Lower Sage Creek

Watershed Assessment

HUC 100800140105

Prepared by the Wyoming Association of Conservation Districts, Cody Conservation District and Natural Resources Conservation Service

March 2023

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Executive Summary

The National Water Quality Initiative (NWQI) was developed to apply watershed protection and restoration "lessons learned" over the past 40 years to improve the quality of America's rural lakes, rivers, streams, wetlands, and coastal waters. Watershed assessments, planning, and implementation of conservation practices are at the heart of the NWQI, with particular focus on increasing voluntary adoption of the right conservation practices and systems, in the right position on the landscape, in the right amount, with the right timing and sequence of implementation. (NRCS, May 2021)

This watershed assessment was completed for the Lower Sage Creek Watershed located in Park County, Wyoming within the larger Shoshone Watershed. This watershed assessment identifies non-point source contributors of sediment and addresses "critical source areas" in the Lower Sage Creek watershed that have the greatest potential for sediment contributions to the Shoshone River. Sedimentation within the Shoshone River is problematic for aquatic species and habitat, irrigation infrastructure and recreation opportunities. This assessment also provides an outreach strategy and conservation management practices that can be implemented to reduce those contributions.

For more information on this process please contact the authors of the report or the Cody Conservation District.

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I. Background and Purpose

Through a collaborative effort between the Cody Conservation District (CCD), Wyoming Natural Resource Conservation Service (NRCS), Wyoming Department of Environmental Quality (WDEQ), Wyoming Association of Conservation Districts (WACD) and NRCS State Technical Advisory Committee members, the Lower Sage Creek Watershed was selected for inclusion in NRCS's FY 2021 National Water Quality Initiative (NWQI) as a Readiness Phase Watershed.

The Lower Sage Creek Watershed was initially chosen by the CCD, NRCS, and Willwood Workgroup 3 (a watershed stakeholder group), based on suggestions and recommendations outlined in the Sediment Watershed Plan for the Shoshone River from Buffalo Bill Reservoir to Willwood Dam. This area is a priority watershed due to its sediment contributions to the Shoshone River. In 2016, the Willwood Irrigation District (WID) conducted scheduled and required maintenance on the penstock and canal gates on Willwood Dam on the Shoshone River downstream of the Lower Sage Creek watershed. When the water levels were lowered for the repairs, 96,000 cubic yards or 6,857 dump truck loads of very fine sand and silt were released downstream of the dam. In response, the WDEQ initiated three work groups operating under the leadership and direction of an Executive Committee. The task assigned to Willwood Workgroup 3, was to evaluate potential sediment runoff sources in upstream watersheds of the Willwood Dam, and where practical, reduce the volume of sediment accumulating at Willwood Dam through implementation of voluntary best management practices (BMPs), designed to reduce the introduction of sediment into the Shoshone River above Willwood Dam. Willwood Workgroup 3, now known as the Shoshone River Partners (SRP), is made up of representatives from WDEQ, WID, NRCS, CCD, Powell Clarks Fork Conservation District, WACD, Trout Unlimited, Wyoming Game and Fish Department, The Nature Conservancy, University of Wyoming Extension Office, Bureau of Land Management, and landowners.

In 2019, The Sediment Watershed Plan for the Shoshone River from Buffalo Bill Reservoir to Willwood Dam and the Working Together to Protect the Shoshone River: A Watershed Plan to Reduce Sediment Loading to the Shoshone River Upstream of Willwood Dam, Wyoming were written by members of the SRP. These documents, written in a Story Map format, address potential sediment contributors upstream of the Willwood Dam.

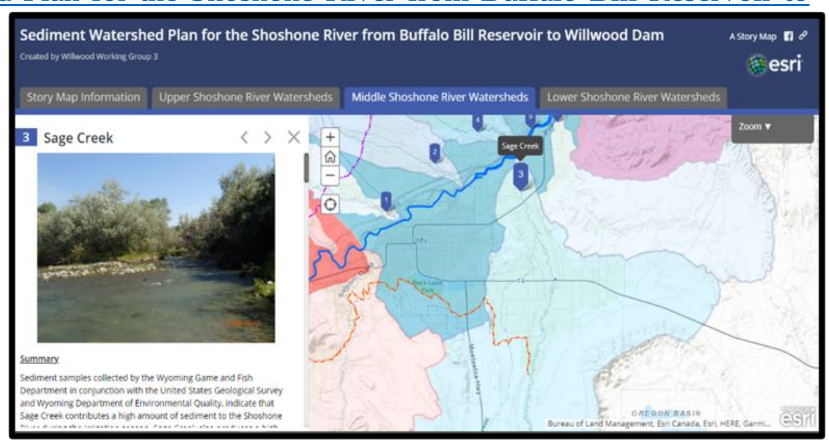


Figure 1: Sediment Watershed Plan for the Shoshone River, Story Map

Preliminary sampling and data analysis indicate Sage Creek is a large contributor of sediment to the Shoshone River, with the Lower Sage Creek watershed contributing relatively more than the Upper Sage Creek watershed due to land use types and practices.

The CCD proposes to work with the NRCS and SRP to prioritize areas for implementation within the watershed that will result in reduced sediment contributions to the Shoshone River, as well as help landowners and other entities implement projects they might not otherwise conduct.

Overview and Location of Watershed

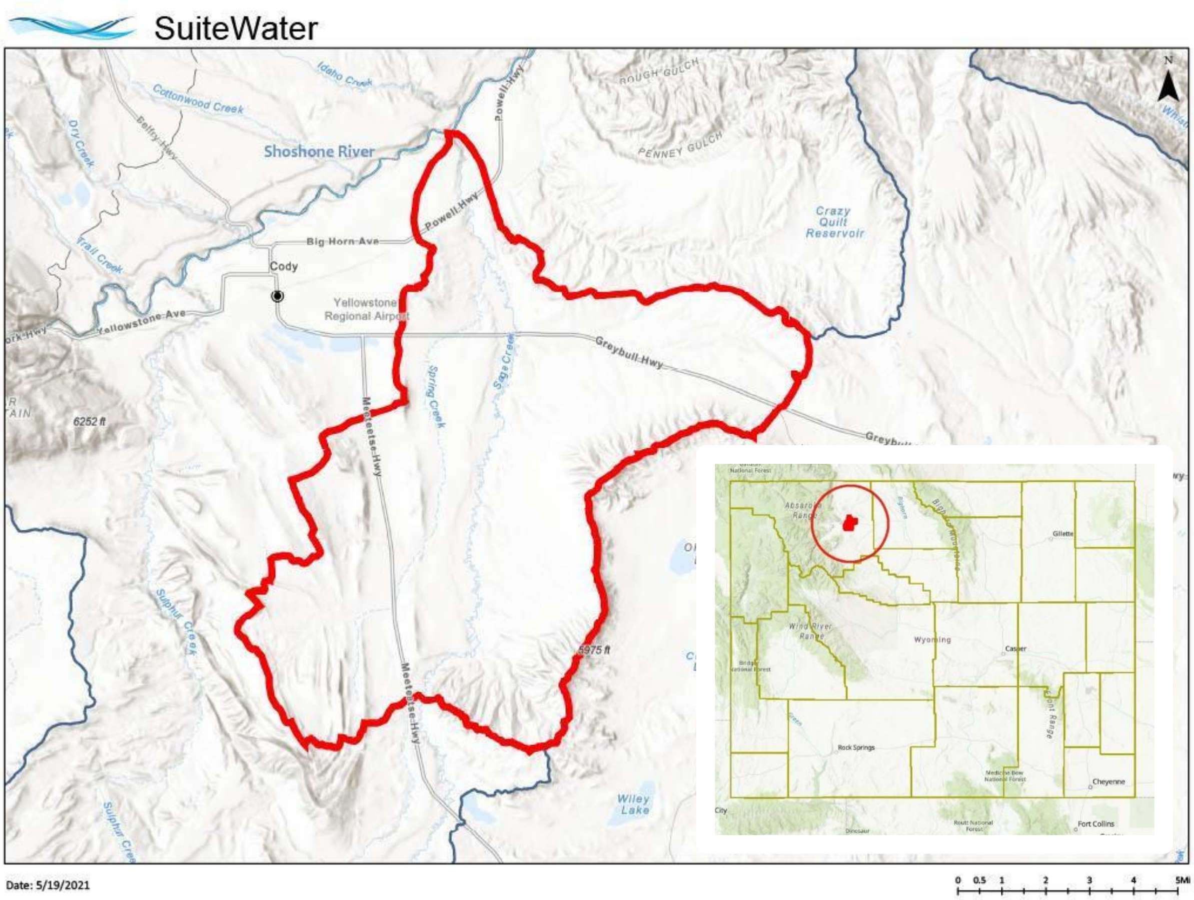


Figure 2: Lower Sage Creek Watershed

The Lower Sage Creek Watershed (HUC 100800140105) is located in eastern Park County, Wyoming. The town of Cody (population 10,028) borders the watershed to the west and northwest with some rural subdivisions encompassed within the northern portion of the watershed. The population of the Lower Sage Creek watershed is 956 (SuiteWater, 2021). It encompasses 26,993 acres.

The Lower Sage Creek Watershed contains native sagebrush and grasslands, annual and perennial crop production, and small acreage landowners. Sage Creek confluences with the Shoshone River in the northern portion of the watershed and represents the largest drainage in the watershed which flows from south to north. Spring Creek is the only perennial tributary within the Lower Sage Creek Watershed. This watershed receives irrigation conveyance water and irrigation return flows from the Cody Canal. The sub-watershed also receives water from stormwater runoff from the City of Cody. (Figure 2).

Water Quality Resource and Constituents Concerns

Sage Creek and the Shoshone River are both classified as 2AB within the WDEQ's Water Quality Rules, Chapter 1, Wyoming Surface Water Quality Standards, and are designated for drinking water, cold water fish, nongame fish, aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic value uses. The Water Quality Division may issue a permit or certification for new or increased discharges to these waters upon making a finding that the amount of resultant degradation is insignificant or that the discharge is necessary to accommodate important economic or social development in the area where the waters are located.

Table 1: WDEQ Surface Water Classes and Use Designations

	Drinking water	Cold water game fish	Warm water game fish	Nongame fish	Fish consumption	Aquatic life other than fish	Recreation[2]	Wildlife	Agriculture	Industry	Scenic value
1	*Yes*[1]	*Yes*[1]	*Yes*[1]	*Yes*[1]	*Yes*[1]	*Yes*	Yes	Yes	Yes	Yes	Yes
2AB	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2A	Yes	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
2B	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2C	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2D	No	If present	If present	If present	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3A	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3B	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3C	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3D	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
4A	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4B	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4C	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes

The Shoshone River is classified by the Wyoming Game and Fish Department as a blue-ribbon trout fishery, as it historically supported a biomass of more than 600 pounds of trout per mile. The Shoshone River sustains naturally reproducing populations of brown trout and mountain whitefish. Rainbow trout and cutthroat trout are regularly stocked. The fishery is important due to the heavy use of the river by anglers.

The Wyoming Surface Water Quality Standards limit turbidity increases from anthropogenic activities in waters designated for cold water game fish and drinking water to less than 10 nephelometric turbidity units (NTU). The standards, Water Quality Rules, Chapter 1, Section 15, also include narrative criteria for settleable solids that limit anthropogenic activities from discharging substances that will settle to form sludge, bank or bottom deposits that result in significant aesthetic degradation, significant degradation of habitat for aquatic life, or adversely affect public water supplies, agricultural or industrial water use, plant life or wildlife.

The standards, Water Quality Rules, Chapter 1, Section 16, also include narrative criteria that limit anthropogenic activities from discharging substances that will result in floating and suspended solids that will result in significant aesthetic degradation, significant degradation of habitat for aquatic life, or adversely affect public water supplies, agricultural or industrial water use, plant life or wildlife.

The primary water quality resource concern identified for the Lower Sage Creek watershed is water quality degradation due to sediment. The secondary resource concern is inadequate habitat for fish and wildlife. Sediment is a concern in the watershed and is a result of both highly erodible soils, natural processes, and anthropogenic sources including, but not limited to bank sloughing from fluctuations in stream flow conditions (stormwater runoff, permitted industrial discharges, and irrigation practices), grazing and pasture management, failing or improperly sized culverts for stream crossings, and stream channel modification. Additional sediments originating from the South Fork Shoshone River that are conveyed in irrigation return flows also contribute to excessive sediment concentrations in the lower Sage Creek Watershed, and subsequently the Shoshone River.

There currently are not any 303(d) listed waters in this watershed, however these resource concerns have been identified due to the degradation listed above and monitoring results over the past several years. In 2017, 2018, and 2020 to 2022, the Wyoming Game and Fish Department (WGFD), in cooperation is the United States Geological Survey (USGS), WDEQ, and the Powell Clarks Fork and Cody Conservation Districts, collected flow, suspended sediment concentration, and bedload data on Sage Creek (at the confluence, above Spring Creek, and above Cody Canal). Sampling results, which are further outlined in section III, *Available Water Quality Data and Resources*, indicate that Sage Creek contributes a high amount of sediment and produces a high volume of water visible plume of turbid water to the Shoshone River during the irrigation season.

Opportunities to Improve Water Quality

Various efforts have taken and continue to take place to try and improve the water quality within the Lower Sage Creek Watershed and surrounding area.

Prior Studies, Plans and Projects

The Powell Clarks Forks Conservation District and Cody Conservation District initiated the 2008 *Shoshone River Watershed Water Quality Management Plan* (revised 2012) to address water quality issues in the Shoshone Watershed. An implementation plan was developed to address resource concerns and various management practices have been implemented since 2008 in the larger Shoshone watershed with landowners and partners (PCFCD, et al., 2012).

Shortly after this plan was completed, the *Shoshone River TMDL* was developed in 2013 to address *E.coli* impairments within the overall Shoshone River Watershed. Similar to the Water Quality Management Plan, a Restoration Strategy was developed to address resource concerns and aid in project development. Although the TMDL addressed *E.coli* impairments, some project recommendations outlined in the implementation plan would also aid in reducing sediment loading. These practices include, but are not limited to improving irrigation efficiency, grazing management practices, increasing upland watering sources for livestock, and riparian enhancement practices. This plan has been used as a guide and reference by the Powell Clarks Fork Conservation Districts and Cody Conservation District in practice implementation and water quality monitoring.

Aqua Engineering, Inc. was selected by the Wyoming Water Development Commission to conduct a *Level II Rehabilitation and Hydropower Study* for the Cody Canal Irrigation District, completed in 2006. This project focused on existing system inventory and problem identification of irrigation structures (Aqua Engineering, 2006). This led to the *Cody Canal Irrigation District Rehabilitation and GIS Level II Study* completed in 2009, and a *Cody Canal Laterals Level II Study* completed in 2018. All of these plans address how to improve existing irrigation infrastructure which in turn reduce erosion, seepage, and sedimentation. These studies can be found on the Wyoming Water Development Commission's website: http://library.wrds.uwyo.edu/wwdcrept/wwdcrept.html.

Recent Studies, Plans and Projects

As indicated in the background section, this effort to address sediment contributions from the Lower Sage Creek watershed was initiated as part of the Willwood Workgroup 3 Steering Committee planning efforts as outlined in the Sediment Watershed Plan for the Shoshone River from Buffalo Bill Reservoir to Willwood Dam. Based off water quality and on-the ground monitoring results, the working group identified the Lower Sage Creek Watershed as a targeted watershed based on the sediment loading it contributes to the Shoshone River. The long-term objective is to reduce the volume of sediment that accumulates at Willwood Dam through implementation of voluntary, best management practices (BMPs) designed to reduce the introduction of sediment into the Shoshone River above Willwood Dam.

Assessment of NRCS Role in Meeting Water Quality Goals

The NRCS field office staff in Powell, Wyoming has the capacity and resources to provide effective and timely technical assistance to landowners within the NWQI watershed. The NRCS staff includes the following: District Conservationist, a Soil Conservationist, and a Soil Conservation Technician. The NRCS Powell Office will have an Engineer on staff in 2023 once the hiring process is completed. In addition, the field office staff can request assistance from State Office and Area Office technical specialists. Technical assistance will include outreach, conservation planning, design, layout, construction check of practices, and practice evaluation.

The Cody Conservation District (CCD) will continue to assist with outreach and promotion of NWQI efforts in addition to providing administrative and planning support through the MOU with NRCS. The CCD will also lead monitoring efforts to evaluate pollutant load reductions achieved by addressing resource concerns.

II. Watershed Characterization

Location of watershed within the drainage network

The Lower Sage Creek Watershed lies within the Shoshone Watershed (10080014) and the Bighorn Watershed (100800). The majority of both watersheds encompass areas in Wyoming with some overlap into Montana. The Shoshone River is a perennial river in northwestern Wyoming that originates at the confluence of the North Fork Shoshone and South Fork Shoshone Rivers at the Buffalo Bill Reservoir. It provides recreation and irrigation to the Big Horn Basin. The headwaters of the North Fork Shoshone and South Fork Shoshone originate in the Absaroka Range in the Shoshone National Forest and flow east and northeast respectively to the Buffalo Bill Reservoir. The Shoshone River flows north easterly through the Big Horn basin in northwestern Wyoming until it confluences with the Big Horn River east of Lovell, Wyoming at Bighorn Lake (PCFCD, Watershed Plan 2012).

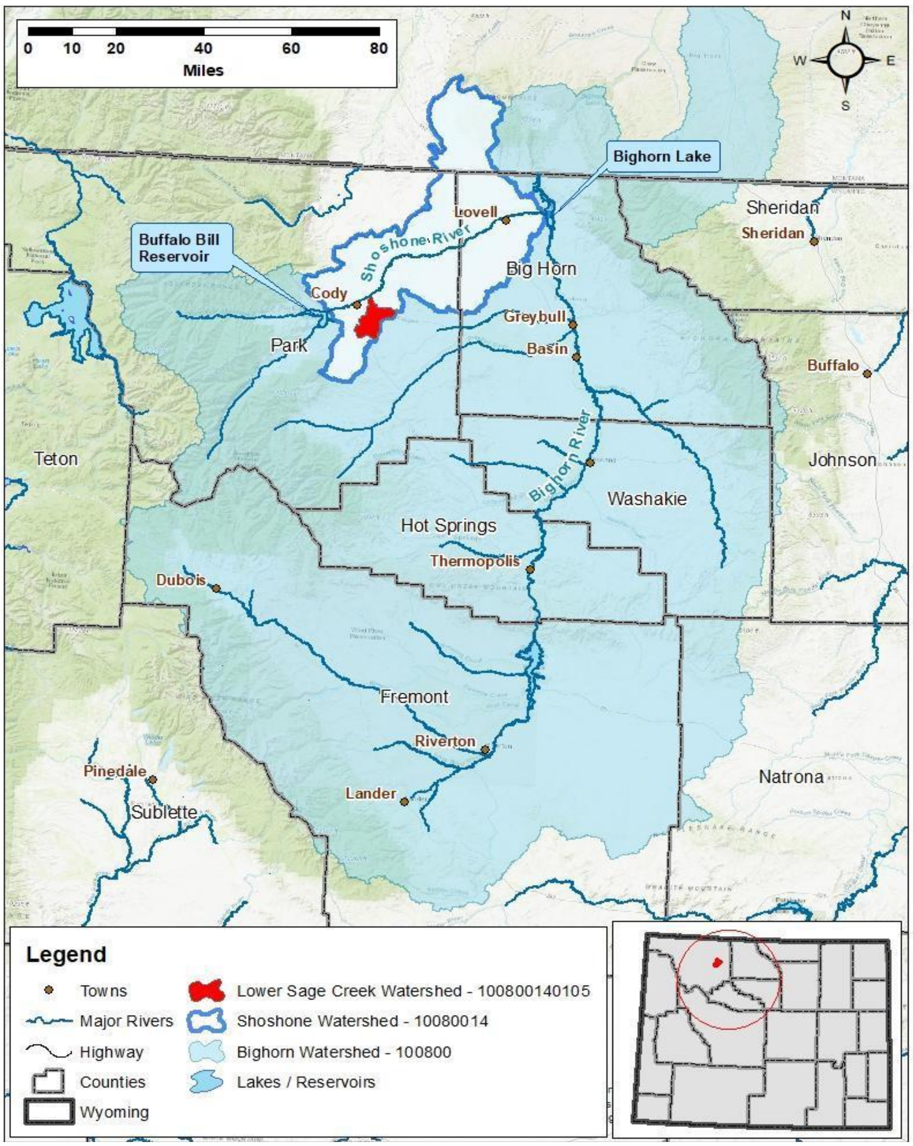


Figure 3: Location of the Lower Sage Creek watershed in drainage network.

