Chapter 7
The Lake Fork Basin

Section 1. Basin Characteristics

The Lake Fork Basin is made up of a diverse array of water users and uses including ranchers and irrigators, full time and seasonal residents, tourists, trout fisheries, boating and angling enthusiasts, and mining. Major tasks for the WMP were to review and assess the available information, update and refine the information, identify data gaps, and recommend future data collection efforts. Information collected as part of the data inventory process served as a key component to both identify needs in the Lake Fork Basin and to improve modeling and field assessment tools being used to assess these needs

Figure 1-1 shows the Lake Fork of the Gunnison River (Lake Fork) Basin boundary, highways and local roads, active streamflow gages, and public land designation. Approximately 85 percent of the land within the basin boundary is public. A significant portion of the private land is adjacent to the Lake Fork and other tributaries and includes ranches and horse properties, the town of Lake City, County based subdivisions, and patented mining claims.

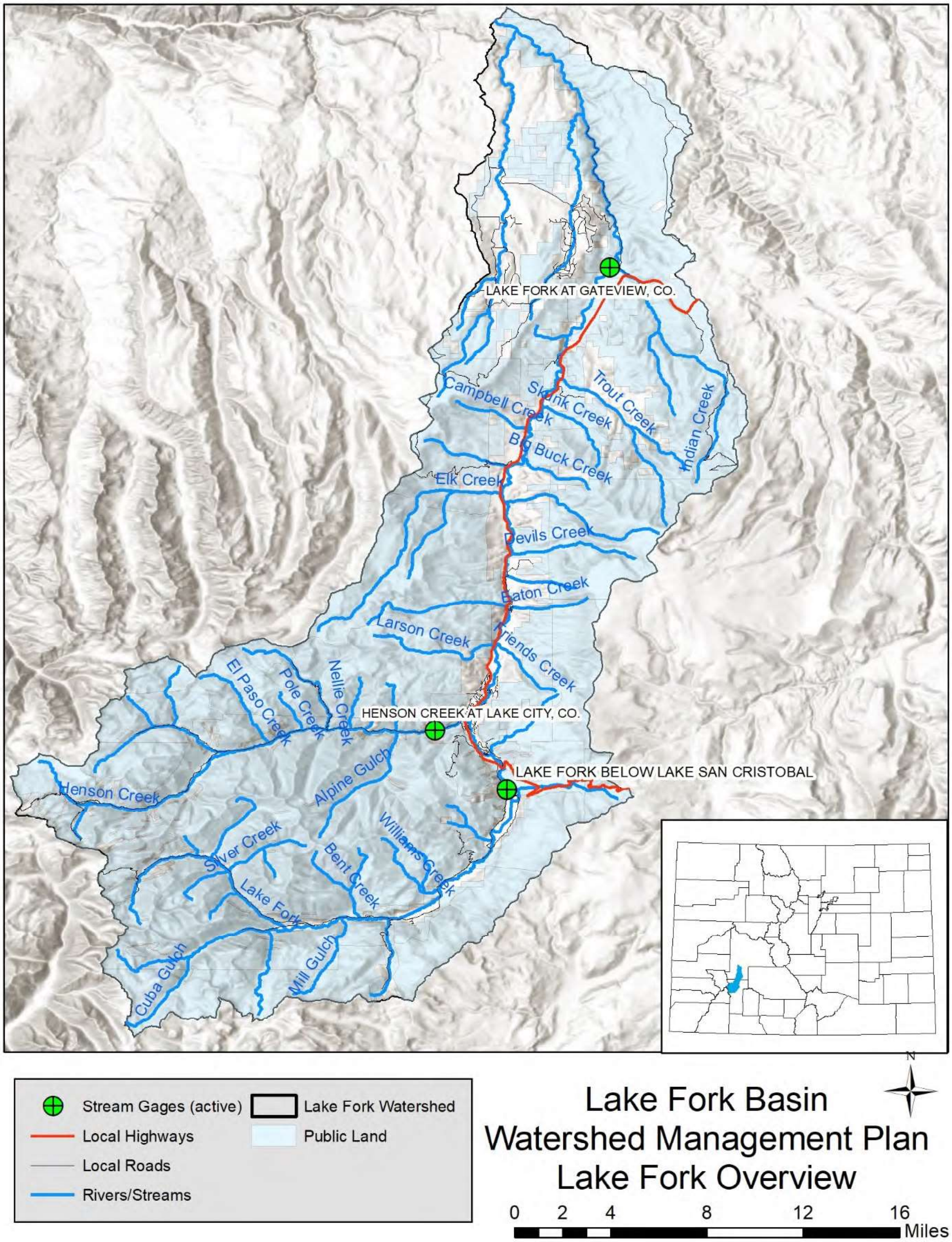


Figure 1-1: Lake Fork Basin Overview Map

Section 2. Data Assessment

2.1 Streamflow Measurements

Three stream gauges currently measure streamflow in the Lake Fork Basin, the Lake Fork at Gateview, the Lake Fork below Lake San Cristobal, and Henson Creek at Lake City. At the time of assessment, only the Lake Fork gauges were used, as the Henson Creek gauge was only recently reactivated. Historic stream flow data was also used from the previously inactive Henson Creek gauge, in addition to two others. Table 2-1 summarizes the drainage area, period of record, and average annual flow for both the active and inactive stream gages. Figure 1-1 includes the locations of the three active gages. A gage was installed on Henson Creek at Alpine Gulch but was only used to monitor flood conditions. To improve water rights administration, the DWR and UGRWCD identified potential locations where additional gages could be installed and the gage at Henson Creek was reactivated. One possible location to install an additionalg gage would be on Elk Creek.

Table 2-1: Summary of Active and Inactive Stream Gages in the Lake Fork Basin

Stream Gage Name	Gage ID	Status	Drainage Area (Sq. Mi.)	Period of Record	Average Annual Flow (acre-feet)
Lake Fork below Mill Gulch	09123400	Inactive	57.5	1982-1986	73,900
Lake Fork below Lake San Cristobal	09123450	Active	106	2013-Present	74,600
Lake Fork at Lake City	09123500	Inactive	115	1918-1924 1932-1937	85,800
Henson Creek at Lake City	09124000	Reactivated	83.1	1918-1919 1932-1937 2019 - present	72,500
Lake Fork at Gateview	09124500	Active	339	1938-Present	168,900

The streamflow in the Lake Fork Basin is highly variable depending on snowpack. Figure 2-2 shows daily flow for the period 2013 through 2017 for the two active gages on the Lake Fork. The following observations can be made based on the figure:

- The runoff pattern and peak flow months are similar for these two locations.
- This period includes wet years of 2014 and 2015 and one of the driest years of record, 2012.
- The difference in annual stream flow between 2012 and 2014 is more than 114,000 acre-feet at the Lake Fork at Gateview gage.

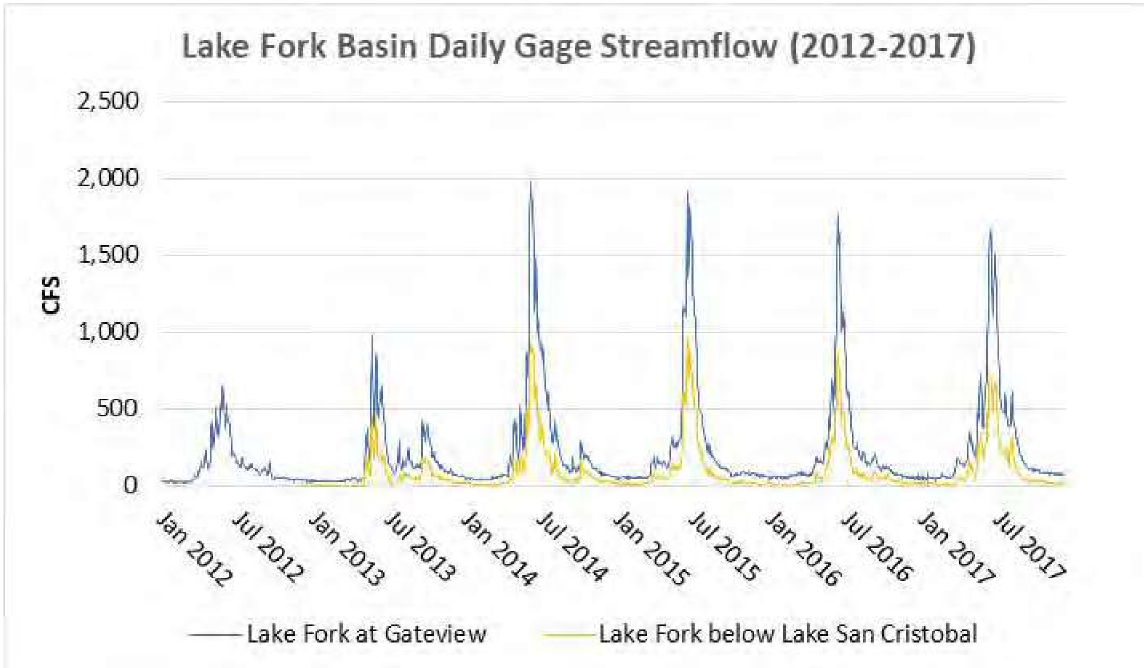


Figure 2-2: Lake Fork Basin Streamflow (2005-2017)

Figure 2-3 shows the historical annual streamflow volume for the period 1938 through 2017, along with the 10-year running average for the Lake Fork at Gateview gage. As shown, streamflow varies widely from year to year. Although the 10-year running average is highly variable, it does not indicate a long-term trend in terms of total flow volumes. The peak runoff is variable depending on snowpack. In average years, the peak generally occurs in early June and shifts to mid or even late June in extremely high runoff years. In about 25 percent of the gaged record corresponding to the driest 25 years, the peak runoff occurred in May. Several of the years with earlier runoff correspond to low flow years seen since 2000. The 1960s decade also showed a significant number of years with earlier runoff, and there does not appear to be a permanent shift in the peak.

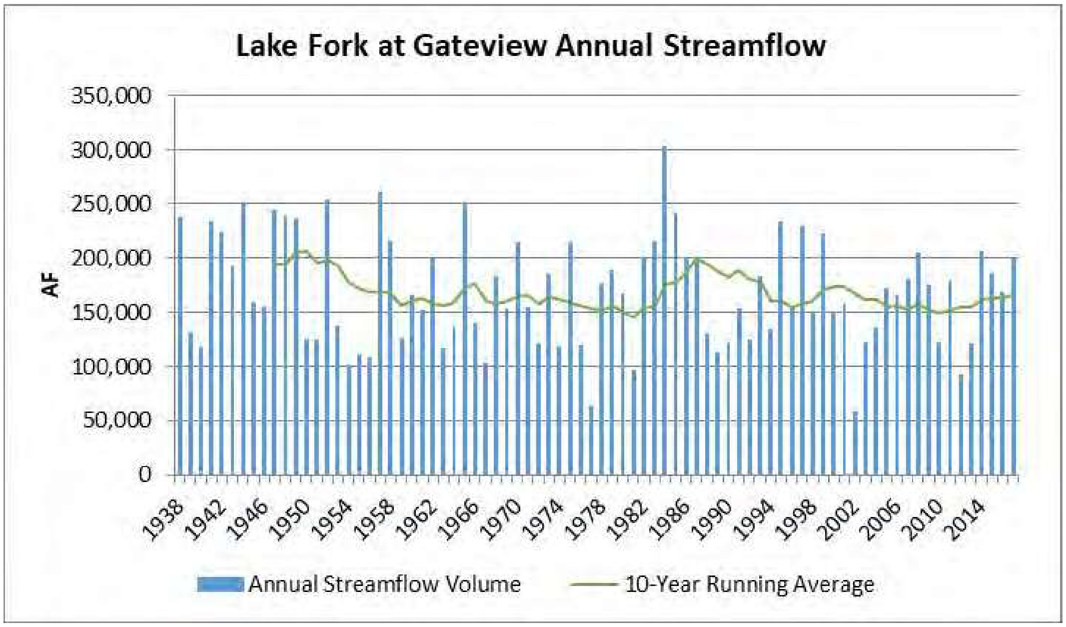


Figure 2-3: Lake Fork at Gateview Annual Streamflow (1938-2017) in acre-feet

Figure 2-4 shows the average monthly flow at the Lake Fork at Gateview gage from 1998 through 2017. Water from snowmelt runoff in May, June, and July accounts for nearly 70 percent of the annual streamflow.

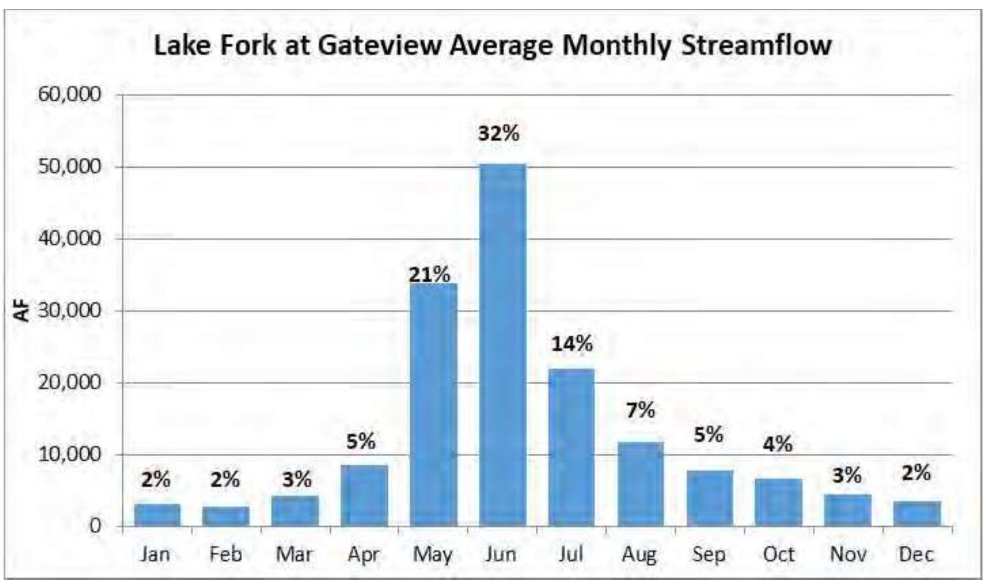


Figure 2-4: Lake Fork at Gateview Average Monthly Streamflow (1998-2017)

2.2 Climate Data

Crop irrigation demands are dependent on weather and temperature during the irrigation season. Figure 2-5 highlights the variability of average irrigation season temperature (May through September) at the long-term NWS Coop station in Lake City. The 10-year running average shows a clear trend toward higher temperatures during the non-irrigation season since 1980. There has not been a trend toward higher temperatures during the October through April period.

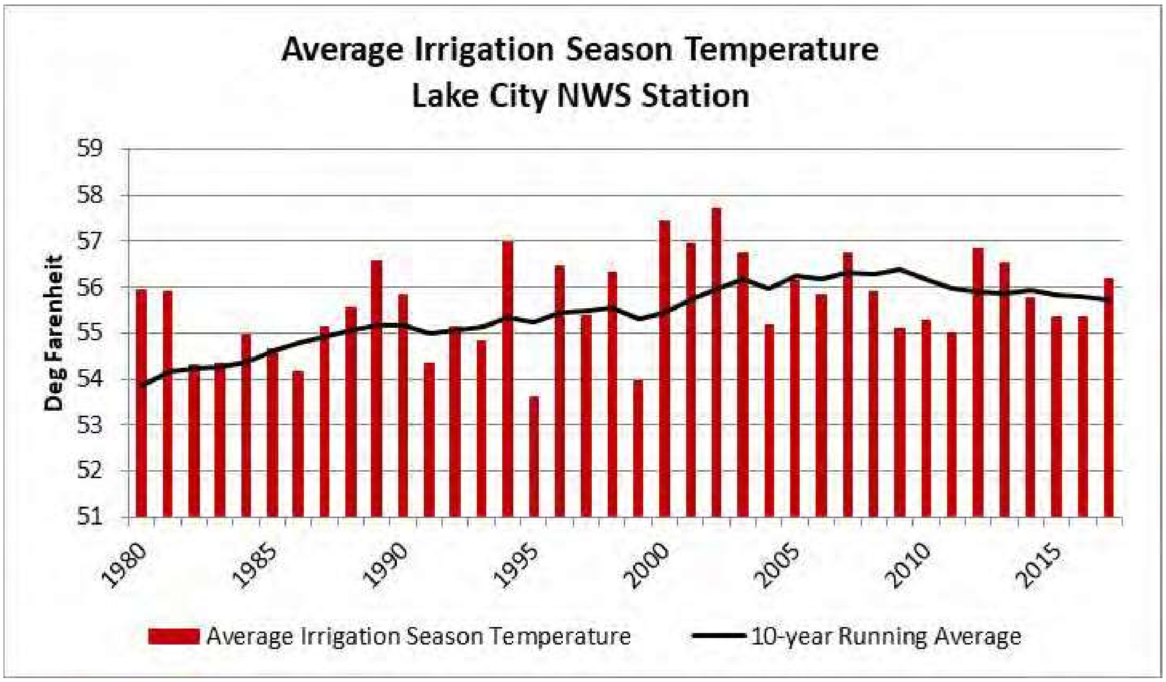


Figure 2-5: Average Irrigation Season Temperature at Lake City (1980-2017)

Precipitation during the irrigation season reduces the amount of water required from irrigation to meet crop demands. Figure 2-6 highlights the variability of total precipitation during irrigation season (May through September) also recorded at the long-term NWS Coop station. As shown, the total precipitation during irrigation season varies from 11.8 inches in 1982 to only 4.1 inches in 1980. Even though precipitation has been relatively high from 2012 through 2017, the 10-year average has yet to recover from the drier summers between 2008 and 2011. Note that although higher irrigation season precipitation reduces the amount of water crops need from an irrigation source, water available from runoff is the primary factor in river diversion variability.

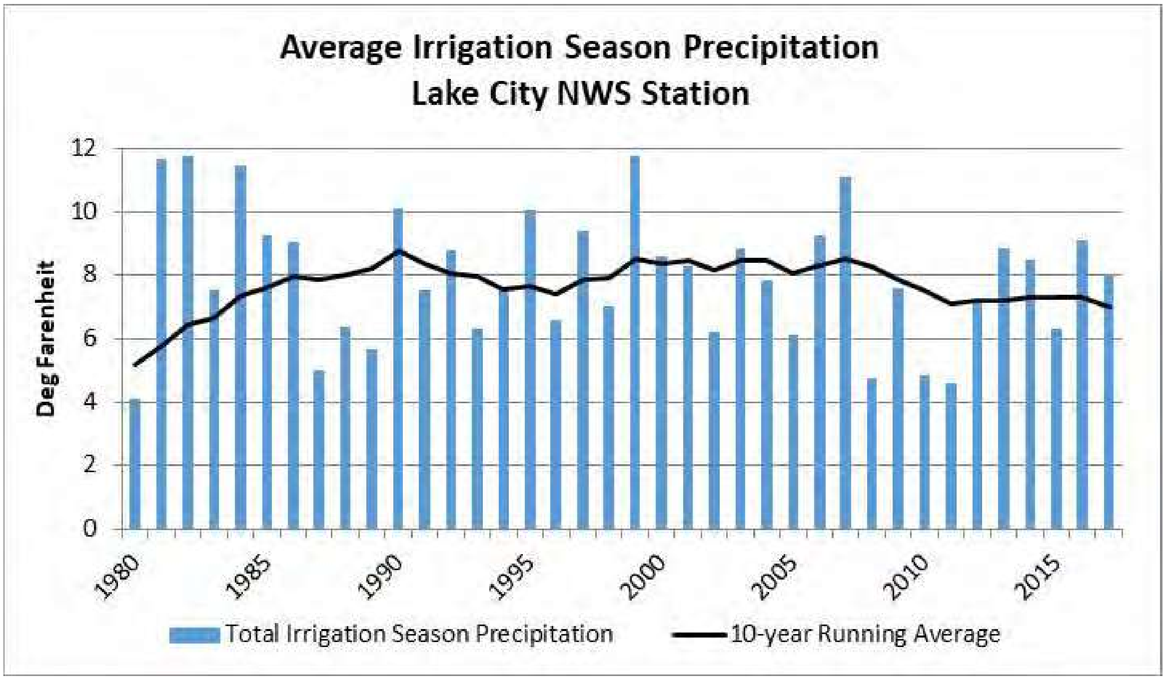


Figure 2-6: Total Irrigation Season Precipitation at Lake City (1980-2017)

2.3 Irrigation Acreage

The majority of consumptive water use in the Upper Gunnison River Basin is for irrigation of pasture grass; therefore, it is essential to accurately represent the irrigated acreage and associated irrigation demand. CWCB developed irrigated acreage snapshots for the Gunnison River Basin for 1993, 2005, 2010, and 2015 as a key component of the CDSS. The data sets include acreage, crop type, and associated river diversion ditch or canal. The WMP assessment determined that the acreage was appropriately represented, but the association between acreage and the supply ditch was not detailed enough to accurately tie the acreage to diversions and associated water rights. Through discussions with CWCB and DWR, it was recognized that the irrigated acreage assessment needed to be refined and disaggregated to represent each ditch discreetly.

During this assessment, consultants worked with local water commissioners and water users to more accurately tie irrigated acreage to the source ditch and associated water rights. This was a major effort and resulted in a more accurate representation of irrigation demands for each active ditch in the Upper Gunnison River Basin. This information was provided to the state, and consultants continue to work with CWCB to make the corresponding updates to the historical GIS snapshot coverages (2010, 2005, and 1993) for inclusion in the State's records. Each of the updated coverages will be made available on the CDSS website.

Given the difficulty in obtaining accurate historical diversion records, it is especially important to understand local and ditch-specific irrigation practices to inform planning efforts.

Although irrigation is not a large user of water in the Lake Fork Basin, it is the basin's largest consumptive water use. Pasture grass is the primary crop grown in the Lake Fork Basin and supports small-scale cattle operations and horse properties. The total irrigated acreage in the Lake Fork Basin as of 2015 is approximately 1,500 acres. Based on review of aerial photos, and discussion with local water experts, there has been only a slight reduction in irrigated acres in recent years.

Pasture grass is grown on all of the irrigated acreage in the basin. Water is applied using flood irrigation techniques. Some of the diversions are "push-up" dams that are re-worked each irrigation season. Depending on spring temperatures, irrigators begin applying water to their fields in early May, with irrigation generally beginning earlier in the lower portions of the Basin. Irrigators get one cutting of hay each summer in late July or early August. After cutting, some users will continue to irrigate while many of the smaller enterprises will keep their fields dry to allow their cattle or horses to graze. It generally takes 1 to 2 weeks to dry out, so diversions are cut back in the first or second week of July. Although this practice is widespread, decreased diversion rates to allow for dry out during the hay harvest are not reported in the diversion records.

There has never been an administrative water right call on the Lake Fork mainstem and there generally is physical water available through the fall. Cutting back or ceasing irrigation during the summer or early fall is generally an irrigator's choice and not reflective of water supply conditions. Several of the lower tributaries to the Lake Fork, including Trout Creek, Elk Creek and Indian Creek, have diversions near the confluence that can cause significant depletion of natural flows. Regardless of diversions, these tributaries experience minimal flows in the late summer.

2.4 Water Rights

DWR created unique identifiers for each of the decreed points of diversion. DWR developed the official water rights tabulation, based on water court decrees, and assigned each water right to the associated ditch. Based on consultants' experience in the Gunnison Basin and other basins throughout Colorado, the water rights assignments in HydroBase are believed to be accurate and appropriate for use in the WMP efforts.

The Lake Fork Basin has minimal active storage; just over 2,000 acre-feet of absolute storage rights primarily for recreation, stock, wildlife, and augmentation. In addition to active storage, there is approximately 14,000 acre-feet decreed by CWCB to protect minimum levels in natural lakes, most of it decreed for Lake San Cristobal. Lake San Cristobal also has active storage for other uses including augmentation, as discussed further below.

Figure 2-7 represents the cumulative absolute direct flow water rights in the Lake Fork Basin, highlighting major basin adjudication dates and key water rights. The DWR Administration Number indicates the water right priorities based on both appropriation date and adjudication date and is used by DWR for administration throughout the state. As discussed in Section 1,1 of

Chapter 2 and shown in the figure, Aspinall Unit water rights are subordinated to current and future Upper Gunnison River Basin water rights junior to the Aspinall Unit water rights up to 40,000 acre-feet of annual depletions.

The figure also highlights the major water rights adjudication dates in the Lake Fork Basin and other key water rights dates that can impact the Lake Fork Basin water rights, including the Gunnison Tunnel adjudication date and the date of the Colorado River Compact.

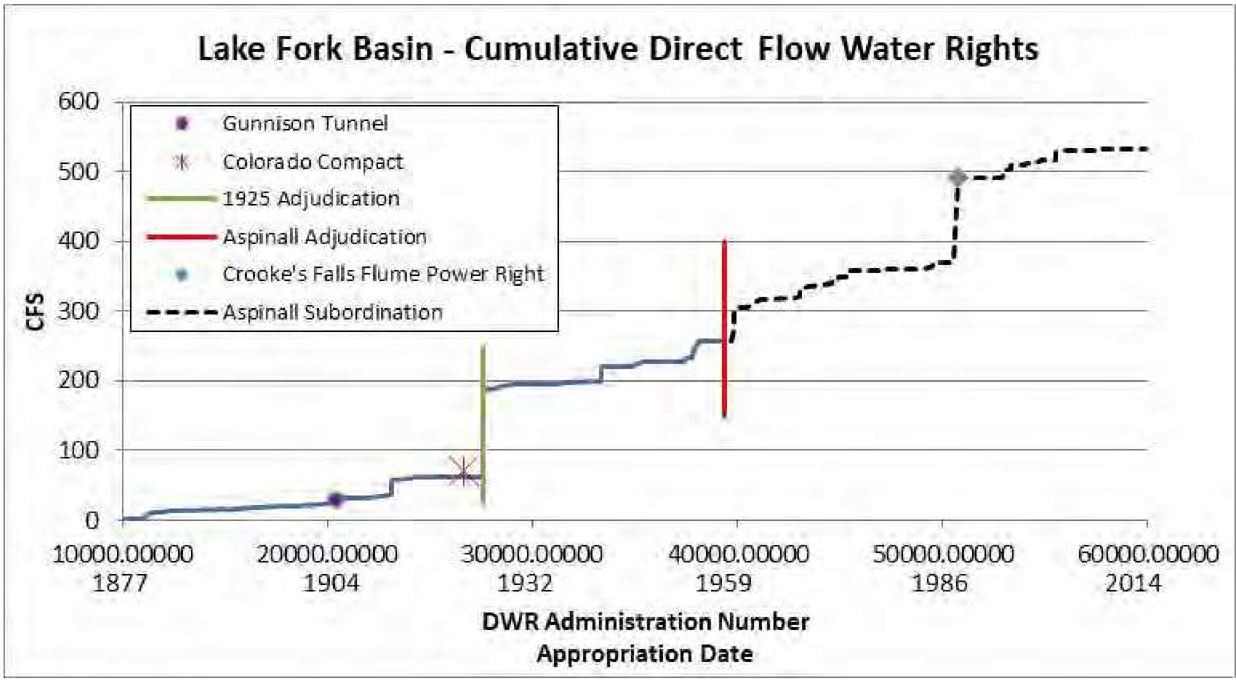


Figure 2-7: Lake Fork Basin Cumulative Absolute Direct Flow Water Rights

There are conditional direct flow water rights totaling 268 cfs in Lake Fork Basin. Two conditional water rights account for most of the decreed rate: Hidden Treasure Pipeline has a 215 cfs conditional water right for commercial use, and Crooke's Fall Flume has a conditional water right for 29 cfs. Most of the remaining conditional water rights are for domestic use, with rates of less than 1 cfs. Conditional storage rights total 2,110 acre-feet in the Lake Fork Basin. Most of the conditional storage rights (1,900 acre-feet) are for all uses, including augmentation, in Lake San Cristobal.

The Lake Fork Basin includes 33 decreed instream flow water rights, shown in Table 2-2 and Figure 2-8. Details of these rights are described in Sections 5 through 10 of this Chapter. These rights are junior to most of the irrigation rights in the basin. Most instream flow rights in the Lake Fork Basin were appropriated between 1980 and 1984. In 2009, three instream flow water rights were increased to accommodate larger flows during runoff and summer months.

