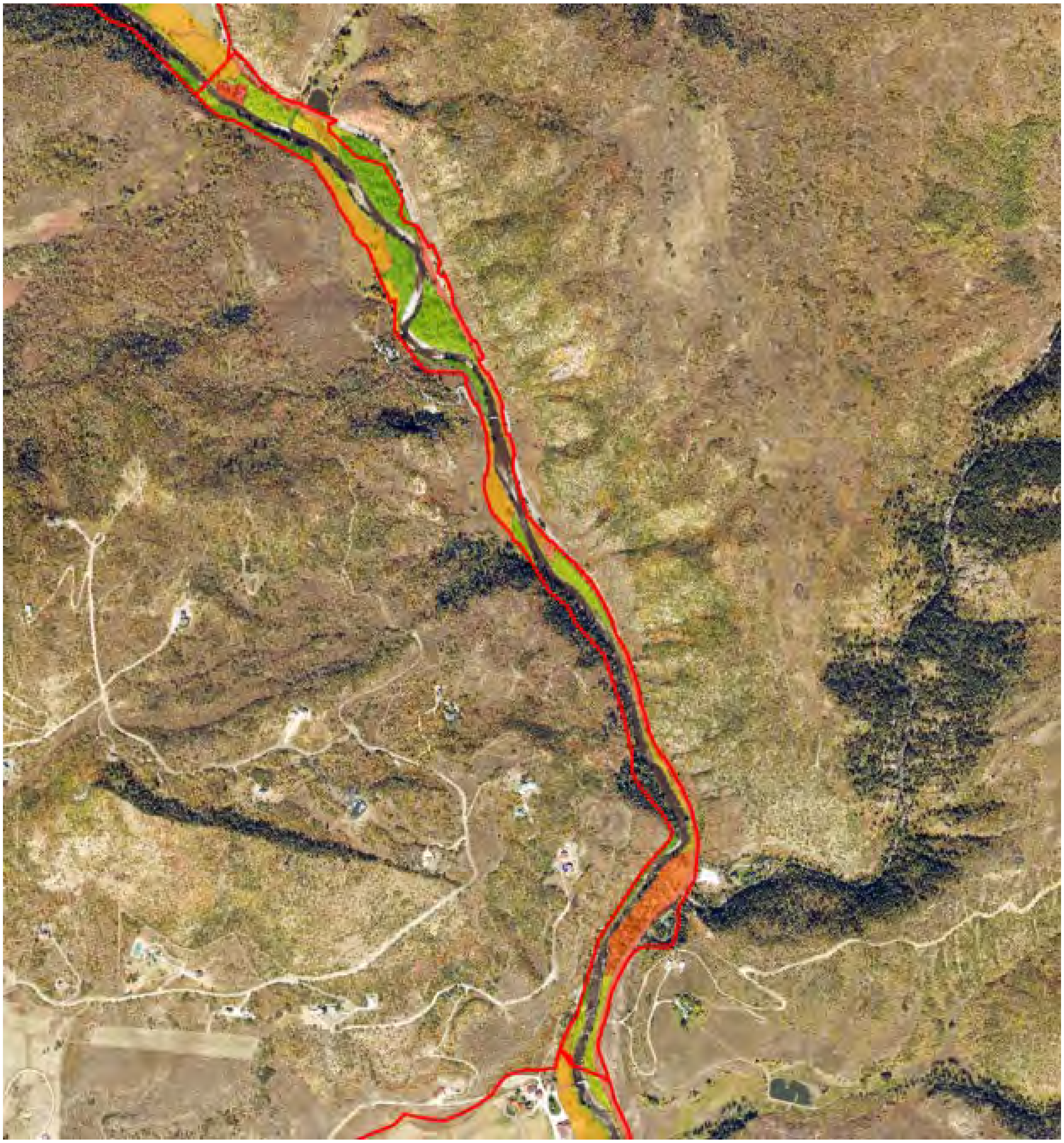


Figure A-6. Riverscape 12 Riparian Condition Mapping