Landscape Characteristics

The majority of the Lower Sage Creek Watershed occurs in the Northern Intermountain Desertic Basins Major Land Resource Area (MLRA) also known as MLRA 32. It's comprised of about 8,910 square miles (23,080 square kilometers). The northern two-thirds of this MLRA is in the Bighorn Basin and in the Middle Rocky Mountains Province of the Rocky Mountain System. This part of MLRA 32 is an elevated, dissected basin surrounded by mountain ranges to the east, west, and south. In some areas the plains are eroded to the clay shale bedrock, and there are areas of badlands.

Withdrawals of freshwater by irrigation use is 99.8% of surface water but only 6% of the land use is cropland. Most of the land is used for grazing. The rangeland consists of desert shrubs and short grasses. Big sagebrush, Gardner's saltbush, rhizomatous wheatgrasses, Indian ricegrass, and needle and thread are the dominant species. Black sage, Gardner's saltbush, and bluebunch wheatgrass are common on shallow soils in the uplands.

Wildlife species in this area consist of antelope, coyote, jackrabbit and sage grouse.

The major soil resource concerns are water erosion, water quality, rangeland health, and soil quality. Conservation practices on cropland include irrigation water management and installation of water and energy-conserving irrigation systems.

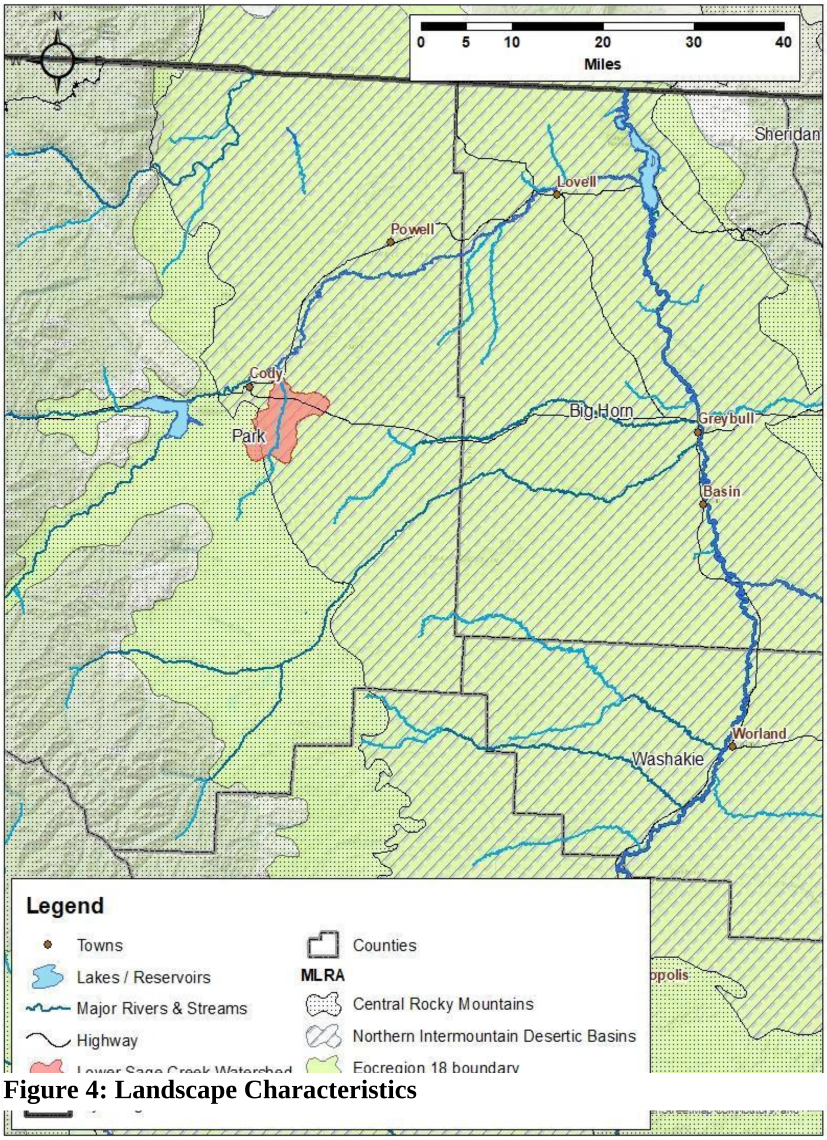


Figure 4: Landscape Characteristics

A small southwestern portion of the watershed occurs in the Central Rocky Mountains MLRA also known as MLRA 43B. This MLRA is made up of the Rocky Mountains and has numerous national forests, including the Shoshone, Bridger and Teton Nationals Forests in Wyoming. It's characterized by rugged, glaciated mountains, thrust- and block-faulted mountains, hills, plateaus and valleys.

Withdrawals of freshwater by irrigation use is 78% surface water and 12.8% groundwater but less than 1% of the MLRA is cropland. The majority of the irrigation occurs on haylands as 65% of the land use is grassland, 31% is Forest, and 3% is water or other. This area supports coniferous forests, alpine grasses, forbs and shrubs and scattered stands of subalpine fir, spruce and whitebark pine occur at high elevations.

Some of the major wildlife species include elk, mule deer, white-talked deer, moose, grizzly bear, black bear, mountain lion, bobcat, lynx, bighorn sheep, mountain goat, coyote, gray wolf, mountain grouse and numerous songbirds. The major soil resource concerns are water erosion, the productivity of the soils and surface compaction. Water resource concerns include degradation of water quality. (https://www.nrcs.usda.gov/resources/data-and-reports/major-land-resource-area-mlra)

The Lower Sage Creek Watershed also occurs within the Wyoming Basin ecoregion (18). This ecoregion is a broad intermontane basin interrupted by hills and low mountains and dominated by arid grasslands and shrublands. Nearly surrounded by forest covered mountains, the region is somewhat drier than the Northwestern Great Plains (43) to the northeast and does not have the extensive cover of pinyon-juniper woodland found in the Colorado Plateaus (20) to the south.

Much of the region is used for livestock grazing, although many areas lack sufficient vegetation to support this activity. The region contains major producing natural gas and petroleum fields. The Wyoming Basin also has extensive coal deposits along with areas of trona, bentonite, clay, and uranium mining (Chapman, et. al, 2004).

Climate

The Cody Muni AP, Western Regional Climate Center Station is the closet weather station to the watershed, which is located on the east side of the town of Cody. It contains recorded monthly climate information from 1951 - 2016.

Table 2: Average monthly climate data at Cody Municipal Airport, WRCC

CODY MUNI AP, WYOMING (481840)

Period of Record Monthly Climate Summary

Period of Record : 01/02/1915 to 06/10/2016

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	35.9	40.0	47.6	56.8	66.1	75.7	85.0	82.8	72.3	60.8	45.9	37.9	58.9
Average Min. Temperature (F)	12.9	16.3	22.9	31.4	40.1	48.1	54.8	52.7	43.6	34.5	23.2	15.7	33.0
Average Total Precipitation (in.)	0.34	0.30	0.53	1.07	1.66	1.62	1.03	0.80	1.01	0.76	0.49	0.31	9.92
Average Total SnowFall (in.)	6.2	5.1	6.5	5.1	0.7	0.0	0.0	0.0	0.4	3.6	5.7	6.0	39.3
Average Snow Depth (in.)	1	1	0	0	0	0	0	0	0	0	0	0	0

Percent of possible observations for period of record.
Max. Temp.: 97.3% Min. Temp.: 97.3% Precipitation: 97.5% Snowfall: 87.3% Snow Depth: 44.8%
Check Station Metadata or Metadata graphics for more detail about data completeness.

Western Regional Climate Center, wrcc@dri.edu

The mean annual temperature for the Lower Sage Creek Watershed is 45° F. The 30-year average max temperature for the majority of the watersheds is 56-59°F and the 30-year average minimum temperature for the majority of the watershed is 32-36°F (SuiteWater, 2023). Temperatures show a wide range between summer and winter and between daily maximums and minimums, due to the high elevation and dry air. This area of Wyoming can also be very windy. Cody's year-round average wind speed is 7.4 mph but can see gusts up to well over 40-50 mph with certain events (Cody Enterprise, 2016).

The mean annual precipitation for the watershed is 9.92 inches. The normal precipitation pattern in this western portion of the Bighorn basin shows peaks in May and June and a secondary spike in September. Average snowfall is around 39.3 inches annually. Wide fluctuations may occur in yearly precipitation and result in more dry years than those with more than normal precipitation.

Growth of native cool-season plants begins about April 1 and continues to about July 1. Cool weather and moisture in September may produce some green up of cool season plants that will continue to late October, pending summer precipitation.

Topography

The average elevation within the watershed is 5,272 ft. with a maximum elevation in the southwestern and southeastern hills at 6,010 ft. and minimum elevation of 4,711 ft. near the confluence with the Shoshone River at the northern point of the watershed.

The average slope of the watershed is 7.1% with a maximum of 72.7% and a minimum of 0% (Model My Watershed). This is a fairly steep watershed, where runoff and erosion can happen rapidly. Late spring snowmelts and summer storms can produce high runoff events due to these steep elevations, soils and geology.

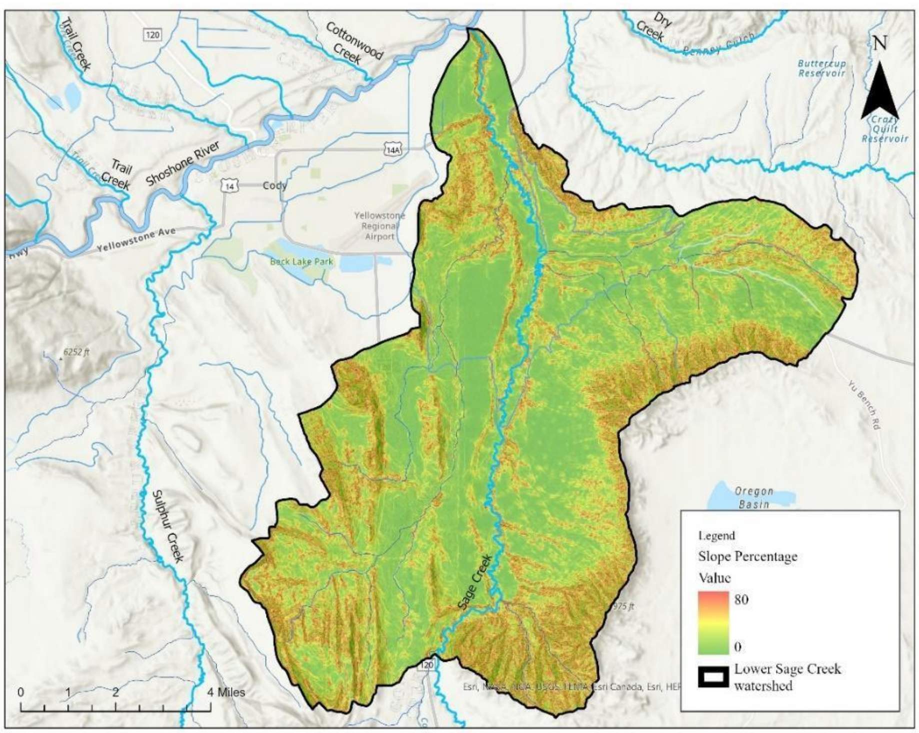


Figure 5: Slope of the Lower Sage Creek Watershed

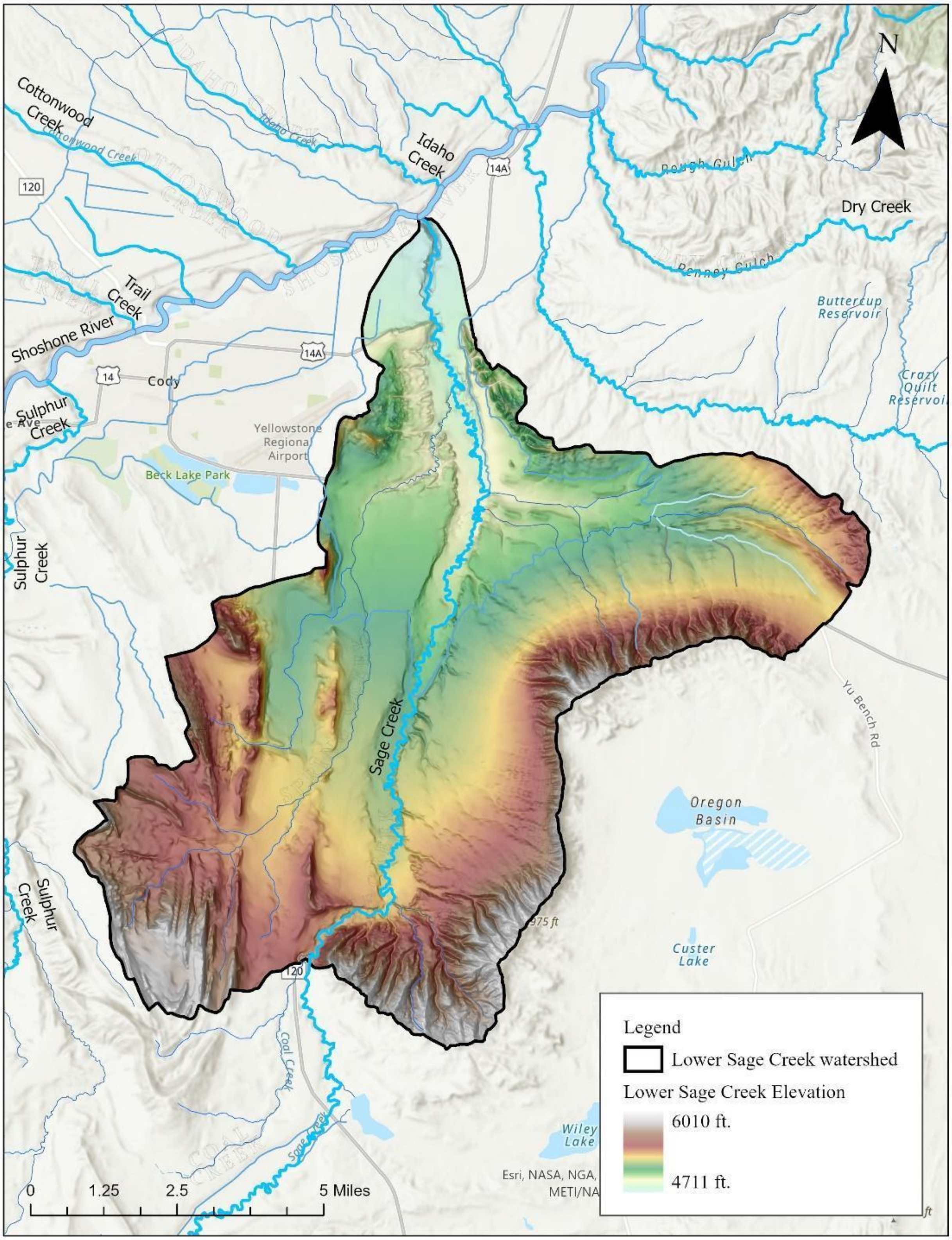


Figure 6: Topography of Lower Sage Creek Watershed

Geology

There are 13 major bedrock geology classifications within the Lower Sage Watershed. The most prominent geologic formation is the **Meeteetse formation (Km)**.

The Meeteetse formation consists of a chalky-white to gray sandstone, yellow, green, and dark-grayish bentonitic claystone, white tuff, and thin coal beds. The formation described by W.G. Pierce, can also form badlands and dinosaur remains are among the fossils that have been recovered from the formation (Pierce. W.G 1941).

The second largest geologic formation, which is dispersed throughout the watershed is the **Mesaverde Formation (N) or the Mesaverde Group (S) (Kmv)** which consist of Light-colored, massive to thin-bedded sandstone, gray sandy shale, and coal beds.

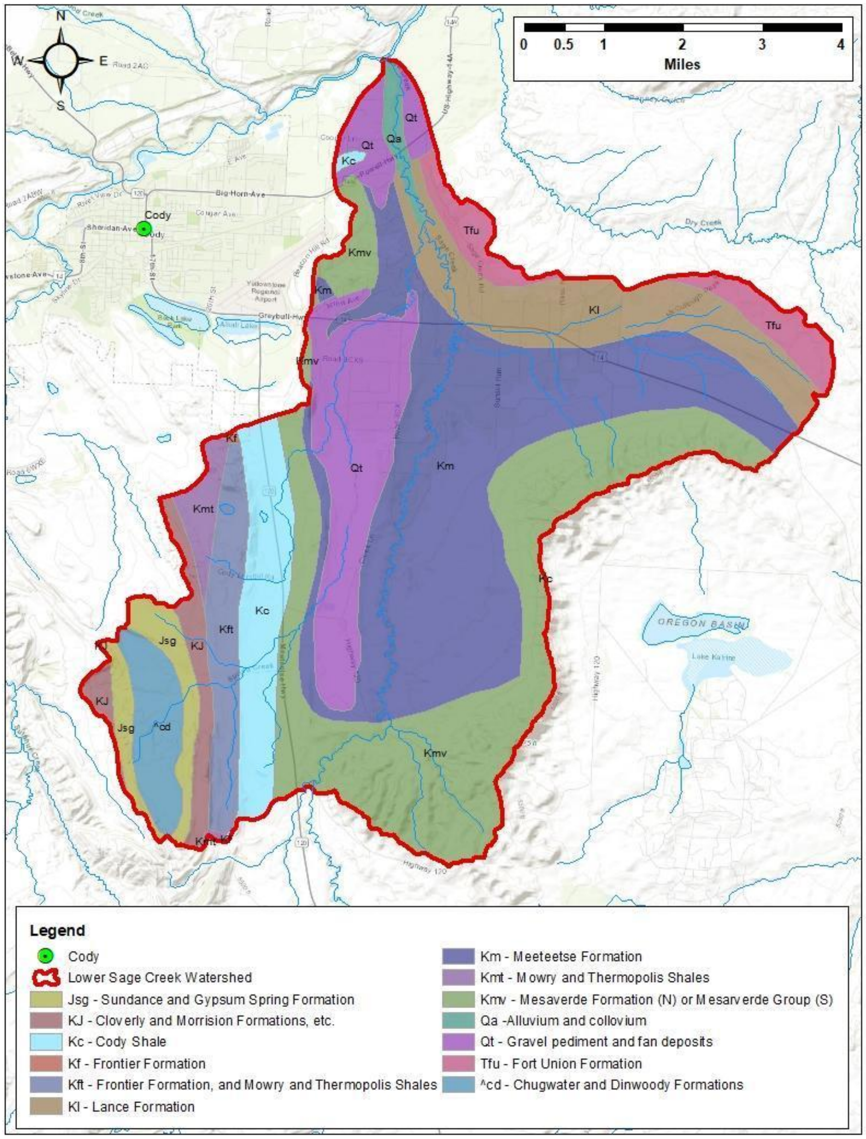


Figure 7: Bedrock Geology of Lower Sage Creek Watershed

Following the Mesaverde Formation is the **Gravel pediment and fan deposits (Qt).** These are mostly locally derived clasts. Also included are some glacial deposits along east flank of Wind River Range and some Tertiary gravels.

The Lance Formation (Kl) is the fourth largest geologic type in the watershed which is comprised of thick-bedded buff sandstone, drab to green shale and thin conglomerate lenses.

The other geological formations in the watershed consist of:

6. Frontier Formation, and Mowry and Thermopolis Shales (Kft) - Frontier Formation- northern Yellowstone area-Yellowish- to medium-gray sandstone, tuffaceous and carbonaceous in lower part; north and south Wyoming-Gray sandstone and sandy shale. The Mowry and Thermopolis Shale date back to the Early Cretaceous.

7. Fort Union Formation (Tfu) - Brown to gray sandstone, gray to black shale, and thin coal beds.

8. Chugwater and Dinwoody Formations (cd) - Chugwater Formation-Red siltstone and shale. Dinwoody Formation-northern Yellowstone area-Olive-drab dolomitic siltstone.

9. Sundance and Gypsum Formation (Jsg) - Sundance Formation-Greenish-gray glauconitic sandstone and shale, underlain by red and gray nonglauconitic sandstone and shale. Gypsum Spring Formation-Interbedded red shale, dolomite, and gypsum.

10. Cloverly and Morrison Formations (N, S) or Cloverly Formation (Hartville uplift), or Inyan Kara Group (Black Hills), and Morrison Formation (NE) (KJ) - Cloverly Formation-north and south Wyoming-Rusty sandstone at top, underlain by brightly variegated bentonitic claystone; chert-pebble conglomerate locally at base.