Table 2-2: Existing CWCB Instream Flow Rights in the Lake Fork Basin

Waterbody Name	Upper Terminus	Lower Terminus	Appropriation Date	Length (miles)	Winter Rate (cfs)	Summer Rate (cfs)
Alpine Gulch	Headwaters of Alpine Gulch	Confluence with Henson Creek	1/26/2010	5.7	1	5
Bent Creek	Near the headwaters of Bent Creek	Confluence with Lake Fork River	1/27/2009	3.0	2	3.55
Cataract Gulch	Outlet of Cataract Lake	Confluence with Cottonwood Creek	3/17/1980	3.8	5	
Cooper Creek	Outlet of Cooper Creek	Confluence with the Lake Fork River	3/17/1980	3.6	2	
Cottonwood Creek	Confluence with Snare Creek and Cuba Gulch	Confluence with Lake Fork River	3/17/1980	4.0	12	
Cuba Gulch	Headwaters of Cuba Gulch	Confluence with Cottonwood Creek	3/17/1980	4.0	5	
Devils Creek	Headwaters of Devils Creek	Steele Ditch Headgate	1/29/1998	3.4	0.75	0.75
Elk Creek	Headwaters of Elk Creek	Confluence with the Lake Fork River	3/17/1980	10	3	
El Paso Creek	Near Headwaters of El Paso Creek	Confluence with Henson Creek	7/7/1983	3.6	3	
Fourth of July Creek	Headwaters of Fourth of July Creek	Carris Thompson Ditch Headgate	1/16/2016	6.0	0.6	1.1
Grizzly Gulch	Outlet of Grizzly Lake	Confluence with the Lake Fork River	1/27/2009	2.1	0.6	2.9

Waterbody Name	Upper Terminus	Lower Terminus	Appropriation Date	Length (miles)	Winter Rate (cfs)	Summer Rate (cfs)
Henson Creek – Lower	Confluence with Nellie Creek	Confluence with the Lake Fork River	5/4/1984	5.5	15	25
Henson Creek – Middle	Confluence with North Fork Henson Creek	Confluence with Nellie Creek	5/4/1984 1/27/2009	3.6	12	23
Henson Creek – Upper	Confluence with Palmetto Gulch	Confluence with North Fork Henson Creek	5/4/1984	7.2	9	
Independence Gulch	Headwaters of Independence Gulch	Confluence with the Lake Fork River	3/17/1980	5.5	1	
Lake Fork River – Lower	Confluence with Henson Creek	Confluence with Blue Mesa Reservoir	3/17/1980	30.4	25	45
Lake Fork River – Middle	Confluence with Cottonwood Creek	Confluence with Henson Creek	3/17/1980	16.4	20	35
Lake Fork River – Upper	Outlet of Sloan Lake	Confluence with Cottonwood Creek	3/17/1980	9.6	18	
Larson Creek	Headwaters of Larson Creek	Confluence with the Lake Fork River	3/17/1980	5.1	2	
Mill Gulch	Headwaters of Mill Gulch	Confluence with Lake Fork River	3/17/1980	3.0	4	
Nellie Creek	Headwaters of Nellie Creek	Confluence with Henson Creek	7/7/1983	5.8	2.5	
North Fork Henson Creek – Lower	Confluence with	Confluence with Henson Creek	5/4/1984	2.4	10	

Waterbody Name	Upper Terminus	Lower Terminus	Appropriation Date	Length (miles)	Winter Rate (cfs)	Summer Rate (cfs)
	Matterhorn Creek					
North Fork Henson Creek – Upper	Headwaters of North Fork Henson Creek	Confluence with Matterhorn Creek	5/4/1984	3.7	2	
Schafer Gulch	Headwaters of Schafer Gulch	Confluence with Henson Creek	5/4/1984 1/27/2009	1.8	1 2.3	
Silver Creek	Near the headwaters of Silver Creek	Confluence with Lake Fork River	3/17/1980	2.2	4	
Snare Creek	Headwaters of Snare Creek	Confluence with Cuba Gulch	3/17/1980	2.8	5	
Trout Creek	Headwaters of Trout Creek	Johnson Ditch Headgate	5/11/1998	7.5	0.75	1.25
Wager Gulch	Headwaters of Wager Gulch	Confluence with Lake Fork River	3/17/1980	2.7	5	
Williams Creek	Near the headwaters of Williams Creek	Confluence with Lake Fork River	3/17/1980	2.3	1	
Willow Creek	Headwaters of Willow Creek	Confluence with Blue Mesa Reservoir	3/17/1980	17.7	2	
Schafer Gulch	Headwaters of Schafer Gulch	Confluence with Henson Creek	5/4/1984 1/27/2009	1.8	1	2.3
Silver Creek	Near the headwaters of Silver Creek	Confluence with the Lake Fork River	3/17/1980	2.2	4	
Snare Creek	Headwaters of Snare Creek	Confluence with Cuba Gulch	3/17/1980	2.8	5	

Waterbody Name	Upper Terminus	Lower Terminus	Appropriation Date	Length (miles)	Winter Rate (cfs)	Summer Rate (cfs)
Trout Creek	Headwaters of Trout Creek	Johnson Ditch Headgate	5/11/1998	7.5	0.75	1.25
Wager Gulch	Headwaters of Wager Gulch	Confluence with Lake Fork River	3/17/1980	2.7	5	
Williams Creek	Near the headwaters of Williams Creek	Confluence with Lake Fork River	3/17/1980	2.3	1	
Willow Creek	Headwaters of Willow Creek	Confluence with Blue Mesa Reservoir	3/17/1980	17.7	2	

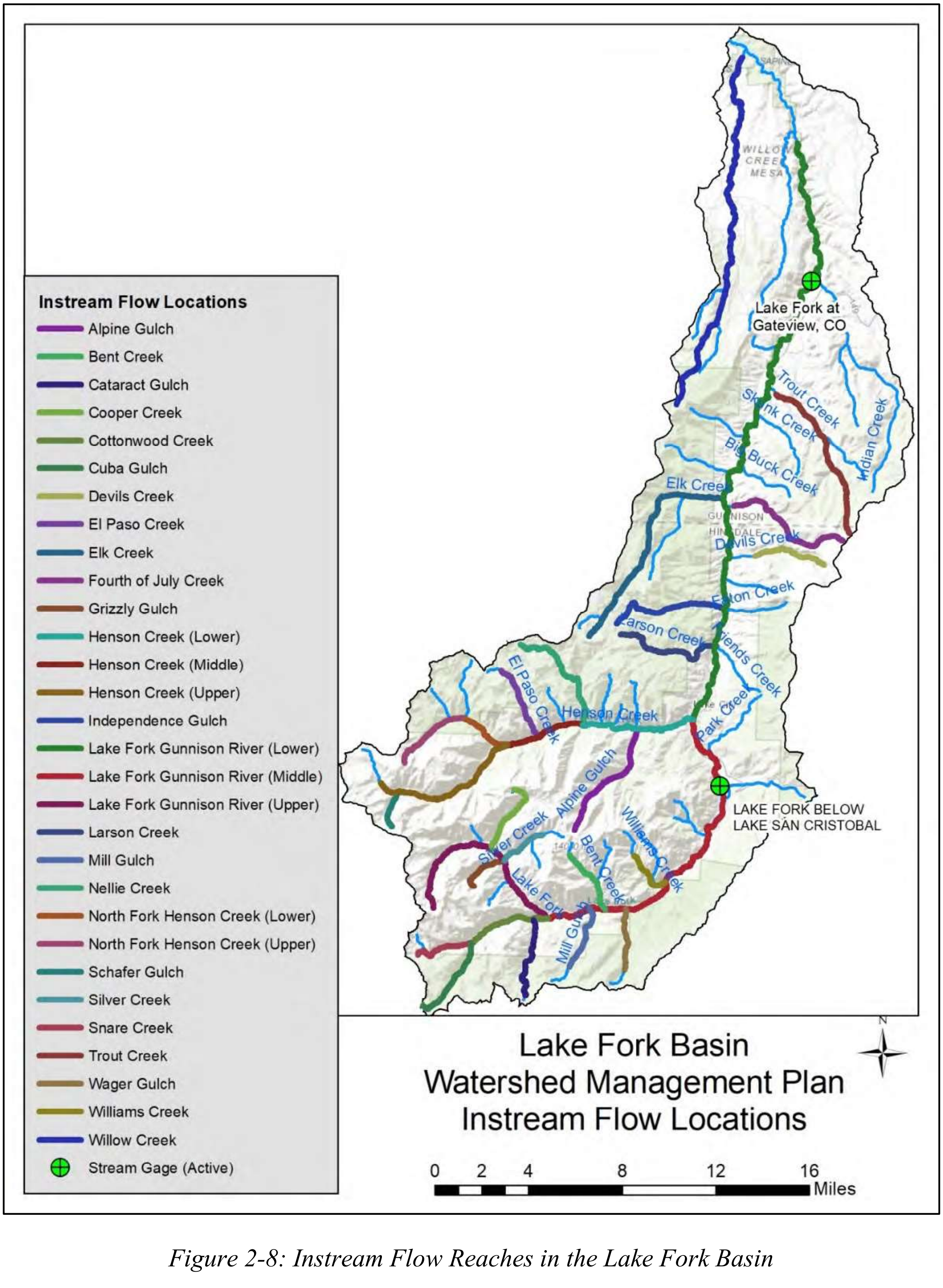


Figure 2-8: Instream Flow Reaches in the Lake Fork Basin

Figure 2-9 shows the instream flow rights along with the cumulative direct flow water rights. Total decreed instream rates are almost half of the rates decreed for irrigation use.

On top of the Lake San Cristobal minimum water level is 950 acre-feet of water reserved for augmentation, and managed by the Lake San Cristobal Water Activity Enterprise, a partnership of UGRWCD, Town of Lake City, and Hinsdale County.

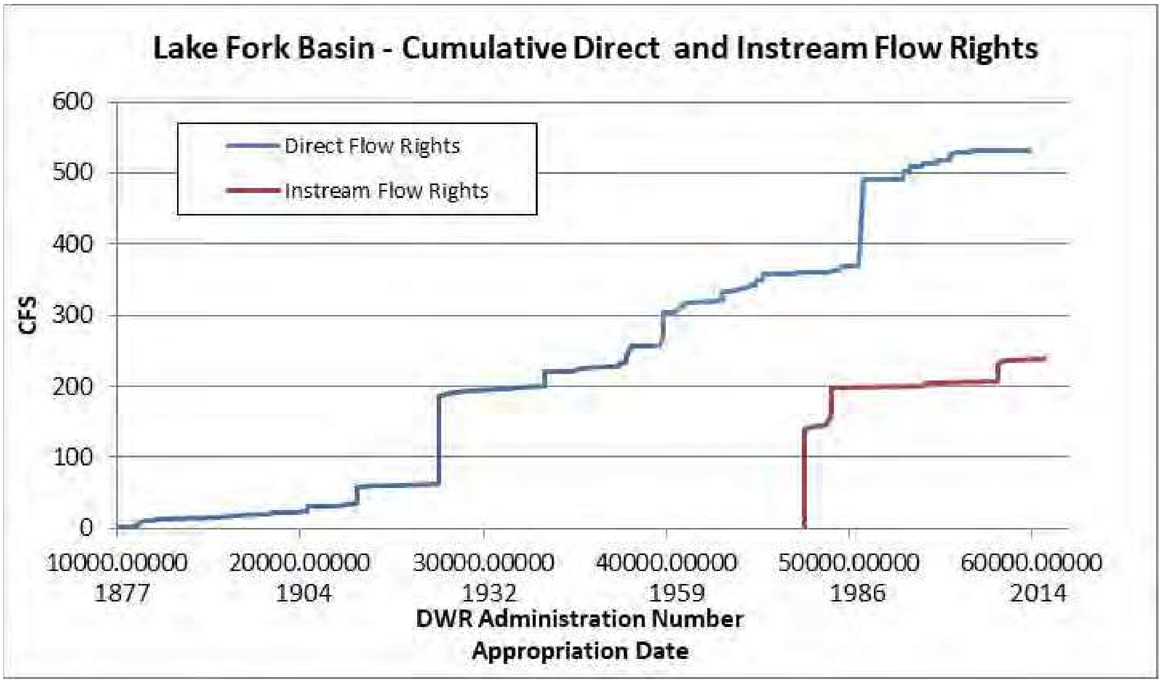


Figure 2-9: Lake Fork Basin Cumulate Direct Flow and Instream Flow Water Rights

CWCB also has storage rights to protect minimum water levels in seven natural lakes in the Lake Fork Basin, totaling 14,017 acre-feet. The largest right for minimum water levels is 13,545 acre-feet for Lake San Cristobal. The other six natural lakes are near the headwaters, above other water right uses.

2.5 Diversion Records

The water commissioner is responsible for recording diversions for over 275 ditches that divert water various uses in Water District 62, of which only a portion divert in the Lake Fork Basin. Many of the ditch headgates are challenging to access and require a significant amount of time to visit. Diversion records are either provided by the water user annually or, most commonly, by a "spot-diversion" record. A spot-diversion is reported when the water commissioner visits the headgate and records the amount of water diverted on that date and time.

DWR uses the "fill-forward" approach where the spot-diversion record is repeated for each day until the water commissioner again visits the headgate and reports an updated diversion rate.

Based on the review of diversion records and discussions with the water commissioner, it is common for him to visit each headgate only once per month during the irrigation season. Note, that although this is typical of most water districts in western Colorado, diversion records do not mimic changes in daily stream or ditch flow. In addition, daily variation in flows, most notably during runoff or following large precipitation events, can cause diversion rates to change throughout the day, which cannot be captured even if the water commissioner visited each diversion once per day. Figure 2-10 provides example diversions in the Lake Fork Basin for 2011 and 2012 where the standard fill-forward approach was used by DWR. In many cases, the irrigation start and stop dates are estimated by the water commissioner rather than reported by the water users. The diversion records do not include information about operational practices; for example, reducing diversions to allow fields to dry before haying.

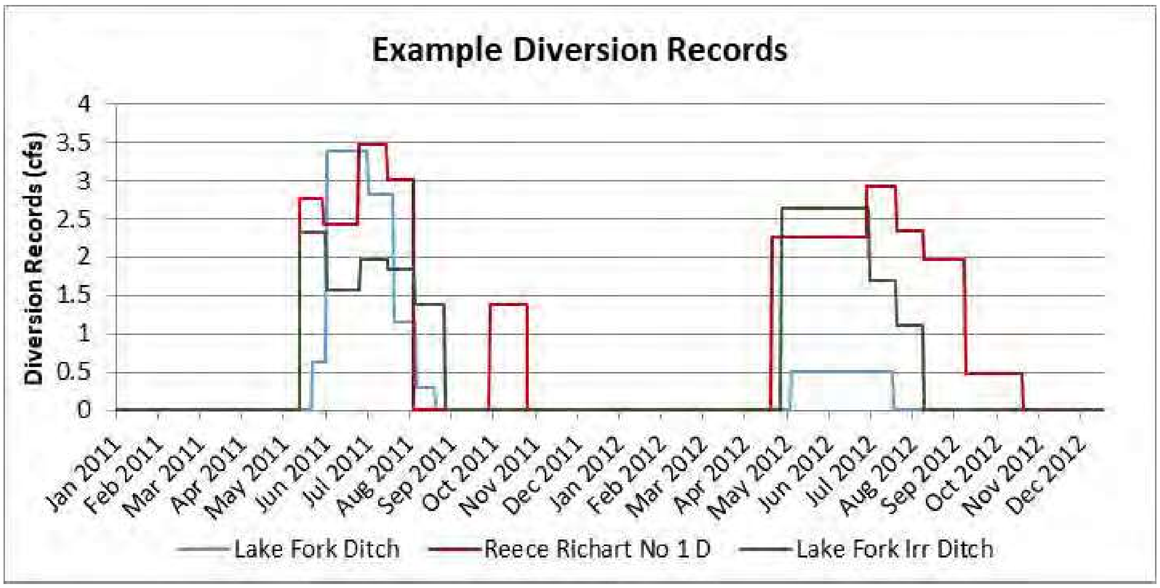


Figure 2-10: Example of the Fill-Forward Approach for Reporting Diversions

Consultants also identified the number of diversions that have Parshall Flumes or other flow control measurement devices that allow both the water commissioner and water users to quickly record diversions. Based on information from the water commissioner, about 90 percent of the headgates actively diverting for irrigation in the Lake Fork Basin have a measurement device. For diversions without measurement devices, the water commissioner either estimates flow for the remaining structures using the “chip-test” approach by estimating velocity and depth to determine flow rate, or simply provides a “water taken but no data available” comment in the official record.

Based on the review of diversion records, discussions with the water commissioner, and feedback from the Division 4 Engineer, the most effective way to improve diversion records is to encourage irrigators to document their use on a daily or weekly basis, in addition to installing flumes. More specifically, they can report dates when they start and stop irrigating each year and provide flume measurements when diversions increase or decrease with flows in the river. An important process for the WMP is to inform irrigators that keeping accurate diversions records and providing those records to the water commissioner is the best way they can protect their water rights.

The diversion records maintained by DWR are still the best source of data available. There are 47 active irrigation ditches in the Lake Fork Basin. For the recent period from 2008 to 2017 (excluding 2016), diversions averaged 17,220 acre-feet per year. Note that Water District 62 had an open water commissioner position in 2016, and no diversions were reported for the year. Similar to streamflow, annual diversions are variable, as shown in Figure 2-11. On average, irrigation diversions in the Lake Fork Basin are around 10 percent of streamflow measured at the Lake Fork at Gateview gage.

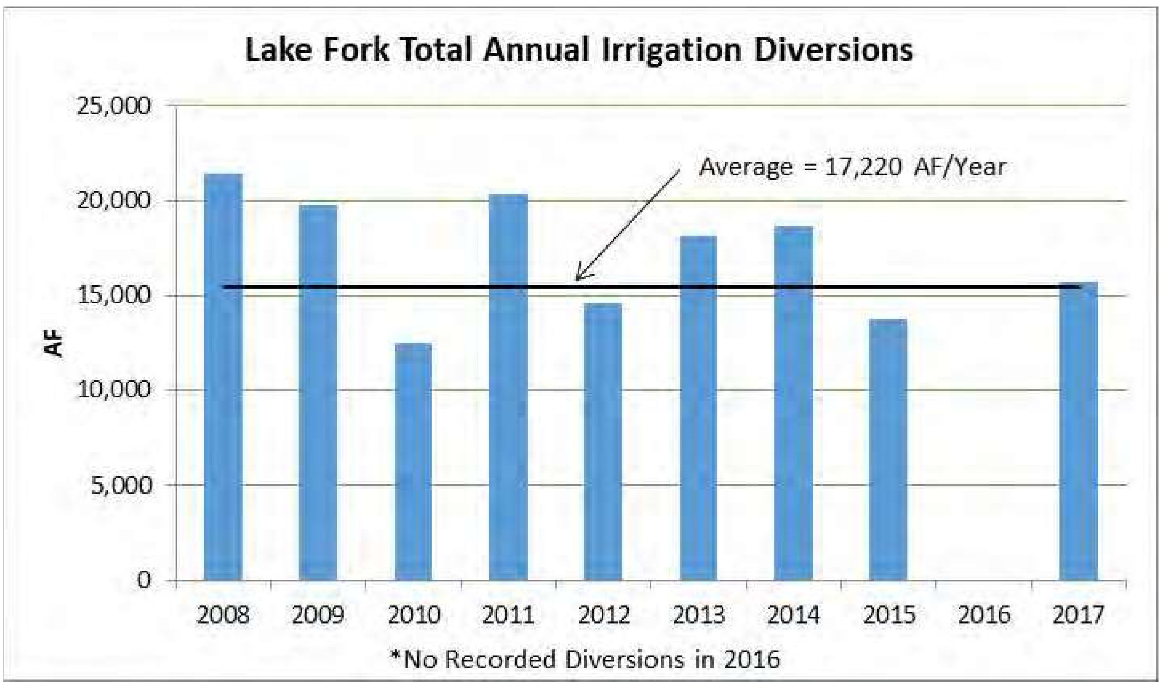


Figure 2-11: Annual Lake Fork Basin Diversions

Figure 2-12 shows total monthly irrigation diversions for a representative average (2009), wet (2008), and dry (2012) hydrologic year in the Lake Fork Basin. As shown, the annual amount diverted is similar for the representative wet and average years. In the 2012 representative dry year, reduced runoff resulted in lower diversions throughout the irrigation season. Water supply dropped off significantly in July 2012.

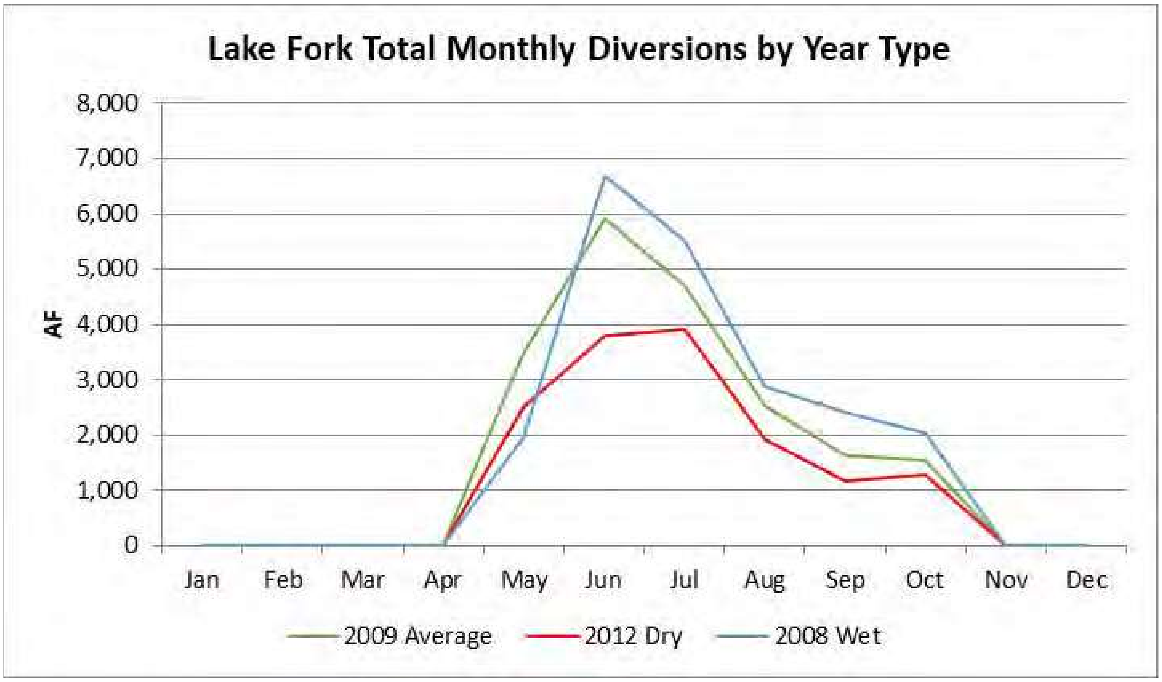


Figure 2-12: Monthly Lake Fork Basin Irrigation Diversions for Representative Years

Figure 2-13 shows the location and magnitude of average annual diversions in the Lake Fork Basin. About half of the ditches divert less than 200 acre-feet per year.

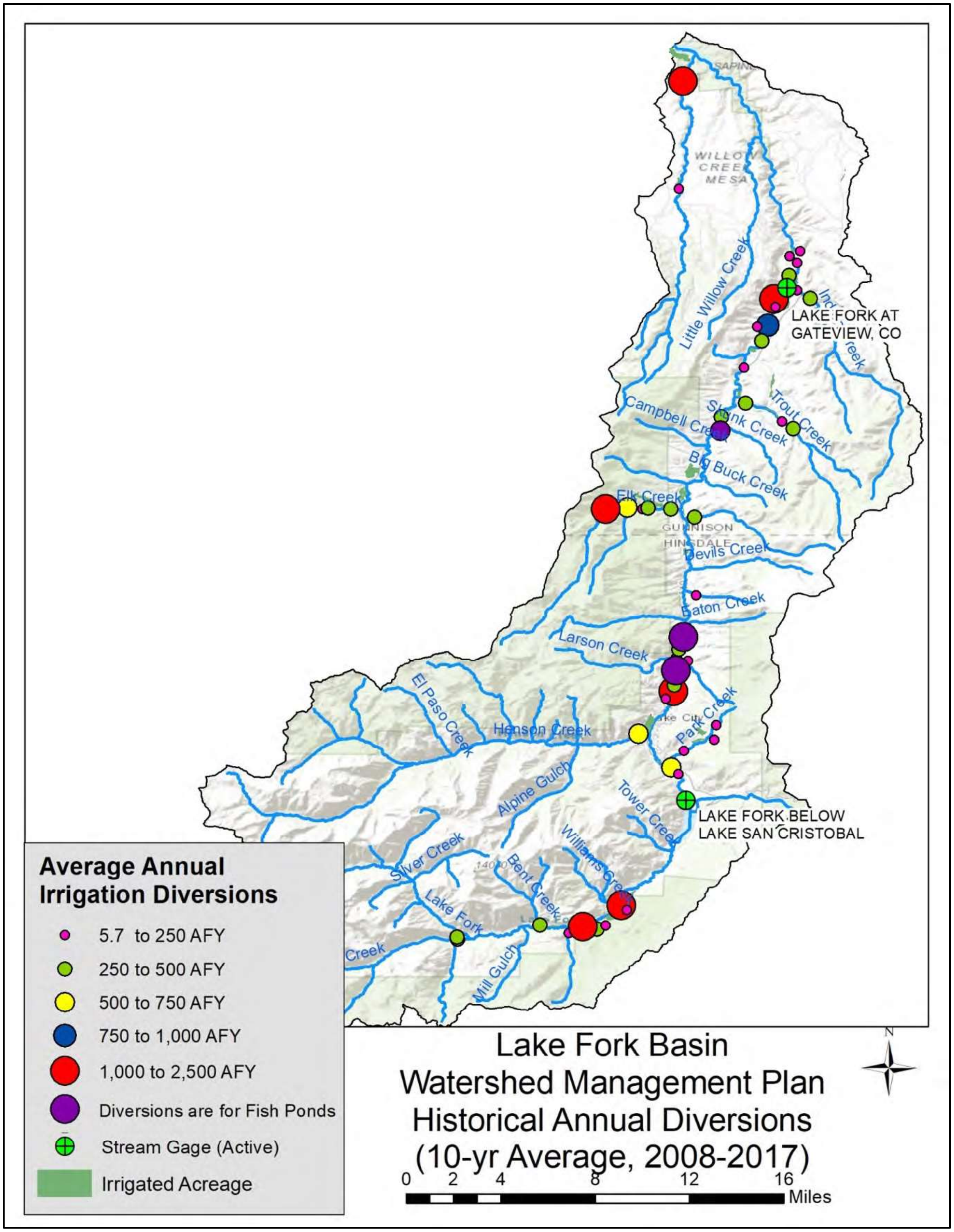


Figure 2-13: Average Annual Historical Irrigation Diversions, 2008-2017

In addition to diversion for irrigation, there are currently over 15 ditches that have recorded diversions to fish ponds for flow-through and evaporation replacement.

2.6 Return Flow Parameters

Representing return flow quantities, locations, and timing are critical for investigating the changes to river flows and water availability at downstream locations. Many of the opportunities to improve watershed health include changes in irrigation use, including efficiency improvements. It is important to accurately represent return flow parameters in StateMod to understand comparative changes to streamflow, and potential impacts to downstream water right holders.

Section 3. Needs Assessment Methods

The Lake Fork Basin was split into six reaches with unique characteristics and challenges. The three Lower Lake Fork Tributaries are combined into one reach description. The approach to investigating consumptive water needs, environmental and water quality needs, and recreational needs was tailored for specific reaches. Figure 3-14 shows the reaches. Table 3-3 summarizes general characteristics of each reach and the issues identified by stakeholders. Specific characteristics and issues are discussed in Sections 5 through 10 of this Chapter.

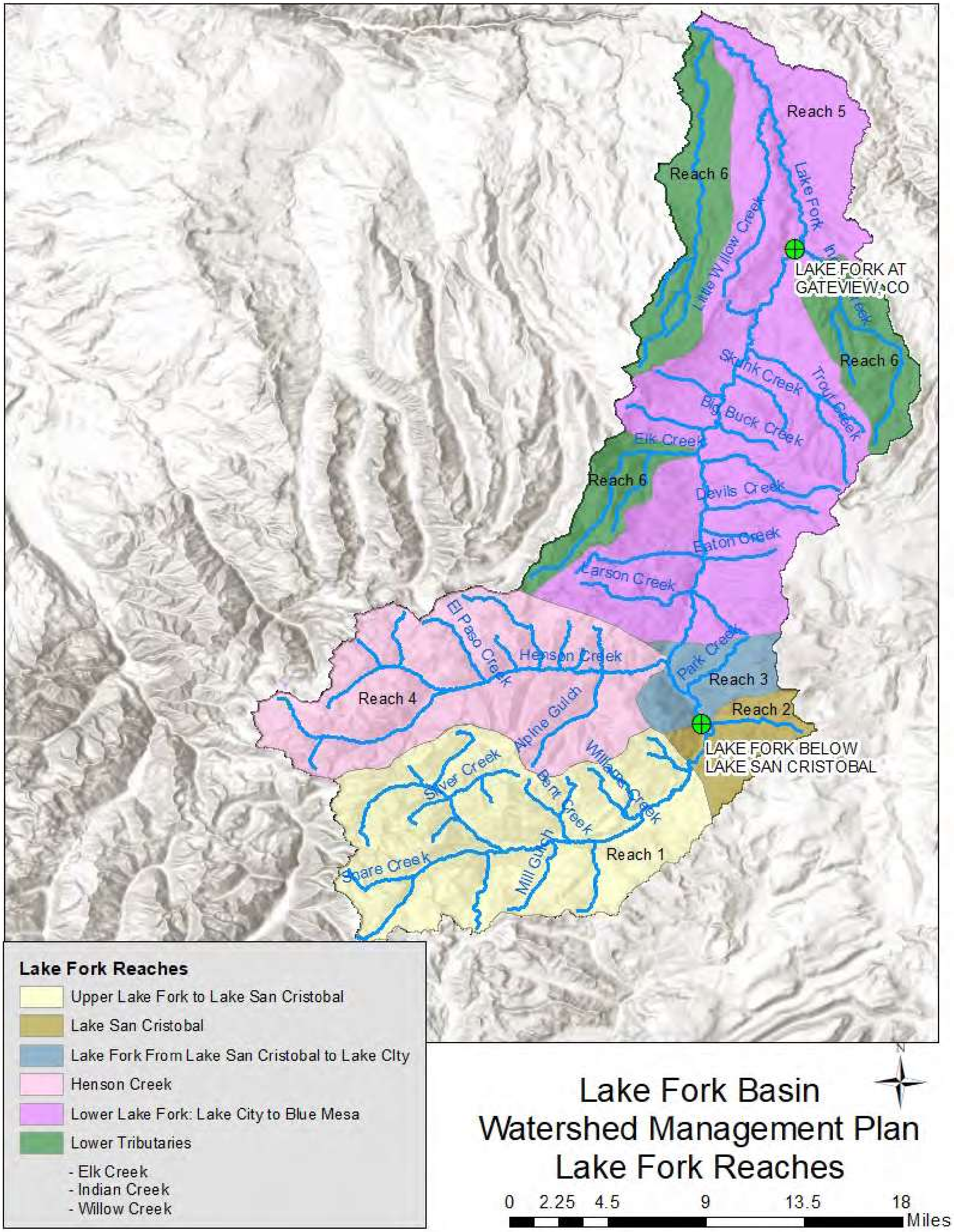


Figure 3-14: Lake Fork Basin Reaches

Table 3-3: Lake Fork Basin Reach Characteristics

Reach	General Characteristics	Stakeholder Identified Issues
Upper Lake Fork to Lake San Cristobal	Predominately agricultural, some domestic use (wells), fish ponds	Water quality, habitat health, habitat connectivity, water supply shortages
Lake San Cristobal	Predominately recreational, augmentation source, domestic use (wells)	Water quality, water temperature, sediment delivery, infrastructure
Lake Fork from Lake San Cristobal to Lake City	Agricultural, municipal, some recreational, hydroelectric power, fish ponds	Water quality, water temperature, water supply shortages, habitat connectivity, fish and macroinvertebrate habitat, land conservation
Henson Creek	Municipal (irrigation and fire protection), domestic use (wells), recreational	Water quality and water supply shortages
Lower Lake Fork: Lake City to Blue Mesa	Agricultural, domestic use (wells), recreational, fish ponds	Water supply shortages, stream stability, flood risk, habitat health, water temperatures, recreational conflicts
Lower Tributaries: Elk Creek, Indian Creek, Willow Creek	Agricultural, domestic use (wells), recreational	Water quality and water supply shortages

Identified uses and needs are different for each reach; therefore, different approaches were used to assess the needs and whether they are currently being met. Current uses and needs can generally be grouped into consumptive categories of agricultural, industrial, and municipal water use, and non-consumptive categories of environmental and recreational flows. Understanding existing uses and assessing future needs for all three categories requires an understanding of hydrologic variability both throughout the year and for different hydrologic year types.