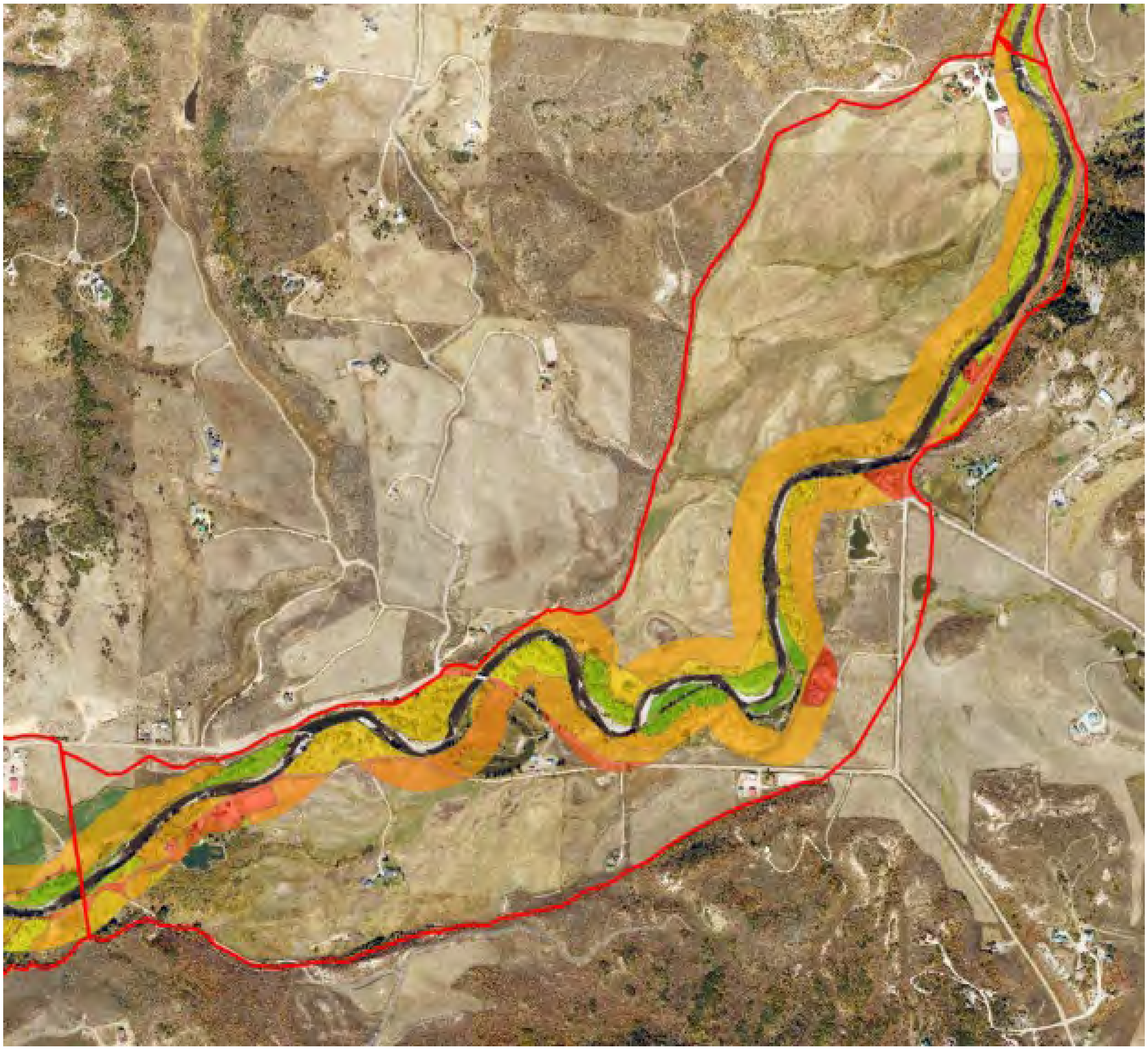


Figure A-7. Riverscape 13 Riparian Condition Mapping