11. Mowry and Thermopolis Shales (Kmt) – Mowry Shale-(age 94-98 Ma)-Silvery-gray hard siliceous shale containing abundant fish scales and bentonite beds. Thermopolis Shale-Black soft fissile shale; Muddy Sandstone Member.

12. Alluvium and colluvium (Qa) – Clay, silt, sand, and gravel in flood plains, fans, terraces, and slopes.

13. Frontier Formation (Kf) - Thrust belt-White to brown sandstone and dark-gray shale; oyster coquina in upper part; coal and lignite in lower part; north and south Wyoming-gray sandstone and sandy shale (Love, J.Dc, 1985).

A majority of the watershed (23,566 acres) is comprised of sandstone, followed by terrace (3,175 acres) and alluvium (252 acres). The identification of these formations coupled with soil types in the next section were used to identify areas of concern for erosion and runoff.

Soils and Soil Interpretations

Information on soil distribution for the Lower Sage Creek Watershed was derived from the Natural Resources Conservation Service (SSURGO) database and web soil survey (NRCS). Soil types and characteristics can be used to determine management practices and the best location for those management practices.

There are 68 different soil types within the Lower Sage Creek watershed. The ten most dominant soil types within the watershed are listed below in Table 3 which make up over 50% of the watershed, with the Maysdorf-Hiland-like-Vonid complex, 3 to 8 percent slopes, as the most dominant type. Loamy soils (specifically Loamy Calcearous Big Horn Basin Rim) make up the majority of the soil composition in the watershed at 62%, followed by Saline upland and Saline sub-irrigated soils at 10%, Sandy soils at 8%, followed by a mix of Coarse upland, Clays and gravels.

Table 3: Dominant soil types within the Lower Sage Creek Watershed

Map unit symbol	Map unit name	Rating	Acres in Lower Sage Creek Watershed	Percent of Watershed
2220	Maysdorf-Hiland-like-Vonid complex, 3 to 8 percent slopes	Loamy Calcareous Big Horn Basin Rim	2,544.00	9.40%
2301	Hiland-Maysdorf complex, 3 to 12 percent slopes	Loamy (Ly) Big Horn Basin Rim	2,421.90	9.00%
5334	Threetop-like-Taluce-like-Travson-like complex, 8 to 50 percent slopes	Loamy Calcareous Big Horn Basin Rim	1,914.30	7.10%
5467	Worf-Fairview-like-Bowdish-like complex, 8 to 60 percent slopes	Shallow Loamy (SwLy) Big Horn Basin Rim	1,414.40	5.20%
396	Turnback-Turnercrest complex, 5 to 25 percent slopes	Sandy (Sy) Big Horn Basin Rim	1,162.50	4.30%
2132	Ulm-Hiland complex, 0 to 3 percent slopes	Saline Upland Clayey (SUC) Big Horn	1,129.80	4.20%
2101	Eaglenest-Hiland complex, 1 to 3 percent slopes	Loamy Calcareous Big Horn Basin Rim	1,018.00	3.80%
18A	Naturita fine sandy loam, 0 to 3 percent slopes — Draft	Loamy Calcareous Big Horn Basin Rim	1,018.30	3.80%
37A	Forkwood-Lamanga-like complex, 0 to 3 percent slopes — Draft	Loamy (Ly) 5-9" Big Horn Basin Precipitat	1,014.90	3.80%
5335	Alvey-like-Hiland-like-Taluce complex, 2 to 10 percent slopes	Loamy Calcareous Big Horn Basin Rim	993.3	3.70%
				54.30%

Hydrologic Soil Groups

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms (NRCS, 2021). The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slower infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Group C (moderate to high runoff potential) represents the majority of the Hydrologic Soil Group in the Lower Sage Creek Watershed at 40%. Groups A and B (lower runoff potential) represent 31% and Group D (high runoff potential) represents 26%. This demonstrates that the soils in the watershed as a whole are susceptible to moderate to high runoff especially areas with dual hydrologic group definitions.

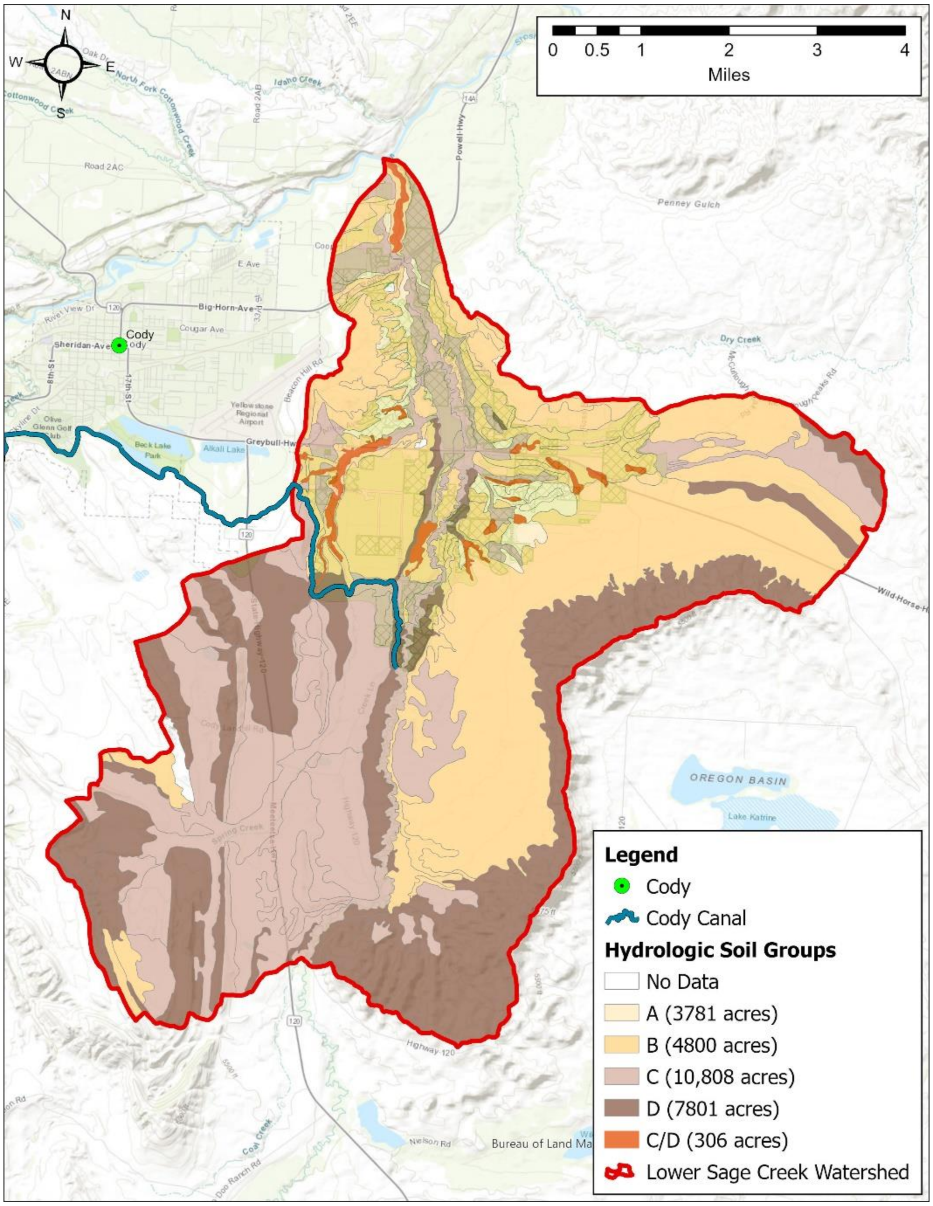


Figure 8: Hydrologic Soil Groups within the Lower Sage Creek Watershed

K Factor

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year (NRCS Web Soil Survey, 2021).

The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from **0.02 to 0.69**. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water (NRCS Web Soil Survey, 2021).

The orange and red areas depicted in the below map represent the most crucial areas in the watershed vulnerable to erosion by water. As evidenced in the K Factor Soils Figure, much of the lower segment of the watershed contains moderate to high K Factor values. This area also corresponds to the more heavily developed portion of the project area and where return flows from the Cody Canal are picked up by Sage Creek.

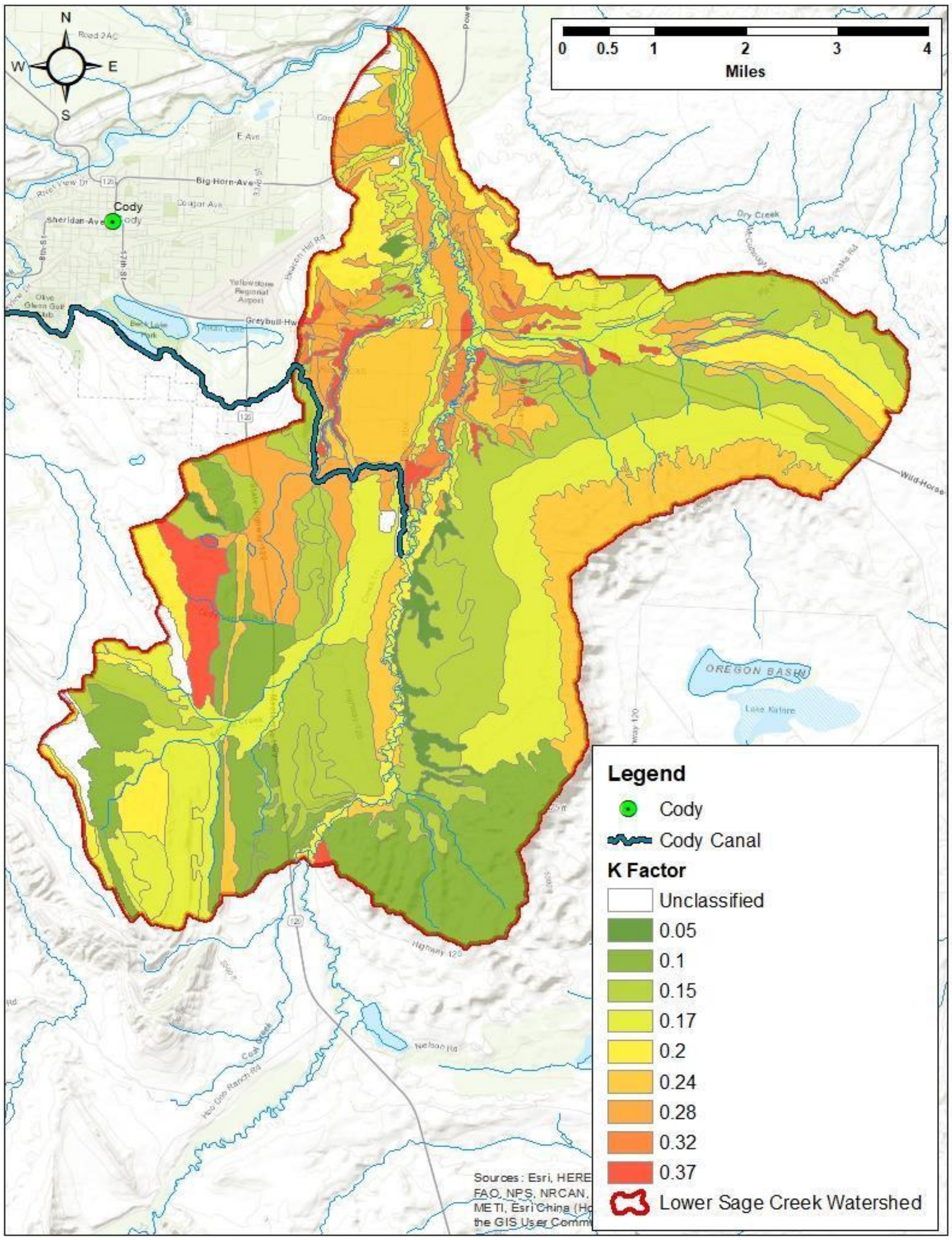


Figure 9: K Factor within the Lower Sage Creek Watershed

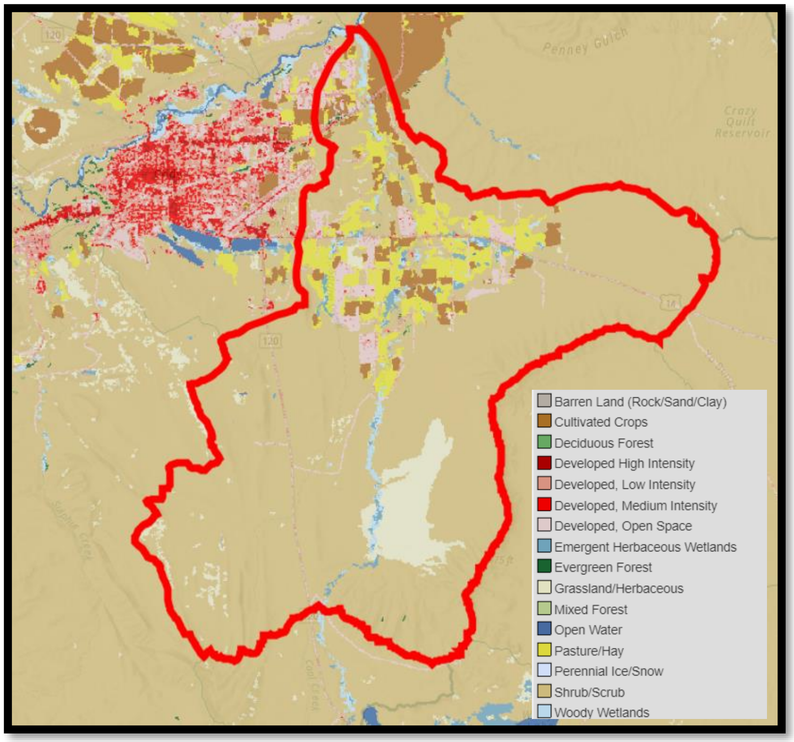


Figure 10: Land Cover within Lower Sage Creek Watershed

Land Cover and Land Use

The primary land cover in the Lower Sage Creek Watershed is Shrub / Scrub (76%), followed by Pasture Hay (alfalfa), Cultivated Crops (10%), and Grassland / Herbaceous (5%). Five percent of the watershed is developed, primarily in the form of subdivisions or small ranchettes. The remaining land cover is made of water, forests and barren lands (Figure 10).

The primary land use within the Lower Sage Creek watershed is irrigated crop and pasture lands although it only makes up 16% of the land area (WWDO via SuiteWater, 2022). Other land uses include, livestock grazing, small acreage subdivisions, the City of Cody landfill, and a gravel mine (Figure 10).

Irrigation occurs on a total of 4,472 acres in the watershed fed by the Cody Canal, the Ross Lateral and other various laterals and small ditch systems which are described in detail in the next section. (Figure 11).

Several BLM grazing allotments occur in the watershed with cattle grazing predominantly occurring on those allotments 9 – 12 months out of the year.

The primary cultivated crops within the watershed consist of Alfalfa (910 acres), Grassland/ pasture (729 acres), Other hay/non alfalfa (770 acres), Barley (120 acres), followed by a small percentage of Sugarbeets, Sod / Grass seed, Corn, Dry Beans and Winter Wheat (Figure 12, 2016 NASS data generated by SuiteWater, 2022).

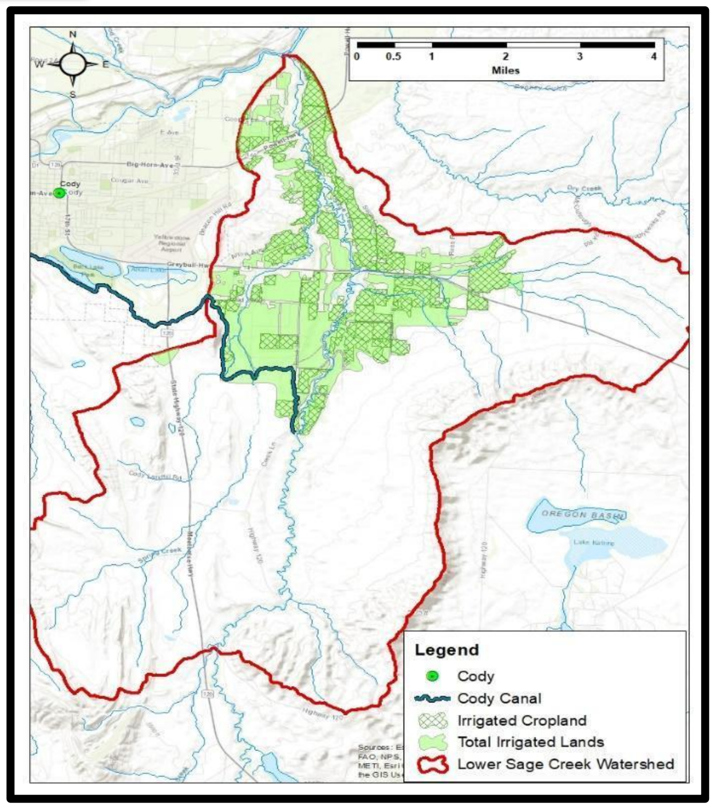


Figure 11: Irrigated Lands in Lower Sage Creek Watershed

Socioeconomic Conditions

The majority of the Lower Sage Creek sub-watershed is managed by the Bureau of Land Management at 59%. The second largest land ownership is private ownership at 37%. The State of Wyoming manages the remaining 4% of the land in the watershed (Figure 13). The watershed lies in the larger Park County where the population per square mile is 4.1 persons per square mile. In 2019 the population estimate for Park County was 29,194. In 2010 it was 28,207, a growth of 3.5% in 9-10 years.

The median income in Park County is $63,582 (2019) which is slightly higher than the median household income in Wyoming (2015-2019) at $62,843[1]. With a healthy median income, closeness to Yellowstone National Park and mountainous terrain, Park County is a sought-after destination to relocate especially for those looking for a more rural, open setting. This is apparent by Park County's 3.5% growth between 2015-2019 where more subdivisions and rural ranchettes are being developed, specifically within the watershed. As mentioned in the previous section, 5% of the land use within the watershed is developed in the form of subdivisions and small ranchettes. Multiple subdivisions and these small acreages are dispersed throughout the north and northwestern portion of the watershed adjacent to the growing town of Cody. The population as of 2010 for the watershed was 956. Most of the residents within the watershed are on private septic systems,

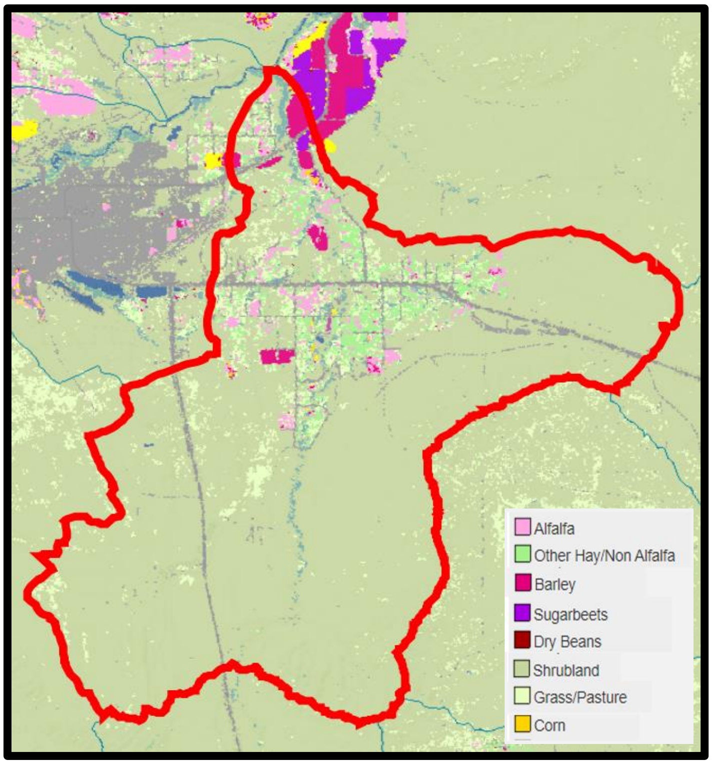


Figure 13: Crops within the Lower Sage Creek Watershed

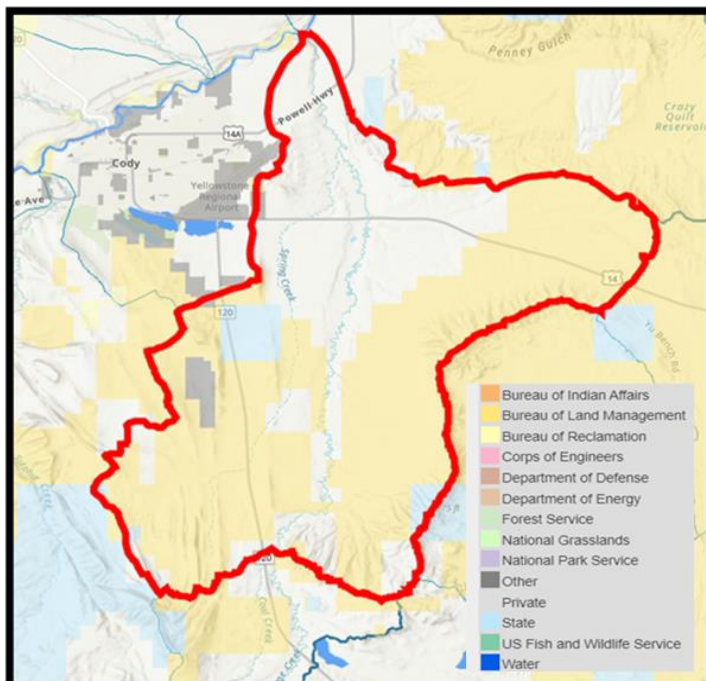


Figure 12: Land ownership in the Lower Sage Creek Watershed

[1] Population and income information was queried from the US Census Bureau's QuickFacts website (www.census.gov/quickfacts/parkcountywyoming).

depicted as green dots in Figure 14. Local soil characteristics and the density of septic systems could be a source of nitrogen loading to Sage Creek via subsurface hydrology.