Section 4. Assessing Current Uses

4.1 Agricultural Water Use

This assessment details irrigation diversions, consumptive use, and return flows to assist in developing options to address issues identified by stakeholders.

Consumptive use analyses compare expected crop water demand to actual crop water use to identify consumptive use shortages. Consumptive use analyses also estimate permanent depletions to the river attributed to crop consumptive use, and temporary depletions to the river which are caused by conveyance and application inefficiencies. Conveyance loss is water that infiltrates into the soil in route to the field. Conveyance losses return to the river, generally within a few days to weeks of diversion. Application losses are the portion of water applied to an irrigated field that returns to the river through surface runoff or infiltrates beyond the crop root zone and lags back the river.

StateCU was used to perform a consumptive use analysis to estimate agricultural water shortages from 1998 to 2017. First, StateCU estimates crop demand – the amount of water the crops could use if provided a full irrigation supply – based on monthly climate data and irrigated acreage. Next, StateCU uses diversion records and estimated conveyance and application efficiencies to determine the actual (supply-limited) crop consumptive use and associated shortages. Consumptive use shortages occur when the crop demand is greater than the crop consumptive use. Diversion records limit the reliability of the consumptive use analysis, because often a single instantaneous diversion rate is reported for up to a 30-day period; and the records do not report actual start and stop dates. Despite their limitations, the diversion records are the best available information for agricultural water use.

Conveyance efficiencies vary based on soil permeability and ditch length and have been estimated for each ditch in the Lake Fork Basin. In the Lake Fork Basin, conveyance efficiencies range from 75 to 90 percent depending on ditch length. Flood irrigation application efficiency is also estimated based on soil types, soil thickness, and underlying geology. The soil profile overlays gravel deposits, therefore application efficiency is relatively low. Based on information from decrees and soil reports, a maximum application efficiency of 45 percent was used for irrigation in the Lake Fork Basin.

The estimated annual diversions often exceed the annual crop demands in the Lake Fork Basin. Based on review of early decrees for water rights on the Lake Fork, a common duty of water was 1 cfs per 40 acres, reflecting that the soils are relatively porous. Note that the Lake Fork soils are not as cobbly or porous as soils in other areas of the Upper Gunnison River Basin, including the East River and the Tomichi Creek Basins. This is still a relatively low duty of water; in other areas in Colorado where the duty of water is typically between 1 cfs per 40 acres and 1 cfs per 80 acres, meaning the soils in the Lake Fork Basin can require up to two times more water than some other areas in the state.

The amount of water diverted at the river headgate is not all available to meet crop demands. The amount available to the crop is the diverted water less ditch conveyance loss and irrigation application losses. For example, if 100 acre-feet is diverted and the conveyance loss is 20 percent, only 80 acre-feet is available at the farm turnout. The maximum flood application efficiency, based on the porous nature of the soil, is 45 percent; therefore, of the 100 acre-feet diverted in this example, only 36 acre-feet (80 acre-feet x 45 percent) is available to meet crop demands. As noted, the accuracy of the crop consumptive use estimate is highly dependent on the accuracy of diversion records.

Excess water applied to the fields during flood irrigation returns to the river over time. Based on irrigation surface runoff; aquifer characteristics; and the location of the irrigated parcels, over 50 percent of diversions not consumed by crops are estimated to return to the river within four days of application, with over 85 percent returning within two months of application.

Figure 4-15 shows the annual variability of agricultural water use for the period 1998 through 2017. The results are for the Lake Fork Basin; but each ditch was represented individually in the consumptive use analysis. Average annual consumptive use from irrigation for 1998 through 2017 was 2,580 acre-feet, varying from a low of 1,890 in the extremely wet summer of 2017 to over 2,900 acre-feet in the hot, high-runoff year of 2011. No diversions were recorded in 2016 and there were also no diversions recorded until May of 2017, which may account for the lower than average consumptive use that year.

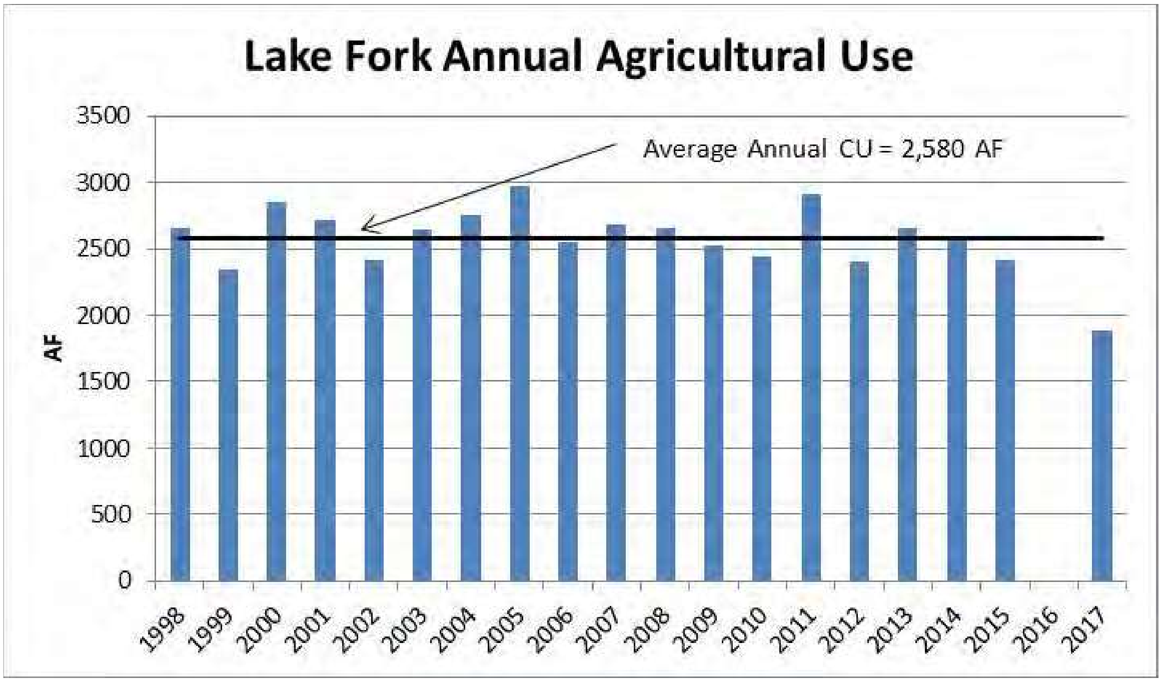


Figure 4-15: Annual Lake Fork Basin Agricultural Use, 1998 through 2017 (acre-feet)

Shortages to consumptive crop demands occur when the amount of water available to the irrigated fields is not enough to satisfy the full crop demands. The Lake Fork has a hydrograph dominated by snowmelt resulting in a supply of river water that is higher during the spring runoff and then decreases as the snowmelt runoff decreases. This leads to agricultural shortages during the late irrigation season and, in many years, throughout the irrigation season. Detailed results of the agricultural water use and needs are presented by reach in the reach sections [appendices]. In many cases, ditches divert water within a reach to irrigate lands physically located in a downstream reach. Because the stream depletions occur at the point of diversion, the consumptive use and associated shortages are reported based on the reach where the diversions occur.

4.2 Domestic Water Use

Municipal water providers and industrial water users were interviewed as part of the stakeholder outreach process. Existing uses and potential future needs were discussed with each entity. Detailed results of municipal and industrial water use and needs are presented by reach in the following sections.

There is one gold mine in the Lake Fork Basin that has been inactive for the past few years. At this, time it is not known if this mine will be reactivated. If such plans were to move forward, extensive analysis would be required to assure that water quantity and water quality of existing uses, including environmental uses and watershed health, would be protected. This assessment does not specifically address the impacts of potential mining operations.

4.3 Environmental Water Use

Several environmental characteristics were assessed and summarized based on information collected from existing studies, stakeholder interviews, and field assessments. The paragraphs below summarize the techniques used in the environmental water use and needs assessment.

4.3.1 Stream and Riparian Characteristics

The current condition of a stream and the adjacent riparian areas reflect the action of both natural processes and human activity. Stream and riparian characteristics provide important context to understand stream stability and watershed function. This assessment included a cursory review of channel and landscape form, debris supply, floodplain connectivity, stream stability, and physical structure. The objective of this portion of the assessment was to preliminarily evaluate issues identified by stakeholders and to support the selection of field assessment locations.

4.3.2 Aquatic Life

Perennial and intermittent streams within the Lake Fork Basin are typically expected to provide high-quality aquatic habitat, except where stressors have decreased the condition of the stream. Historic abandoned mines and runoff from developed areas are examples of water quality stressors that occur in some portions of the basin. some portions of the Lake Fork, environmental stressors overlap. The overlap may create outsized effects on the aquatic community. For example, the stress imposed by elevated zinc concentrations is exacerbated when stream temperatures are also elevated.

4.3.3 Water Quality

Aquatic life, recreation, agriculture, and water supply uses are applied to segments in the Lake Fork Basin. Each of the use classifications has specific standards for many water quality parameters. The water use classification with the most conservative criteria (e.g., lowest value) is applied as the effective standard for each parameter (e.g., temperature, nitrogen or lead). This approach assures that all water uses are protected because the use with the most conservative criteria is applied as the standard. In the Lake Fork Basin, the numeric standards associated with aquatic life (most metals), recreation (*E. coli*) or water supply (arsenic, iron) are typically the lowest and are therefore applied as the effective standard for many parameters.

4.3.4 Existing Instream Flow Water Rights

As part of this assessment, existing instream flow water rights were reviewed. During the review, the consultants evaluated original cross-section data, field notes, and R2CROSS model output. Unfortunately, due to their age, some instream flow segments in the Lake Fork Basin lacked some of the components included in the original proposal. Nevertheless, the review provided useful insights related to the existing instream flow water rights. In general, the original R2CROSS output and preliminary instream flow water rights were revised downward as a result of professional judgment and input from the local water commissioner, typically because of water availability limitations. The resulting instream flow rights are not consistent with current protocols for instream flow proposals. In many cases, the existing instream flow water rights in the Lake Fork Basin do not fully meet the physical criteria to preserve the natural environment to a reasonable degree.

In Sections 5 through 10 of this Chapter, a summary of the existing instream flow water rights is provided, as well as identifying locations where it may be possible to appropriate a new instream flow water right or enlarge the existing instream flow with a new instream flow appropriation or acquisition. Additional field work is likely needed to for any future instream flow proposals. Figure 4-16 shows the field assessment locations for the Lake Fork Basin. R2CROSS assessments and pebble counts were completed at nine locations. Further information about the R2CROSS results are presented in the respective reach sections.

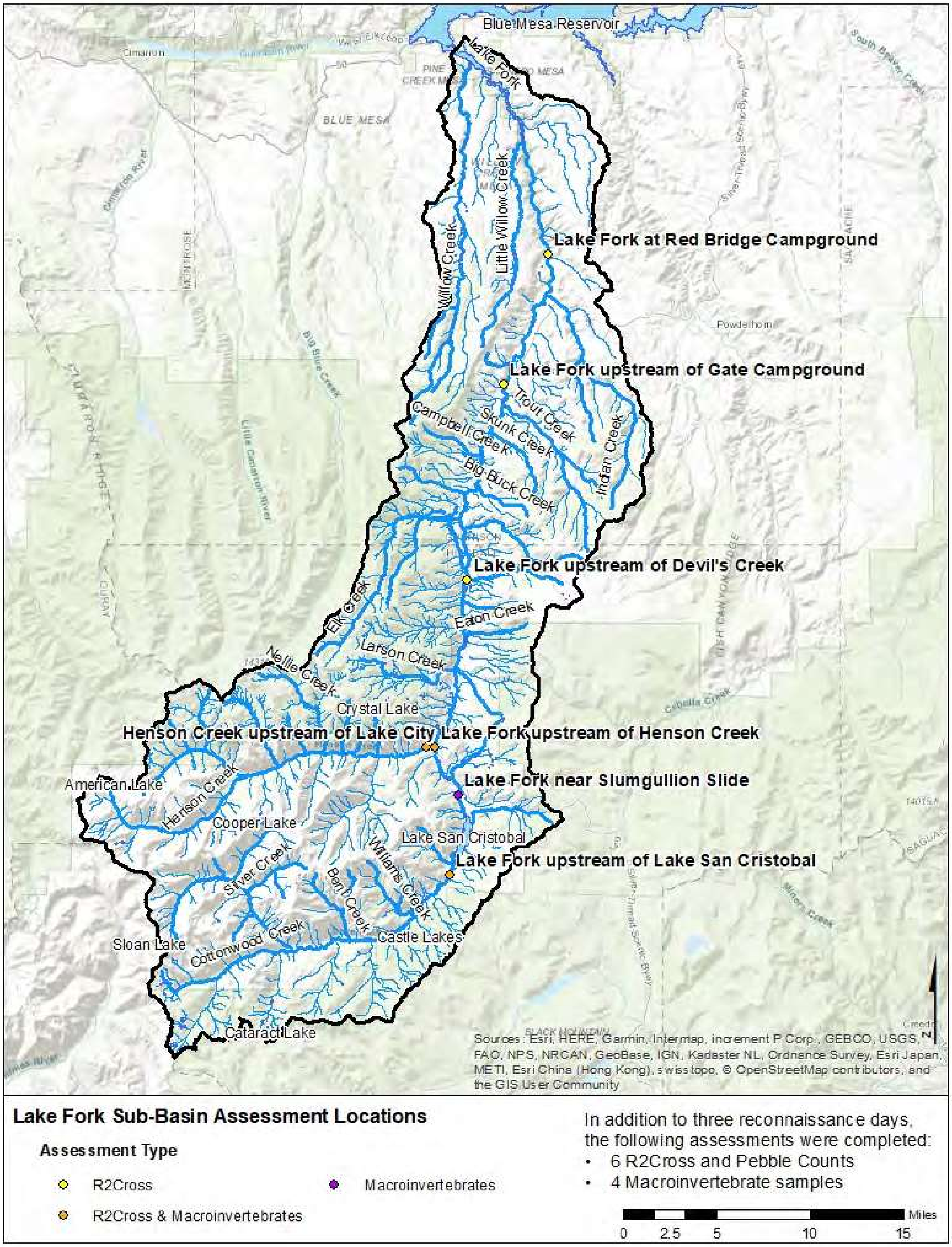


Figure 4-16: Lake Fork Sub-Basin Assessment Locations

Streamflow gages can be used to assess whether the instream flows are met at the gage location; however, the single active gage in the Lake Fork Basin does not represent the low-flow point within the lower instream flow reach; and there are not active streamflow gages within any of the other instream flow reaches in the Lake Fork Basin. In addition, in order to appropriate an instream flow right through the water court process, the initial requested flows are often reduced to account for river depletions associated with existing water rights.

4.3.4 Flow Limited Areas

Dry up or near dry up locations are presented by reach in the following sections.

4.3.5 Environmental Flow Goals

Recommendations related to existing and potential instream flows are presented for each reach in this section.

4.4 Recreational Water Use

Recreation is one of the primary land and water uses in the Lake Fork Basin. Recreation occurs year-round and includes hiking, biking, camping, fishing, birdwatching, kayaking, rafting, OHV use, Nordic skiing, backcountry skiing and snowboarding, snowmobiling, and hunting, among others. Water sports, like rafting, kayaking, standup paddle boarding, and tubing are increasingly common on larger reaches within the basin. Angling, including float fishing and wading, is also an important use in the basin.

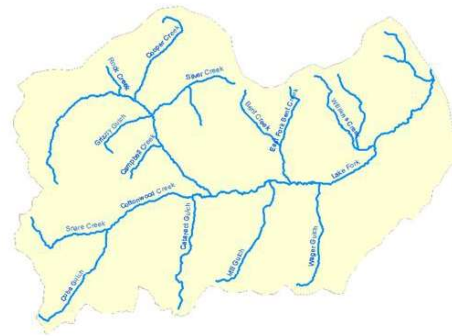
Recreation and tourism are a critical part of the local economy and culture. River recreation supports several businesses, including fly-fishing shops and outfitters, commercial guides, rentals, and retail stores, and jobs within the community. Due to recent increases in tourism and recreation, the community is very engaged on issues related to recreation management.

As part of this assessment recreational users were surveyed to better understand how they enjoy rivers in the area. Six unique surveys were created for each recreational boating reach in the Lake Fork Basin. To be eligible to complete a survey, the user had to confirm that they had floated the reach in the past. The criterion was used to avoid bias, particularly for Class V waters.

The four-page survey included questions related to craft type, floating experience, and infrastructure (parking, restrooms, fences, etc.). The survey included flow calendars for high and low flow years. Survey respondents used the calendar to identify the week of the month when they prefer to flow the reach, and could also reference flows, if needed. For rafting and kayaking, users were asked to identify high, medium, and low flow conditions on selected reaches. This approach was preferred over asking respondents to estimate stream flows, as most users are better able to remember when they floated a reach, but the particulars of flow may be difficult to recall. Where an adequate number of surveys were gathered, the use data was correlated with average daily stream flows at the nearest downstream gage. Data related to infrastructure and other components of the survey were tabulated and are reported in the reach summaries below.

Anglers were interviewed to determine quality of fishing along various reaches and needs for habitat and infrastructure improvements.

Section 5. Reach 1 - Upper Lake Fork to Lake San Cristobal



The Lake Fork of the Gunnison River forms in American Basin, near the summit of Cinnamon Pass, and flows into Lake San Cristobal approximately 4 miles south of Lake City. This reach drains approximately 107 square miles of rugged terrain including three peaks over 14,000 feet. The Lake Fork and its tributaries total approximately 72 miles in this portion of the Lake Fork sub-basin.

5.1 Agricultural Water Use

There are 11 active irrigation diversions in the Upper Lake Fork to Lake San Cristobal reach, serving approximately 164 acres of flood irrigated pasture grass. Table 5-1 shows the total irrigation water rights, combined annual average and range of diversions, crop demands, actual crop consumptive use, and shortage estimates for the 11 ditches in this reach from 1998 to 2017. There was an open water commissioner position in the Lake Fork in 2016 and no diversions were recorded; therefore 2016 was not included in the table statistics. Table 3-2 presents the total for all of the agricultural diversions in the watershed reach (i.e. includes diversions located on the Lake Fork and its tributaries).

Table 5-1: Agricultural Water Use Statistics Upper Lake Fork to Lake San Cristobal

Reach Statistics	1998 to 2017 Average excluding 2016	1998-2017 Range excluding 2016
Number of Irrigation Structures	11	n/a
Irrigated Acreage	164	n/a
Water Rights	39.283 cfs	n/a
Diversions	3,060 acre-feet	2,130 – 4,480 acre-feet
Crop Demand	190 acre-feet	150 - 210 acre-feet
Crop CU	180 acre-feet	150 - 200 acre-feet
Shortage/Need	10 acre-feet	0 - 10 acre-feet
Percent Shortage	3%	0% - 14%

Figure 5-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, the French Ditch 2 and French Ditch 3 commingle to serve common acreage and the three Reece Richart ditches commingle to serve common acreage. All of the ditches are unlined, and each individual ditch is estimated to lose 10 percent of diverted water during delivery to the irrigated fields. Return flows from this reach, estimated to be an average of 2,800 acre-feet per year from 1998 to 2017, accrue to the Lake Fork River above Lake San Cristobal.

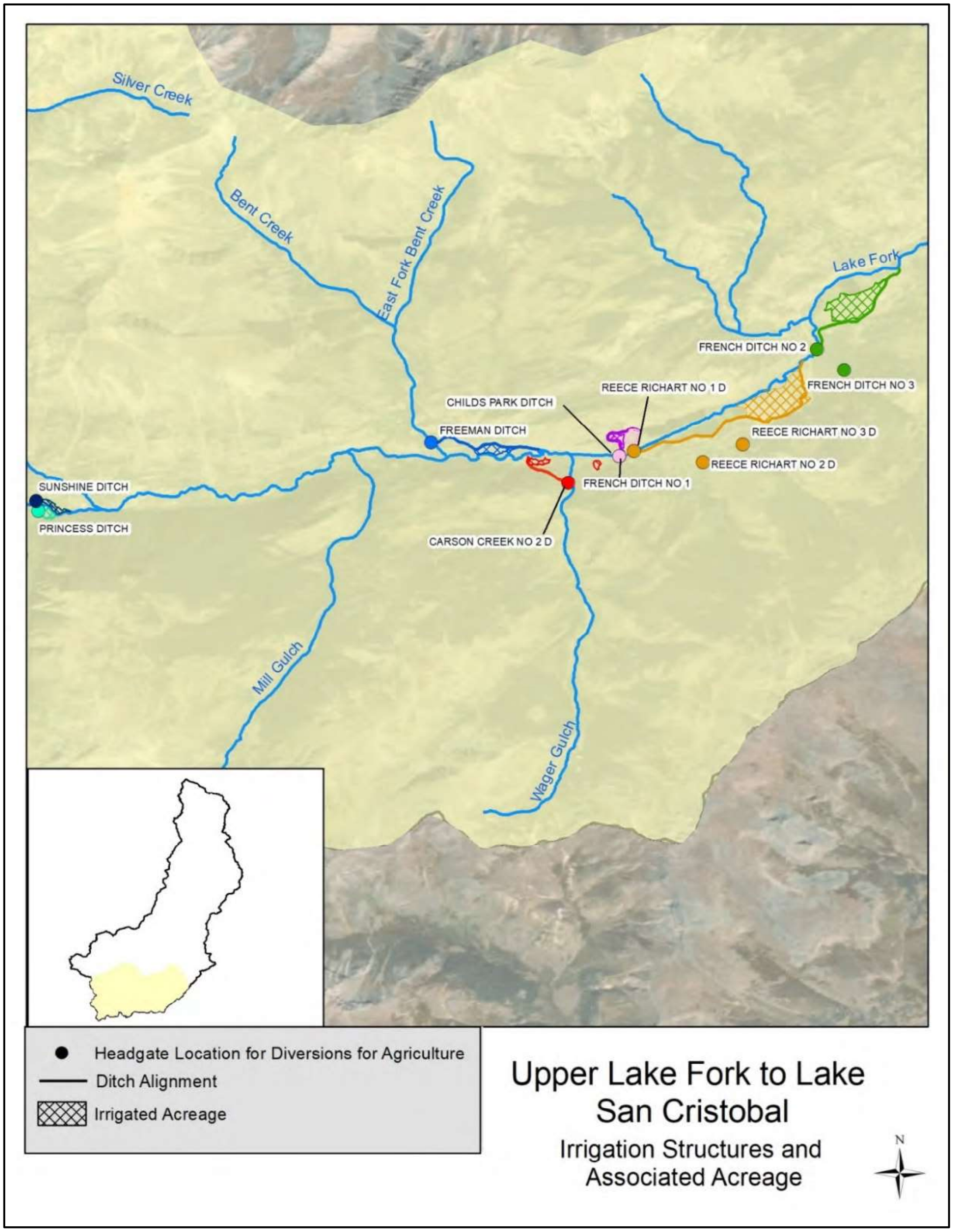
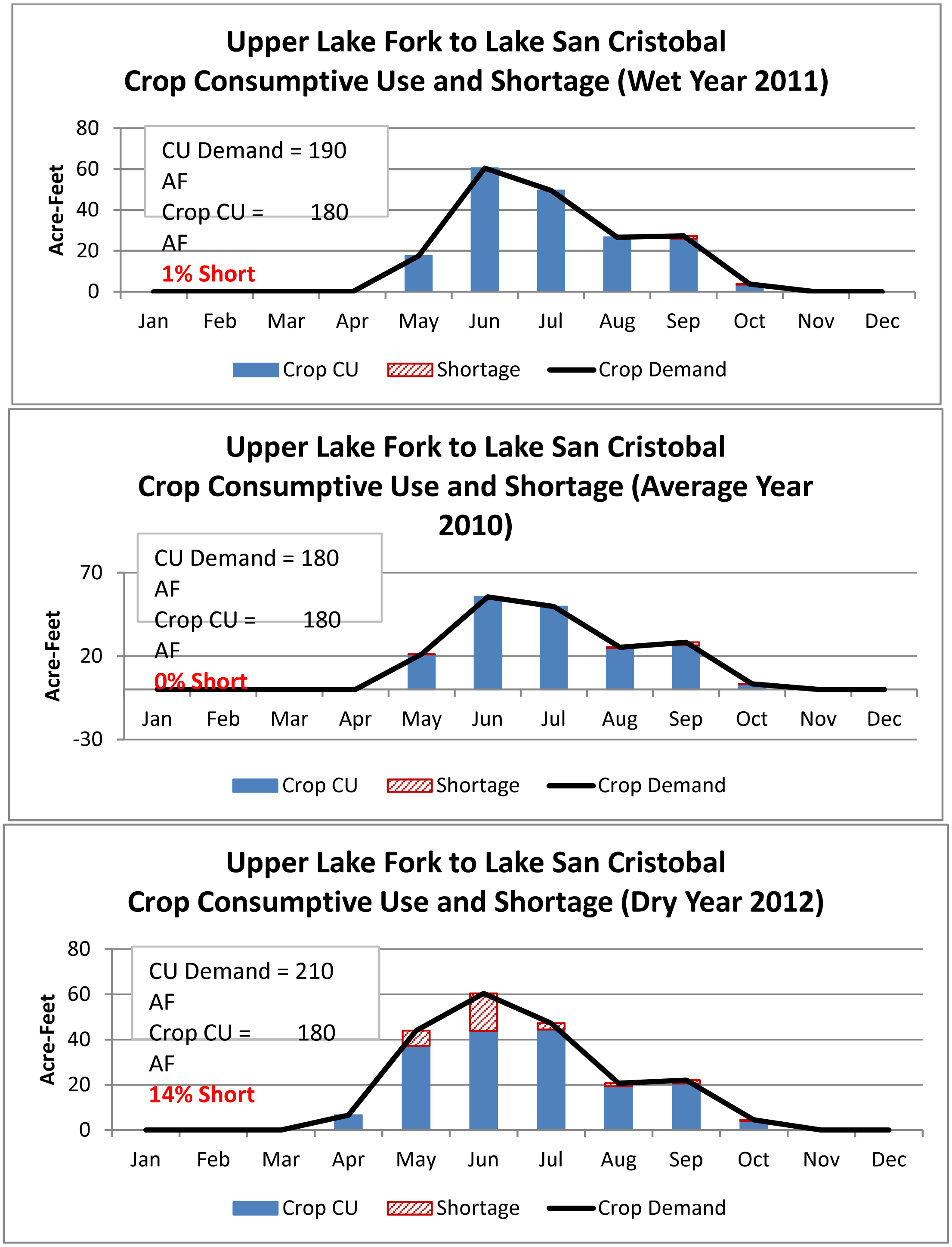


Figure 5-1: Upper Lake Fork to Lake San Cristobal, Irrigation Structures and Acreage

Figure 5-2shows the monthly crop demands, crop consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). As shown, ditches in this reach generally receive a full supply in wet and average years, and experience minor shortages in drier years. Note that in all three representative years, the crop demand in August significantly from July and is generally less than September. In all three of the representative years, a portion of the August demand was met from monsoonal rainfall.

Figure 5-2: Upper Lake Fork to Lake San Cristobal – Crop Consumptive Use and Shortage



5.2 Domestic Water Use

There are no diversions for municipal or industrial use in this headwater reach and no identified needs in the future.

Most of the residences within this reach are near County Road 30 (Cinnamon Pass Road) and the mainstem of the Lake Fork River between Cottonwood Creek and Lake San Cristobal. Wells provide household water and individual onsite wastewater treatment systems are used to manage wastewater.

There are several springs with water rights near Edith Mountain, at historic mine sites, and on private lands throughout the reach.

5.3 Environmental Water Use

5.3.1 Stream and Riparian Characteristics

Steep glaciated valleys and canyons form the headwaters of the Lake Fork River. Slopes are covered with talus or a thin veneer of soil and sensitive alpine tundra vegetation. The streams, which are both intermittent and perennial, are steep entrenched channels that are often scoured to bedrock. Tributaries that flow on an intermittent basis are often even steeper and more entrenched. Following large precipitation events these headwater tributaries occasionally flow as debris torrents. Avalanche paths often parallel these drainages. These flow events can be quite dramatic as evidenced by this past winter's avalanche cycle.

Due to the steep slopes and the materials found on the slopes, hillslopes in the headwaters are naturally susceptible to mass erosion which includes landslides, earth flows, debris avalanches, debris flows, torrents, and snow avalanches. These sporadic events provide massive natural sediment sources as shown in Photo 5-1. Evidence of recent mass erosion is very common throughout the headwaters area. Natural mass erosion events are probable throughout the headwaters area. These natural hillslope processes are an enormous source of sediment to the Lake Fork River. Natural mass erosion dominates sediment supply in the headwaters. These events form the background that human impacts must be evaluated against.

Photo 5-1: View from the Summit of Cinnamon Pass.
Steep hillslopes covered with evidence of mass erosion.

Stream channels in the headwaters area are extremely efficient at moving sediment. In contrast, the lower portion of the reach has lower gradient channels where the valley widens and flattens below Sherman. These changes decrease the channel's capacity to carry sediment and often results in large sediment deposits and frequent adjustments to channel form and location. Alluvial deposits occur where flow from steep drainages deposit and bury riparian areas. A large event such as this happened at Sherman town site in the 1960s, from Cataract Gulch.

The area down gradient of the confluence of the Lake Fork and Cottonwood Creek is also a prime example of these natural dynamics in action. Over time, the lower angle valley channel will winnow away accumulated sediment. The stream system may establish a tenuous and temporary equilibrium, but natural sediment delivery and erosion processes are very dynamic due to the topography, geology, and climate. Human efforts to confine or stabilize the stream channel may be effective for brief periods, but long-term stability should not be expected in this environment. Where possible, infrastructure and other resources should be located away from the riparian corridor.

Willows and riparian vegetation have colonized portions of narrow stream corridors in larger headwater tributaries where sediment deposition has supported soil development. In the valley reaches below Sherman, large wetland complexes support a variety of aquatic and wildlife habitats. These wetland complexes also attenuate flood flows and store water to support late season flows. Some development, including homes and man-made ponds occur within the riparian corridor. In some cases, including near Castle Lakes, the Lake Fork River has been straightened.

Approximately two miles up-valley from Lake San Cristobal, the valley narrows and the Lake Fork River flows through a small canyon with an increased channel slope and narrower riparian corridor. The valley widens as the Lake Fork flows into Lake San Cristobal.

5.3.2 Aquatic Life

From 2004 to 2018, approximately 20 macroinvertebrate samples were collected from multiple locations within the headwaters of the Lake Fork River and its larger tributaries. Most of the samples attained the Multi-metric indices (MMI) criteria used to assess macroinvertebrate community health and indicated that the macroinvertebrate community is healthy and robust. A portion of the samples did not attain the MMI criteria. Following a detailed review of sample collection methods, macroinvertebrate identification methods, water quality data, and habitat conditions, the Water Quality Control Division did not list the upper Lake Fork as impaired for aquatic life use.

The Upper Lake Fork River supports a modest fish population that mainly includes introduced species such as brook and brown trout; and less frequently rainbow trout. Lake Fork Falls, immediately upstream of Sherman, is a substantial habitat barrier that creates to distinct fish populations- up and downstream of the waterfall. Smaller features, including waterfalls and bedrock glides, may also create habitat barriers.

5.3.3 Water Quality

The Upper Lake Fork reach has been sampled on three occasions. The sample events were large characterization projects where major tributaries, abandoned mine features, and the mainstem of the Lake Fork were sampled to identify pollution sources. The existing water quality data suggests impairment at some locations in the Upper Lake Fork reach. The metal pollutants are characteristic of mineralized watersheds with abandoned mine features. Some samples collected near abandoned mine features had elevated metal concentrations; others did not. The data suggests that both ambient background conditions and abandoned mine features supply metals in this upper part of the reach. Based on data collected during these events, metal concentrations in the Lake Fork River downstream of Cottonwood Creek was supportive of aquatic life uses. Table 5-2 and Figure 5-3 summarize impairments and potential water quality impairments in this reach.

Table 5-2: Impaired and potentially impaired stream reaches in the Lake Fork River from the headwaters to Lake San Cristobal.

Listed Portion of Stream	Affected Use	Potentially Impaired (M&E List)	Impaired (303(d) List)	Impairment Priority
Lake Fork River upstream of Cooper Creek	Aquatic Life Use	Dissolved Cadmium	NA	NA
		Dissolved Zinc		
	Water Supply Use	Total Arsenic		
		Dissolved Manganese		
Lake Fork River between Cooper Creek and Silver Creek	Aquatic Life Use	Dissolved Cadmium	NA	NA
		Dissolved Zinc		
	Water Supply Use	Total Arsenic	Dissolved Manganese	Low
		NA		
Lake Fork River between Silver Creek and Cottonwood Creek	Aquatic Life Use	Dissolved Cadmium	NA	NA
		Dissolved Zinc		
	Water Supply Use	**Total Arsenic**		
		Dissolved Manganese		

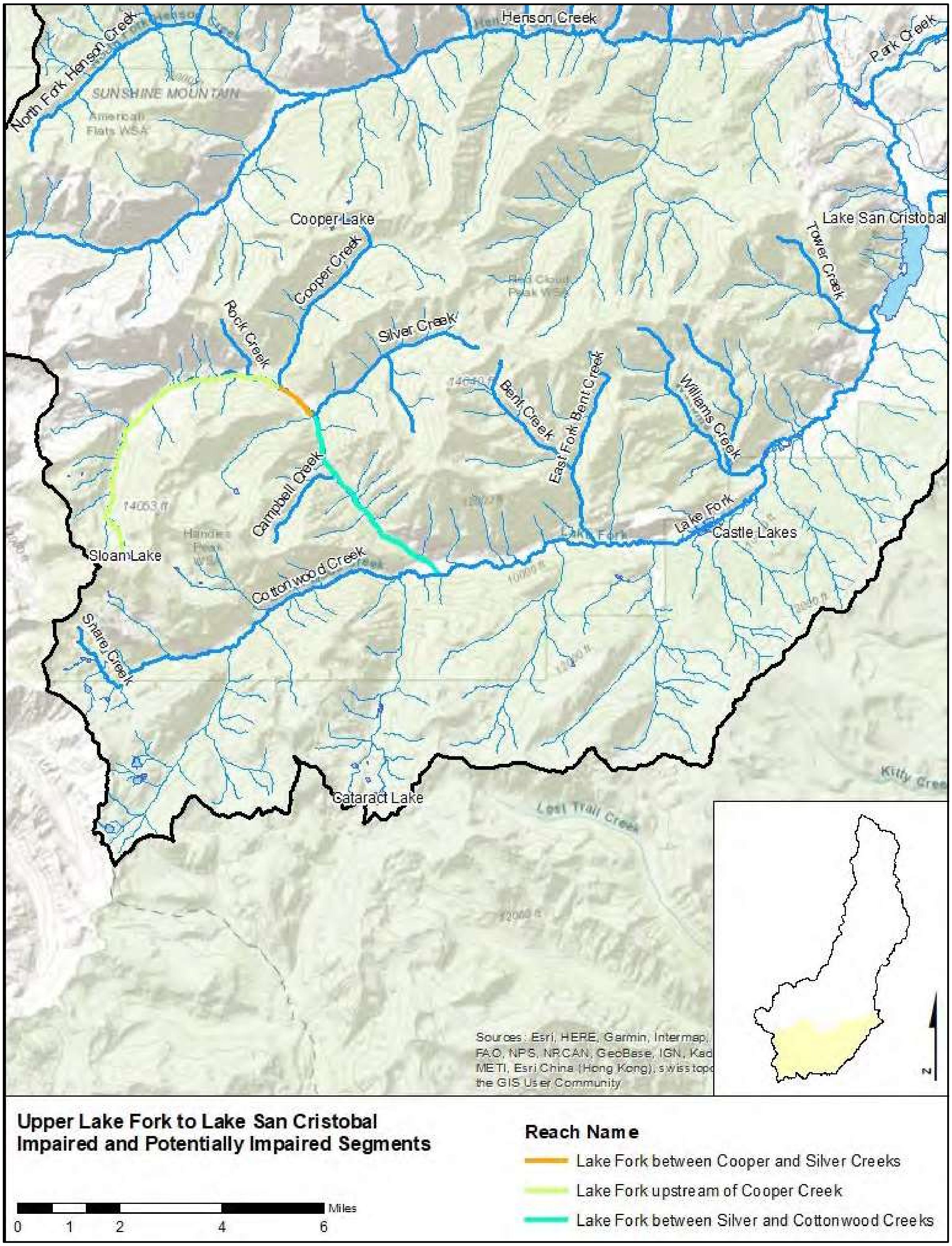


Figure 5-3: Impaired and potentially impaired stream reaches in the upper Lake Fork River from the headwaters to Lake San Cristobal

5.3.4 Water Temperature

The Bureau of Land Management installed continuous temperature sensors to characterize stream temperatures in the Lake Fork River at Mill Creek Campground and in Cottonwood Creek downstream of Cataract Gulch as shown in Table 5-3. Both locations attained the applicable stream temperature standards.

Table 5-3: Summary of stream temperature monitoring data collected in the Lake Fork River from the headwaters to Lake San Cristobal.

Location	Monitoring Start Date	Monitoring End Date	Number of Summers	Standard Attained
Cottonwood Creek downstream of Cataract Gulch	10/30/2013	10/25/2017	3	Yes
Lake Fork River at Mill Creek Campground	11/5/2012	9/24/2015	2	Yes

5.3.5 Existing Instream Flows

There are 13 instream flow reaches in the headwaters of the Lake Fork River upstream of Lake San Cristobal as shown in Figure 5-4. Ten of the instream flow water rights are year-round flat rates. In 2009, the BLM supported instream flow water rights for Grizzly Gulch and an increase to the summer rate for Bent Creek.

Photo 5-2. The Lake Fork River approximately 1 mile upstream of Lake San Cristobal during 2018 R2Cross and pebble count.

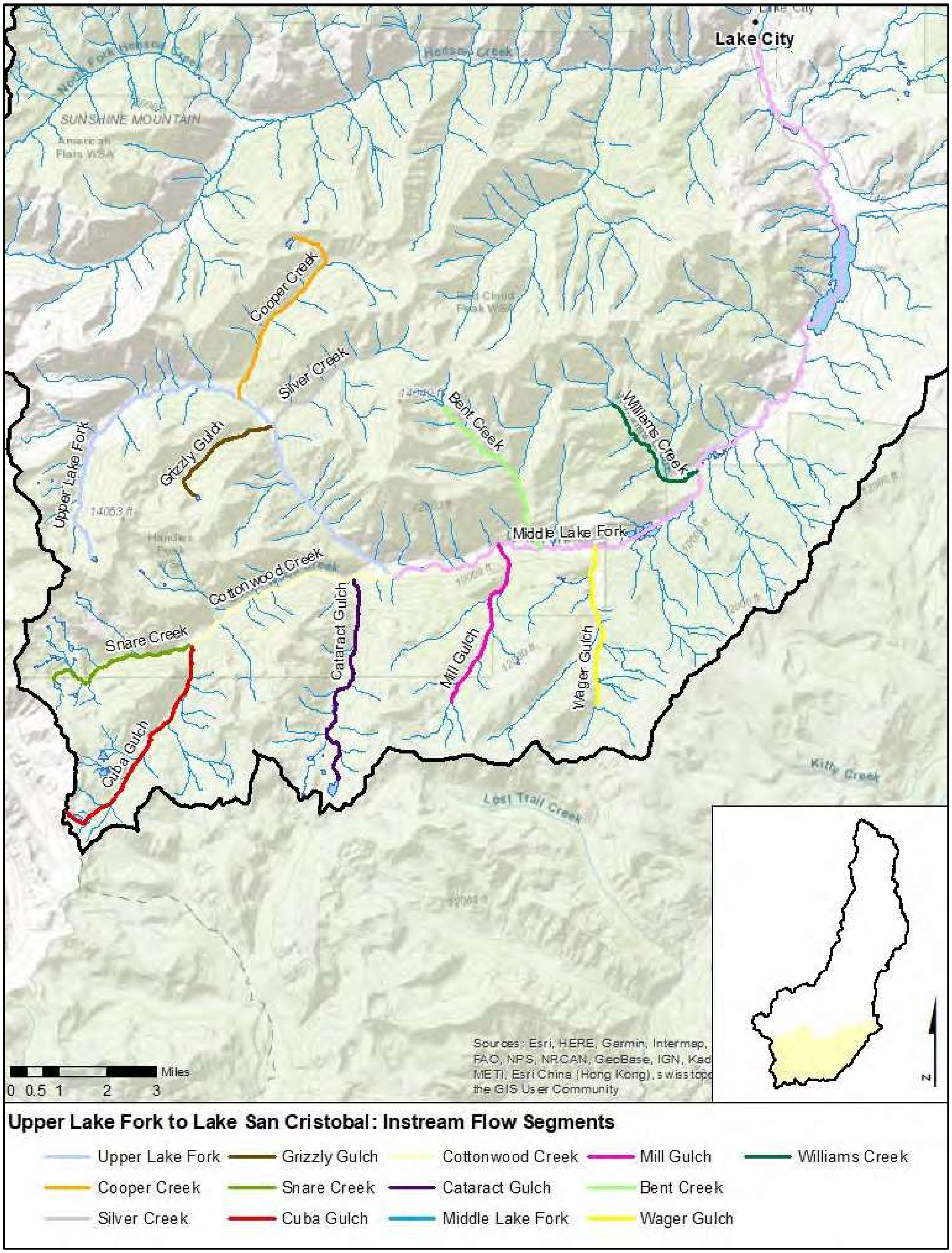


Figure 5-4: Instream flow water rights in the Upper Lake Fork to Lake San Cristobal

5.3.6 Flow-limited Areas

Lake Fork River upstream of Cottonwood Creek does not have any substantial diversions and stream flows are unaltered. Stream flow in Cottonwood Creek is unaltered until just above the confluence with the Lake Fork River (the Princess and Sunshine Ditches divert water from Cottonwood Creek just above the confluence with the Lake Fork River).

Diversions near the mouth of Wager Gulch and the mouth of Bent Creek may take a substantial portion of water from the tributary channel and limit habitat connectivity with the Lake Fork River.

During the latter part of the summer and early fall of average and dry years, stream flows in the mainstem of the Lake Fork River downstream of Bent Creek may decline as a result of irrigation within the reach. In the Lake Fork River upstream of Lake San Cristobal, average monthly flows, derived from the nearest gage, range from 131 cfs in July to 50 cfs in September. Given that water rights in the reach total about 72 cfs, diversions may alter stream flows substantially. It is generally understood that all water diverted within this reach returns to the Lake Fork River upstream of Lake San Cristobal due to highly porous substrate.

5.3.7 Environmental Flow Goals

The Lake Fork River upstream of Cottonwood Creek and nearly all of Cottonwood Creek have unaltered natural stream flows. Diversions from the Lake Fork River from the confluence with Bent Creek to downstream of Castle Lakes may substantially alter stream flows in the Lake Fork in dry and average years.

5.4 Recreational Water Use

The headwaters of the Lake Fork River from American Basin to Lake Fork Falls, immediately upstream of Sherman, are classified as a Class 5 whitewater kayaking reach called Cinnamon Gorge. This extremely technical run is paddled by expert kayakers during peak flow conditions in wetter than average years.

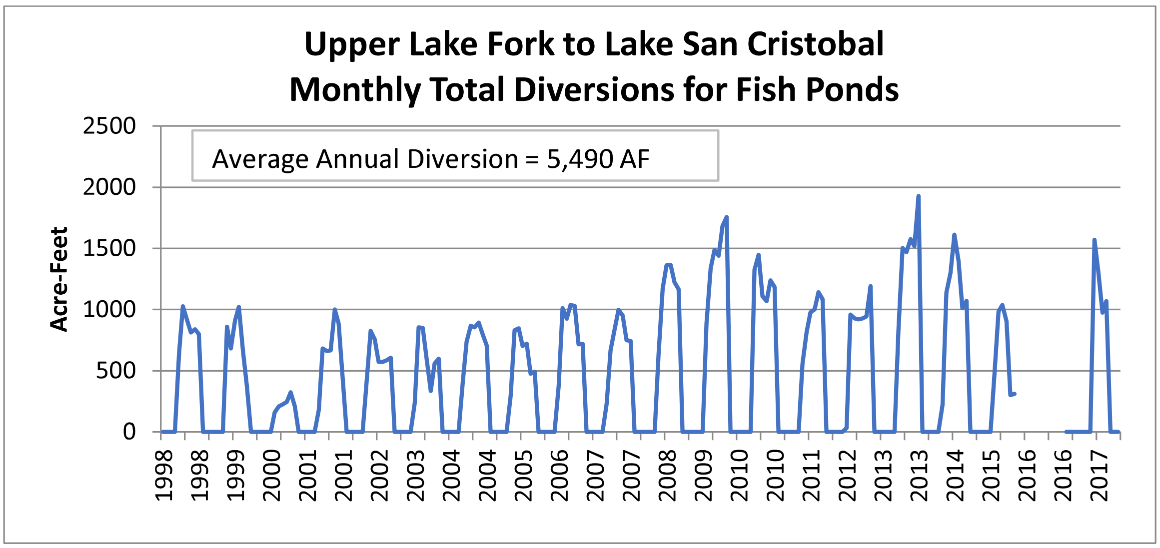
The quality of fish habitat varies widely in this reach. The Lake Fork River downstream of Lake Fork Falls provides fishing opportunities on a mixture of public and private lands. Some private landowners in this portion of the watershed are avid anglers and promote their properties as prime fisheries.

5.4.1 Fish Pond Diversions

There are several private fish ponds within this reach. Figure 5-5 shows the location of the six measured river diversions that fill fish ponds within the reach. The only depletions associated with pond diversions are replacement of pond evaporation; the diversions are generally flow-through and can result in significant de-watering of the river between the diversion and the river return location. Table 5-4 shows the total recorded diversions for fish ponds within the reach. Diversion for fish ponds typically begin in late April or early May and end in October. As noted previously, the water commissioner position was vacant in 2016 and no diversions were recorded.

Most of the ponds are unlined and do not have storage decrees. Depletions associated with the junior diversions to replace pond evaporation are generally replaced under small augmentation plans. Average annual diversions from the 1998 through 2017 period were 5,490 acre-feet, compared to average annual diversions for irrigation for the same period of 2,980 acre-feet.

Table 5-4: Monthly Total Diversions for Fish Ponds



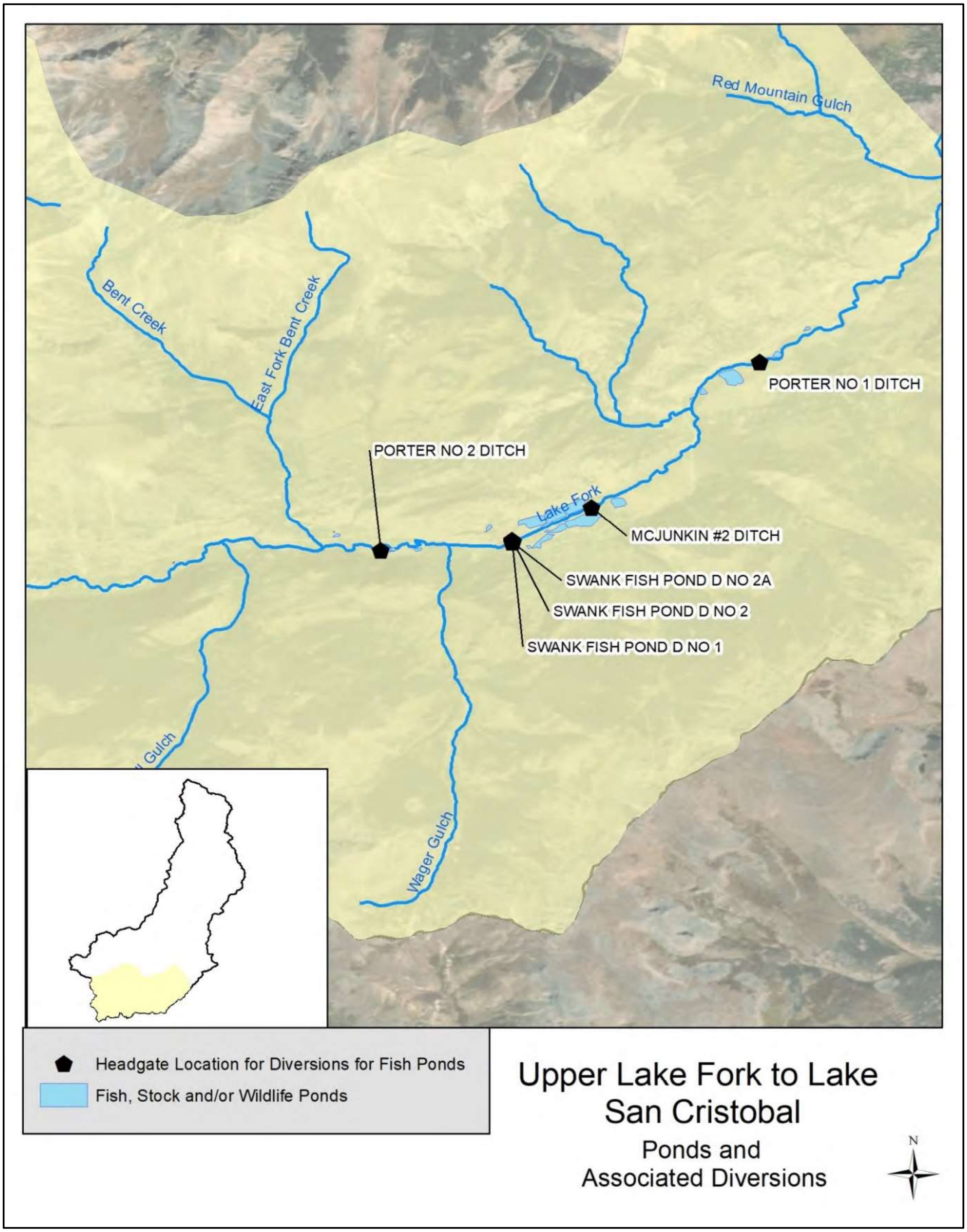


Figure 5-5: Upper Lake Fork to Lake San Cristobal, Fish Pond Diversions

5.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Quality of well water in highly mineralized areas.

Issue: Historic abandoned mines. The Colorado Division of Reclamation, Mining and Safety (DRMS) continues to work with private landowners and BLM to assure that mine features have safety closures in place to protect public health. The Cinnamon Pass project will be completed in the next 1-2 years. DRMS and BLM are evaluating the need for reclamation at the draining Gnome Mine in American Basin. Surface water, seeps, and drainage from the adit flow through mine waste en route to the Lake Fork River. Cooper Creek has a large abandoned mine that needs further assessment, especially in regard to impacts on aquatic life. This will be discussed as we move forward with planning in the next phase.

Issue: Habitat connectivity between the Lake Fork River and selected tributaries: Diversions near the mouth of Wager Gulch and the mouth of Bent Creek may take most of the tributary steam's flow and eliminate habitat connectivity between the tributary and the Lake Fork River. Additional data collection and discussion with landowners and CPW staff is recommended to determine whether habitat connectivity is a priority for these tributaries.

Issue: Potential for summer rate increases for instream flow water rights in tributaries to the Lake Fork. In 2009, BLM staff completed field work to support two instream flow water rights in the Upper Lake Fork. Because the majority of the Upper Lake Fork is public land, it may be worthwhile to prioritize tributaries where additional development is most likely to occur (e.g. private in-holdings associated with mining claims).

Issue: Potential for cutthroat trout reintroduction above the falls, once brook trout populations are removed.

Issue: Additional macroinvertebrate samples, fish surveys, and habitat assessment may be useful to further characterize conditions in this reach. Techniques to delineate man-made impairments (e.g. effects from historic abandoned mines or channel-straightening) from natural impairments (e.g. natural mineralization and sediment transport processes) will be critical in future studies. Specific objectives should be developed prior to initiating additional studies.

Issue: Better characterize low flows and habitat limitations, if any, in Wager Gulch and Bent Creek.

Section 6. Reach 2 - Lake San Cristobal

Approximately 800 years ago, a massive volume of hydrothermally altered volcanic sediment slumped from the edge of Mesa Seco (Lipman 1976, USGS, 1996). [73][74] The earth flow traveled nearly 4.5 miles downhill and dammed the Lake Fork of the Gunnison River to create Lake San Cristobal. The earth flow continues to evolve. Researchers have used radiometric dating and soil development to identify two significant periods of movement (Madole, 1996; Parise et al, 2003; Coe et al)[75][76][77]. The second earth flow began about 300 years ago; this movement occurs on and in the original slide sediments (Parise et al, 2003; Coe et al, 2003). Recent investigations by the USGS and academic researchers suggest that continued movement of the slide is most common at the narrow neck near the middle as well as near the head and toe of the active slide (Parise et al, 2003; Coe et al 2003; USGS, 1996). The active slide is now 2.4 miles long, with a leading edge that is up to 25 feet tall and that continues to flow downslope as much as 20 feet per year in some areas (Parise and Guzzi, 1992)[78]. Variations in material density, water content, precipitation, and weather drive the movement measured in recent years (Coe et. al; 2003).

The bizarre angles of trees growing on some areas of the slide provide clear evidence of recent shifts of the landslide. The bulk of the earth flow is weathered yellow and red material with textures ranging from clay to silty sand derived from the original volcanic sediments (Chelborad et. al, 1996)[79]. The degree of soil development is limited on the slide, an indicator of both continued movement and young geologic age (Parise et al, 2003). Due to hydrothermal alteration of the sediments prior to the slide, the earth flow material is high in soluble salts, iron (Chelborad et. al 1996) and significant quantities of other metals.

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73 Lipman, P. (1976). *Caldera-collapse Breccias in the western San Juan Mountains, Colorado.* Geological Society of America Bulletin, Vol. 87, pgs. 1397-1410.

74 US Geological Survey (1996). *The Slumgullion Earth Flow: A Large-Scale Natural Laboratory.* USGS Survey Bulletin 2130, US Printing Office, Washington.

75 Madole, R.F. (1996). *Preliminary Chronology of the Slumgullion Landslide, Hinsdale County, Colorado.* USGS Survey Bulletin 2130, US Printing Office, Washington.

76 Parise, M. et al (2003). *The Slumgullion Landslide (Southwestern Colorado, USA): Investigation and Monitoring.*

77 Coe, J. A. et al (2003). *Seasonal movement of the Slumgullion Landslide determined from Global Positioning System surveys and field instrumentation, July 1998-March 2002.* Engineering Geology, Vo. 68, Issues 1-2, Pgs. 67-101.

78 Parise, M. and Guzzi, R. (1992). *Volume and Shape of the active and inactive parts of the Slumgullion Landslide, Hinsdale County, Colorado.* USGS Open-File Report 92-216.

79 Chleborad, A.F. et al (1996*). Geotechnical Properties of Selected Materials from the Slumgullion Landslide.* USGS Survey Bulletin 2130, Chapter 11, pgs. 67-72.

In the 1950s USGS investigated increasing the spillway height of Lake San Cristobal to increase the size of the lake and store additional water. A large spillway was deemed undesirable due to the on-going instability of the Slumgullion Landslide.

As the state's second largest lake, Lake San Cristobal is a popular recreational site. Local and visitors enjoy swimming, motorized boating, stand-up paddle boarding, and fishing on the lake. Hinsdale County operates Wupperman Campground on the eastern shores of the lake. There are several homes and an RV park on the north end of Lake San Cristobal.

6.1 Agricultural Water Use

There are no diversions for agricultural use from Lake San Cristobal and no identified needs in the future.

6.2 Domestic Water Use

There are no direct diversions for municipal or industrial use in this reach. The top 3 feet of water in Lake San Cristobal is decreed for augmentation and is used to replace out-of-priority depletions by wells or other diversion structures that would otherwise be curtailed by a senior water rights call in the Lake Fork or Gunnison River. The augmentation storage is owned by the Lake San Cristobal Water Activity Enterprise (LSCWAE) and managed by the UGRWCD. The Enterprise sells Augmentation Certificates to water users who require augmentation and currently has an adequate inventory to satisfy anticipated future needs. The Town of Lake City relies on Enterprise Augmentation Certificates to augment the Town's municipal wells.

Homes around the lake derive their household water from springs and wells. Most homes are on individual septic systems. The Lake View Cabin subdivision at the south end of the lake has its own sewage system in place.

6.3 Environmental Water Use

6.3.1 Stream and Riparian Characteristics

The inlet of Lake San Cristobal supports a large wetland complex that provides vital habitat to wildlife and aquatic life. In 2013, the 156-acre wetland was placed into a conservation easement held by Colorado Open Lands (a certified land trust). The conserved wetland is littered with beaver ponds, relic channels, and a wide variety of riparian vegetation. The conservation easement allows public access for fishing.

View of Lake San Cristobal. Photo courtesy of Hall Realty/Lakecity.com

6.3.2 Aquatic Life

Rainbow trout and lake trout call Lake San Cristobal home. Colorado Parks and Wildlife stock Lake San Cristobal with rainbow trout.

Due to its elevation, water temperatures, and chemistry, Lake San Cristobal is not ideal habitat for zebra and quagga mussels. However, CPW regularly monitors to for the presence of zebra and quagga mussels, and to date, they have not been identified in the lake. However, there is need for more active education here, as there is potential threat of invasion with the number of boats that are brought in.

Didymosphenia geminata, commonly known as didymo, or rock snot, is a species of diatom that produces nuisance growths in cold freshwater rivers and streams with low nutrient levels. Didymo has been identified at the lake outlet. It is not known at this time what effect its presence has on aquatic life.

6.3.3 Water Quality

In 2010, Lake Fork Valley Conservancy (LFVC) staff and volunteers collected water quality samples from one meter below the surface and one meter above the lake bottom. Manganese concentrations exceeded the water supply standard (50 µg/l) in 12 of 13 instances. The manganese water supply standard is not a human health-based standard, but rather a secondary water supply standard, intended to assure that the water is palatable and that infrastructure (i.e. pipes and fixtures) are not damaged (Herman, 1996). Manganese concentrations in Lake San Cristobal are not detrimental to aquatic life. It appears that the Fleece-Ilma Mine Site and Slumgullion Creek deliver manganese to Lake San Cristobal. The

Lake Fork River also contributes manganese, but the contributions are small relative to the contributions from the Fleece-Ilma Mine and Slumgullion Creek.

To date, all nitrate, nitrite and ammonia measurements have been below regulatory criteria. Chlorophyll data does not indicate that problematic algal blooms occur in Lake San Cristobal. In fact, the nutrient status of the lake may limit primary productivity; which is typical of high-altitude lakes.

LFVC staff also used Secchi disks to assess water clarity during 2010; the data indicate that the water clarity is exceptionally high. Relative to similar lakes, as reported in the *Colorado Lake and Reservoir Management Association Database*, Lake San Cristobal generally has higher clarity, as measured by Secchi disk depth.

6.3.4 Water Temperature

In 2009 and 2010, LFVC and EPA staff and volunteers used multi-parameter probes to measure water temperatures. Water temperatures were sufficiently cool to protect aquatic life and displayed typical stratification patterns. However, the data were not collected frequently enough to assess attainment with the applicable temperature standards.

6.3.5 Existing Natural Lake Level Right

Instream flows are not applied to lakes. However, natural lake levels are used to preserve the natural environment in and adjacent to lakes. Lake San Cristobal has a natural lake level protection of 13,545 acre-feet with an appropriation date of May 12,1976 (Case No W-3366-77). In connection with the adjudication of the storage right discussed in Section 6.2 above, the UGRWCD negotiated an injury with mitigation agreement with the Colorado Water Conservation Board to protect this natural lake level water right.