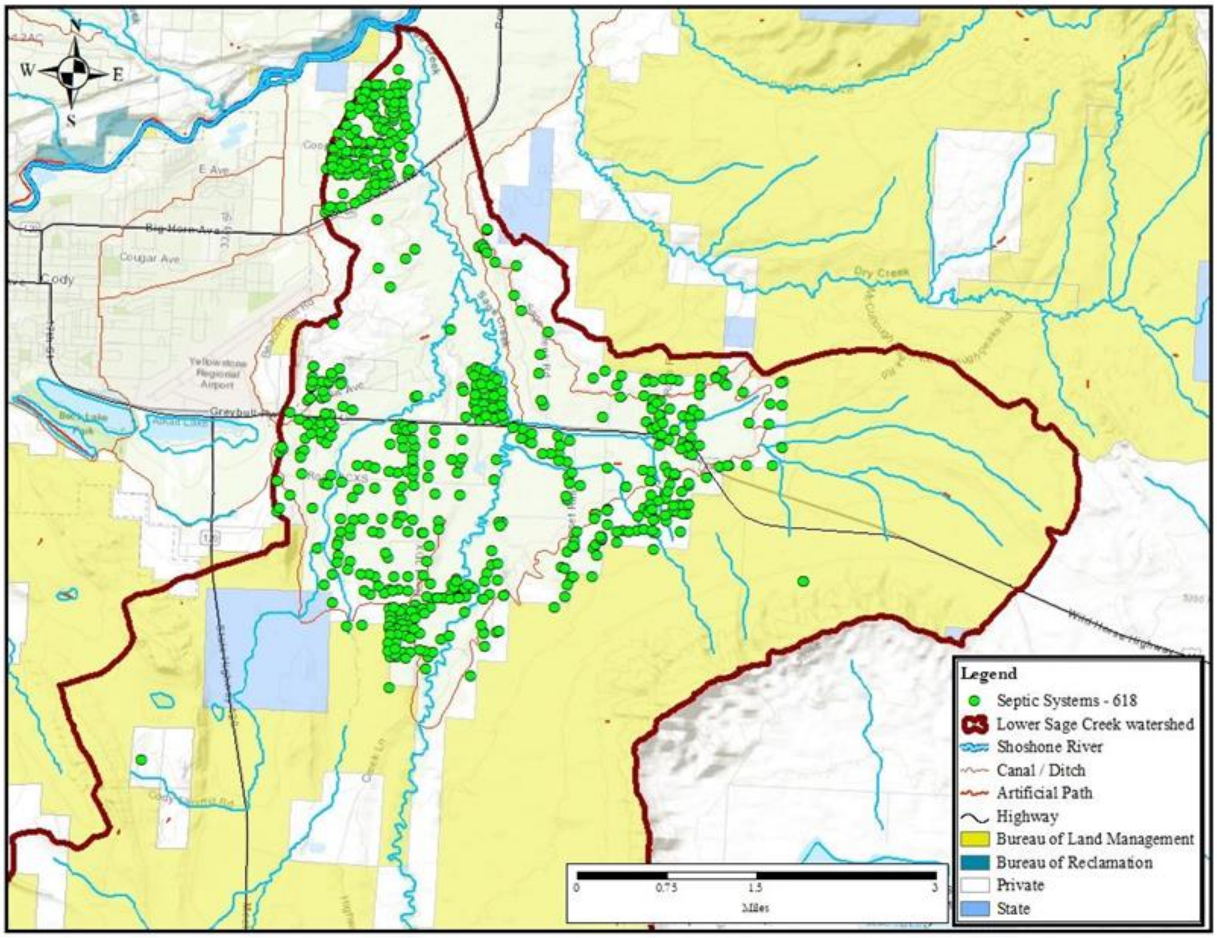


Figure 14: Septic System Locations within the Lower Sage Creek Watershed

Planning in Park County

The Park County Planning and Zoning Department is responsible for the administration and enforcement of the County's Development Standards and Regulations. The Department processes Building and Zoning Permits, Small Wastewater System Permits, Flood Development Permits, Subdivision permits as listed in the section above, and Special Use Permits. To help with planning efforts and priorities in the county (and as per state law in 1975), the Board of County Commissioners have adopted two County Land Use Plans since 1975. A revision was completed in 1998 and is still in use today. However, as of September 2021 the Board of County Commissioners released a Request for Proposals to update the 1998 Land Use Plan.

There are 12 planning areas in Park County. In 1996, the Planning and Zoning Commission developed Comprehensive Policy Statements for 11 of the 12 planning areas. One of those 12 areas is the Sage Creek Area Comprehensive Policy Statement.

Also in September of 2021 the Board of County Commissioners adopted the Park County, Wyoming Natural Resource Management Plan for State and Federal Lands. A Natural Resource

Management Plan (NRMP) is a form of land use planning that serves as the basis for communicating and coordinating with the federal and state government entities and their agencies on land and natural resource management issues that influence the local area and economy (Park County Planning and Zoning Department, 2021).

III. Hydrologic and Water Quality Characterization

Sage Creek and Tributaries

Sage Creek originates just north of Meeteetse Rim and northeast of Carter Mountain in the Absaroka Mountain Range. It flows northeast where it meets several tributaries including in downstream order, South Fork Sage Creek, Horner Creek, Ashworth Creek, and Hoodoo Creek all within the Upper Sage Creek watershed. Sage Creek then continues to flow northeast where it confluences with Spring Creek and then with the Shoshone River both in the Lower Sage Creek watershed (Figure 15).

The watershed is approximately 25 miles long from its headwaters to its confluence with the Shoshone River near Cody, the lower seven miles of which are impacted by operation of the Cody Canal. The upper 17 miles are sporadically developed for irrigation where the terrain has permitted ditch construction and is level enough for cultivation.

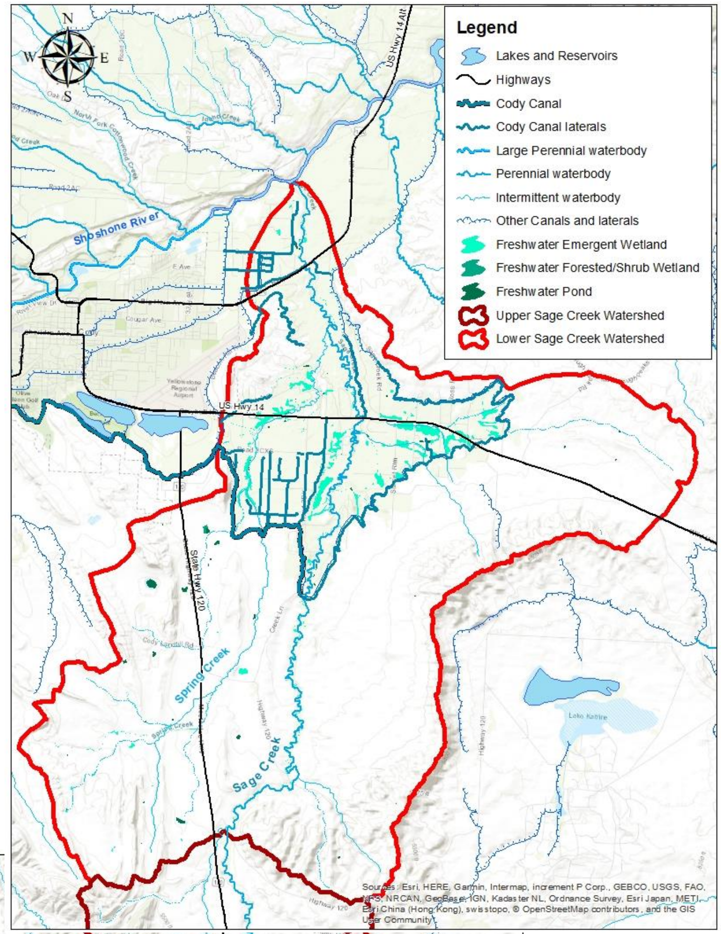
Lakes and Reservoirs

A number of reservoirs have been developed to enhance the water supply of the Sage Creek drainage. The furthest upstream of these (Foster No. 1 Reservoir) is the actual beginning of the South Fork Sage Creek drainage. This unique reservoir sits astride the geographic divide between the Meeteetse Creek drainage and South Sage Creek. In that location, it is constructed to be able to deliver water to either drainage through outlet gates at each end of the reservoir for irrigated lands along either stream. It is built to store 573-acre feet of water. In addition to what it stores on-channel, a supply ditch from the Meeteetse Creek drainage can supply water to the reservoir.

Another sizable reservoir is the Upper Sage Creek watershed is the Coe Enlargement Reservoir, located about 3.5 miles downstream from Foster No. 1. This facility was built in the 1890's as the Perkins and Kinney Reservoir and holds around 750-acre feet of water primarily as a secondary supply for the Edgar Ditch that serves approximately 676 acres of land along the South Fork Sage Creek.

The largest irrigation /reservoir development on Sage Creek is officially appropriated under the names of the Sage Creek Canal, Sage Creek Reservoir, and Wiley Reservoir. Wiley Reservoir has been locally known at various times by the names of Quick Reservoir, Nielson Reservoir, Deseret Reservoir, and most recently, Monster Reservoir. This development, located off channel of Sage Creek, was initiated in 1901 with construction of the Sage Creek Canal taking water out of Sage Creek for irrigation of 996 acres and / or alternately storing it in Sage Creek Reservoir which was built to hold 440-acre feet of water. In 1912, the additional Wiley Reservoir was built to hold 689-acre feet of Sage Creek water diverted also through the Sage Creek Canal. Through the years, both the irrigated land total and the reservoir storage in this complex were increased to where the present-day demand on Sage Creek at this development site is 1,550 acres of irrigated land and almost 4,000 acre feet of reservoir storage. Numerous other small reservoirs are located throughout the Upper and Lower Sage Creek watersheds and are used for irrigating small parcels of land and watering livestock. All together they approximately store a total of less than 50-acre feet (Tabulation of Adjudicated Water Rights, Water Division III, State Board of Control, 1999)

There are various wetlands throughout the drainage, however, they only make up about 3% of the total land area, the majority of which lie north of the Cody canal within the irrigated portion of the watershed (Figure 15, USFWS, 2019).



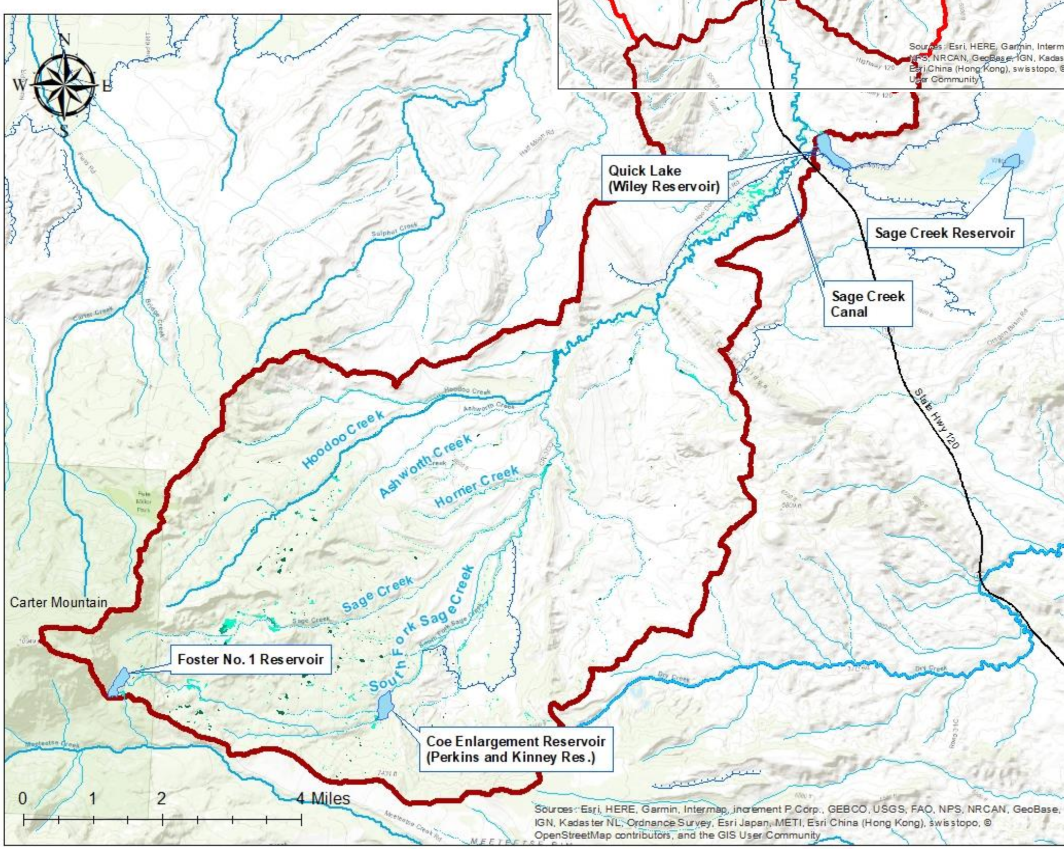


Figure 15: Location of the Upper and Lower Sage Creek watersheds and the Drainage network.

Available Water Quality Data and Resources

Flow monitoring in the Sage Creek watershed.

There currently are no permanent stream gaging stations in the watershed, however discharge measurements within the Upper and Lower Sage Creek watersheds have been obtained in the past by various entities. In the early 2000's discharge measurements were modeled from existing data as part of the Wind/Bighorn River Basin plan which is described in detail in the next section (BRS, 2003), released in 2003 and updated in 2010. Average monthly stream flows (in Acre Feet) were calculated at three separate nodes (over the course of almost 30 years (1971-2003) on surface waters within the Upper and Lower Sage Creek watersheds (Table 4). In 2003, the measurements were calculated for wet, normal, and dry years; whereas the 2010 report only reported normal but reflect the wet discharge averages reported in the 2003 report.

Table 4: Average annual Streamflow from Wind / Bighorn River Basin 2003 & 2010 Reports for Sage Creek, Ashworth Creek, and South Fork Sage Creek.

	2003 Results					2010 Results		
Name (Node)	Wet	Normal	Dry	Ave. Ac. / Ft.	**Ave. CFS**	Normal	Av. Ac./ Ft.	**Ave. CFS**
Ashworth Creek Natural Flow	53.75	24.25	10.6	29.53	**14.76**	53.75	53.75	**26.87**
Sage Creek Natural Flow	344.25	163.66	74.91	194.27	**97.13**	344.25	344.25	**172.12**
South Fork Sage Creek Natural Flow	1.3	0.5	0.25	0.68	**0.34**	1.3	1.3	**0.65**

The WGFD, Cody Conservation District, and Powell Clarks Fork Conservation District have conducted discrete monitoring events since 2017 within the Lower Sage Creek watershed. Like the sediment samples, flow measurements reflect a stratified approach taken for observing runoff conditions, in ambient, rain, or snowmelt conditions in both irrigation and non-irrigation seasons. Flow measurements for Sage Creek above the Cody Canal Crossing have varied from 0.2 cfs to 12 cfs, with a median value of 2.2 cfs. Discharge above the confluence with Spring Creek indicate discharge increases from 2 cfs to 55 cfs during irrigation season. Near the terminus of Sage Creek, discharge measurements ranged from 20 cfs to 83 cfs, also with increased flow conditions observed during irrigation season.

Surface and Groundwater Water Quality Sampling Sites

Shoshone Watershed

E.coli and Fecal Coliform sampling conducted by the Cody Conservation District in 2004-2005 and subsequent sampling by the WDEQ resulted in tributaries to the Shoshone River and a segment of the River itself requiring a Total Maximum Daily Loads (TMDL) and Watershed Implementation Plan. Load reduction targets were approved in 2013 to address pathogen concentrations observed in the Shoshone Watershed (Shoshone River TMDL).

In the fall of 2020, the Cody Conservation District resumed water quality monitoring efforts in the Shoshone River Watershed, specifically Dry Gulch (for which TMDLs were developed), and Dry Homesteader Creek. Currently these sites are evaluated for *E. coli* concentrations and sediment loading to the Shoshone River. As CCD's monitoring strategy expands to incorporate drainages targeted for watershed improvement projects, additional *E. coli* monitoring is anticipated to occur.

Lower Sage Creek Watershed

Current water monitoring efforts in the Lower Sage Creek Watershed began in 2017 and have included measuring discharge as previously mentioned, turbidity, conductivity, pH, water temperature, suspended sediment concentrations, and bedload at the three locations depicted in Figure 16. The Wyoming Game and Fish Department, Powell Clarks Fork Conservation District, and Cody Conservation District staff have partnered to conduct sediment sampling.

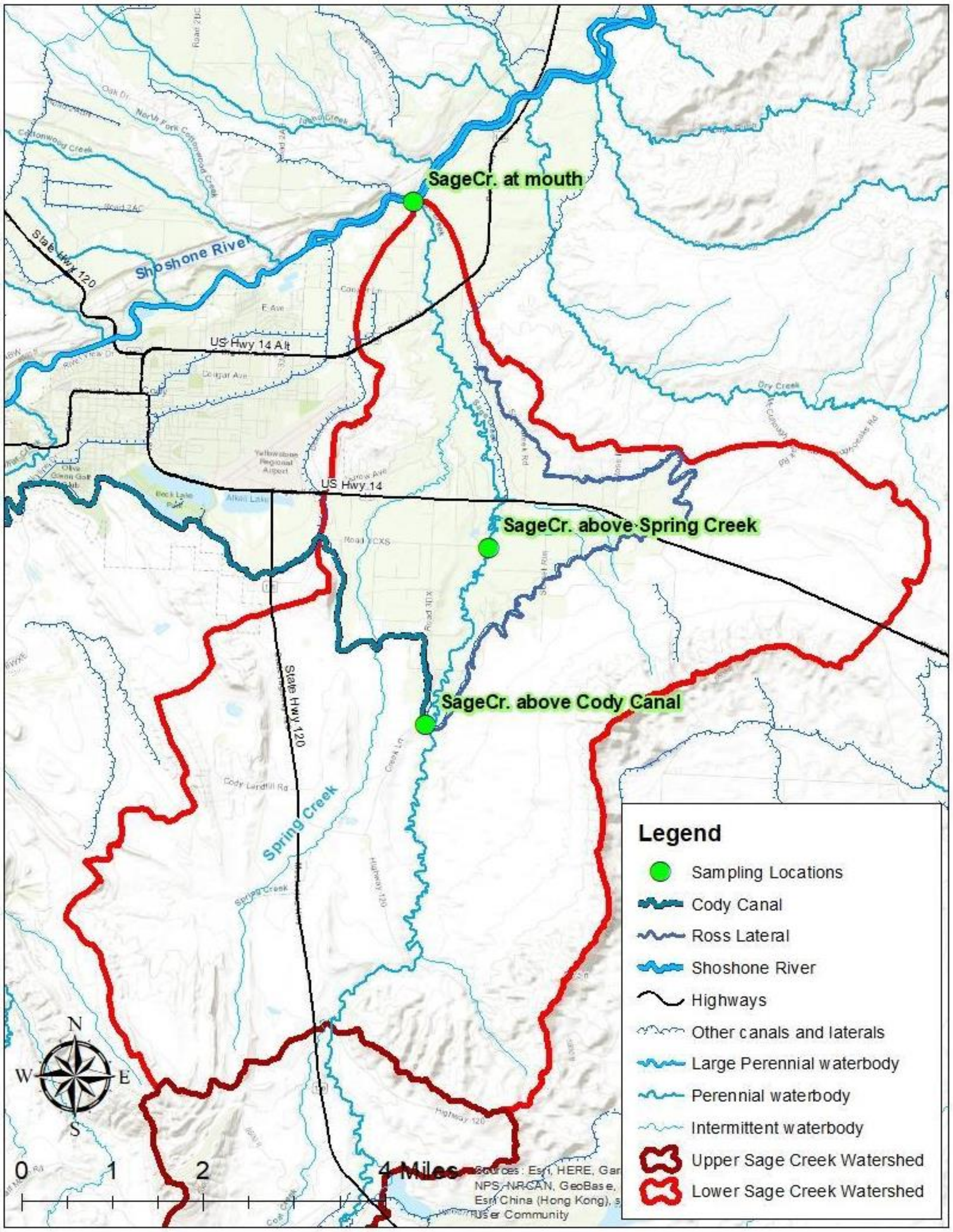


Figure 16: Sampling Locations in the Lower Sage Creek Watershed

Additionally, the two conservation districts are partnering on a camera study of tributaries between Buffalo Bill Dam and Willwood Dam to collect photographic data at regularly scheduled intervals to pair with turbidity data collected at Willwood Dam downstream. No current groundwater sampling sites are in the Lower Sage Creek Watershed.