6.3.6 Environmental Flow Goals

The goal in Lake San Cristobal is to maintain a lake level that meets both augmentation needs as decreed in the LSCWAE storage right, and ecosystem needs of the surrounding lake wetlands.

6.4 Recreational Water Use

Lake San Cristobal is one of the most pristine lakes in the state that has such available access. It is a popular recreation site with multiple boat launches, docks, and access points. Many varieties of water-based recreation occur in Lake San Cristobal, such as motorized boating, Kayaking, standup paddle boarding, fishing. Human powered boating is increasing in popularity.

6.5 Needs for this Reach: Issues Identified

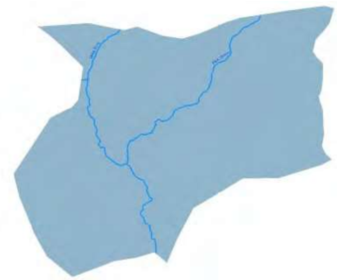
This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Fleece-Ilma Mine site and sediment retention ponds. The Fleece-Ilma Mine Site is located immediately west of Lake San Cristobal. A minimal amount of reclamation and stabilization work has been completed by the mine owners and through a bond forfeiture. However, the current condition of the site poses a risk to water quality in Lake San Cristobal and in downstream portions of the Lake Fork River. Previous water quality evaluations have confirmed low pH and very high metal concentrations at the mine site.

Issue: Sediment delivery and instability in Slumgullion Creek adjacent to Lake San Cristobal. Slumgullion Creek drains the southern half of the Slumgullion Slide debris. Erosion and sediment delivery are common due to a lack of riparian and upland vegetation which is attributed to the low pH and high metal concentrations found in the slide materials.

Issue: Infrastructure needs at the Lake. Hinsdale County has identified need for an updated water supply system at Wupperman Campground. In addition, the access points at the lake need better day use infrastructure and educational kiosks to inform about invasive species and recreation regulations.

Section 7. Reach 3 - Lake Fork from Lake San Cristobal to Lake City



The Slumgullion Slide forms the East side of the Lake Fork River from the outlet of Lake San Cristobal to the Highway 149 road crossing; or about 1.2 miles. Park Creek is the largest tributary to the Lake Fork River within this reach.

Several historic abandoned mines litter the hillslopes upgradient of the Lake Fork River. This complex of mines was heavily mined in the late 1800s and early 1900s and are linked via a network of shafts and adits to the Fleece Ilma mine at the outlet of Lake San Cristobal.

The Vickers Ranch is located in the Park Creek tributary watershed. 1,500 acres of the upper ranch is under conservation easement with The Nature Conservancy. The lower ranch has been subdivided into numerous home sites. This ranch still contains extensive wetland pasture and relatively intact riparian corridor.

The Golden Wonder Mine, the only recently active mine in the watershed, is also located within this reach, accessible via the Vickers Ranch. It is located in Deadman Gulch, which has shown evidence of impact from historic and possibly more recent mining activity. Efforts are underway to conduct a TMDL for the Gulch.

7.1 Agricultural Water Use

There are three active irrigation diversions in the Lake Fork River from Lake San Cristobal to Lake City that serve 109 acres of flood irrigated pasture. Table 7-1 shows the total irrigation water rights, combined annual average and range of diversions, crop demands, actual crop consumptive use, and shortage estimates for the 11 ditches in this reach from 1998 to 2017. As discussed in Section 2, there was an open water commissioner position in the Lake Fork in 2016 and no diversions were recorded; therefore 2016 was not included in the table statistics. In addition, 2012 and 2013 were excluded as discussed below. Table 3-2 presents the total for all of the agricultural diversions in the watershed reach (i.e. includes diversions located on the Lake Fork and its tributaries).

Table 7-1: Agricultural Water Use Statistics
Lake Fork River from Lake San Cristobal to Lake City

Reach Statistics	1998 to 2017 Average excluding 2012, 2013,2016	1998-2017 Range excluding 2012, 2013,2016
Number of Irrigation Structures	3	n/a
Irrigated Acreage	114	n/a
Water Rights	11 cfs	n/a
Diversions	360 acre-feet	180 - 570 acre-feet
Crop Demand	210 acre-feet	170 - 250 acre-feet
Crop CU	100 acre-feet	60 - 160 acre-feet
Shortage/Need	110 acre-feet	110 - 90 acre-feet
Percent Shortage	49%	19% - 71%

Figure 7-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. All of the ditches are unlined and are estimated to lose 10 percent of diverted water during delivery to the irrigated fields. Return flows from this reach, estimated to be an average of 240 acre-feet per year from 1998 to 2017, accrue to the Lake Fork from Lake San Cristobal to Lake City reach.

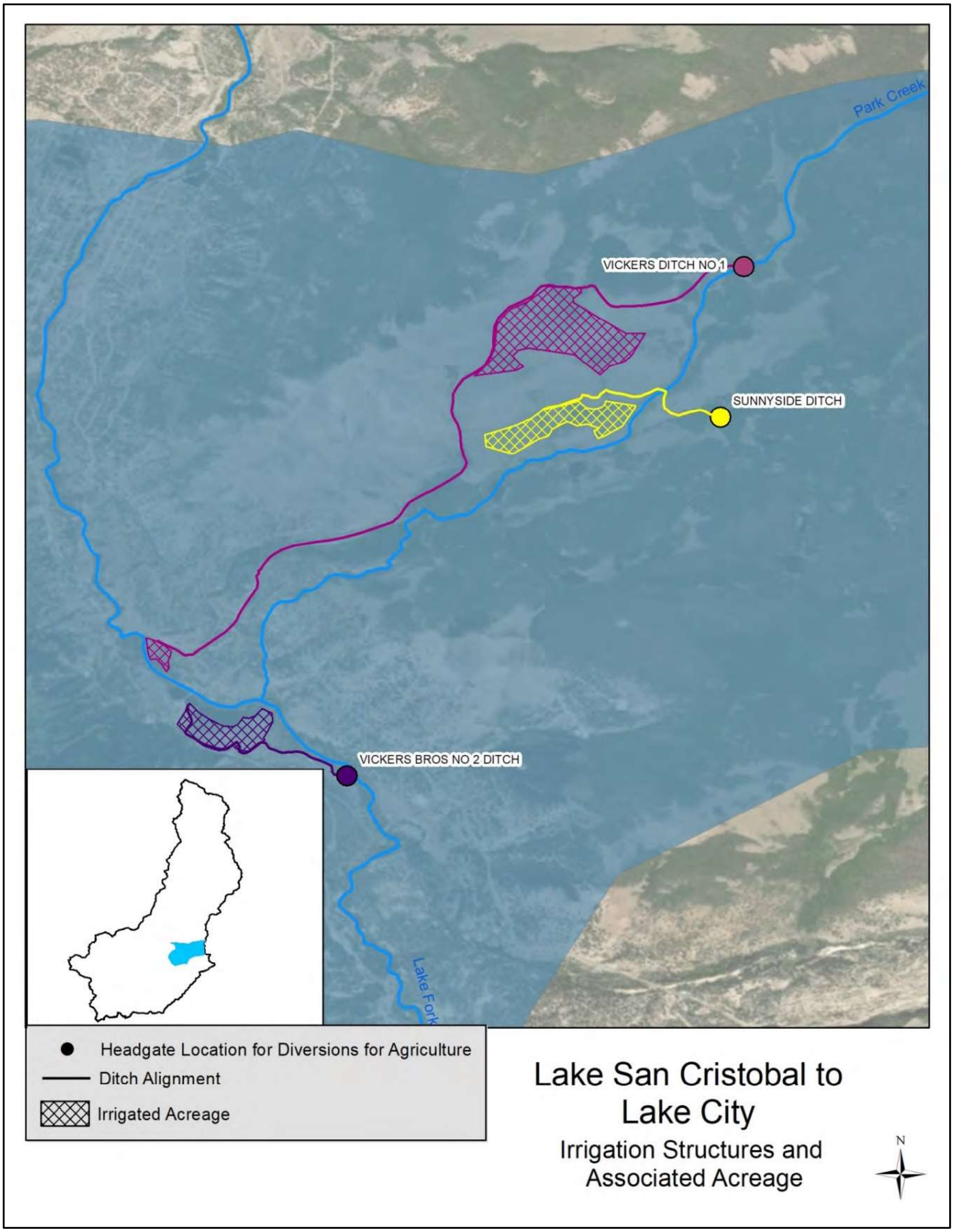
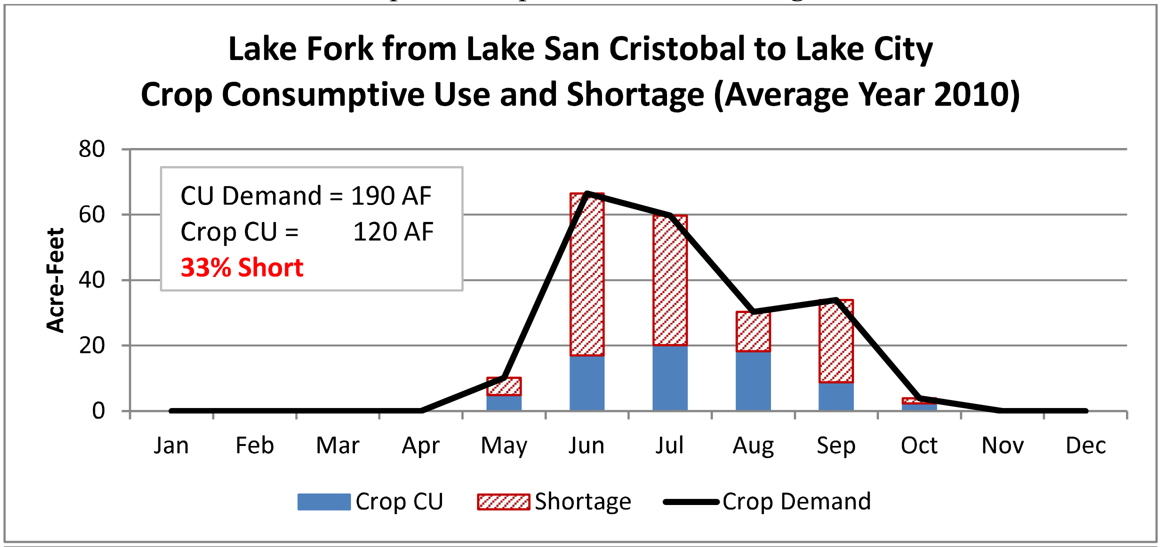


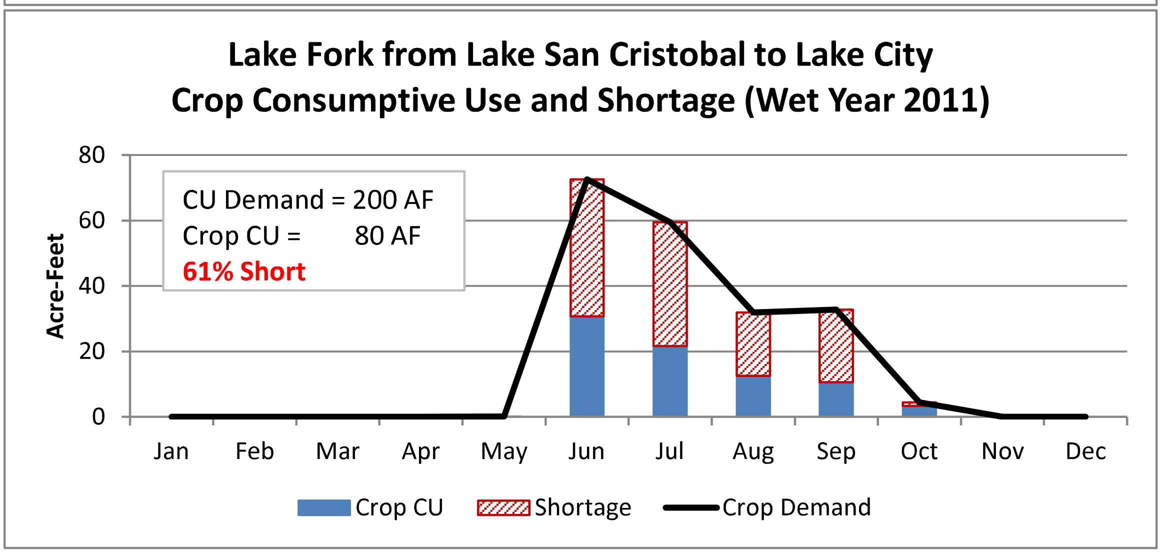
Figure 7-1: Lake San Cristobal to Lake City, Irrigation Structures and Acreage

Figure 7-2 shows the monthly crop demands, crop consumptive use, and associated shortages for two recent years, chosen to highlight hydrologic variability between a wet year (2011) and a relatively average year (2010). Vickers Brother No 2 Ditch diverts from the Lake Fork and received a full supply in most years of the analysis; shortages are almost all attributable to the two ditches diverting from Park Creek. This small tributary has water available to irrigate pasture only during peak runoff; therefore there are significant shortages throughout the summer.

During the 2012 dry representative year selected for the WMP, Vickers Brother No 2 Ditch had water available for use, but did not divert according to the water commissioner notes. They also did not divert in 2013. The notes do not indicate if there was a headgate maintenance issue. This skewed the results for those years and the representative dry year (2012) is not shown and not included in the statistics in Table 7-1. Beginning in 2014, the ditch started diverting at pre-2011 levels.

Figure 7-2: Lake Fork from Lake San Cristobal to Lake City
Crop Consumptive Use and Shortage





7.2 Domestic Water Use

The town of Lake City water supply is provided from two wells located within the city limits, drilled to a depth of 60 feet and 70 feet. Both wells are classified as groundwater by the CDPHE. These wells are located at the mouth of Henson Canyon in Pumphouse Park and at the north end of Memorial Park.

According to the town clerk, the wells serve a full-time population of 408, in addition to seasonal homes and numerous tourists in the summer season. Total number of water taps and associated accounts for both residential and business uses are 589. As with other municipalities, the consumptive use of the pumped water is approximately 5 percent for indoor use. During the lawn and landscaping season, consumptive use increases to a high of 90 percent of water pumped in July and August. Figure 7-3 shows the volume of groundwater pumped for municipal use and the associated consumptive use for 2017. Lawn irrigation return flows and treated effluent return to the Lake Fork within the Lake San Cristobal to Lake City reach.

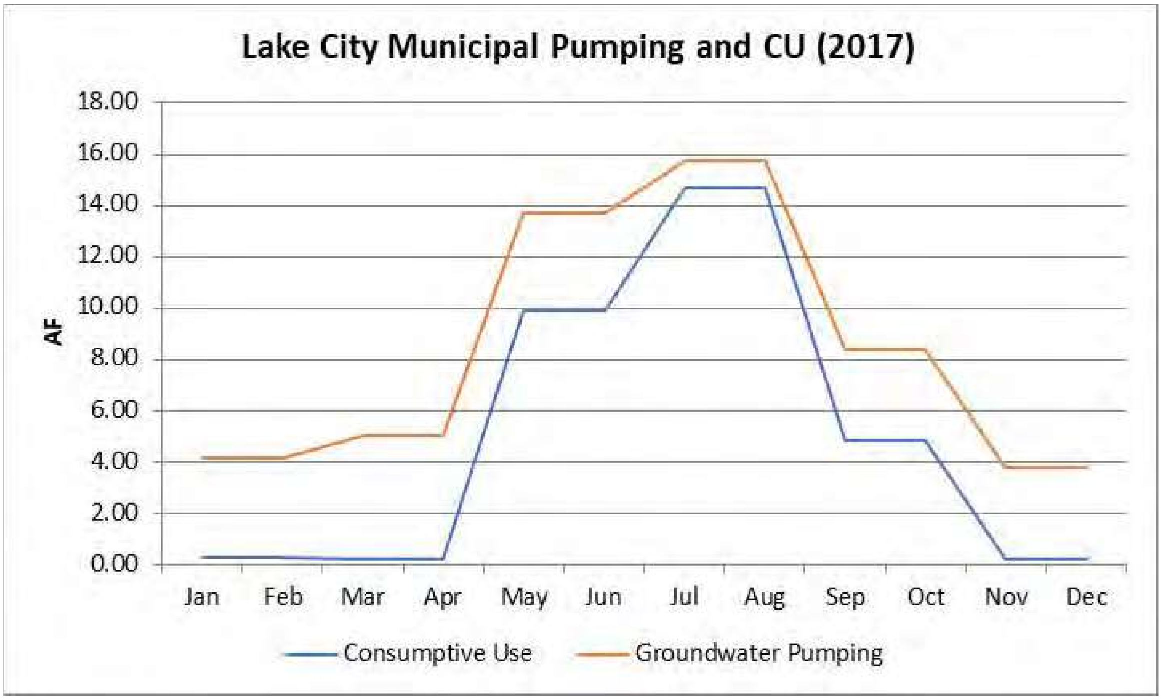


Figure 7-3: Lake City Municipal Pumping and CU (2017)

The Town of Lake City Drinking Water Quality Report, was prepared in 2018 using data collected in 2017 (the most recent version of the report currently available), found that copper concentrations in the distribution system exceeded the action limit. The Town was eventually removed from the exceedance list as it was shown that this elevated copper level was from one individual home that had corroded copper pipes. Copper can be mobilized within drinking water distribution systems as corrosive waters (low pH or low hardness water) flow through copper plumbing. Copper plumbing is typically found in private homes, but on occasion is used within older portions of public distribution systems. Copper mobilization within the distribution system can be exacerbated by seasonal use, where water is exposed to copper plumbing for a longer period while the property is vacant. In some cases, copper mobilized from the distribution system may create challenges for wastewater treatment facilities that are required to meet copper limits; particularly if those facilities discharge into low hardness waters, like the Lake Fork River.

Town wastewater is treated at a facility at the north end of Town. Effluent from this site has met all water quality standards. There are an additional two subdivision wastewater treatment systems along this reach, but data is not available regarding water quality. In the 1990s, a hydro-electric plant was constructed at the Black Crooke mill site on the Lake Fork south of Lake City.

This facility only provides electricity to the adjacent home and is not connected to the electricity grid. This property is currently on the market and the potential exists to upgrade this site to provide electricity to the town.

7.3 Environmental Water Use

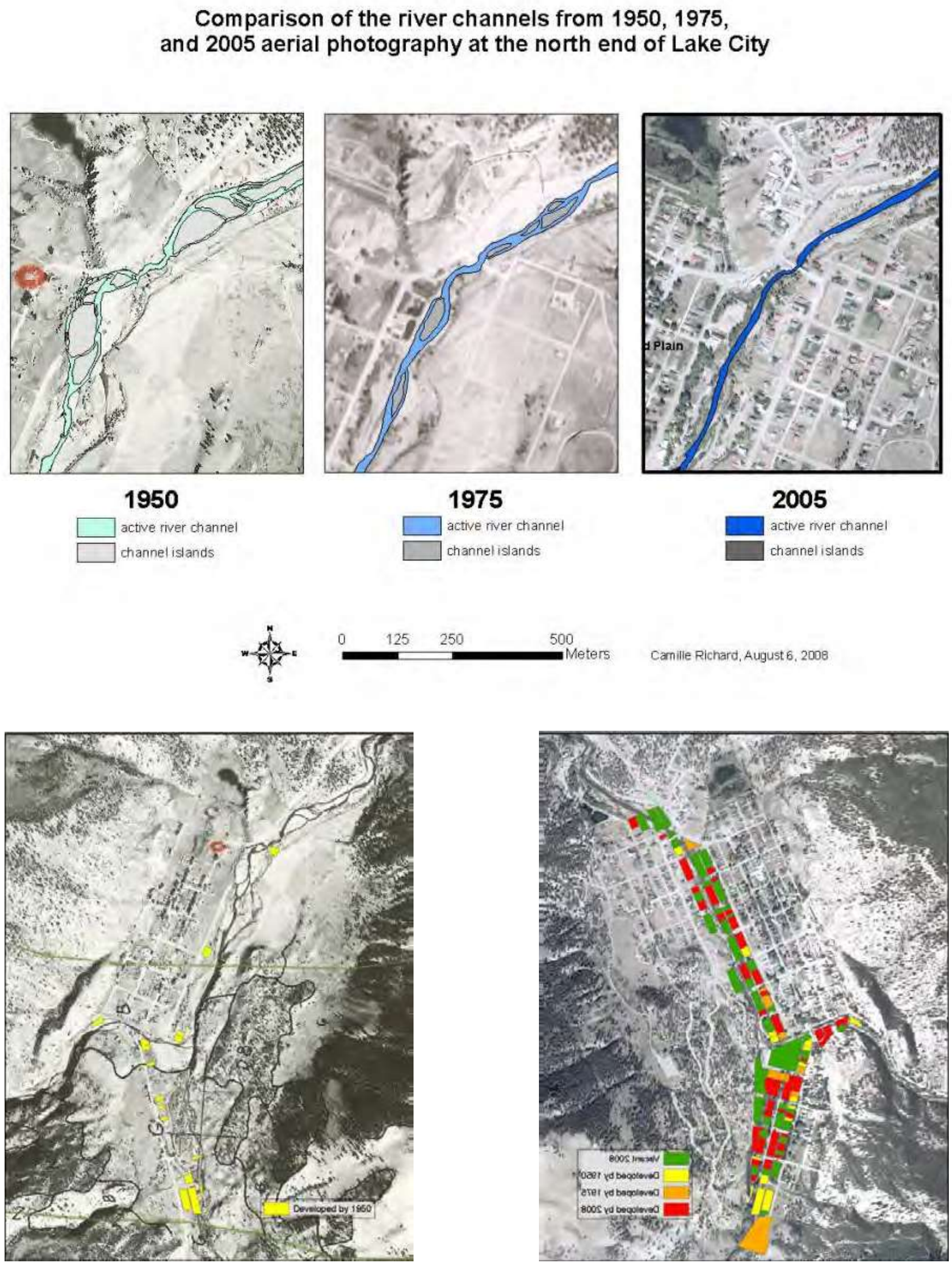
7.3.1 Stream and Riparian Characteristics

The Lake Fork River in this reach is somewhat confined by small canyons, slide debris, and development within the riparian corridor from the outlet of Lake San Cristobal to Lake City. Spruce trees, willows, alders, and other riparian vegetation typically form a narrow ribbon within the riparian corridor.

Native vegetation has been altered by development within the riparian corridor, especially in the vicinity of the Town. Figure 7-4 shows changes in the river from the 1950s to 2005 and the constriction of the river due to development. This created a number of problems, including aggradation of the river channel, channel braiding, reduction of fisheries habitat, and instability of banks.

The Lake Fork Valley Conservancy has been actively restoring the river channel along this stretch of river in Lake City. This work, where completed, has stabilized banks, and improved aquatic and riparian habitat along the reach in the town. The structures have also helped attenuate flood waters by keeping the river flows mainly within the defined channel, at flow levels that have exceeded 2,000 cfs on the Lake Fork and over 1,000 cfs on Henson Creek. Stakeholders have not reported additional channel stability issues. Some identified concerns related to fish habitat on private lands near Lake City, mainly in terms of access, but also due to channelized sections that have not yet been addressed in the restoration effort.

Figure 7-4: Constriction of the Lake Fork due to development. The two images at bottom show scale of development in the Town of Lake City from 1950 and 2008



7.3.2 Aquatic Life

In 2018 two macroinvertebrate samples were collected from the Lake Fork River. The first was near the Slumgullion Slide and upstream of the Silver Thread Scenic Byway (Highway 149) and the second was in Lake City upstream of Spring Street and Henson Creek. The objective was to collect baseline data and evaluate the effect of the Slumgullion Slide (primarily composed of acidic and metals-laden materials). The multi-metric index (MMI) scores for both sites indicate the aquatic life use may be impaired within the reach. This finding is generally consistent with stakeholder observations regarding fishing quality within this reach.

This reach of the Lake Fork River supports rainbow and brown trout. The hydroelectric dam, located approximately 0.6 miles north of Lake City, likely prohibits fish movement. There may be additional natural features that prevent fish passage. Stakeholders reported that fish populations and size may decline above the hydroelectric dam (relative to the lower Lake Fork River).

7.3.3 Water Quality

In 2010, Deadman Gulch segment was added to the 303(d) List for impairment of aquatic life standards for cadmium, copper, iron, manganese, pH, and selenium, and for impairment of the iron standard for domestic water supply (Table 7-1). The data was collected by EPA and LFVC staff between 2004 and 2007. CDPHE listed historic mining as the primary cause of non-attainment. Historic mining occurred in Deadman Gulch and exploration activities continue at the Golden Wonder Mine. The active mining section of DRMS plans to sample the Golden Wonder Mine and Deadman Gulch in 2019.

Table 7-1: Impaired stream reaches in the Lake Fork River sub-basin between Lake San Cristobal and Lake City.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
Deadman Gulch and its tributaries	Aquatic Life Use	NA	Dissolved Cadmium	High
			Dissolved Copper	High
			Total Iron	High
			Dissolved Manganese	Low
			pH	High
			Dissolved Selenium	High
			Dissolved Zinc	High
	Water Supply Use		Dissolved Iron	Low

Deadman Gulch is an intermittent drainage that flows in the spring during and following snowmelt. Deadman Gulch may also flow following large precipitation events in the summer and fall. Intermittent flows have prevented additional sample collection and total maximum daily load (TMDL) development.

Although metal concentrations in Deadman Gulch readily exceed aquatic life standards, Deadman Gulch does not appear to have a substantial effect on water quality in the Lake Fork River. USGS sampled the Lake Fork River approximately 1.5 miles downstream of Deadman Gulch every other month for six years from 2007 to 2013 (USGS-09123490, n= 42). Table 7-2 summarizes selected water quality analytes and applicable water quality standards for the Lake Fork River downstream of Deadman Gulch. Metal concentrations were less than the applicable standards in all samples.

Table 7-2: Summary of selected water quality analytes and aquatic life standards in the Lake Fork River downstream of Deadman Gulch (samples collected by USGS at 09123490 from 2007 to 2013, n=4)

Analyte	Min.	Avg.	85th Percentile	Max.	Chronic Standard	Attains Chronic Standard	Acute Standard	Attains Acute Standard
Hardness (mg/L)	37	69	NA	106	NA			
Dissolved Cadmium (µg/L)	<0.02	<0.02	0.021	0.03	0.5	Yes	1.3	Yes
Dissolved Copper (µg/L)	<0.5	<0.5	1.19	3.4	7	Yes	9.5	Yes
Dissolved Iron (µg/L)	<6	16	23	37	Water supply standard 300 µg/L-attained			
Dissolve Manganese (µg/L)	18	50	71	151	1,458	Yes	2,639	Yes
pH (s.u.)	6.6	NA	NA	8.4	Within acceptable range of 6.5 to 8.5			
Dissolved Zinc (µg/L)	<1	1.5	2.5	7	86	Yes	114	Yes

Deadman Gulch, however, does affect residents of the subdivision near its confluence with the Lake Fork. One homeowner has abandoned their pond due to high concentrations of metals in the water. Ground water wells in this area are also of poor quality, most likely due to the high mineralization in the area.

Water quality samples were recently taken from the Lake Fork at the Weems Malter Placer subdivision, upstream of Deadman Gulch. Results showed elevated sulfates and metals, most likely originating from the slide materials, but several upstream mine workings are present and draining. It is not clear what portion of these metals and salts are anthropogenic in nature.

7.3.4 Water Temperature

The Bureau of Land Management installed a continuous temperature sensor in the Lake Fork River downstream of Lake San Cristobal, as shown in Table 7-3. Stream temperatures attained the applicable standards to protect aquatic life.

Table 7-3: Summary of stream temperature data in the Lake Fork River downstream of Lake San Cristobal.

Location	Monitoring Start Date	Monitoring End Date	Number of Summers	Standard Attained
Lake Fork River downstream of Lake San Cristobal	10/25/2013	9/24/2015	2	Yes

7.3.5 Existing Instream Flows

There is one instream flow water right in this reach. An instream flow water right for the Lake Fork River from the confluence with Cottonwood Creek to the confluence with Henson Creek was appropriated in March of 1980, as shown in Table 7-4. This 16-mile reach of the Lake Fork River has a winter instream flow rate of 20 cfs and a summer rate of 35 cfs. The original R2CROSS surveys in the 1980s produced a winter rate of 35 cfs and a summer rate of 80 cfs. The preliminary values were reduced based on channel form and discussions with the local water commissioner.

Table 7-4: Summary of instream flow water rights in the Lake San Cristobal to Lake City reach.

Waterbody Name	Upper Terminus	Lower Terminus	Appropriation Date	Length (miles)	Winter Rate (cfs)	Summer Rate (cfs)
Lake Fork River	Confluence with Cottonwood Creek	Confluence with Henson Creek	3/17/1980	16.4	20	35

Augmentation water stored in Lake San Cristobal to address out of priority depletions for the Lake Fork River was appropriated in 2003 and 2008 by the Lake San Cristobal Water Activity Enterprise (LSCWAE), which is administered by the UGRWCD. This project involved the installation of Obermeyer weir gates that control the top three feet of water level in the lake. Releases of the augmentation water from Lake San Cristobal increase flows in the Lake Fork River downstream of Lake San Cristobal, during times of water administration, for both instream flow rights as well as consumptive uses.