The following organizations partner to conduct bacteria and sediment monitoring in the watershed:

- Wyoming Department of Environmental Quality (WDEQ)
- Wyoming Department of Agriculture (WDA)
- Cody Conservation District (CCD)
- Powell Clarks Fork Conservation District (PCFCD)
- Willwood Working Group 3 (WWG3) (Watershed Steering Committee)
- United States Geological Survey (USGS)

Table 5 summarizes surface water sampling and assessment efforts for parameters of interest in the watershed. Sampling has not occurred on a routine basis. Rather, samples were obtained based on data needed to complete a stratified baseline dataset consisting of samples taken during ambient and rain or snowmelt conditions in both irrigation and non-irrigation seasons.

Table 5: Surface Water Quality Sampling in the Lower Sage Creek Watershed

Parameter of Interest	Measured As	Sampling Locations	Period of Record
Sediment	Suspended Sediment Concentration (SSC), Bedload, Turbidity (NTU)	44.558885, -108.997166 (Sage Cr. at mouth), 44.50424, -108977 (Sage Cr. above Spring Cr.), 44.475148, -108989283 (Sage Cr. above Cody Canal)	2017-2018, 2020-2022
Pathogens	Total Coliform (MPN/100ml), *E. coli* (MPN/100ml)	(none currently)	2004-2005
Discharge	Flow (cfs)	44.558885, -108.997166 (Sage Cr. at mouth), 44.50424, -108977 (Sage Cr. above Spring Cr.), 44.475148, -108989283 (Sage Cr. above Cody Canal)	2017-2018, 2020-2022

Biological monitoring

No aquatic monitoring has been conducted within last five years in Sage Creek. The WGFD conducted investigatory fisheries, macroinvertebrate, and water quality sampling in Sage Creek in 1976 and 1977. Based on the results of the sampling fish species present within Sage Creek include Brown trout, Flathead Chubb, Fathead chub, Lake chub, long nose sucker, mountain sucker, mountain whitefish, plains minnow, and white sucker.

Sage Creek is the only tributary upstream of Willwood Dam that contains enough flow during October and November to provide spawning habitat for Brown Trout.

Partner sampling

During 2017-2020, the WGFD conducted Wyoming Habitat Assessment Methodology (WHAM) Level I inventories to assess habitat conditions on several drainages in the Shoshone River

Watershed, including Sage Creek (Quist et. al 2005). In addition to evaluating instream and riparian habitat conditions, potential sources for sediment loading were identified.

The WDEQ also collected data below Sage Creek from 2017 to 2019 to assess nutrient contributions to the Shoshone River from various tributaries between the Buffalo Bill Reservoir and the town of Lovell, Wyoming. Data from these inventories and monitoring efforts will be reviewed once the reports are released.

Runoff and streamflow Hydrology and Irrigation

In 2003 BRS, Inc. and partners released the Wind/Bighorn Basin (WBHB) Plan for the Wyoming Water Development Commission (WWDC) as one of a series of River Basin Plans, across the state. The WBHB Plan includes the Wind River, Clarks Fork of the Yellowstone and Bighorn River Basins and focuses on major water uses including agricultural, municipal, domestic, industrial, environmental, and recreational, and water use from storage. The basin plan documents current water uses, surface and ground water availability, and projects future uses and demands for water based on various planning scenarios (BRS., et al., 2003).

An important part of the river basin planning process is to estimate water availability within the river basins for future development and use. The availability of surface water was determined through the construction and use of a spreadsheet simulation model, based on an original spreadsheet model that was developed by Anderson Consulting Engineers for the Bear River Basin, and calculates water availability based on the amount of streamflow, less historical diversions, compact requirements and minimum flows (BRS., et al, 2003).

The model is intended to simulate existing river operations for dry, average and wet year hydrologic periods between 1973 – 2001. The primary data required for the spreadsheet models included streamflow, actual (or estimated actual) diversion, full supply diversions, irrigation returns and reservoir operations.

The basic model calculation procedure is shown in Figure 7. Natural flows for each main channel and tributary were either taken from gage data (preferred but not normally available) or estimated using the regional regression techniques. Then the incremental gains and losses were calculated for each reach. This was performed by locating the first downstream gaged node and constructing a “basin” containing all the known upstream inflows, diversion and reservoir operations. Gaged and ungaged gains and losses were calculated within each basin, and a mass balance (or water budget) was computed at each node (BRS, et. Al. 2003).

The Sage Creek “reaches” were developed as part of the Shoshone Planning Model Schematic as shown in Figure 8. Reaches are a group of nodes that represent an entire tributary or a portion of the main river. The three reaches analyzed as part of Sage Creek watershed include Sage Creek – Reach 2390, South Fork Sage Creek – Reach 2392 and Ashworth Creek – Reach 2394.

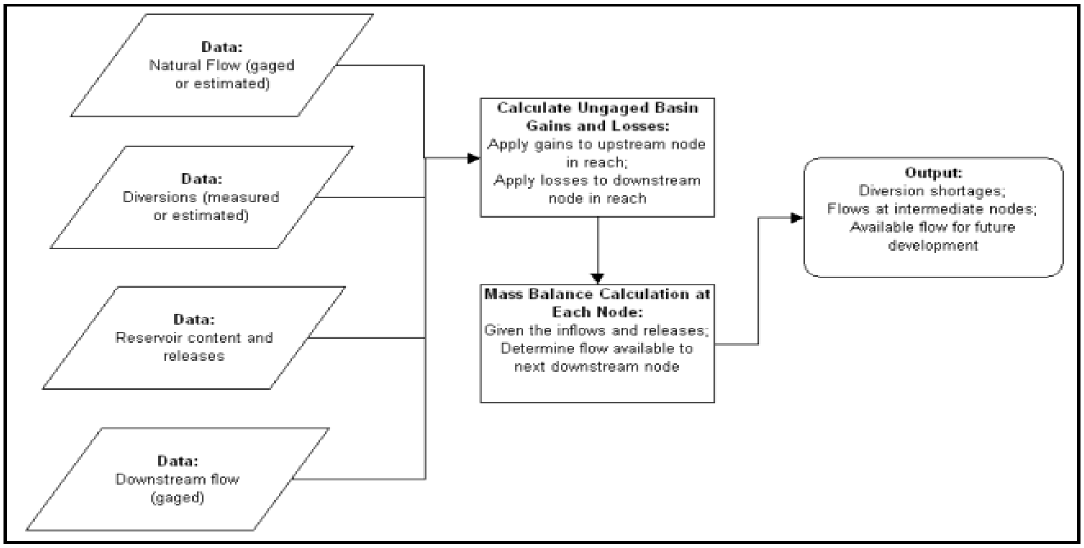


Figure 17: Generalized Model Flowchart

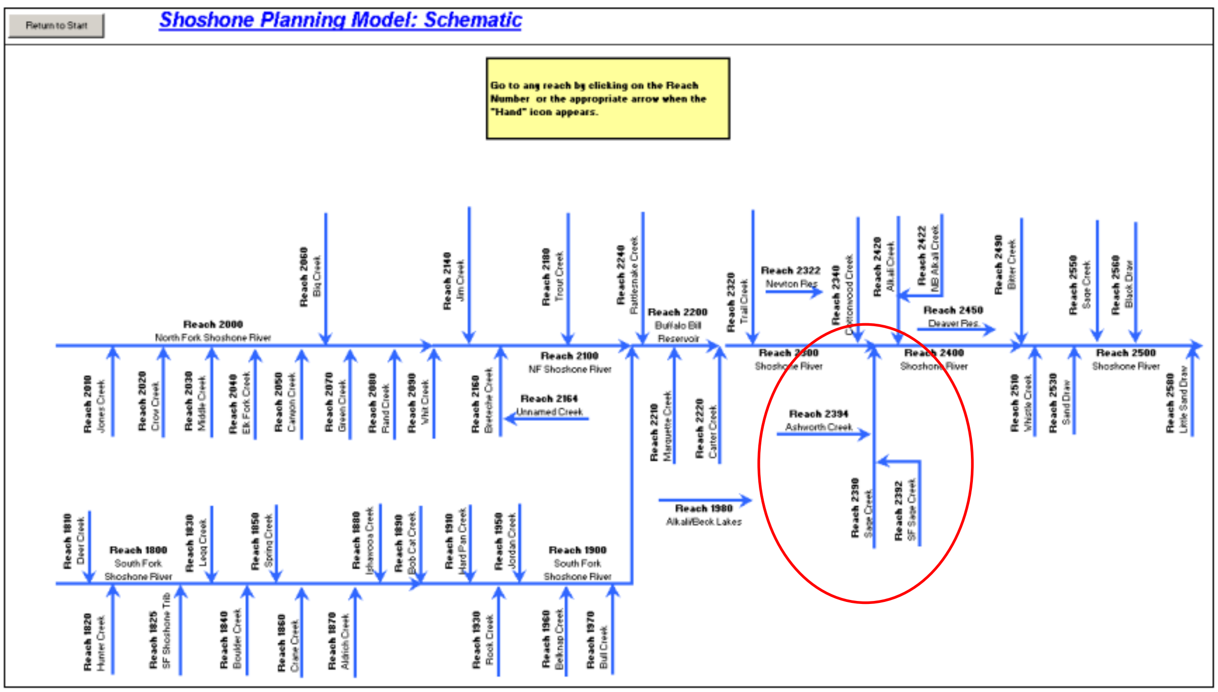


Figure 18: Reach Schematic – Shoshone Model

Cody Canal

The Cody Canal diversion headgates are located approximately 2 miles upstream of Buffalo Bill Reservoir on the South Fork of the Shoshone River. Cody Canal has water rights dating back to 1895, making this District one of the most senior diverter on the South Fork of the Shoshone River. William F. Cody signed the original application for the water right. (Aqua Engineering, 2006).

The Cody Canal terminates at Sage Creek and water continues past Sage Creek as the Ross Lateral. During the irrigation season, Sage Creek is used to convey water from the Cody Canal to the Lower

Sage Creek lateral, located on the north side of the Highway 14 crossing on Sage Creek (Figure 16).

The Cody Canal releases 40 to 60 cfs (cubic feet per second) into Sage Creek at the Canal crossing and then withdraws between 30 and 40 cfs at the Lower Sage Creek lateral head gate. Spring Creek is also used as an emergency spill (Kauffman Spill) to regulate water levels in the Cody Canal.

There are numerous laterals (McNeil, Holm, Bell, Moller, Shultz, Ross, Lower Sage, Frost) and smaller ditch systems throughout the Sage Creek watershed that deliver irrigation water to users on approximately 4,348 acres. Sage Creek also receives irrigation return flows from Cody Canal laterals, field pipes, and the City of Cody storm water runoff. The Cody Canal also receives irrigation return flows from irrigators from the Lakeview canal and laterals which are eventually transported to Sage Creek along with as runoff from ephemeral draws during storm events. (Sediment Watershed Plan 2019).

Runoff-budget

Data does not exist for detailed hydrologic analysis of the Sage Creek watershed, but the limited existing data, when coupled with demand assumptions based on known water rights in the watershed can provide some basic water budget information about the drainage on an average annual basis. Discharge in Sage Creek in the early spring is driven by snowmelt and some spring rains in the upper portion of the watershed and diversions from the Foster No. 1 Reservoir and Coe Enlargement Reservoirs and tributaries. However, the primary driver of flow and discharge in the lower portion of the watershed in late spring through mid-fall is water diverted from the Cody Canal as mentioned above and as indicated by the results in Table 2. Based on the information provided in the previous sections from the Wind/ Bighorn River Basin Plan spreadsheet models and data gathered by the WGFD and CCD, we can generally get a good representation of annual inputs as precipitation and irrigation, and outputs within the watershed.

Natural streamflow and outflows from Foster No. 1 Reservoir and Coe Enlargement Reservoirs produce an average 31 ac. ft. per month on an annual basis to the South Fork Sage Creek drainage. By the time South Fork Sage Creek confluences with Sage Creek which then confluences with Ashworth Creek, the mainstem of Sage Creek produces an average of 1,260 ac. ft. per month on an annual basis. Downstream, Wiley Reservoir and Sage Creek Reservoir divert an average of 15 cfs or 900 ac. ft. per month on an annual basis from Sage Creek leaving an average of 6 cfs or 360 ac. ft. per month on an annual basis to flow downstream to the Cody Canal crossing in the Sage Creek channel. There is a gain of 50 cfs (100 ac. ft. per day) when the Cody Canal dumps into Sage Creek during the irrigation season at the Sage Creek crossing. With this additional flow, data has indicated a high of around 110 ac. ft. per day just above Spring Creek. Further downstream with Spring Creek inputs, data has indicated the flow at the confluence of Sage Creek and the Shoshone River vary from around 40 to 160 ac. ft. per day. These numbers fluctuate with seepage and return flows, or lack thereof any given year, especially areas with soils with high K-factors (Figure 9), hydric soils; particularly D (Figure 8), and cultivated/bare areas with little to no vegetative cover.

Although some of these input/ outputs are modeled, the limited data that is available indicates that the Sage Creek watershed is in balance to irrigate the watershed in its current state on a normal year, for primarily hay and other crop production. On average, if Sage Creek gains 50 cfs a day from the Cody Canal, when added to the 6 to 9 cfs already in Sage Creek during the irrigation season (153 days), that will produce 4 ac. ft. of water dispersed across the 4,348 irrigated acres north of the Cody Canal. (59 x 2 x 153 / 4,348 acres). However, in times when either the Cody Canal and its laterals or the diversions along Sage Creek receive a limited water supply, irrigation may become compromised in the entire area including the Lower Sage Creek watershed.

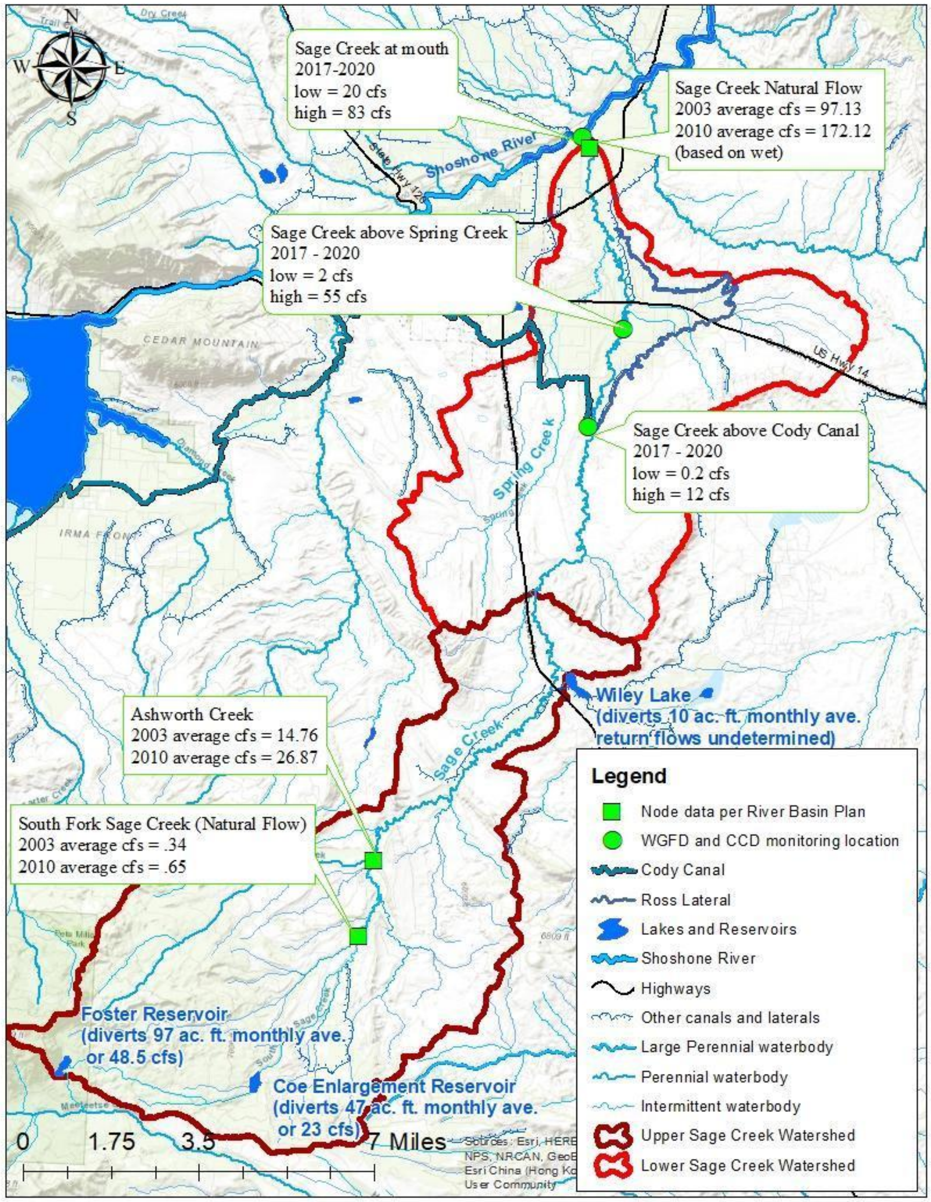


Figure 17: Water budget of the Sage Creek drainage

Water quality conditions in the watershed

The Model My Watershed application was used to generate sediment and nutrient loadings in the Lower Sage Creek watershed. The Model My Watershed application utilizes the Generalized Watershed Location Function Enhanced (GWLF_E) model that was developed for the MapShed application. Model My Watershed is part of the Stroud Water Research Center's WikiWatershed initiative. WikiWatershed is a web toolkit designed to support citizens, conservation practitioners, municipal decision-makers, researchers, educators, and students to collaboratively advance knowledge and stewardship of fresh water (Model My Watershed, 2022). As with any model, these figures are estimates based on inputs to the model and are used primarily as a starting point for determining sources and critical areas (i.e., those areas in need of specific practices to address a resource concern) of the watershed.

Table 6: Lower Sage Creek Watershed Average annual loads and sources from 30-years of daily fluxes (Simulated by the GWLF-E MapShed model and USEPA National Climate Data)

Sources	Sediment	Total Nitrogen	Total Phosphorus
Total Loads (lb)	1,524,169.60	6,261.40	869.6
Loading Rates (lb/ac)	56.48	0.23	0.03
Mean Annual Concentration (mg/L)	115.34	0.47	0.07
Mean Low-Flow Concentration (mg/L)	203.38	0.82	0.15
Sources	**Sediment (lb)**	**Total Nitrogen (lb)**	**Total Phosphorus (lb)**
Stream Bank Erosion	**1,466,009.10**	923.7	509.3
Cropland	38,367.30	322.6	89.7
Hay/Pasture	9,263.60	51.4	26
Low-Density Open Space	4,410.00	126.3	13.1
Medium-Density Mixed	3,179.40	57.9	5.9
Low-Density Mixed	1,771.20	50.7	5.3
Wooded Areas	645.4	67.8	4.4
High-Density Mixed	308	5.6	0.6
Open Land	168.5	86	1.9
Wetlands	47.1	22.5	1.2
Barren Areas	0	0.4	0
Farm Animals	0	163.4	42.8
Subsurface Flow	0	4,150.20	169.3
Point Sources	0	0	0
Septic Systems	0	232.7	0

As depicted in the above table, the annual sediment loading estimate is quite significant in the Lower Sage Creek Watershed, and is caused primarily by streambank erosion, cropland and hay/pasture lands as also represented on the corresponding pie charts on the next few pages. The increase in developed lands has also contributed significantly to the sediment loading. Nitrogen and Phosphorus loading by subsurface flow (irrigation), stream bank erosion and cropland runoff is also significant.