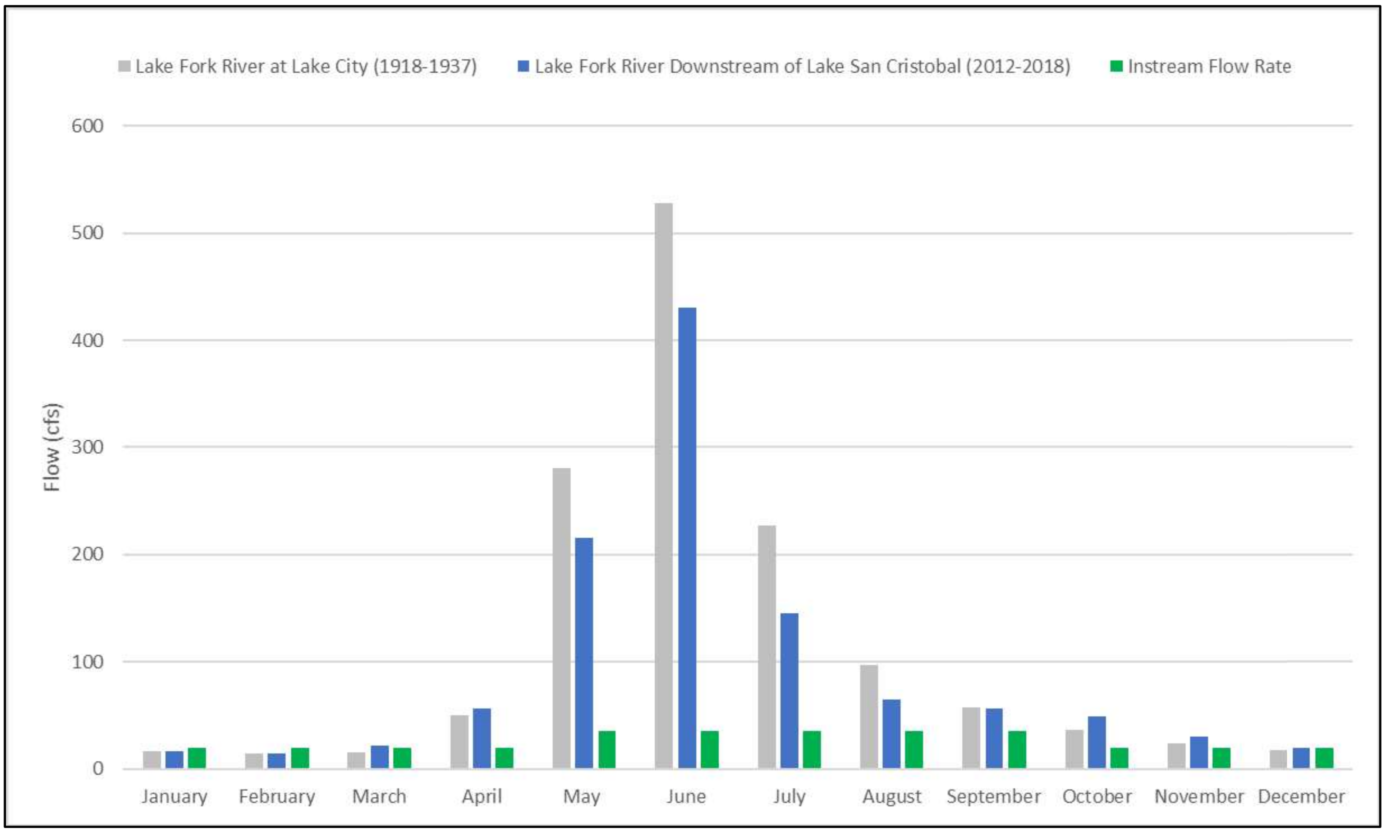
7.3.6 Flow Limited Areas

Diversions from Park Creek may limit flow in Park Creek and decrease habitat connectivity with the Lake Fork River. However, natural habitat barriers may also be present in Park Creek near the Lake Fork River (i.e. very steep channel as stream descends to valley bottom).

7.3.7 Environmental Flow Goals

Average monthly flows measured in this portion of the Lake Fork River suggest that it may be possible to expand the existing instream flow rate from April to August, as shown in Figure 7-5. 2018 R2CROSS results produced a summer instream flow recommendation of 66 cfs, based on the average of two cross-sections completed in the reach. The existing winter instream flow rates seem appropriate based on average monthly flows and 2018 R2CROSS results.

Figure 7-5: Average monthly flows in the Lake Fork River at Lake City (USGS 09123500) from 1918 to 1937, Lake Fork River downstream of Lake San Cristobal (USGS 09123450) from 2012 to 2018, and existing instream flow rates for the Lake Fork River from the confluence with Cottonwood Creek to Henson Creek.



Future planning efforts should include a more detailed analysis of macroinvertebrate, fish, and creel survey data to determine the condition, distribution, and needs of the aquatic community within this reach. A better understanding of the aquatic community is needed to develop moderate or ideal environmental flow goals.

Park Creek, the largest tributary to the Lake Fork between Lake San Cristobal and Lake City, lacks an instream flow water right. The Park Creek watershed supports multiple lakes, wetlands, and wildlife habitat. In recent years, Vickers Ranch has expanded operations to include land development, hospitality and tourism business in addition to traditional agriculture operations. As such, there may be an interest in protecting wildlife and riparian health in addition to maintaining healthy pastures. Interest has already been expressed in protecting the wetland and riparian zones along the Lake Fork in the lower ranch area.

Wades Gulch, which drains the north side of Red Mountain and flows through the south edge of Lake City before its confluence with the Lake Fork River, supports a healthy riparian area. This tributary may be a candidate for an instream flow water right. StreamStats reports that average flows from the 2.5 square mile watershed range from a low of 0.3 cfs in February to a high of 13 cfs in June.

7.4 Recreational Water Use

Much of the Lake Fork from Lake San Cristobal to Lake City is private, and not readily accessible to the public. There are some private parcels that do have fishing access easements. Angling is the main recreational use along this reach. Floating only occurs through the Town. The major put-in for Lake Fork is at Memorial Park for access to the lower Lake Fork.

Above town, floating is uncommon due to Crooke Falls hydroelectric dam, as well as Argenta Falls below Lake San Cristobal.

7.4.1 Fish Pond Diversions

Figure 7-7shows the location of the two identified river diversions that fill fish ponds within the reach. The only depletions associated with pond diversions are replacement of pond evaporation; the diversions are generally flow-through and can result in significant de-watering of the river between the diversion and the river return location. According to the water commissioner, Moseley Ditch diverts from the Lake Fork to fill an off-channel pond, but diversion records are not maintained. In addition, there are several ponds that can fill from Park Creek during the runoff. No measurement information is maintained for these ponds. Figure 7-6 shows the total recorded through the Vickers Bros No 1 Ditch for fish ponds within the reach. Diversion for fish ponds typically begin in late April or early May and end in October. As noted previously, the water commissioner position was vacant in 2016 and no diversions were recorded.

Most of the ponds are unlined and do not have storage decrees. Depletions associated with the junior diversions to replace pond evaporation are generally replaced under small augmentation plans. Average annual measured diversions from the 1998 through 2017 period were 780 acre-feet, compared to average annual diversions for irrigation for the same period of 330 acre-feet.

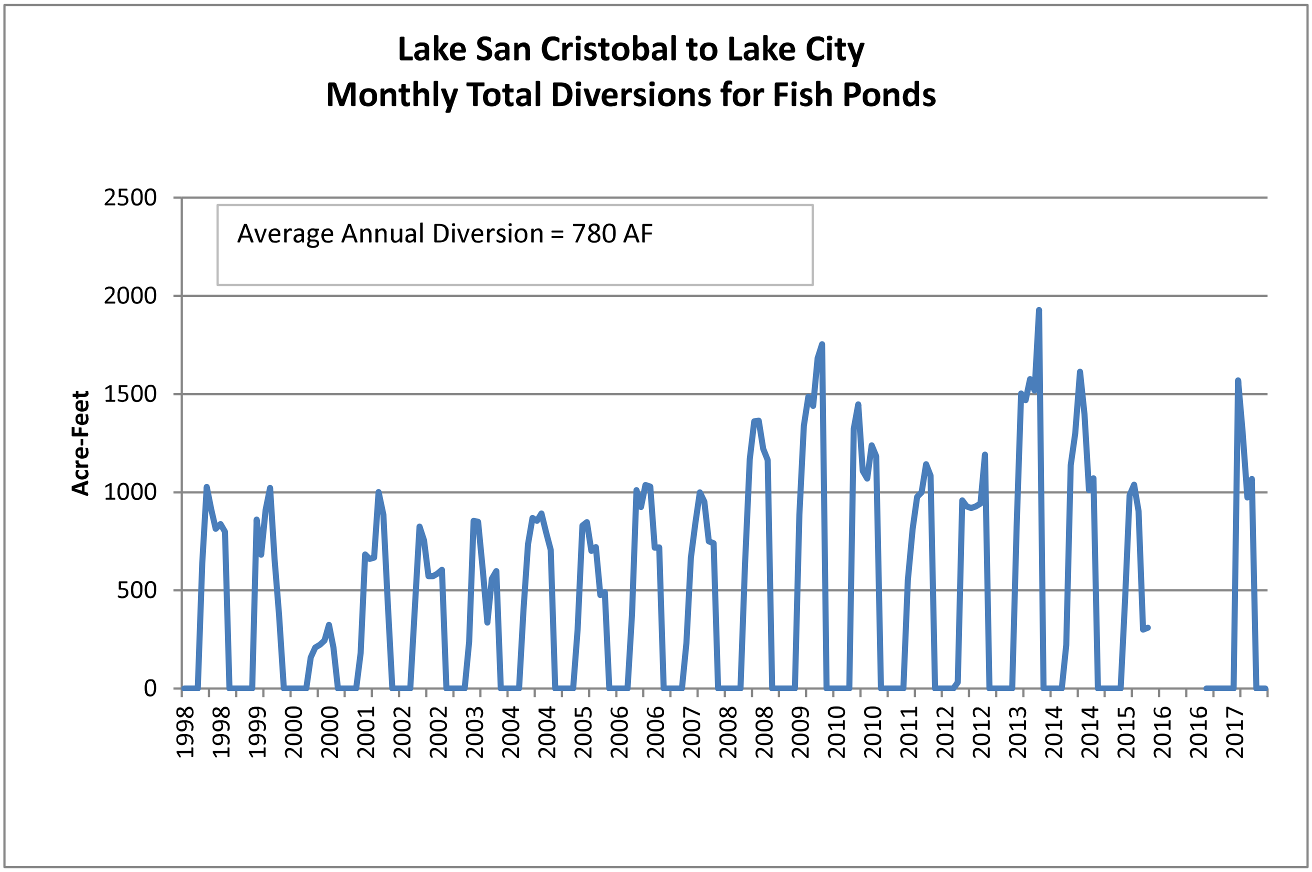


Figure 7-6: Lake Fork from Lake San Cristobal to Lake City Measured Diversions for Fish Ponds

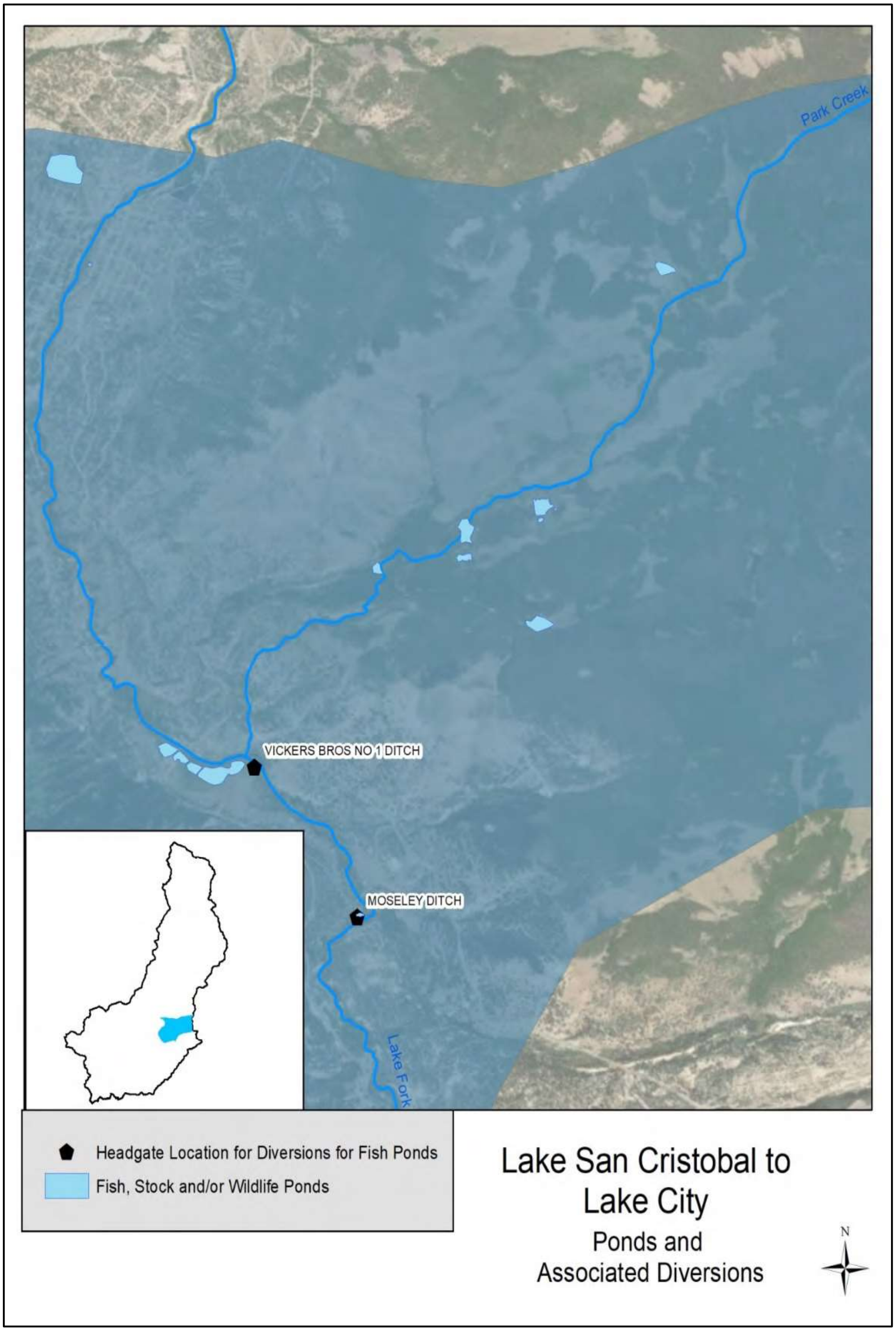


Figure 7-7: Lake Fork from Lake San Cristobal to Lake City, Fish Pond Diversions

7.5 Needs for this Reach: Issues Identified

Issue: Gladiator Mine complex and its impacts on the Lake Fork.

Issue: TMDL development for Deadman Gulch: Deadman Gulch, an intermittent tributary the Lake Fork River near the base of Slumgullion Pass and the Packer Memorial site, is on the 303(d) List for impairment of the aquatic life standards for multiple metals. The Golden Wonder Mine is located within the Gulch and a TMDL will ensure that future mining operations do not exceed recommended standards.

Issue: Development activities at the Golden Wonder Mine in Deadman Gulch

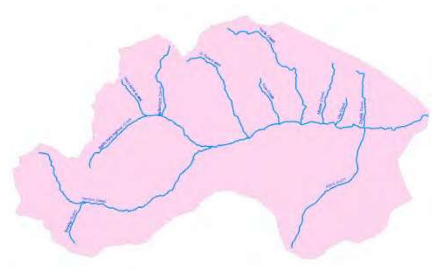
Issue: Potential instream flow water right for Park Creek. The Park Creek watershed supports multiple lakes, wetlands, and habitat. It would benefit from an instream flow right.

Issue: Potential enlargement of summer instream flow rate and segmentation for Lake Fork River. A review of stream flow data suggests that the Lake Fork River may require a higher summer instream flow to better preserve the natural environment.

Issue: Land Conservation: Several properties along this reach have potential for conservation, including the toe of the Slumgullion Earthflow, lower Vickers Ranch, Pete's Lake wetland, and riparian habitat in Lake City. The Lake Fork Valley Conservancy is currently working on a conservation easement for their 58 acres on Slumgullion Earthflow.

Issue: Pete's Lake. Pete's Lake is a 5 acres wetland located at the north end of town and is owned by the Town of Lake City. Wetland quality was compromised in 2002 due to the lake being drained to meet instream needs on the Lake Fork. This affected habitat, especially for bird breeding and increase in weeds at the wetland periphery. The LFVC has proposed a water storage and habitat improvement project that will raise the water level up to 1.5 feet and isolate mid lake islands to promote bird breeding habitat. In addition, the Town of Lake City will once again apply for a water storage right for environmental and recreational purposes, which can be released for downstream calls on the Lake Fork.

Section 8. Section 8. Reach 4 - Henson Creek



The headwaters of Henson Creek form at the northwestern borders of the Uncompaghre and Lake City Calderas and contain highly mineralized zones. Henson Creek flows southeast toward Engineer Pass Road (County Road 20) and the confluence with Palmetto Gulch. Henson Creek flows east to Whitmore Falls, a large and scenic waterfall. Down-valley the drainage widens and allows for a riparian area upstream of the confluence with the North Fork of Henson Creek, at Capital City. The North Fork of Henson Creek drains the northern aspects of Dolly Varden and Sunshine mountains. Below the confluence with the North Fork, Henson Creek descends through a steep and narrow canyon, where the creek is further confined by Engineer Pass Road. Tributaries to Henson Creek within this reach are steep and dynamic channels that deliver ample sediment, debris, and water. Large avalanche paths are common throughout the Henson Creek Basin.

The majority of the Henson Creek Basin is managed by the BLM as either wilderness or wilderness study areas. Private lands tend to occur near Henson Creek and Engineer Pass Road. The USFS Uncompaghre Wilderness occurs along the northern edge of thebasin.

The Henson Creek Basin was mined extensively from the summit of Engineer Pass to Lake City and many prominent sites in between. For over a decade, the Lake Fork Valley Conservancy, BLM, and DRMS have partnered to reclaim nine mines in the Henson Creek Basin. DRMS has also completed many safety closures to prevent the public from accessing the workings of historic mines.

Engineer Pass Road links Lake City to Ouray and Silverton. This connection provides substantial recreational and economic opportunities for the community. Throughout the summer Engineer and Cinnamon Pass roads provide access to stunning alpine terrain, historic mine sites, hiking, camping, biking, climbing, and other outdoor pursuits. Limited fishing and kayaking occur in Henson Creek and the North Fork of Henson Creek.

8.1 Agricultural Water Use

There are no diversions for agricultural use in this headwater reach and no identified needs in the future.

8.2 Domestic Water Use

The Lake City Town Ditch diverts water from Henson Creek for irrigation and fire protection, at 5 cfs from May 1 to October 1.

There are several springs and wells with water rights near historic mine sites, and on private lands throughout the reach. Most of the residences in the Henson Creek Basin are near Engineer

Pass Road and Henson Creek. Wells provide water for household use and individual onsite wastewater treatment systems are used to manage wastewater.

8.3 Environmental Water Use

8.3.1 Stream and Riparian Characteristics

Steep glaciated valleys and canyons form the headwaters of Henson Creek. Slopes are covered with talus or a thin veneer of soil and sensitive alpine tundra vegetation. The streams, which are both intermittent and perennial, are steep entrenched channels that are often scoured to bedrock. Tributaries that flow on an intermittent basis are often even steeper and more entrenched. Following large precipitation events these headwater tributaries occasionally flow as debris torrents. Avalanche paths parallel these drainages.

Photo 8-1. View from the summit of Engineer Pass. The drainage in the foreground is Palmetto Gulch near the Hough Mine reclamation site. The background slopes are characteristic of steep tributaries to Henson Creek.

Due to the geology and steep slopes, hillslopes in the headwaters are naturally susceptible to mass erosion which includes landslides, earth flows, debris avalanches, debris flows, torrents, and snow avalanches. Natural mass erosion events are probable throughout the headwaters area. These sporadic events provide massive natural sediment sources, as shown in Photo 8-1. Evidence of recent mass erosion is very common throughout the headwaters area. These natural hillslope processes are an enormous source of sediment to the Lake Fork River. Natural mass erosion dominates sediment supply in the headwaters.

Henson Creek and its tributaries are extremely efficient at moving sediment. In contrast, the valley widens and flattens somewhat near Capital City. These changes decrease the channel's capacity to carry sediment and often results in large sediment deposits and frequent adjustments to channel form and location. Over time, the lower angle valley channel will winnow away accumulated sediment. The stream system may establish a tenuous and temporary equilibrium, but natural sediment delivery and erosion processes are very dynamic due to the topography, geology, and climate. Human efforts to confine or stabilize the stream channel may be effective for brief periods, but long-term stability should not be expected in this environment.

Willows and riparian vegetation have colonized portions of narrow stream corridors in larger tributaries to Henson Creek where sediment deposition has supported soil development. In the reach near Capital City, large wetland complexes support a variety of aquatic and wildlife habitats. These wetland complexes also attenuate flood flows and store water to support late season flows.

Downstream of Capital City and the confluence with the North Fork of Henson Creek, Henson Creek flows through a steep canyon en route to Lake City. Tributaries and hillslopes within this portion deliver large volumes of sediment as Henson Creek cuts through several narrow canyon reaches. The Ute-Ulay mine site and its two dams are in the lower stretch of Henson Creek. At several points County Road 20 further confines Henson Creek. There are a handful of small and undersized bridges that span Henson Creek near Lake City.

8.3.2 Aquatic Life

From 2015 to 2018, five macroinvertebrate samples were collected from locations in the Henson Creek Basin. MMI scores at four locations, including the headwaters of Henson Creek, Henson Creek downstream of Palmetto Gulch, the North Fork of Henson Creek, and Henson Creek near Lake City, attained the aquatic life use criterion. A very limited number of macroinvertebrates occur in Palmetto Gulch due to metals loading from historic mine sites. Based on the samples collected to date, Palmetto Gulch is likely impaired for aquatic life use, but has not been nominated or listed as such.

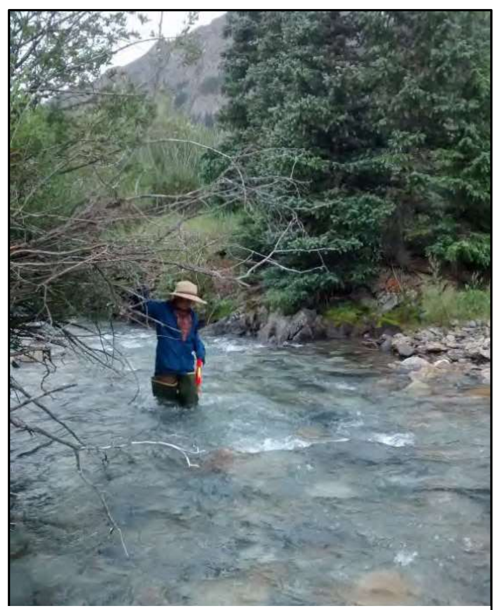


Photo 8-2: Field staff prepare transects for macroinvertebrate sample collection in the North Fork of Henson Creek in August 2015.

Henson Creek supports a small fish population that includes brook, brown, and rainbow trout. Whitmore Falls, upstream of Capital City, is a substantial habitat barrier. In the past, CPW stocked Colorado Cutthroat upstream of Whitmore Falls; the waterfall prevents competition with other species of trout downstream, but these were out-competed by brook trout upstream. Other local experts recommend caution if additional stocking is considered in this reach, as upper Henson Creek may be a naturally fishless stream, which is rarer and allows for unique and robust macroinvertebrate communities (Alexander, 2018). Smaller features, including waterfalls and bedrock glides, may create habitat barriers in other portions of Henson Creek.

8.3.3 Water Quality

Historic abandoned mines in Palmetto Gulch, a tributary to Henson Creek, are the primary source of metals in the Henson Creek Basin. Prospecting in the Lake City area started in 1870, with several mines active in Palmetto Gulch within a few years. Mining continued for several decades.

In 2002 Palmetto Gulch was added to the 303(d) List for impairment of the aquatic life standards for dissolved cadmium and zinc. This initial impairment listing added momentum to a collaborative effort to further characterize mine features, water quality conditions, and develop and implement reclamation projects in the Henson Creek Basin. Table 8-1 and Figure 8-1summarize the water quality impairments and potential impairments in the Henson Creek Basin.

Table 8-1: Impaired and potentially impaired stream reaches in the Henson Creek Basin.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
Mainstem of Palmetto Gulch including all tributaries	Aquatic Life Use	Dissolved Silver	NA	NA
		pH	NA	NA
		NA	Dissolved Copper	NA
		NA	Total Iron	M
		Dissolved Cadmium – TMDL approved in June 2010		
		Dissolved Zinc – TMDL approved in June 2010		
	Water Supply Use	NA	Dissolved Manganese	Low
Mainstem of Henson Creek from the headwaters to the confluence with the Lake Fork River	Aquatic Life Use	Dissolved Cadmium – TMDL approved in July 2010		
		Dissolved Zinc – TMDL approved in July 2010		
	Water Supply Use	Total Arsenic	NA	NA
All tributaries and wetlands of Henson Creek, except for the North Fork of Henson Creek	Water Supply Use	Total Arsenic	NA	NA
North Fork of Henson Creek Including all tributaries and wetlands except for Henson Creek	Water Supply Use	Dissolved Manganese	NA	Low
Tributaries to the Lake Fork River, including wetlands, within the Powderhorn and Uncompahgre Wilderness Areas[1]	Water Supply Use	NA	Total Arsenic	High
		Dissolved Iron	NA	NA

[1] The tributaries within wilderness areas in Henson Creek have not been sampled. Arsenic and iron concentrations measured in streams in the Raggeds Wilderness provided the information necessary to list the wilderness tributaries. Given the data set in the Henson Creek Basin, the total arsenic listing is likely appropriate, but the M&E listing for dissolved iron may not be appropriate.

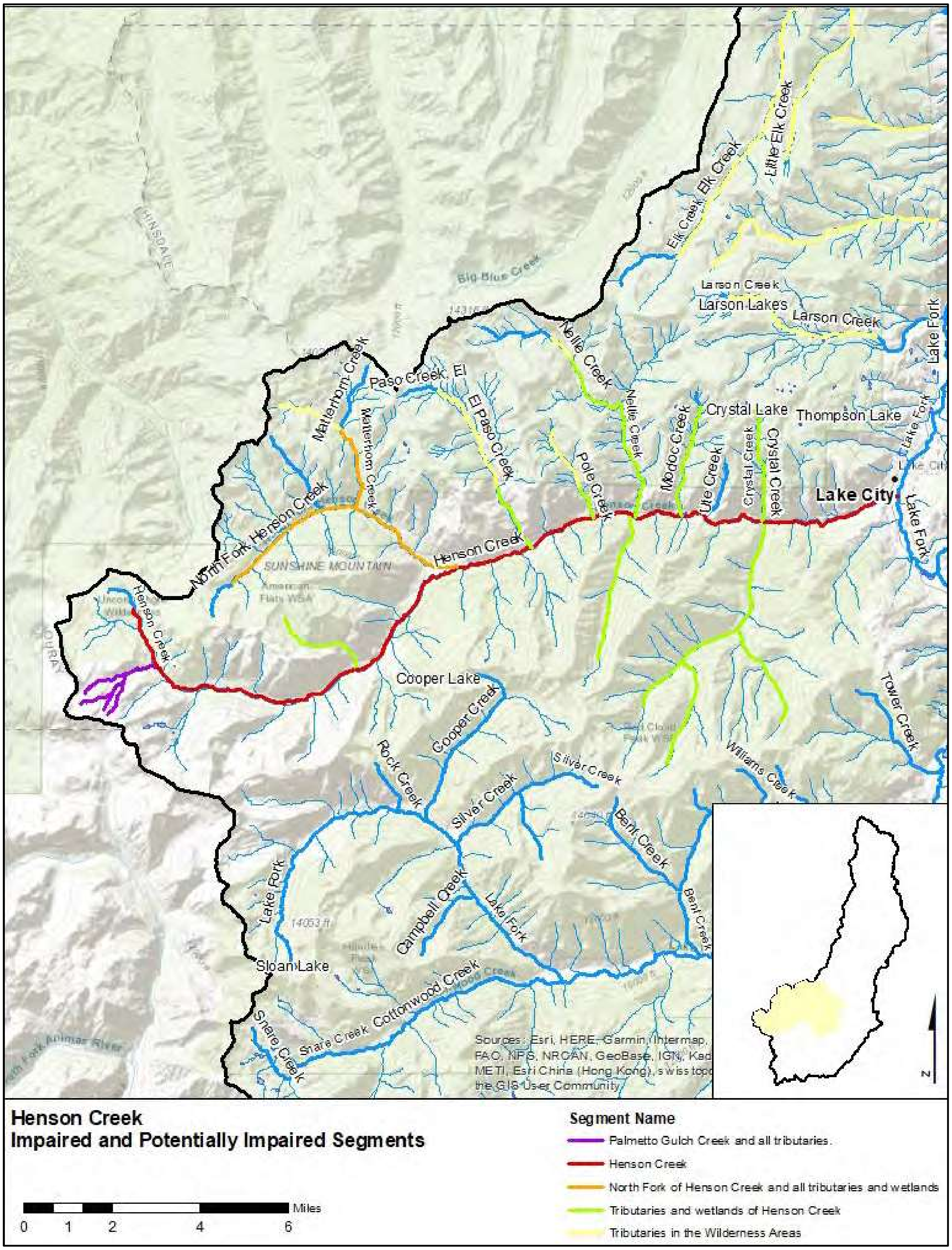


Figure 8-1: Impaired and potentially impaired stream reaches in the Henson Creek Basin

Palmetto Gulch drains just over one square-mile of alpine tundra below the summit of Engineer Pass. Three small unnamed tributaries, locally referred to as North, Middle, and South Palmetto Gulch flow into Palmetto Gulch. Field surveys completed by DRMS staff identified 12 mine waste piles and four adits, which equates to one abandoned mine feature per 40 acres (Owen, 2009).

Photo 8-3: Drainage from the Hough Mine en route to North Palmetto Gulch in September 2016, one year following reclamation. The right side of the photo includes edge of the mine waste repository.

The Hough Mine, located just below the summit of Engineer Pass at nearly 13,000 feet, was the largest mine in Palmetto Gulch. Prior to reclamation the site had an open draining adit, a partially collapsed shaft, and two large waste dumps with a footprint of approximately seven acres. Major reclamation activities included consolidating contaminated mine wastes into a repository, lining and capping the repository to prevent surface water infiltration, constructing three run-on channels to divert water around the repository, and revegetation of disturbed areas. A grate is installed over the adit and drainage flows into a constructed channel. Reclamation at the Hough Mine took two field seasons and was completed in late fall of 2014. Revegetation was completed in early summer 2015.

The Roy Pray Mine is in Middle Palmetto Gulch. In 2003, the bulkhead at the Roy Pray Mine was sealed to prevent acid mine drainage. In 2005 a permanent diversion and collection structure was installed to further control water movement on site. The waste pile associated with the adit was moved in 2005 to prevent leaching from the mine waste (Krabacher *et al.*, 2006). Data collected in recent years suggests that maintenance work is required to assure the bulkhead continues to function as designed. In 2018, DRMS staff drilled into the Roy Pray mine workings to collect data that will be used to improve the bulkhead's performance. The Sara Woods Mine is also in Middle Palmetto Gulch.

The Wyoming Mine is in South Palmetto Gulch. During reclamation, run-on water was routed around waste rock to prevent contamination and amendments were added to the waste rock to neutralize acidity and reduce metals mobilization.

Metal concentrations measured in 2016, one after year reclamation at the Hough Mine, are promising. Initial results indicate that metal concentrations in North Palmetto Gulch have declined relative to historic and pre-reclamation concentrations and that metal concentrations decline as the distance from the mine increases. In Palmetto Gulch, initial results suggest that the concentrations of some metals have declined following reclamation. Reclamation may have decreased the concentration of selected metals throughout Henson Creek.

Additional sample collection occurred in 2016 and 2017, preliminary evaluations of the data suggest that metal concentrations continued to decline in North Palmetto Gulch, Palmetto Gulch downstream of North, Middle and South Palmetto Gulch, and in Henson Creek. Further, revised cadmium standards were adopted in late 2017. Additional data collection and or analysis is recommended to evaluate the current attainment status of aquatic life standards in Henson Creek downstream of Palmetto Gulch, downstream of the North Fork of Henson Creek, and Henson Creek near Lake City.

The Yellowstone Mine is tributary to the North Fork of Henson Creek. Reclamation activities at the site have isolated mine water from surface water and revegetated disturbed areas.

8.3.4 Water Temperature

BLM staff installed two continuous temperature sensors in the Henson Creek Basin in recent years. One sensor was installed in the North Fork of Henson Creek at the County Road 20 bridge, upstream of the confluence with Henson Creek. The other sensor was installed in Henson Creek near Alpine Gulch, shown in Photo 8-4. Water temperatures at both locations attained the aquatic life standards during all three summers that the sensors were deployed, shown in Table 8-2.

Photo 8-4: BLM employees remove the temperature sensor from Henson Creek near Alpine Gulch in October 2017.

Table 8-2: Summary of stream temperature data in the Henson Creek Basin.

Location	Monitoring Start Date	Monitoring End Date	Number of Summers	Standard Attained
North Fork of Henson Creek	9/11/2014	10/25/2017	3	Yes
Henson Creek at Alpine Gulch	11/1/2013	10/25/2017	3	Yes

8.3.5 Existing Instream Flows

Figure 8-2 shows there are nine instream flow reaches in the Henson Creek Basin. Eight of the reaches were established in 1984. In 2009 BLM staff secured summer rate increases for the middle Henson Creek and Shafer Gulch reaches. The Alpine Gulch instream flow water right was established by the BLM in 2010. Five of the existing instream flow water rights have year-round rates and four reaches have winter and summer rates.

Securing instream flow water rights in the Henson Creek Basin, particularly in tributaries without historic mine features or limited water quality impacts, could be pivotal to the effort to restore Henson Creek. Tributaries, such as Schafer Gulch, El Paso Creek, and Alpine Gulch generally have better water quality than Henson Creek, which provides both dilution and high-quality habitat. Tributaries may support repatriation of additional aquatic life in Henson Creek. Further, there are multiple private land in-holdings in the Henson Creek Basin that could be developed in the future. Wildlife habitat, grazing, and recreational use in the Henson Creek Basin benefit from instream flows.

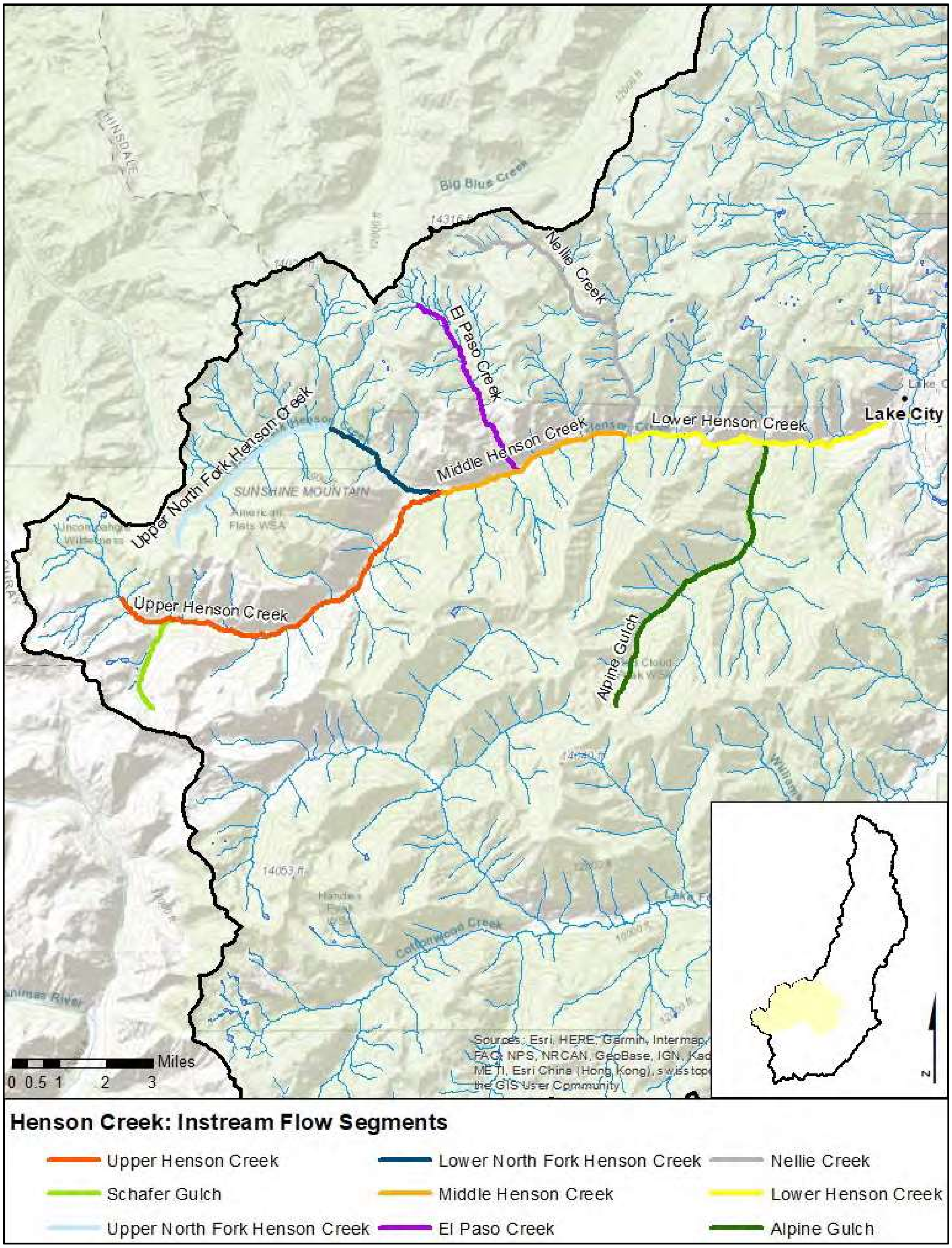


Figure 8-2: Instream flow water rights in the Henson Creek Basin

8.3.6 Flow-limited Areas

Snowfall and precipitation support groundwater and surface water flows in Henson Creek. The only diversion in the reach is in Lake City immediately upstream of the confluence with the Lake Fork River. Flow-limited areas were not identified in this reach due to very limited water use.

8.3.7 Environmental Flow Goals

Henson Creek flows freely to the Lake Fork, except for one small diversion near Lake City. The historic gage on Henson Creek was reestablished in early May of 2019 to support flood management and mitigation. Another gage was established at Alpine Gulch at the same time to provide early flood warning.

8.4 Recreational Water Use

Angling occurs along Henson Creek below Capital City. Whitewater boating occurs in Henson Creek Canyon from below the Ute-Ulay Dam to where the canyon flattens. The reach is very technical, class V, and requires extensive scouting to assure each portion of the reach is passable. It is generally understood that kayaking in the reach is limited to peak or near peak flows in above average years.

The lower portion of Henson Creek, from Gene Brown’s Bridge to Lake City is an adventurous float during high flow. This short reach is best enjoyed in kayaks or on standup paddle boards. Most of the land within this reach is public. Recreational use surveys are being gathered to better characterize use patterns and potential recreational improvements needed on this reach, as part of a future Lake Fork River Recreation Corridor Plan.

8.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Historic abandoned mines impair water quality.

Issue: Assess conditions at historic mine sites in the Henson Creek Basin following 2019 avalanche season: Historic sized avalanches decimated slide paths and adjacent forested hillsides in the Henson Creek Basin during March of 2019. Avalanche debris may have disturbed reclamation sites, safety closures, and historic mine features.

Issue: Roy Pray Mine maintenance activities.

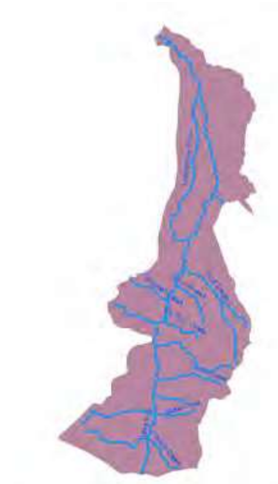
Issue: Review of water quality data from Palmetto Gulch and Henson Creek.

Issue: Potential to establish additional instream flow reaches in the Henson Creek Basin.

Issue: Extent of recreational use (kayaking) and angling in the Henson Creek Basin.

Issue: Water quality for household wells.

Section 9. Section 9. Reach 5 - Lower Lake Fork: Lake City to Blue Mesa



This reach stretches from the Town of Lake City to the where the Lake Fork flows into Blue Mesa Reservoir in Curecanti National Recreation Area. The river flows 32 miles to its confluence with the Gunnison River and drains an area of approximately 135 square miles. The Lake Fork River becomes a fourth order stream at Lake City, where Henson Creek flows into the Lake Fork. Stream flows in the are seasonally high in May and June due to snowmelt runoff. Flows on the Lake Fork near its terminus range from less than 50 CFS in the winter months to a historic recorded high of 2,900 CFS in May 1984. he river has carved a spectacular canyon on its journey to the Gunnison River, and is a prime destination for recreational activities such as boating and fishing. Much of this stretch is considered Gold Medal waters, although not formally designated as such.

The riparian corridor of the Lower Lake Fork has been identified as a riparian community of high global biodiversity significance by the Colorado Natural Hertitage Program (narrowleaf cottonwood - blue spruce / thinleaf alder riparian woodland (*Populus angustifolia* - *Picea pungens* / *Alnus incana* woodland. Adjacent upland vegetation is comprised of both sagebrush parks and montane forests. The sagebrush park zone is part of the large semiarid inter-montane Gunnison Basin, dominated by sagebrush shrub land and steppe vegetation. The montane zone is located at elevations of 7000 to 9000 feet, above the sagebrush park zone, although they are commonly intermixed, and both zones include aspen patches. Dominant forest species are Ponderosa pine, Douglas fir and quaking aspen. In much of the lower watershed, soil properties and topographic aspect favor one zone over the other. Highest elevation areas of this reach are dominated by Engelmann spruce, with sub-alpine fir in wetter areas and quaking aspen in lower reaches.

9.1 Agricultural Water Use

There are 28 active irrigation diversions in the Lower Lake Fork reach, serving approximately 719 acres of flood irrigated pasture grass. Table 9-1 shows the combined water rights, average annual and range of diversions, crop demands, actual crop consumptive use, and shortage estimates for the 28 ditches from 1998 to 2017. There was an open water commissioner position in the Lake Fork in 2016 and no diversions were recorded; therefore 2016 was not included in the table statistics. The information provided represents the sum of the information for each diversion.

Table 9-1: Agricultural Water Use Statistics – Lake Fork from Lake City to Blue Mesa.

Reach Statistics	1998 to 2017 Average excluding 2016	1998-2017 Range excluding 2016
Number of Irrigation Structures	28	N/A
Irrigated Acreage	719	N/A
Water Rights	103.575 cfs	N/A
Diversions	9,040 acre-feet	5,640 – 12,540 acre-feet
Crop Demand	1,510 acre-feet	1,290 – 1,50 acre-feet
Crop CU	1,330 acre-feet	1,200 – 1,480 acre-feet
Shortage/Need	180 acre-feet	90 - 170 acre-feet
Percent Shortage	12%	3% - 27%

Figure 9-1 and Figure 9-2 show the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, the B and B Ditch and Baker No 2 Ditch commingle to serve common acreage; F S William No 1 Ditch and Lake Fork Irrigating Ditch commingle to serve common acreage, and Lake Fork No 1 Ditch and Spring Branch Ditch commingle to serve common acreage.

There are two irrigation diversions on Indian Creek near the confluence with the Lake Fork (Indian Creek Irrigating Ditch and Indian Creek North Ditch that commingle with Addington No 1 Ditch and Moore Ditch to irrigate common acreage near the confluence of Indian Creek and the Lake Fork. Because they irrigate common acreage with Lake Fork ditches, their use is included with this reach instead of with the Lower Lake Fork Tributary section.

About 240 acres of the 710 total acres (about 1/3) is irrigated from diversions on smaller tributaries near the confluence with the Lake Fork. The crop demand associated with these ditches account for the majority of the shortages in the reach in wet and average years; ditches that irrigate from the mainstem generally receive a full supply except in dry hydrologic years.

All of the ditches are unlined and are estimated to lose approximately 10 percent of diverted water during delivery to the irrigated fields, depending on ditch length. Return flows from this reach, estimated to be an average of 7,710 acre-feet per year from 1998 to 2017, accrue to the Lake Fork just downstream the irrigated lands.

Figure 9-1: South half of lower Lake Fork from Lake City to Blue Mesa Reservoir (Map 1 of 2), Irrigation Structures and Acreage

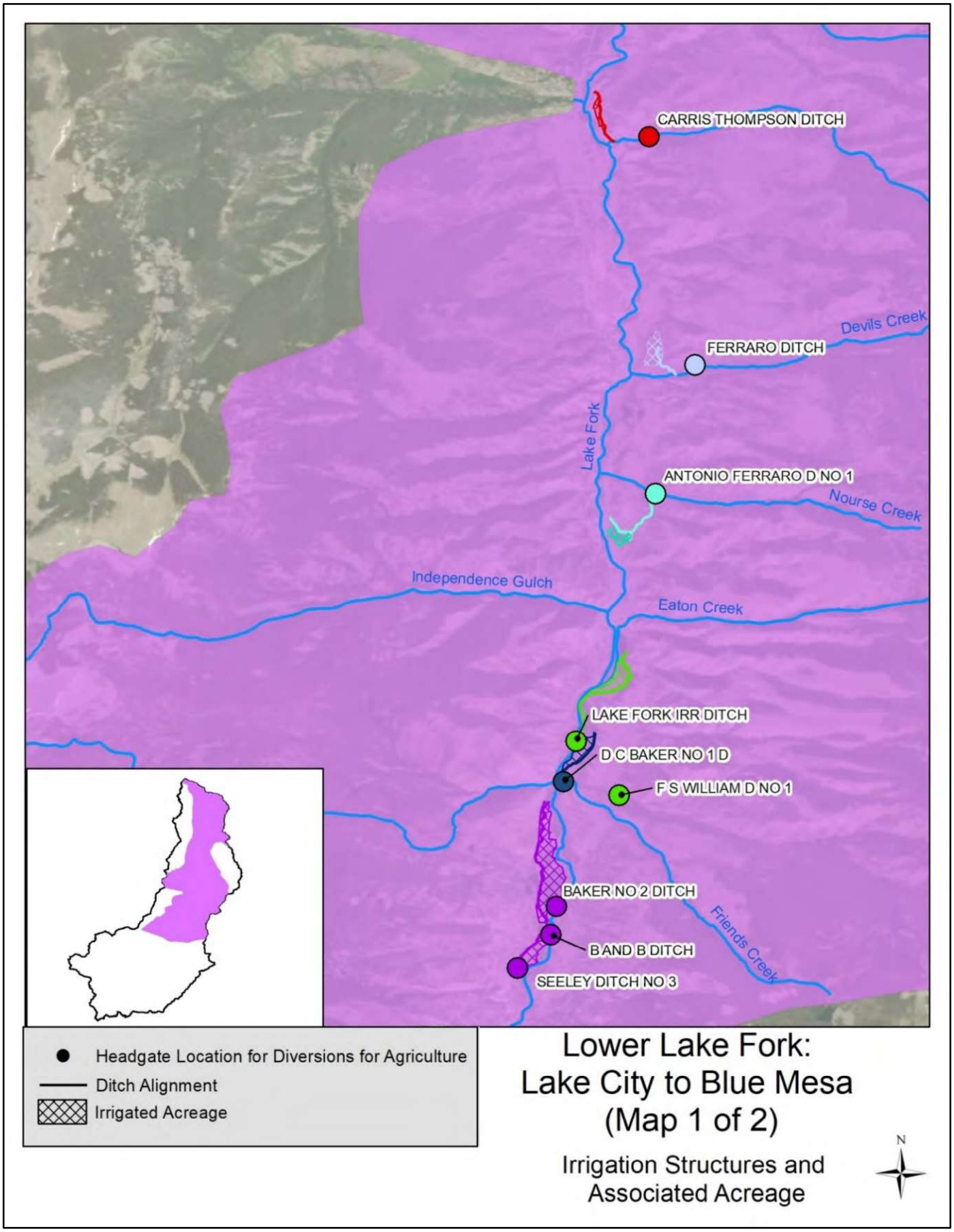


Figure 9-2: North half of lower Lake Fork from Lake City to Blue Mesa Reservoir (Map 2 of 2), Irrigation Structures and Acreage

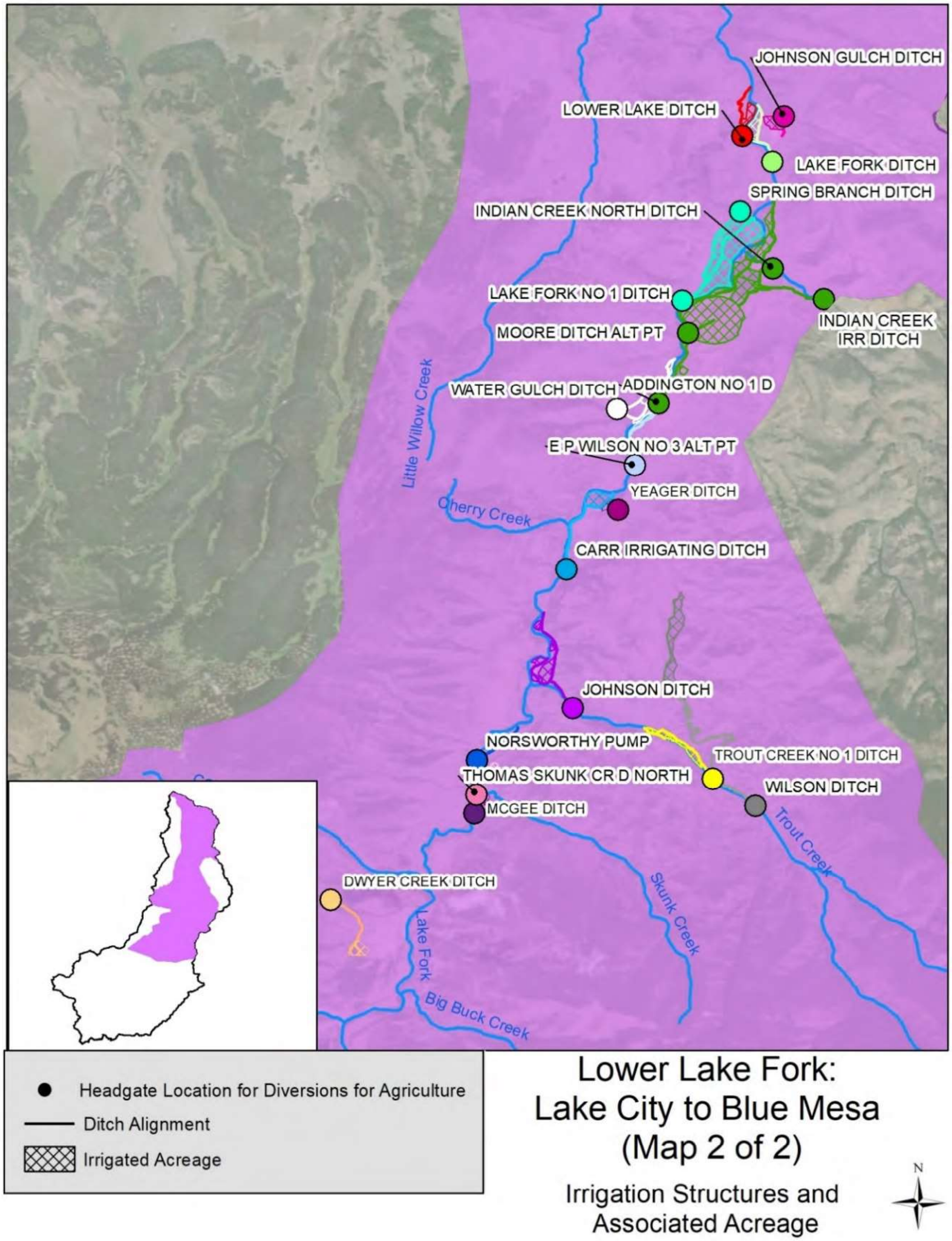
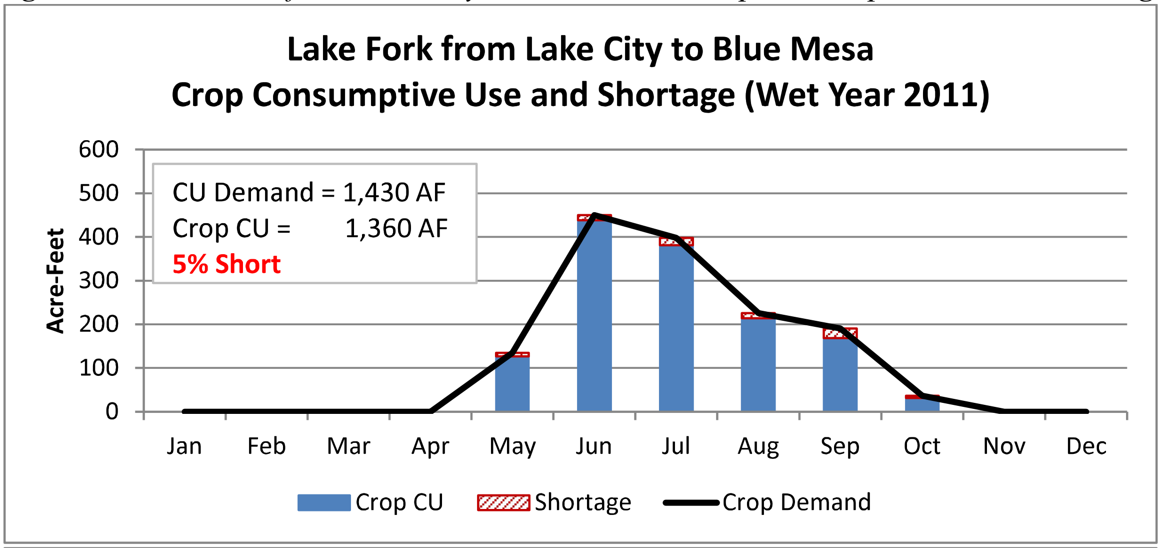
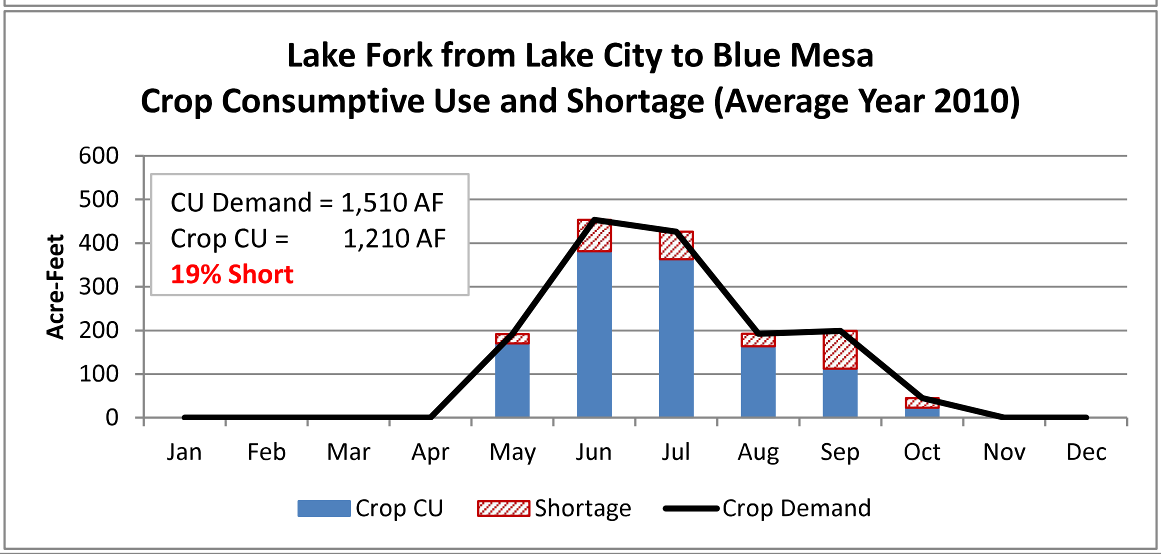
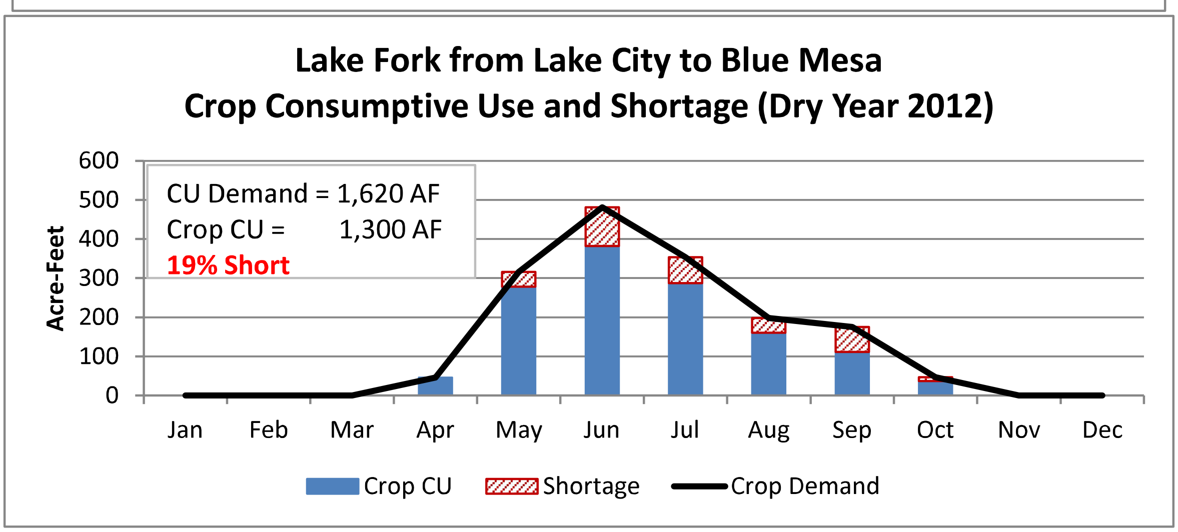


Figure 9-3 shows the monthly crop demands, crop consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). There were minimal shortages during the representative wet year, and the shortages were associated with acreage irrigated from the smaller tributaries. Each of the ditches supplying water from the smaller tributaries experiences shortages during the representative average and dry years.

Figure 9-3: Lake Fork from Lake City to Blue Mesa – Crop Consumptive Use and Shortage







9.2 Domestic Water Use

There are no diversions for municipal or industrial use in this headwater reach and no identified needs in the future.

There are homes and small subdivisions distributed along the Lake Fork River from Lake City to Blue Mesa. These developments are generally adjacent to Highway 149 or near county roads. Wells provide household water and individual onsite wastewater treatment systems are used to manage wastewater. None of the lower Lake Fork subdivisions below Lake City have centralized wastewater treatment systems.

9.3 Environmental Water Use

9.3.1 Stream and Riparian Characteristics

The Lake Fork River downstream of Lake City passes through striking landforms that are predominantly attributed to the volcanic geology. The geology in this area is a complex mixture of caldera margins, ash, lava, and debris deposits attributed to ancient volcanic activity. Erosional processes act on many of the relatively soft deposits to form steep tributary gullies, hillslopes, and small canyons. Following large precipitation events these tributaries occasionally flow as debris torrents and naturally deliver ample volumes of sediment to the streams and rivers. Natural mass erosion events are probable throughout the lower Lake Fork Basin.

Tributary channels and adjacent hillslopes are extremely efficient at moving sediment. In contrast, lower gradient channels where the valley widens and flattens decrease the channel's capacity to carry sediment and often results in large sediment deposits and frequent adjustments to channel form and location. Over time, the lower gradient channel will winnow away accumulated sediment. The stream system may establish a tenuous and temporary equilibrium, but natural sediment delivery and erosion processes are very dynamic due to the topography, geology, and climate.

The Lake Fork River is somewhat confined by small canyons, slide debris, and development within the riparian corridor from Lake City to Blue Mesa. Blue Spruce, willows, alders, and other riparian vegetation typically form a narrow ribbon within the riparian corridor. In some areas native vegetation has been altered by development within the riparian corridor.

In some instances, stakeholders reported channel stability issues. Several man-made constrictions, like undersized bridges, and channel stabilization features, armored banks, and vane structures are apparent in aerial imagery.

Stream stability and channel manipulation on a 1.3-mile section of the Lake Fork River approximately 1.5 mile north of Lake City.

Photo 9-1: Lake Fork River in September 1998 (image by USGS via Google Earth). In the center of the image multi-thread channels navigate large, wide sediment deposits. A low-water ford allowed vehicles to cross the river. Prior stream stability and channels configurations are unknown.