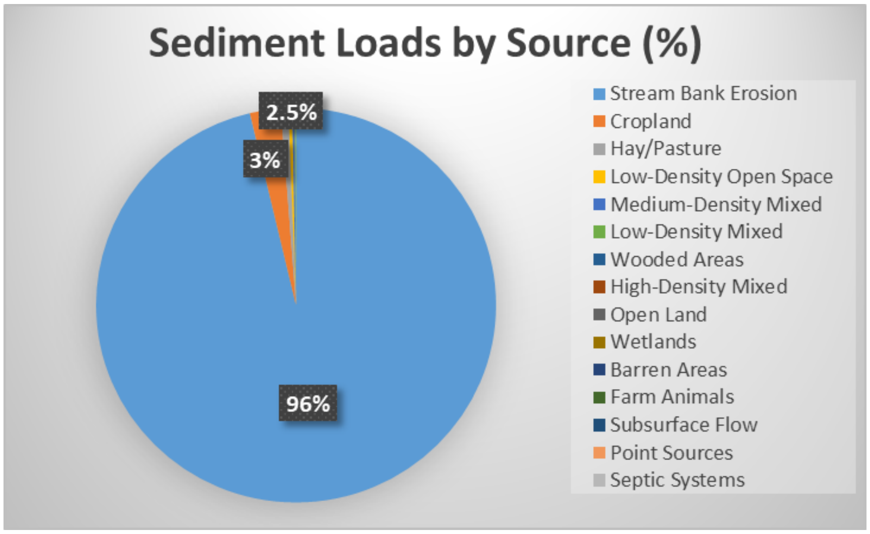


Figure 18: Sediment Loading by Source

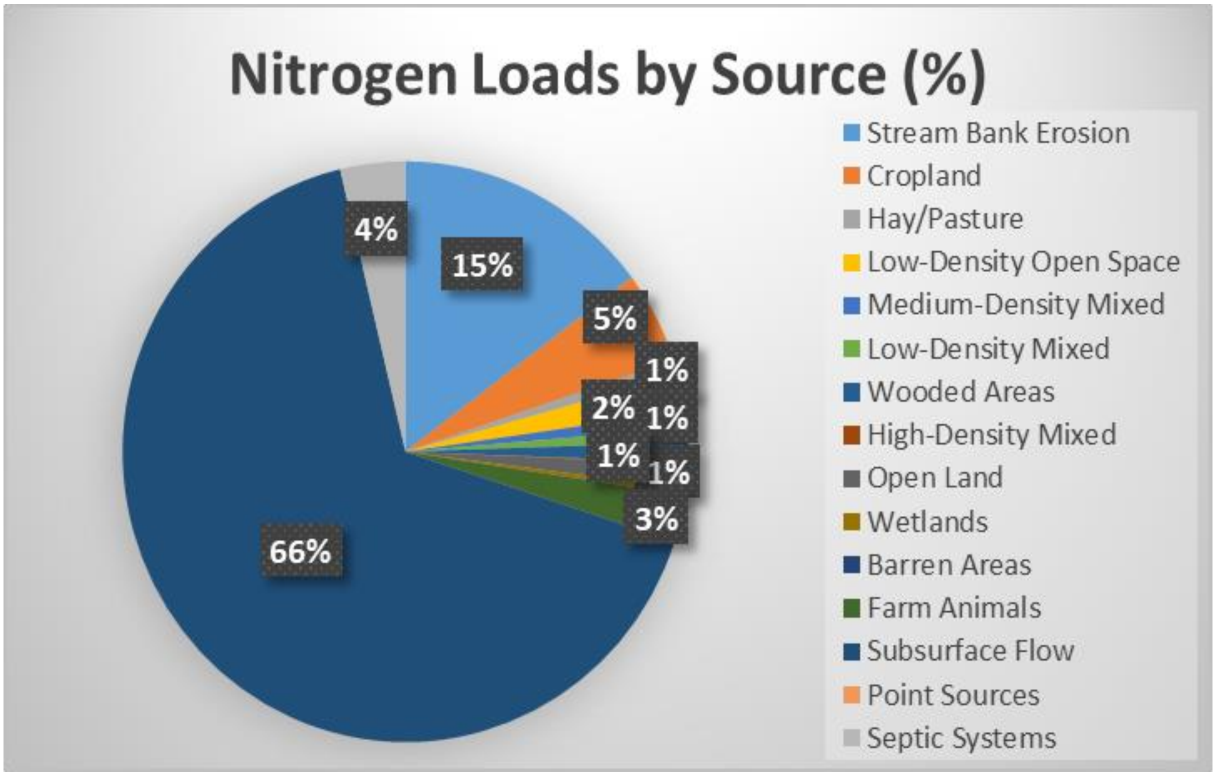


Figure 19: Nitrogen Loading by Source

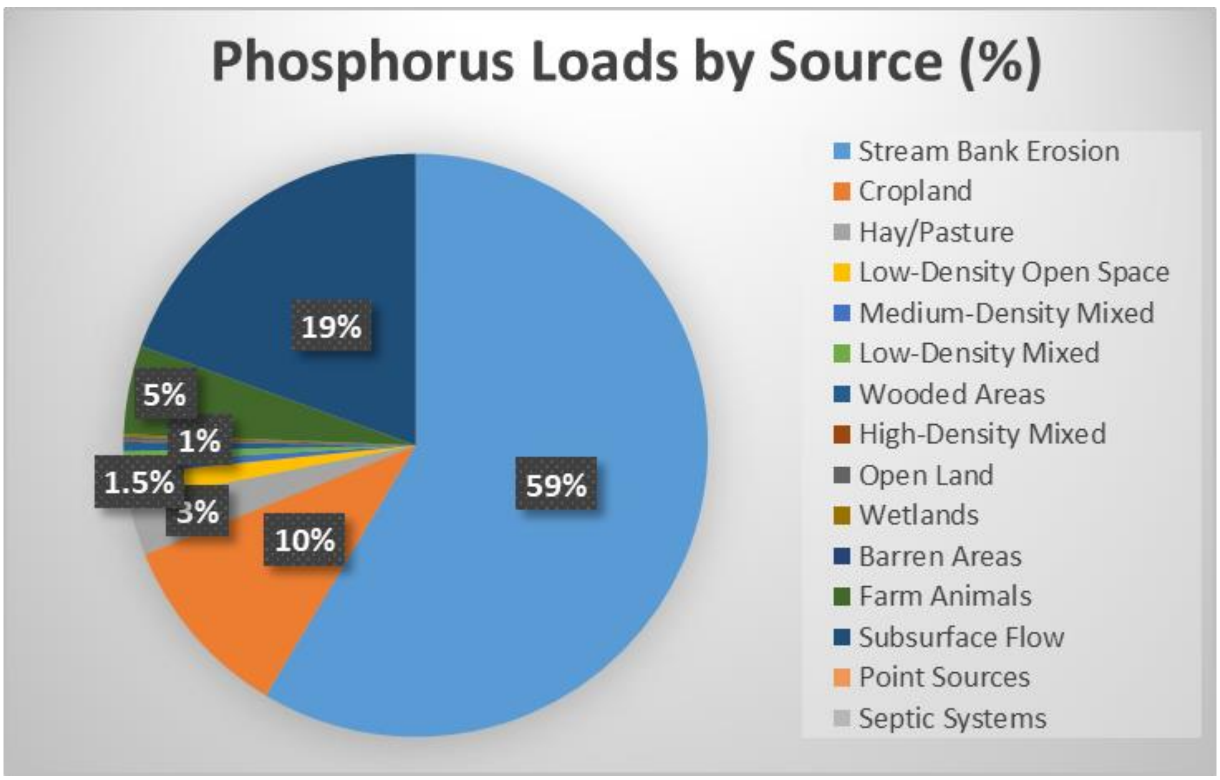


Figure 20: Phosphorus Loading by Source

These findings are generally corroborated by the WDEQ's 2020 Integrated 305(b) and 303(d) Report. According to the Report, of streams assessed in the Yellowstone-Shoshone Watershed, channel instability was among the top four most common stressors. Of the stream segments with channel instability, 94% of the unstable stream segments were due to excess sediment, 28% were attributed to accelerated bank erosion, and 25% were linked to channel incision (WDEQ 2020). Elevated nutrient concentrations (total nitrogen, nitrate+nitrite-N or total phosphorus) was also among the top four most common stressors in the Watershed.

Flow, suspended sediment concentration, and bedload data have been collected at three sites on Sage Creek (at the confluence, above Spring Creek, and above Cody Canal). These results, which are further outlined in section III, Available Water Quality Data and Resources, indicate that Sage Creek contributes a high amount of sediment to the Shoshone River which mirrors the Model my watershed results.

Elevated turbidity and suspended sediment concentrations typically occur during precipitation events, with the highest readings occurring during storm events in the irrigation season. Figure 23and Figure 22 depict the variation in turbidity and suspended sediment concentrations observed at the sample locations and Table 7 provides a summary of the data.

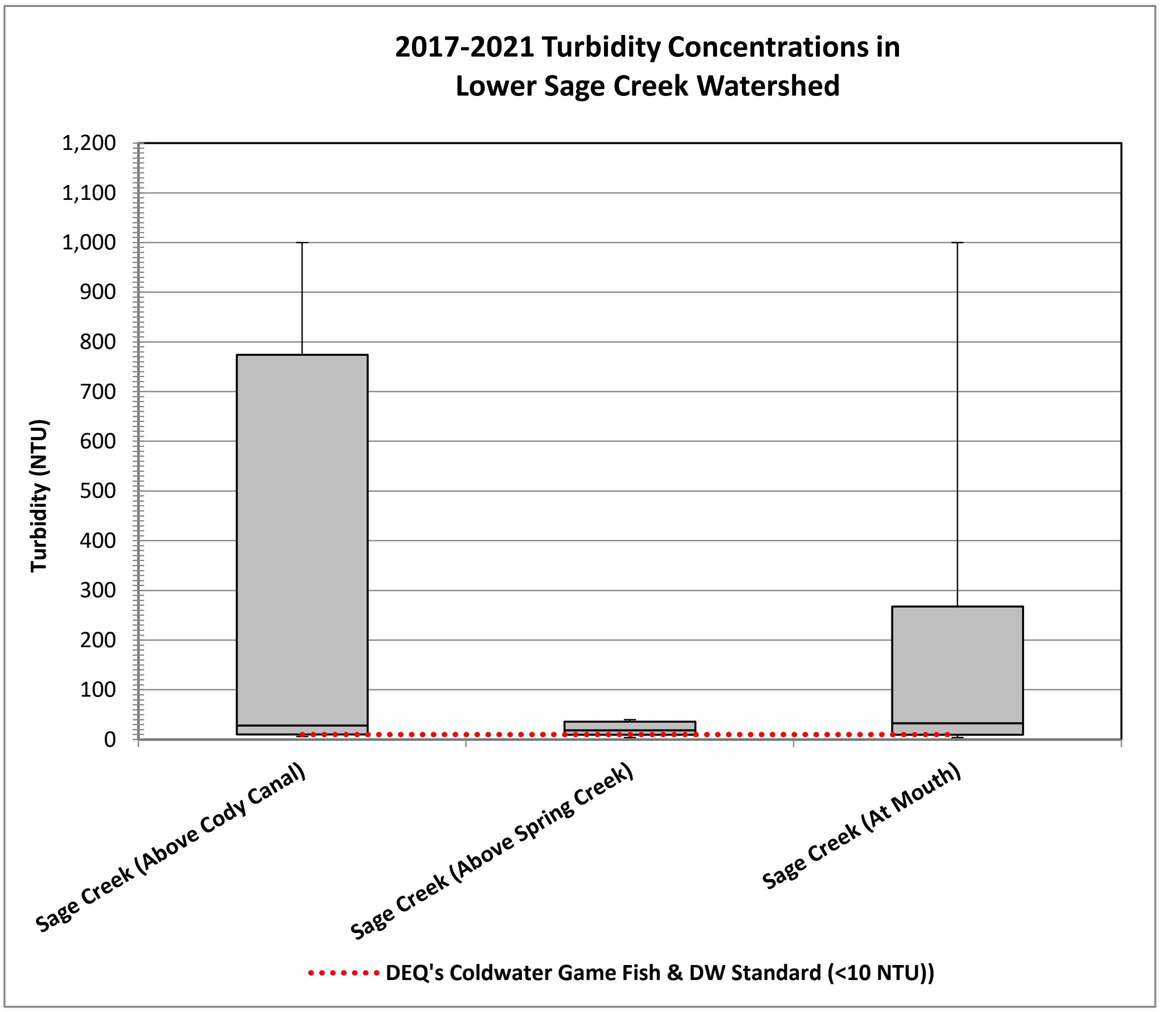


Figure 21: Turbidity Concentrations in Lower Sage Creek

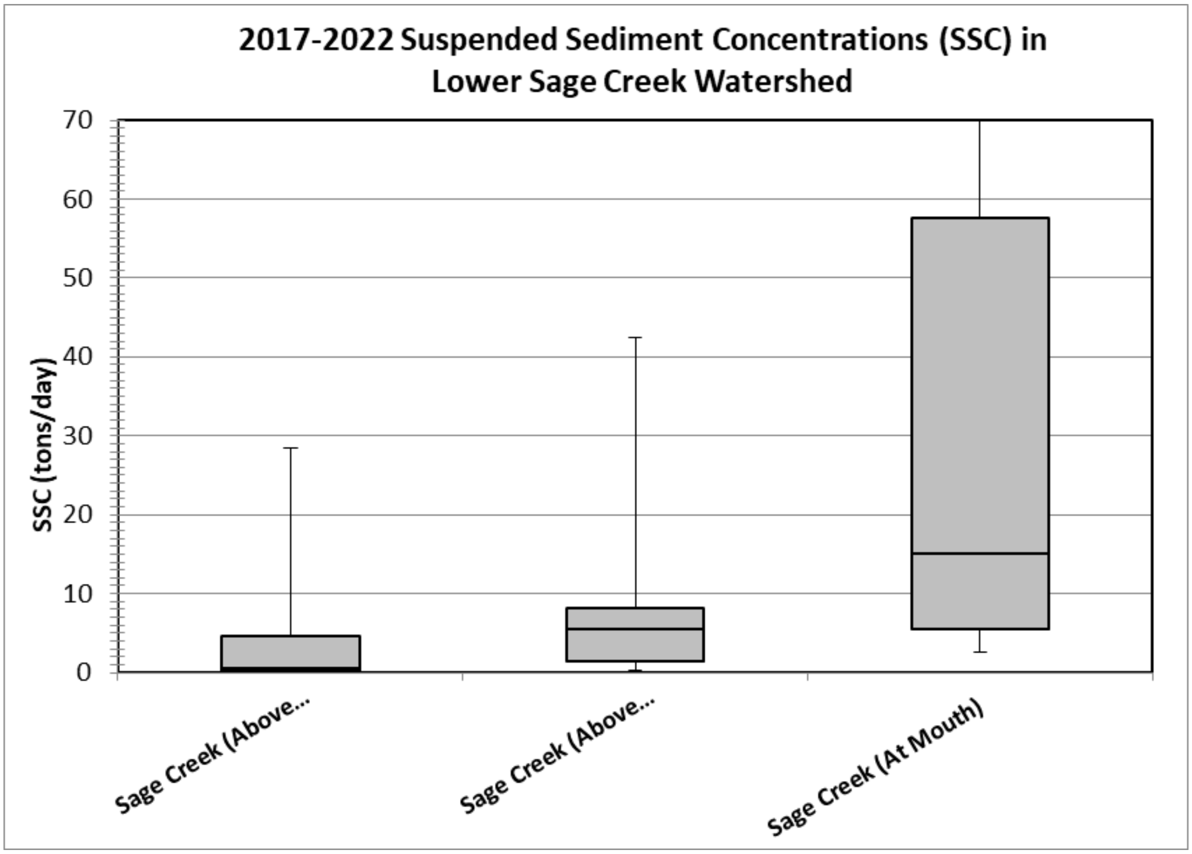


Figure 22: Suspended Sediment Concentrations (SSC) in Lower Sage Creek Watershed

Table 7: Summary of Turbidity and Suspended Sediment Concentration Data (2017-2022)

Site	*Season*	*Event*	*# Samples*	AVG FLOW (cfs)	MIN Flow (cfs)	Max Flow (cfs)	AVG Turbidity (NTU)	AVG SSC ton/day	MEDIAN SSC ton/day	MIN SSC ton/day	MAX SSC ton/day
Sage Creek above Cody Canal, near Cody, WY	Irrigation	No Event	5	3.43	1.41	8.87	213	1.83	0.52	0.31	6.89
		Storm	1	0.21	0.21	0.21	96	0.14	0.14	0.14	0.14
	Non-Irrigation	No Event	2	2.86	2.22	3.5	24	1.2	1.2	0.2	2.2
		Storm	1	12.05	12.1	12.1	>1000	28.37	28.37	28.37	28.37
Sage Creek above Spring Creek, near Cody, WY	Irrigation	No Event	6	36.37	2.14	45.2	24	11.42	5.59	0.2	42.42
		Storm	1	36	36	36	18	7.28	7.28	7.28	7.28
	Non-Irrigation	No Event	2	5.21	4.77	5.65	6	1.08	1.08	0.39	1.78
Sage Creek at mouth, near Cody, WY	Irrigation	No Event	4	37.38	28.6	49.8	266	7.4	4.6	2.55	17.87
		Storm	6	59.87	22.1	81.8	417	107.1	25.77	11.13	551.9
	Non-Irrigation	No Event	5	26.42	20	31.7	6.25	7.18	8.31	1.62	12.41
		Storm	5	35.99	22	74.4	275	23.8	15.98	8.29	54.96

IV. Resource Analysis and Source Assessment

Figure 23: WGFD WHAM Survey: 2017-2020

Causes of Water Quality Issues in the Watershed

The Model My Watershed Models indicated that 1,466,009.10 lbs of Sediment are caused by streambank erosion annually within the watershed. Streambank erosion is the most immediate source of in-stream sediment. Natural processes that influence channel morphology in the watershed include stormwater and snowmelt runoff and the sediment supply upstream of the project area. Other factors affecting the rate of streambank erosion include unstable streambanks due to manipulation of channel alignment, removal of riparian vegetation, excessive livestock occupation, and concentrated stormwater runoff, introduction of produced water and irrigation return flows, all of which result in highly variable discharges the channel must manage (Figure 25 & Figure 26).

Cropland and Hay/ Pasture

Approximately 10% of the land use within the watershed is cropland and hay/pasture. However, Cropland and Hay/Pasture lands can contribute around 47,000 lbs or 19 tons of Sediment to the watershed on an annual basis (Table 6). It is also the 3rd highest contributor for Nitrogen and Phosphorus to the watershed. These areas coupled with poorly drained soils and limited vegetation between the cropland/pasture and waterways can provide for significant contributions (Figure 27).

Figure 24: WGFD WHAM Survey: 2017-2020

Low-Density & High-Density Development, and Open lands

Developed and open areas represent 5% of the watershed, however as more areas become sub-divided and developed, we see more bare soils from construction sites, newly constructed dirt roads, and small acreage pastures, all of which are vulnerable for erosion from rainfall and runoff. Sediments can be found in both native soils and materials used for building unpaved roads and driveways.

Figure 25: WGFD WHAM Survey 2017-2020

Subsurface Flow (Runoff and irrigation)

Subsurface flow refers to the flow of water below earth's surface as part of the hydrologic cycle. Subsurface flow may return to earth's surface as perched flow, such as from a spring or seep, or subsurface (baseflow) return to streams, creeks and rivers (Kansas State University). This flow can bring various elements to the surface including nitrogen and phosphorus especially in areas with heavy fertilization or livestock presence. This flow coupled with irrigation return flows can provide for high contributions to downstream waterways (Figure 28 & Table 3)

Other sources

Some sediment, nutrient and phosphorus contributions from farm animals, septic systems and wooded areas were present as indicated by the model and will be considered when determining practices with the above listed sources. The Model My Watershed application indicates that there are low number of farm animals in the watershed (32 Horses, 72 sheep, 0 Cows). While it is known there are no large feedlots in the watershed, conversations between the CCD, NRCS, landowners and other entities have indicated that the model underestimates the number of farm animals from small acreage farms and ranchettes in the project area.

Figure 26: WGFD WHAM Survey 2017-2020

Tools used to address Water Quality Issues and Resource Concerns and Preliminary Analysis

Streambank Erosion Reconnaissance and Analysis

The Wildlife Habitat Assessment Method (WHAM), assessments performed in 2017 to 2020 by WGFD included three segments on Sage Creek and one segment on Spring Creek (Figure 25). Information consisted of visual observations of stream type, flow, substrate, riparian and upland vegetation, large- and small-scale disturbances, and an overall segment narrative. During the WGFD's WHAM survey, approximately 15 miles of stream were assessed; of that nearly 6.9

miles were determined to be experiencing some degree of bank and channel instability.

Overall, segments downstream of the Cody Canal (Segment 1 and 2 – Sage Creek) show increased disturbance in sediment characteristics and flow regime than segments upstream (Segment 3 – Sage Creek and Segment 2 – Spring Creek). However, compared to Segment 3 and Segment 2 – Spring Creek, Segment 1 and 2 appeared to have more robust riparian vegetation in both age and function. Generally, observations of introduced vegetation, larger sediment sizes, and steam width increase with distance downstream while estimated max channel depth decreases.

During the assessment Spring Creek was dry and a defined channel was often difficult to interpret. Additionally, Segment 1 was the only segment that appeared to have habitat suitable for beavers.

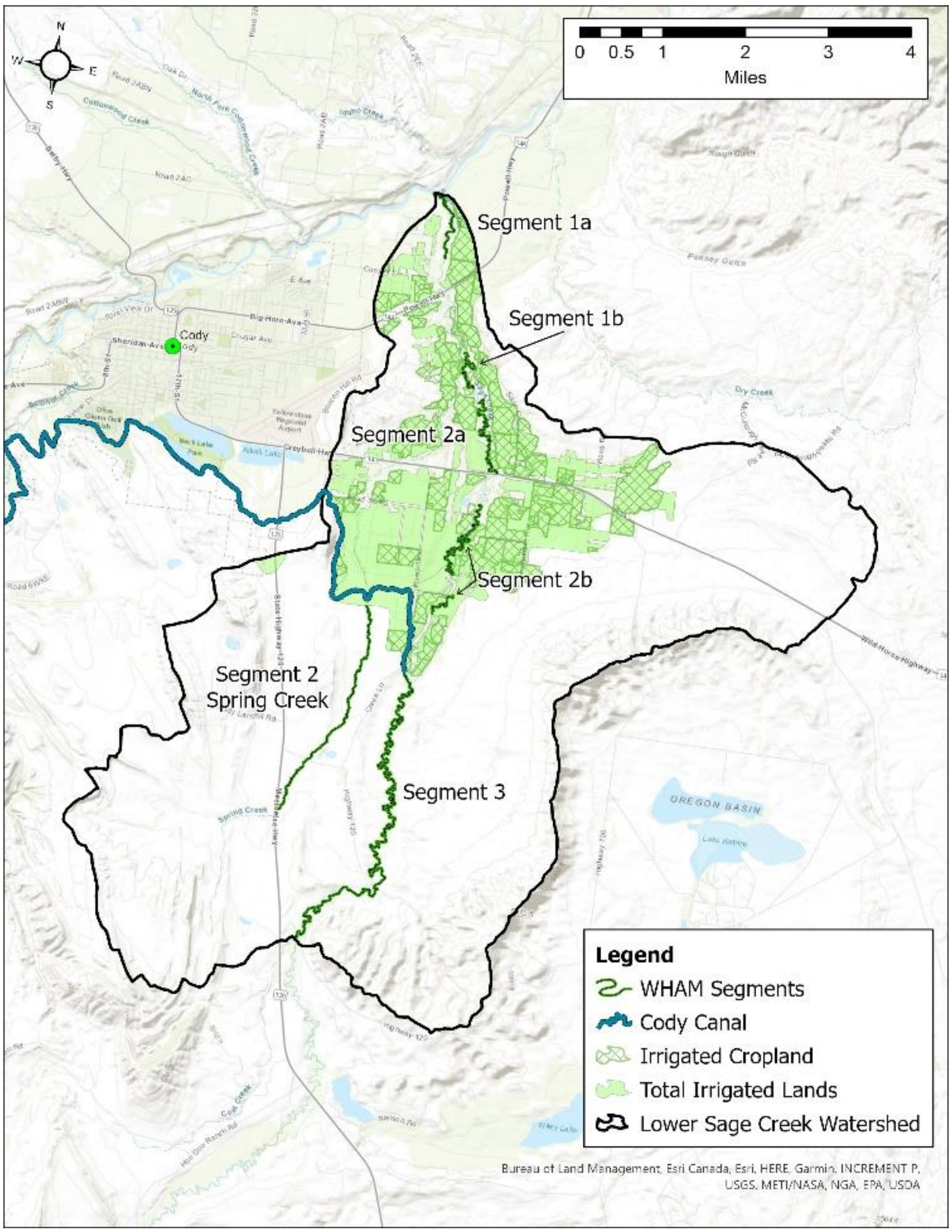


Figure 27: WHAM Segments

Sub-watershed Resource Analysis

Utilizing the Model My Watershed application and GIS, sub-watersheds of the Lower Sage Creek watershed were delineated to gather specific sediment, nutrient and phosphorus information to certain areas of the watershed. This information, similar to what was generated for the overall Lower Sage Creek watershed (Figure 20 - Figure 22), was generated to get a better understanding of where the majority of the sediment, nitrogen and phosphorus are coming from inside the watershed. Four sub-watersheds were delineated and ranked highest to lowest based on their total sediment, nitrogen, and phosphorus contributions normalized by their area (Figure 28).

The four sub-watersheds include:

- The mainstem of Sage Creek from its confluence with the Shoshone River to State Highway 14,
- The mainstem of Sage Creek where it crosses State Highway 14 upstream,
- An unnamed tributary upstream from its confluence with Sage Creek and State Highway 14, and
- Spring Creek, upstream of its confluence with Sage Creek.

This analysis indicates that contaminant contributions are highest on the main stem of Sage Creek, and more specifically, farther downstream in the watershed likely where land use is most influential. Specific contributors of sediment, nitrogen, and phosphorus were also delineated by sub-watershed and indicate cropland, streambank erosion, and sub-surface flows are among the largest contributors in all four sub-watersheds (Figure 31).

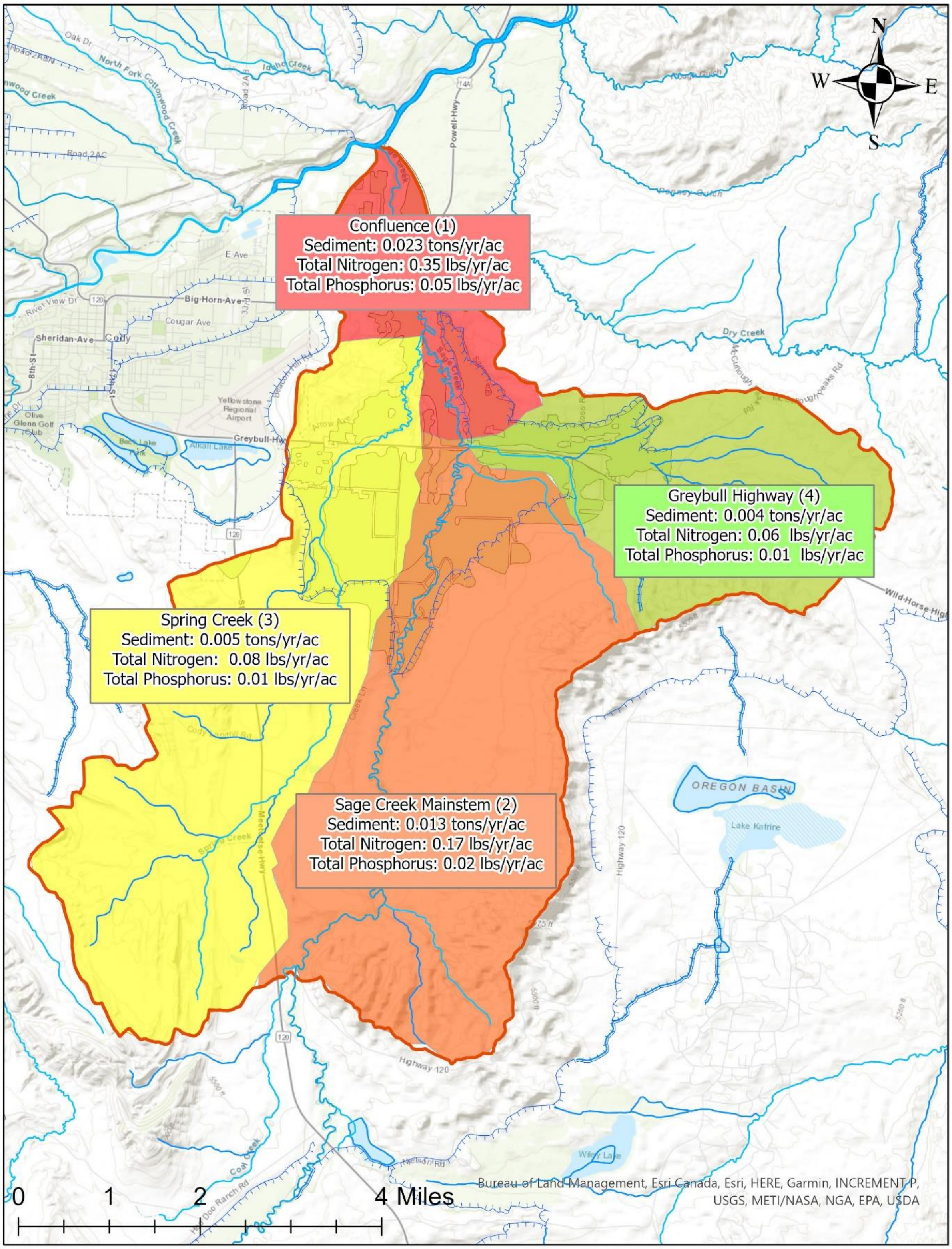


Figure 28: Pollutant Loading in each of the four sub-watersheds

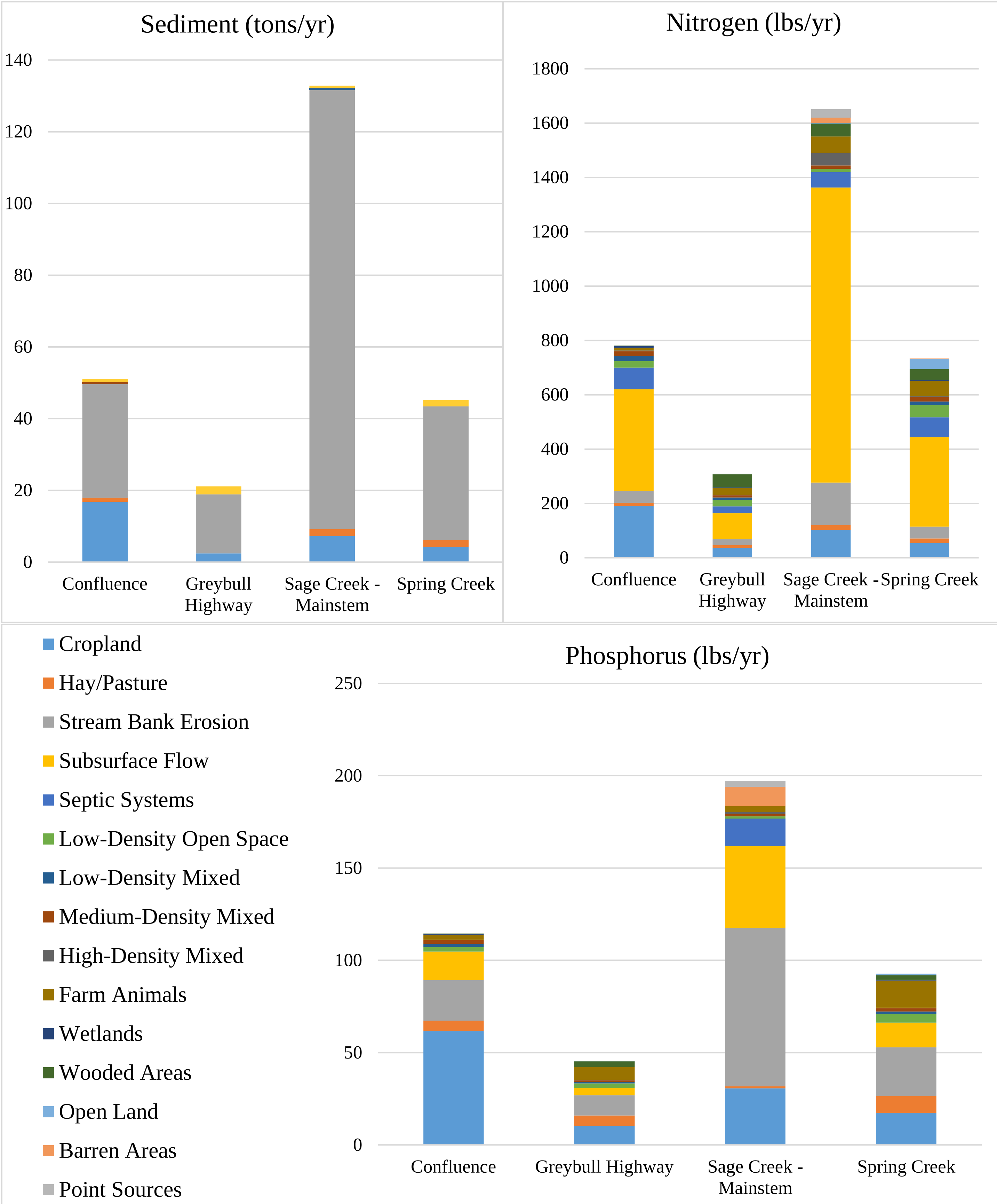


Figure 29: Pollutant Sources in each of the four sub-watersheds

Analysis of treatment and opportunities

Potential contributors to bank instability include grazing and livestock access, canal seepage upslope of Sage Creek, culverts, return flows and produced water, both of which are variable depending on irrigation and oil production activity. In addition to the WHAM survey, a visual assessment of aerial imagery was conducted to assist with the quantification of resource needs and applicable practices presented in the Planned Practice Scenarios and Cost Estimate Section.

Producer Involvement

One of the first steps to evaluate how and where to focus implementation involved holding a meeting with the public and producers in the area to determine interest and project needs and to inform them about the NWQI Program. Through education, awareness, and a discussion with various community members in the Watershed, the CCD and NRCS hoped to gather feedback on where the highest priority for assistance on projects that dealt with irrigation efficiency and cropland loading projects would be. A producer meeting was held in September 2021by the CCD, WACD and NRCS. From that meeting, several landowners voiced their concerns with streambank erosion while others expressed an interest in irrigation infrastructure improvements.

The CCD and other watershed stakeholders are presently coordinating with the Cody Canal Irrigation District (CCID), as they embark on a Feasibility Study to identify projects that improve water efficiency and upgrade/replace critical infrastructure that has exceeded design life expectancy. The goal of the CCID is to identify efficiency improvement projects to eliminate late season shortages and delivery challenges. Additionally, the CCID has requested assistance in identifying a project that would pipe water from the end of the Cody Canal to the Lower Sage Creek lateral (eliminating use of Sage Creek for irrigation water conveyance). If a feasible alternative is identified, the CCD anticipates working with the CCID through the NWQI Program and other opportunities to bring this project to fruition.

While producers in the Lower Sage Creek Watershed have been willing to work with local, state, and federal partners to implement conservation practices, the CCD suspects many newer residents are not as familiar with conservation programs available to address resource concerns. Therefore, targeted education and outreach measures will be critical as the CCD progresses into the project implementation phase.

Current Level of Treatment

Table 8 on the next page demonstrates the level of treatment that has taken place since 2019 as part of the NWQI program. This table shows what practices have been applied, how many of each practice, how many acres have been impacted and the costs associated with the practices. Some of the preferred practices that have been implemented include Irrigation Water Management, Irrigation Pipeline, Sprinkler Systems, Nutrient Management, and others.

As depicted in Table 8, funding has been utilized to install cropland and irrigation practices that not only help improve the water quality but also improve agriculture production. So far, over $157,174.02 has been applied to contracts by the NRCS, with an additional four planned contracts ready for installation. Between certified and planned practices, over 1,108 acres will be treated prior to implementation of the NWQI Program in the Watershed.

Along with the practices mentioned above, other NWQI Core and Supporting Practices that could occur in the watershed based on the landscape, land uses, soils and NWQI recommendations include Cover Crop (340), Irrigation System - Surface and Subsurface (443), Structure for Water Control (587), Fence (382), (Livestock pipeline (516), Pumping Plant (533) and Watering Facility (614). A list of potential Core Practices to be utilized is expanded upon in Table 9.

Table 8: NRCS Practices Implemented in the Lower Sage Creek Watershed: 2019-2023

Practice	Code	Units	Amount	Planned	Status
Sprinkler System	442	Ac	145	2019	Certified
Sprinkler System	442	Ac	168	2019	Certified
Irrigation Pipeline	430	Ft	2026	2019	Certified
Pumping Plant	533	no	1	2019	Certified
Pumping Plant	533	no	1	2019	Certified
Structure for Water Control	587	no	2	2019	Certified
Nutrient Management	590	Ac	157	2020	Certified
Cover Crop	340	Ac	129	2019	Certified
Conservation Cover	327	Ac	2	2020	Certified
Irrigation Water Management	449	Ac	157	2019	Certified
Irrigation Water Management	449	Ac	157	2020	Certified
Irrigation Water Management	449	Ac	157	2021	Certified
Irrigation Pipeline	430	Ft	1808	2022	Planned
Irrigation Pipeline	430	Ft	1	2022	Planned
Irrigation Pipeline	430	Ft	1	2022	Planned
Irrigation Pipeline	430	Ft	1	2022	Planned
Structure for Water Control	587	No	1	2022	Planned
Irrigation System, Surface and Subsurface	443	Ac	23	2023	Certified
Irrigation System, Surface and Subsurface	443	Ac	14	2023	Certified

Table 9: Lower Sage Creek Watershed Potential Water Improvement Practices

Practice	Code	Avoiding	Controlling	Trapping
Conservation Cover	327	X		X
Conservation Crop Rotation	328	X		
Residue and Tillage Management, No Till/Strip Till/Direct Seed	329		X	X
Contour Farming	330		X	X
Contour Orchard and Other Perennial Crops	331		X	X
Contour Buffer Strips	332			X
Cover Crop	340	X		X
Critical Area Planting	342		X	X
Residue and Tillage Management, Reduced Till	345		X	X
Well Water Testing	355	X		
Field Border	386		X	X
Riparian Herbaceous Cover	390			X
Riparian Forest Buffer	391			X
Filter Strip	393		X	X
Stream Habitat Improvement and Management	395	X		
Grade Stabilization Structure	410		X	X
Grassed Waterway	412		X	
Irrigation Reservoir	436		X	
Irrigation Water Management	449		X	
Access Control	472	X		
Prescribed Grazing	528	X		
Drainage Water Management	554		X	
Heavy Use Area Protection	561	X		
Trails and Walkways	575		X	
Streambank and Shoreline Protection	580	X		
Nutrient Management	590	X		
Terrace	600		X	
Vegetative Barrier	601			X
Saturated Buffer	604			X
Tree/Shrub Establishment	612	X		X
Vegetated Treatment Area	635			X
Water and Sediment Control Basin	638		X	X
Constructed Wetland	656			X

V. Summary and Recommendations

Goals and Interim metrics

The primary goal of this initiative is to assist landowners and other entities implement projects that result in reduced sediment loading to Sage Creek, and ultimately, the Shoshone River. Other benefits anticipated include reducing nutrient and bacteria loading. Runoff from natural sources as well as cropland, pastureland, residential, and urban areas carry sediment, *E.coli*, and other constituents. To develop management strategies for achieving measurable pollutant load reductions, the following objectives were identified:

Management Objective: Reduce the amount of sediment loading from urban, residential, and agricultural land uses in the Sage Creek Watershed.

Goal 1: Evaluate compliance of Sage Creek with Wyoming Water Quality Standards. If in non-compliance, implement measures to reduce human-influenced discharges to meet standards.

Indicators: Turbidity, Flow, Suspended Sediment Concentration, *E. coli*, and Nutrient Parameters, contingent upon funding and WDEQ recommendations. Other metrics may include qualitative assessments and bank and channel stability measurements.

Source of Impact: Naturally occurring erosion, run-off from cropland, pastureland, subdivisions and associated development, sediment from earthen irrigation conveyances, stream channel and bank instability from discharges exacerbated by irrigation water and stormwater runoff entering Sage Creek.

Management Objective: Increase Public Awareness of Water Quality Issues and Promote Implementation Conservation Measures. Coordinate with other stakeholders to maintain collaborative approach in addressing sediment and nutrient loading to the Shoshone River. Partners include, but are not limited to the UW-Water Research Program, UW Extension Office, WGFD, Wyoming Water Development Office, U.S. Geological Survey, and WDEQ.

Goal: Increase voluntary-based stakeholder participation in implementing practices to improve overall stewardship of aquatic and terrestrial resources in the Sage Creek and Shoshone River drainages.

Indicators: Evaluation of stakeholder participation in resource conservation programs, evaluation of watershed health metrics through monitoring data and any watershed assessments

Source of Impact: Lack of awareness of water quality issues and/or programs available to assist in addressing resource concerns. Development of coordinated stakeholder efforts to identify and fund larger-scale project opportunities.

Management Objective: Evaluate Effectiveness of Outreach and Implementation Strategies

Goal: Identify and implement evaluation methods to assess effectiveness of practices implemented and additional measures needed to achieve sediment load reduction goals.

Indicators: Monitoring data, acres treated and practices implemented will be evaluated to determine if there has been a decrease in loads due to implementing practices. This evaluation will help determine if and where to continue outreach and projects in the watershed.

Source of Impact: Lack of watershed-specific, more detailed monitoring strategy; landowner participation/site access.

These goals will used as a guide beginning in June 2023 and will be evaluated every 6 months by the NRCS, Cody Conservation District Board and staff and Wyoming Association of Conservation Districts and at the conclusion of the Initiative.

The CCD will hold at least one annual meeting or other outreach related event to promote the program and update the Lower Sage Creek community on the progress of this project. Other forms of outreach will include pre and post site visits to evaluate the success of projects implemented and landowner satisfaction with the performance of measures implemented.

Critical Source Areas

To best utilize implementation funding, critical source areas were identified based on their potential to reduce pollutant loading in the Lower Sage Creek watershed (Figure 30). Attributes used in determining critical areas included irrigated lands, soils with a K-Factor greater than or equal to 0.32, soils with a C/D or D Hydrologic Soil group, and areas within 250 m of perennial streams in the watershed. These areas were identified because of their use in the USDA's Revised Universal Soil Loss Equation (RUSLE), as well as considerable observed and modelled contributions of sediment from stream bank erosion. The RUSLE was utilized to identify Critical Source Areas based on the ability of RUSLE to predict average annual erosion rates over time for a broad range of land uses, including those common in the lower Sage Creek Watershed. These attributes were then overlayed and counted to further categorize areas into areas of greatest concern (three or more attributes), moderate concern (two attributes), lesser concern (one attributes), and least concern (no attributes present).

Generally, areas that are considered most vulnerable are those downstream of the Cody Canal and within 250 m of Sage or Spring Creek (Figure 30). Land uses with relatively higher percentages in areas of greatest concern include Alfalfa, Grassland/Pasture, Other Hay/Non-Alfalfa, and Developed Open Space, whereas areas of least/lesser concern generally had larger percentages of Shrubland (Table 10). This information coincides with monitoring data, Figure 28, and the WAHM assessment performed by WGFD, indicating that containment loading is likely higher downstream of the Cody Canal.

Areas downstream of the Cody Canal have a large potential for projects related to improving irrigation practices, installing riparian fencing, and invasive vegetation treatment to reduce sediment and nutrient loading in the watershed.

Ultimately, areas determined as critical source areas in this section are inherently limited by the spatial resolution of the available data. Many factors should be used when considering if a project is priority for funding including landowner participation, critical source area ranking, permitting, and project acreage among others. The critical source areas determined in this section will be one tool used in determining project priorities outlined in Section IV of this document.

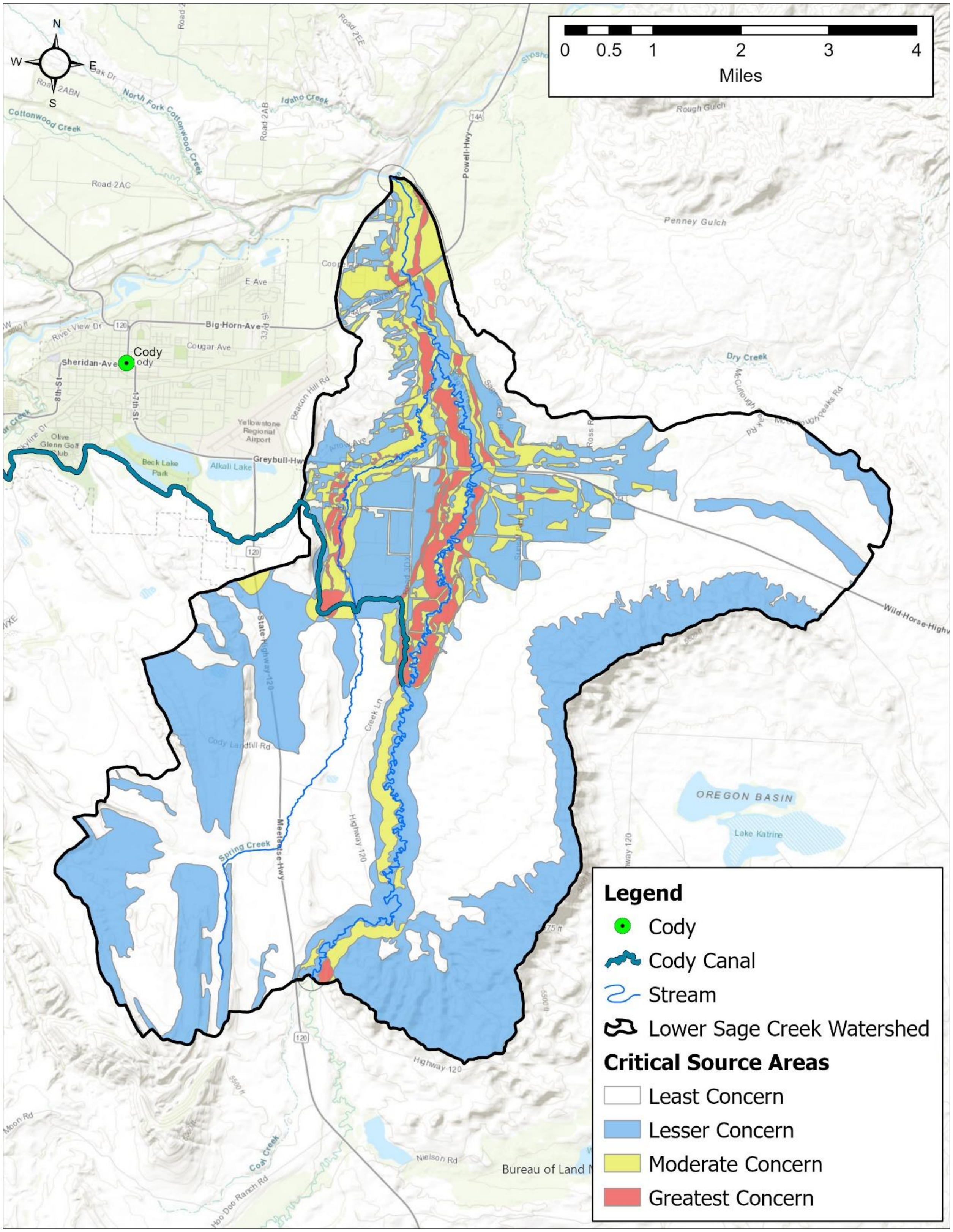


Figure 30: Critical Source Areas in the Lower Sage Creek Watershed

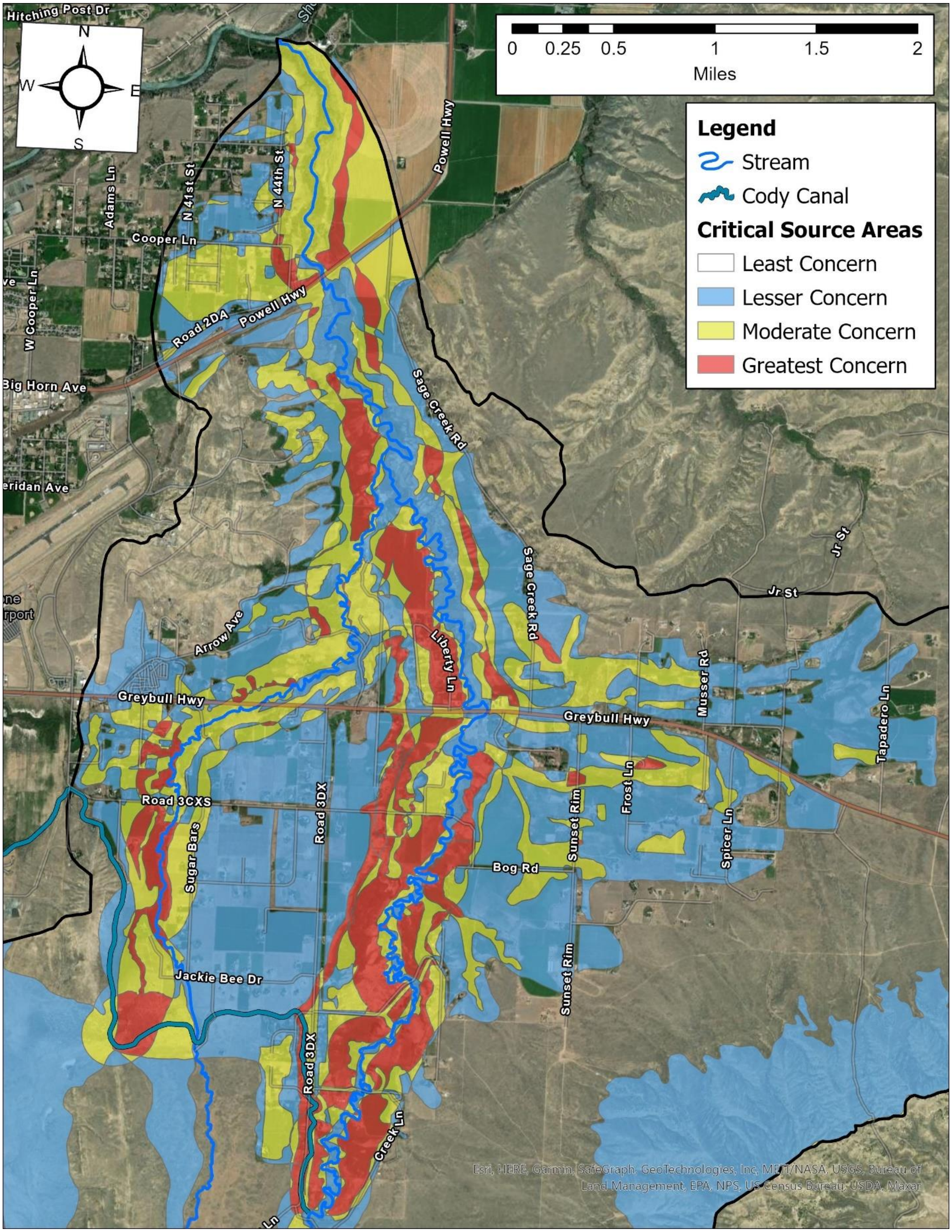


Figure 31: Larger scale map of Critical Source Areas focused on areas north of Cody Canal

Table 10: Summary of Critical Source Area's Land Use, Land Classifications, and Surface Management Agency

	Acreage and Percent in each Critical Area			
	Greatest	**Moderate**	**Lesser**	**Least**
Total	893	2189	10690	13323
Land Use/Land Classification				
Alfalfa	113 (12.6%)	160 (7.3%)	300 (2.8%)	57 (0.4%)
Barley	30 (3.3%)	91 (4.2%)	21 (0.2%)	7 (0.1%)
Dev./Low Intensity	25 (2.8%)	91 (4.2%)	153 (1.4%)	117 (0.9%)
Dev./Open Space	66 (7.4%)	125 (5.7%)	456 (4.3%)	249 (1.9%)
Grassland/Pasture	154 (17.3%)	247 (11.3%)	406 (3.8%)	67 (0.5%)
Herb. Wetlands	32 (3.5%)	78 (3.6%)	117 (1.1%)	11 (0.1%)
Other Hay/Non-Alfalfa	157 (17.6%)	278 (12.7%)	611 (5.7%)	62 (0.5%)
Shrubland	261 (29.3%)	947 (43.2%)	8378 (78.4%)	12619 (94.7%)
Surface Management Agency				
Private	853 (95.5%)	2000 (91.4%)	4375 (40.9%)	2593 (19.5%)
Bureau of Land Management	8 (0.9%)	153 (7%)	5324 (49.8%)	10417 (78.2%)
State	32 (3.6%)	30 (1.4%)	655 (6.1%)	256 (1.9%)
Local Government	0 (0%)	5 (0.2%)	335 (3.1%)	47 (0.4%)

Overview of Planned Practice Scenarios and Cost Estimates

Based on WHAM surveys, aerial imagery assessments, prior projects completed, and current landowner interest, the NRCS and CCD developed a series of practice scenarios. Table 11 provides an overview of the practices identified and cost estimates of planned projects.

Table 11: Table of planned practice scenarios and cost estimates

Practice	Code	Practice Scenario	Scenario Units	Extent	Cost Share
Conservation Cover	327	HU-Native Species	ac	15	$3,133.80
Cover Crop	340	HU-Cover Crop - Basic (Organic and Non-organic)	ac	50	$3,657.50
Fence	382	HU-Barbed/Smooth Wire	ft	10000	$28,500.00
Livestock Pipeline	516	HU-Below Frost PVC, HDPE, IPS, PE	ft	10000	$32,400.00
Nutrient Management	590	HU-Basic NM (Non-Organic/Organic)	ac	500	$4,240.00
Obstruction Removal	500	HU-Removal and Disposal of Fence - N Mtn	ft	5000	$5,300.00
Pumping Plant	533	HU-Electric-Powered Pump, greater than 5 to 30 Horsepower	hp	400	$196,536.00
Water Well	642	HU-Typical Well, 100- to 600-foot depth with 4-inch Casing	linear ft	500	$30,335.00
Watering Facility	614	HU-Automatic or Winter, No Storage, less than 450 gal	Each	40	$48,417.20

Irrigation Pipeline	430	HU-Polyvinyl Chloride (PVC), Pipe, less than or equal to 8 inch	lb	55000	$200,200.00
Irrigation System, Surface and Subsurface	443	HU-Polyvinyl Chloride (PVC) Gated Pipe	lb	55000	$273,350.00
Sprinkler System	442	HU-Center Pivot System	ft	20000	$1,417,400.00
Sprinkler System	442	HU-Wheel Line System	ft	20000	$422,000.00
Structure for Water Control	587	HU-Active Screen	Each	10	$66,339.70
Structure for Water Control	587	HU-Stationary Screen	cfs	20	$71,412.00
Irrigation Reservoir	436	HU-Small Excavated Regulating Pit	cu-yd	2500	$17,325.00
Streambank and Shoreline Protection	580	Bankfull Bench and Vegetative Bioengineering	ft	9200	$335,984.00
Streambank and Shoreline Protection	580	Rock Riprap with Bankfull Bench and Vegetative Bioengineering	cu-yd	5000	$743,300.00
				Total	**$3,899,830.20**

Practice scenarios are projected to be broken out in the following years based on NRCS guidance:

FY 2024: $389,980.45

FY 2025: $779,881.01

FY 2026: $1,211,044.54

FY 2027: $1,128,980.54

FY 2028: $389,943.66

Documentation of NEPA Concerns

The National Environmental Policy Act (NEPA) was signed into law on January 1, 1970. NEPA requires federal agencies to assess the environmental effects of their proposed actions prior to making decisions. Using the NEPA process, agencies evaluate the environmental and related social and economic effects of their proposed actions (USEPA, 2020).

The NRCS utilizes a planning process that incorporates an evaluation of potential environmental impacts using an Environmental Evaluation Worksheet (NRCS-CPA-52). The Environmental Evaluation (EE) is "the part of the planning that inventories and estimates the potential effects on the human environment of alternative solutions to resource problems (7 CFR 650.4 and GM 190 Part 410.4(D)). NRCS is required to conduct an EE on all actions to determine if there is a need for an Environmental Assessment (EA) or an Environmental Impact Statement (EIS). The NRCS-CPA_52 form is used by NRCS to document the results of the evaluation and show compliance with NRCS regulations implementing NEPA as stated in 7 CFR Part 650 (NRCS, CPA-52 Worksheet).

In Wyoming, District Conservationists, Planners and NRCS employees utilize the Integrated Resource Management Analyst (IRMA) application (https://irma-wy.wygisc.org/) to quickly and easily, assess cultural resources and wildlife resources when filling out the EE. IRMA is used to inventory and evaluate impacts to cultural resources for a given project. It is also used to inventory and evaluate impacts to federal and state endangered and threatened species and habitats. The SuiteWater application (https://SuiteWater.wygisc.org/) is another resource that can be used by Conservation Districts when assessing threatened and endangered species within a given area.

IRMA and SuiteWater determined that the following wildlife and cultural resource priorities fall within the Lower Sage Creek Watershed:

- Wyoming Game and Fish Department – Sage Grouse Core Areas (v4)
- Wyoming Game and Fish Department – Mule Deer Crucial Range
- USFWS Area of Influence for Ute Ladies'-tresses
- Various cultural block surveys, linear surveys and inventoried acres have occurred within the watershed mainly related to pipelines, seismic lines, telephone lines and irrigation projects.

Planned and completed practices shown in Table 6. have already been evaluated and no additional EAs or EISs have been required. Each planned practice has met the criteria for categorical exclusions. For future implementation, the CCD, NRCS, and other partners will endeavor to avoid adverse impacts from practices to the extent possible. If adverse impacts are unavoidable, they will be minimized or mitigated as necessary.

Additionally, all NRCS restoration and implementation activities will follow Field Office Technical Guides (FOTG) and the USDA National Engineering Manual.

VI. Outreach Plan

In September 2021, project partners began outreach efforts for the Lower Sage Creek Watershed NWQI. A letter was sent out to several landowners whose property is directly adjacent to Lower Sage Creek. The letter described the project and invited landowners to a public meeting. At the public meeting, the CCD, WACD, and NRCS gave a presentation to attendees and scheduled site visits with interested landowners. Notice of the public meeting was also posted on the CCD social media sites and website. The CCD has also spoke about the Lower Sage Creek Watershed NWQI during several public presentations, events, and on a Big Horn Basin podcast over the past year.

Project partners will continue outreach efforts going forward. The CCD will continue to speak about this funding opportunity during public presentations. The CCD will also consider additional targeted, notice mailings to landowners within the Lower Sage Creek Watershed. Some mailings will target landowners other than those directly adjacent to Lower Sage Creek. Information in mailings will include 1) general overview information of NWQI, 2) information on NRCS practices that fall under NWQI, and 3) targeted messaging about streambank erosion and potential solutions. The CCD will also holding a second public meeting to discuss this opportunity with interested landowners as the CCD moves into the implementation phase of the project.

Since the first public meeting, the CCD and NRCS have completed several initial landowner site visits. Initial site visits looked at potential projects for irrigation improvements and streambank stabilization. The CCD will continue to pursue landowner site visit opportunities.

In July 2022, the CCD and partners met with the NRCS Streambank Restoration Team to discuss streambank stabilization techniques. Similar streambank erosion issues are seen along Lower Sage Creek, which was determined in initial landowner site visits. The CCD and partners are considering offering a landowner workshop on Lower Sage Creek to discuss feasible, low-cost streambank restoration techniques. Potential techniques would include willow plantings, streambank tree abutments, willow facines, and beaver dam analogues. The primary goal of this workshop would be to provide Lower Sage Creek landowners with potential solutions to address streambank erosion.

In the future, the CCD anticipates that several conservation practices will be implemented within the Lower Sage Creek Watershed that will assist in sediment reduction efforts. To accomplish our goals, the CCD, NRCS, and other partners will continue to work collaboratively to provide NWQI outreach, meet with landowners, and formulate solutions to address water quality concerns within this watershed. The CCD, in conjunction with NRCS staff, will develop a ranking process to prioritize project applications received. The CCD will also maintain regular contact with the NRCS as projects undergo the agency’s review process.

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