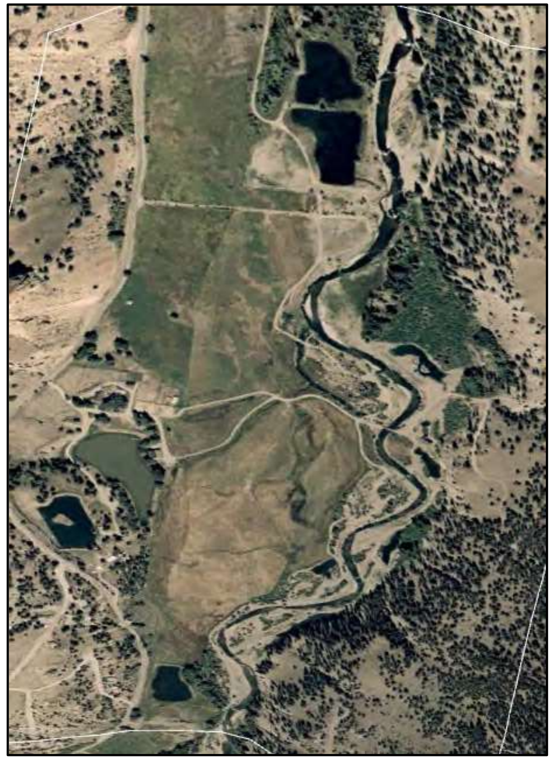


Photo 9-2: Lake Fork River in October 2005 (image by USDA Farm Service Agency via Google Earth). A large channel stabilization project was completed some time between 1998 to 2005. The project increased the channel sinuosity, narrowed the channel width, and installed many cross vanes and J-hooks throughout the reach. The project objectives were to improve fisheries, A bridge was installed across the river and a picnic pavilion was later built immediately downriver from the bridge.

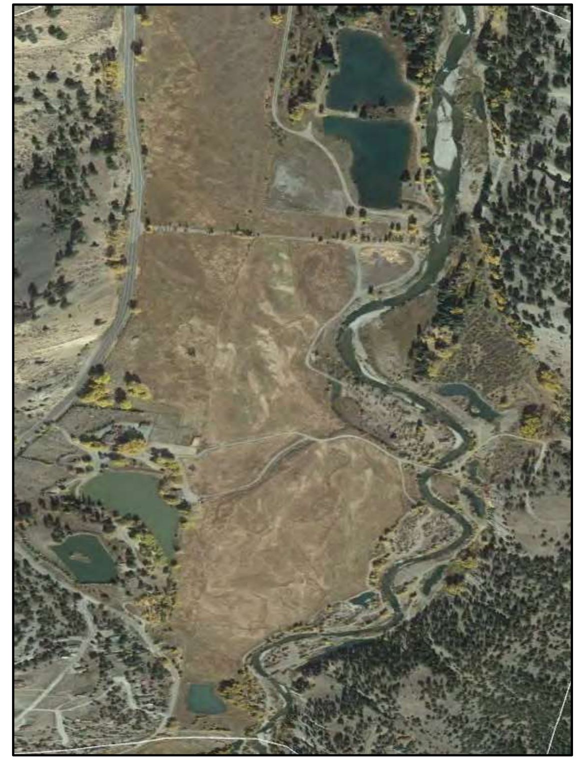


Photo 9-3: Lake Fork River in October 2015 (image by Google Earth). Notice that the channel width has increased throughout the reach. Which combined with decreased water depth likely reduces habitat quality. Sediment deposition has buried at least two cross vanes on the lower portion of the reach. It also appears that this sediment deposition has affected the performance of the diversion structure used to fill the ponds near the bottom of the reach. Access roads developed during construction remain and likely limit floodplain connectivity within the reach.

9.3.2 Aquatic Life

Since the late 1990s several organizations have sampled macroinvertebrates at multiple locations in the Lake Fork River from Lake City to Blue Mesa. Collectively, the results suggest that the macroinvertebrate community near Lake City is not as robust as in the lower portion of the reach.

The Lake Fork River from Lake City to Blue Mesa supports excellent fisheries, considered by many to be Gold Medal standard, although not designated as such. Brown trout and rainbow trout occur throughout the reach. Kokanee salmon occur from Red Bridge to Blue Mesa, but also swim upstream to Lake City during spawning. In 2016, CPW surveyed a 1.2-mile reach near Red Bridge Campground to characterize the density of fish greater than five inches in length. CPW found 733 brown trout and 351 rainbow trout per mile (CPW, 2016). Both rainbow trout and kokanee are stocked within this reach.

Overwinter and refuge habitat, especially deeper pools, may influence the distribution of fish within this reach. Near Lake City the Lake Fork River tends to be relatively shallow with fewer pools. While the Lower Lake Fork River has generally experienced less manipulation and benefitted from some habitat restoration projects near Red Bridge Campground. The restoration projects were completed in the 1990s as compensation for habitat lost due to the construction of the Aspinall Unit (Blue Mesa, Morrow Point, and Crystal reservoirs). CPW reported that fish weight and number of "quality-sized" fish doubled in the years following the habitat restoration project near Red Bridge Campground (CPW, 2016). BLM staff have suggested that it may be necessary to complete maintenance on restoration work completed in the late 1990s to assure habitat improvements are maintained.

The lower Lake Fork River, near the Gateview Campground, supports a large heron rookery.

9.3.3 Water Quality

In 2018 the Lake Fork River downstream of Eaton Creek to Blue Mesa Reservoir and tributaries located in wilderness areas within the upper Gunnison River basin were listed as impaired for total arsenic for water supply use, shown in Table 9-2 and Figure 9-4. The wilderness tributaries were also classified as potentially impaired for dissolved iron for water supply use. Tributaries within wilderness areas in the Lake Fork Basin have not been sampled. The data that resulted in the listing were collected from Oh-Be-Joyful Creek near Crested Butte. Because tributaries within the upper Gunnison Basin share many characteristics, the listings were retained for all wilderness tributaries. There is need to conduct follow-up sampling to see if this listing is appropriate for the Lake Fork reach. TO date, no TMDLs have been completed for these listings.

The National Park Service samples water quality in the Lake Fork River at Red Bridge Campground. Based on an extensive analysis of water quality data collected from 2001 to 2014 indicates that water quality standards were rarely exceeded. E. coli, pH, chloride, ammonia, nitrite, cadmium, manganese, selenium, silver, and zinc were less than water quality standards in all 63 samples collected in the study period. In less than 5 percent of the samples phosphorus, copper, and lead exceeded the applicable water quality standard (NPS, 2019).

Table 9-2: Impaired and potentially impaired stream reaches in the Lake Fork River Basin from Lake City to Blue Mesa.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
Mainstem of the Lake Fork River and all tributaries and wetlands from a point immediately above the confluence with Eaton Creek to Blue Mesa Reservoir	Water Supply Use	NA	Total Arsenic	High
Tributaries to the Gunnison River, including wetlands, within the Powderhorn and Uncompahgre Wilderness Areas	Water Supply Use	NA	Total Arsenic	High
		Dissolved Iron	NA	NA

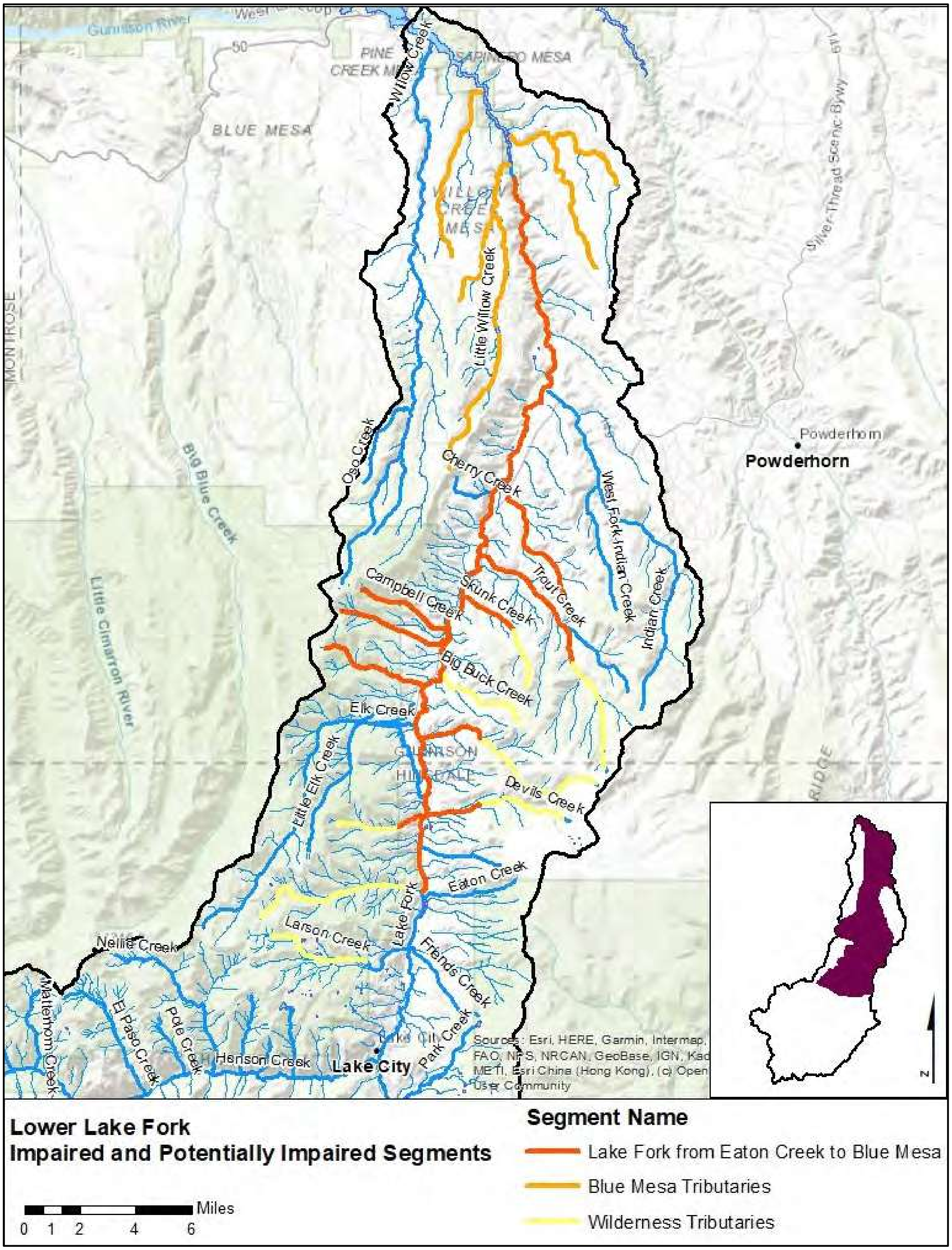


Figure 9-4: Impaired and potentially impaired stream reaches in the Lake Fork River Basin from Lake City to Blue Mesa Reservoir.

9.3.4 Water Temperature

BLM staff installed two continuous temperature sensors in the Lake Fork River in recent years. One sensor was installed in the Lake Fork River at Devil's Creek (Photo 9-4) and the other was installed in the Lake Fork River at Gateview Campground. Water temperatures at both locations attained the aquatic life standards during each of the summers that the sensors were deployed, shown in Table 9-3 and Figure 9-5.

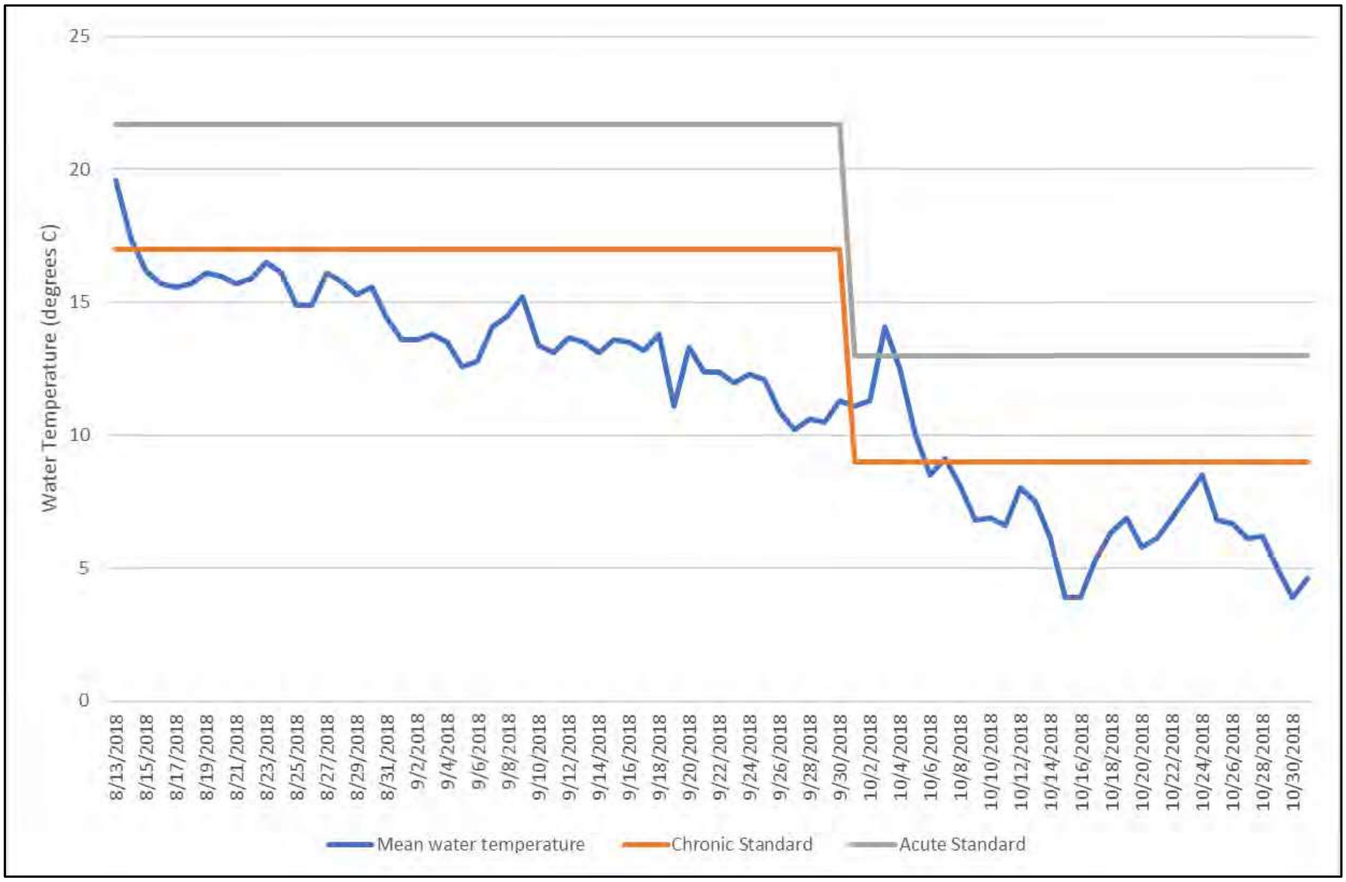
Photo 9-4: Lake Fork River near the confluence with Devil's Creek. This area is a popular fishing area.

In August 2018, USGS, with support from several partners, installed a continuous temperature sensor. Stream temperatures in the late summer of 2018 may have exceeded the aquatic life standards, due to extreme drought. CWCB released water from Lake San Cristobal to help reduce water temperatures and meet instream flows in the Lake Fork River downstream of the Lake.

Table 9-3: Summary of stream temperature data in the Lake Fork River from Lake City to Blue Mesa.

Location	Monitoring Start Date	Monitoring End Date	Number of Summers	Standard Attained
Lake Fork River at Devil's Creek	10/4/2012	9/24/2015	2	Yes
Lake Fork River at Gateview Campground	9/11/2014	9/7/2017	3	Yes

Figure 9-5: Average daily stream temperature in Lake Fork River at Gateview August 13, 2018 to October 31, 2018.



9.3.5 Existing Instream Flows

There are six existing instream flow water rights in the Lake Fork Basin between Lake City and Blue Mesa Reservoir, shown in Figure 9-6. The instream flow water rights for Larson Creek and Independence Gulch are year-round rights.

There are several named tributaries that lack instream flow water rights in this reach including Little Willow Creek, Nourse Creek, Eaton Creek, Friends Creek, Cherry Creek, Campbell Creek, Narrow Grade Creek, Big Buck Creek, and Skunk Creek. These tributaries were not investigated as part of this assessment.

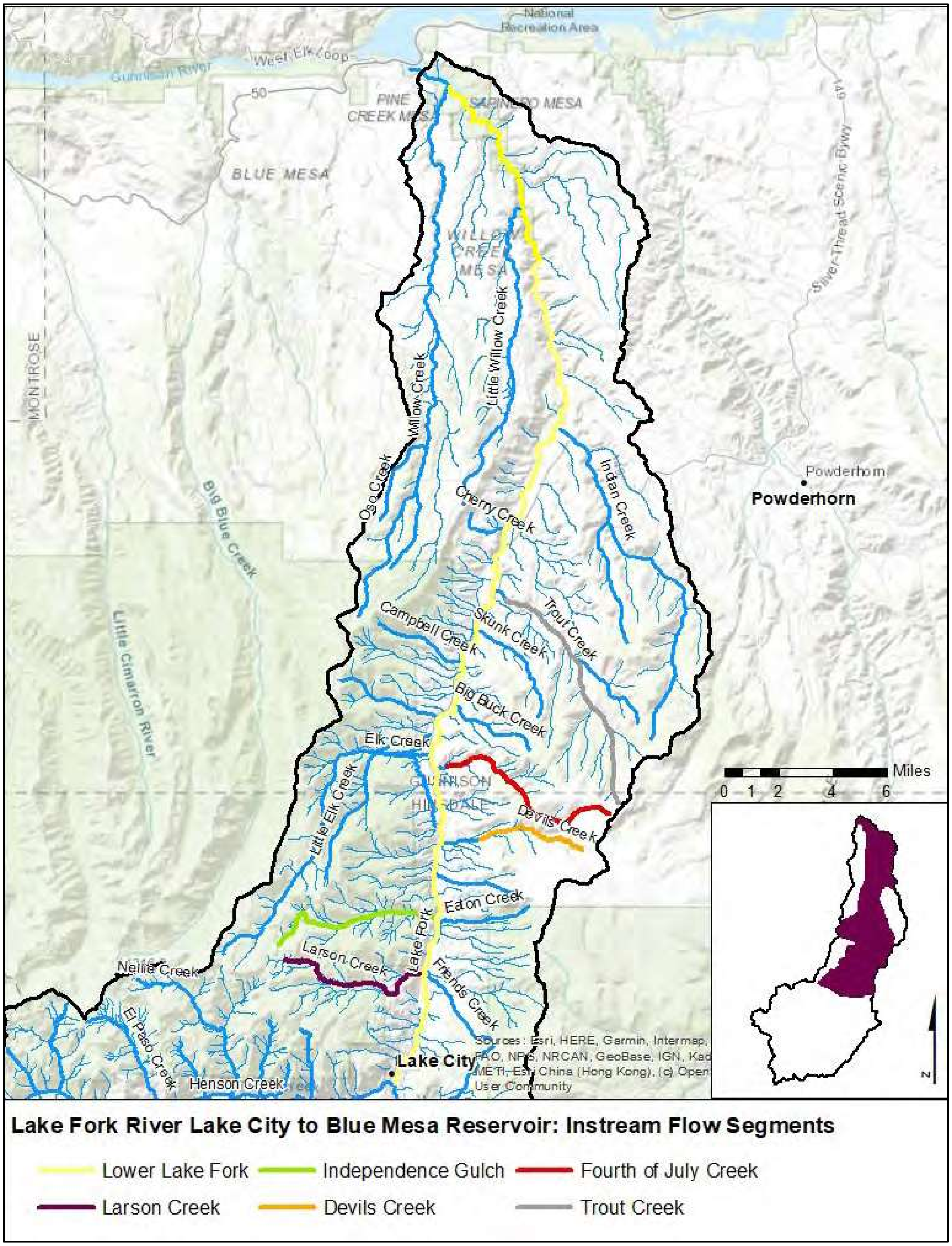
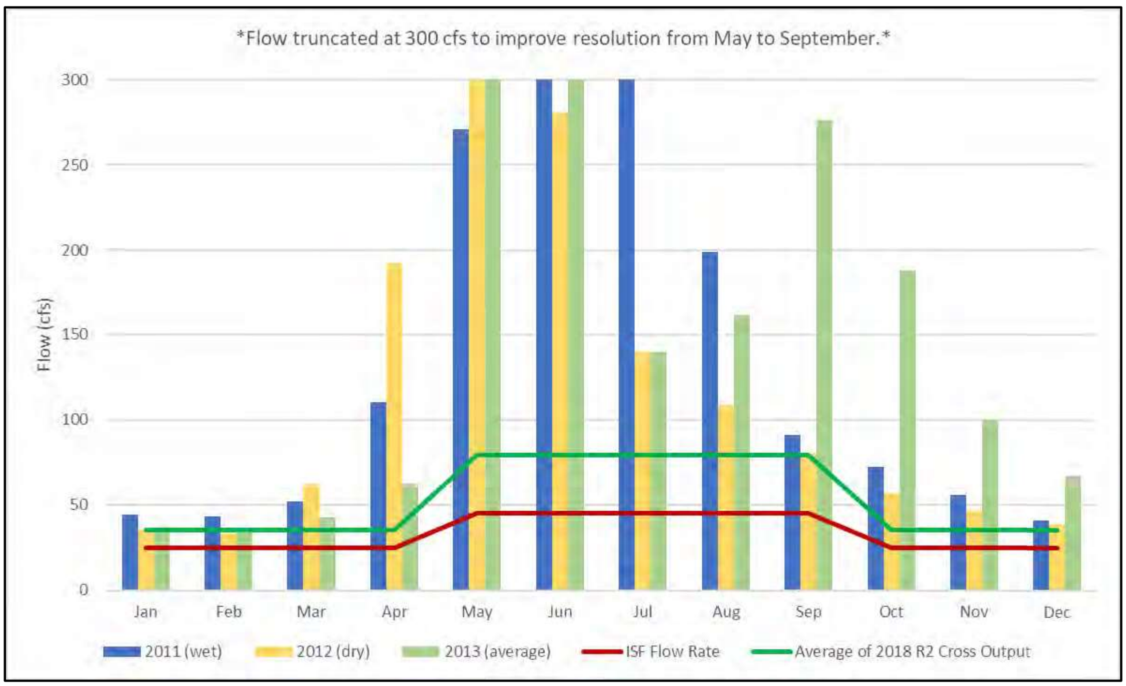


Figure 9-6: Instream flow water rights in the Lake in the Lake Fork River Basin from Lake City to Blue Mesa Reservoir.

The existing instream flow water right on the Lake Fork River from Henson Creek to Blue Mesa Reservoir provides minimum flow protections of 25 cfs in the winter and 45 cfs in the summer. As the original proposal was developed, staff noted that the winter rate did not meet the hydraulic criteria and the summer rate was reduced based on discussions with the water commissioner. However, a review of average monthly flows shows that stream flows consistently exceed the existing instream rates, shown in Figure 9-7. Like the original R2CROSS assessments, the 2018 R2CROSS assessments created recommendations higher than the existing instream flow water rights for both summer and winter.

Figure 9-7: Lake Fork River at Gateview (USGS 09124500) monthly average flows in 2011 (wet), 2012 (dry), and 2013 (average), along with existing instream flow rates, and the average of the 2018 R2Cross results (n=3).



As mentioned in previous sections, it may be possible to increase existing instream flow rates on upstream reaches of the Lake Fork River and Henson Creek, shown in Figure 9-8.

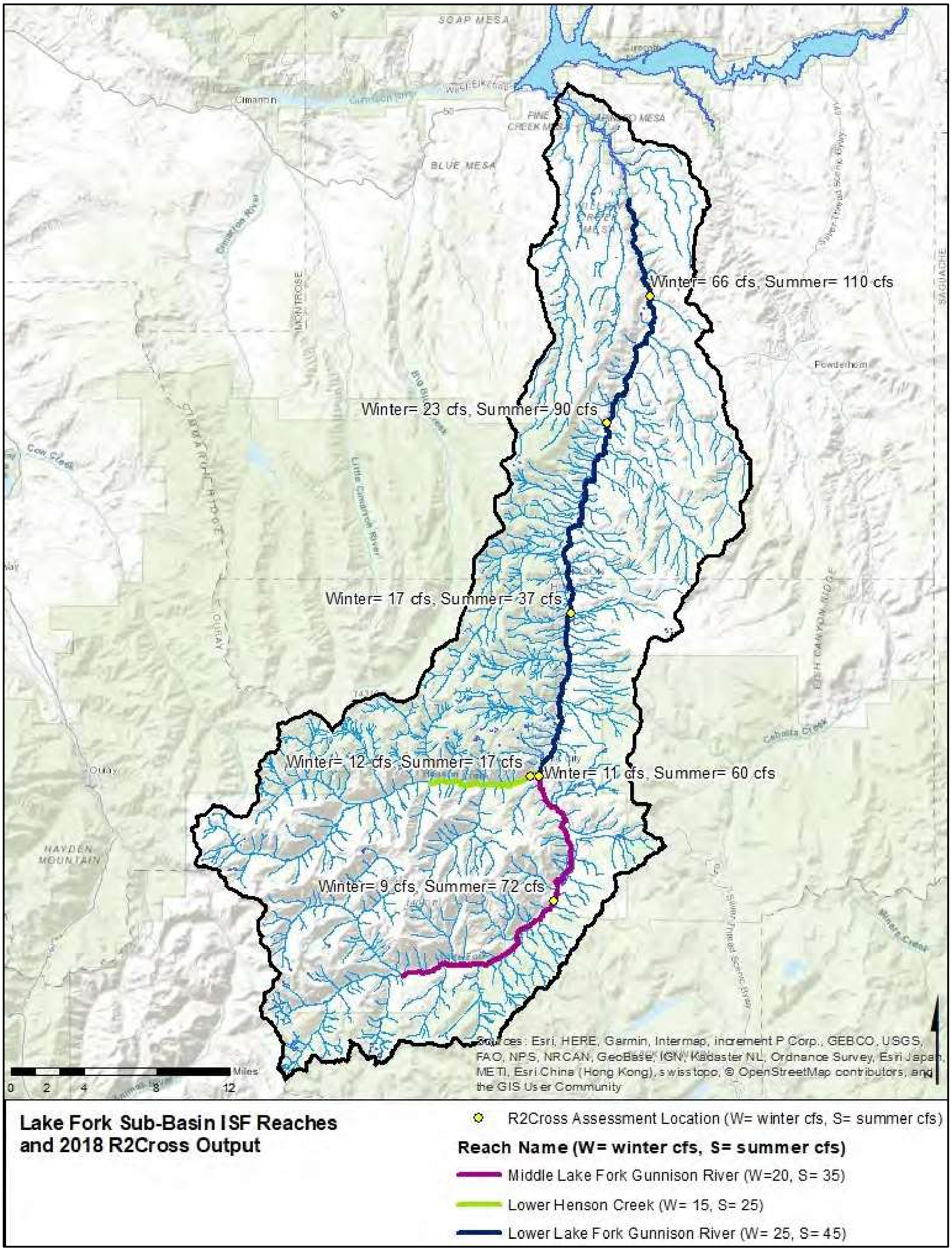


Figure 9-8: Existing instream flow water rights in the Lake Fork Sub-basin and 2018 R2CROSS Output

9.3.6 Flow-limited Areas

Water rights calls have not been recorded in the Lake Fork River Basin from Lake City to Blue Mesa Reservoir, which is promising with respect to flow-limited areas. Gentleman's agreements to avoid calls are common in the Upper Gunnison Basin so call records may not fully characterize flow issues. Based on water rights within the reach, 116.5 cfs, stream flows may be reduced significantly by diversions in low and average flow years from July to October. Under these circumstances, habitat downstream of large diversion structures may become fragmented (i.e. fish may not be able to travel upstream of the diversion), water temperatures may increase, and the vigor of riparian vegetation may be decreased in down-gradient areas.

The lower termini of the Devils Creek, Fourth of July Creek, and Trout Creek instream flow reaches end at headgates which suggests that these areas are flow-limited and may, at times, lack connectivity with the Lake Fork River.

9.3.7 Environmental Flow Goals

The Lake Fork River downstream of Lake City is an excellent candidate for tiered environmental flow goals for the following reasons:

- Outstanding fishery and macroinvertebrates.
- Good to excellent water quality conditions.
- Consistent attainment of stream temperature standards. Limited data suggest that temperatures may exceed the chronic standard during low flow conditions, which could be remedied or improved with alternative water management practices.
- Several miles of public access, and reasonably good infrastructure at three existing campgrounds, to allow for recreational use.
- Water rights held by CWCB and LSCWAE and stored in Lake San Cristobal provide opportunities for water releases to protect aquatic life.

9.4 Recreational Water Use

The Lake Fork Town Run (called Lake City Town Reach in WSR Guidebook) has many variations. Some users, especially those with standup paddle boards or innertubes, run the River through town from Memorial Park to the 8 ½ Street Bridge. Other users, including kayakers and rafters, run the river down to Independence Gulch Trailhead for a total distance of 12 miles or to Devils Creek Bridge, an additional two miles. This reach is most suitable under high flow conditions, or in above average years.

Devils Creek to The Gates is a popular float for both anglers and entry-level white-water enthusiasts, although this stretch can be more technical at high water due to narrow and winding canyon walls. Standup paddle board use is becoming increasingly common too. This stretch is most popular during moderate flows, approximately 600-800 cfs, for scenic views and fishing.

Low bridges prevent rafting at higher flows, but smaller craft can negotiate under these structures at high flow.

Lower Lake Fork Canyon below Red Bridge Campground flows across BLM and National Park Service land and is a popular white-water river run, especially at high flow. This area has good access and recreational amenities and there is currently no need for any boating infrastructural improvements.

9.4.1 Fish Pond Diversions

There are several private fish ponds within this reach. Figure 9-10 shows the location of the eight measured river diversions that fill fish ponds within the reach. The only depletions associated with pond diversions are replacement of pond evaporation; the diversions are generally flow-through and can result in significant de-watering of the river between the diversion and the river return location. Figure 9-11 shows fish ponds in the lower section of the Lake City to Blue Mesa reach; note that there are no measured diversions to fish ponds in that section. Figure 9-9 shows the total recorded diversions for fish ponds within the reach. Diversion for fish ponds typically begin in late April or early May and end in October. As noted previously, the water commissioner position was vacant in 2016 and no diversions were recorded.

Most of the ponds are unlined and do not have storage decrees. Depletions associated with the junior diversions to replace pond evaporation are generally replaced under small augmentation plans. Average annual diversions from the 1998 through 2017 period were 3,230 acre-feet, compared to average annual diversions for irrigation for the same period of 9,040 acre-feet.

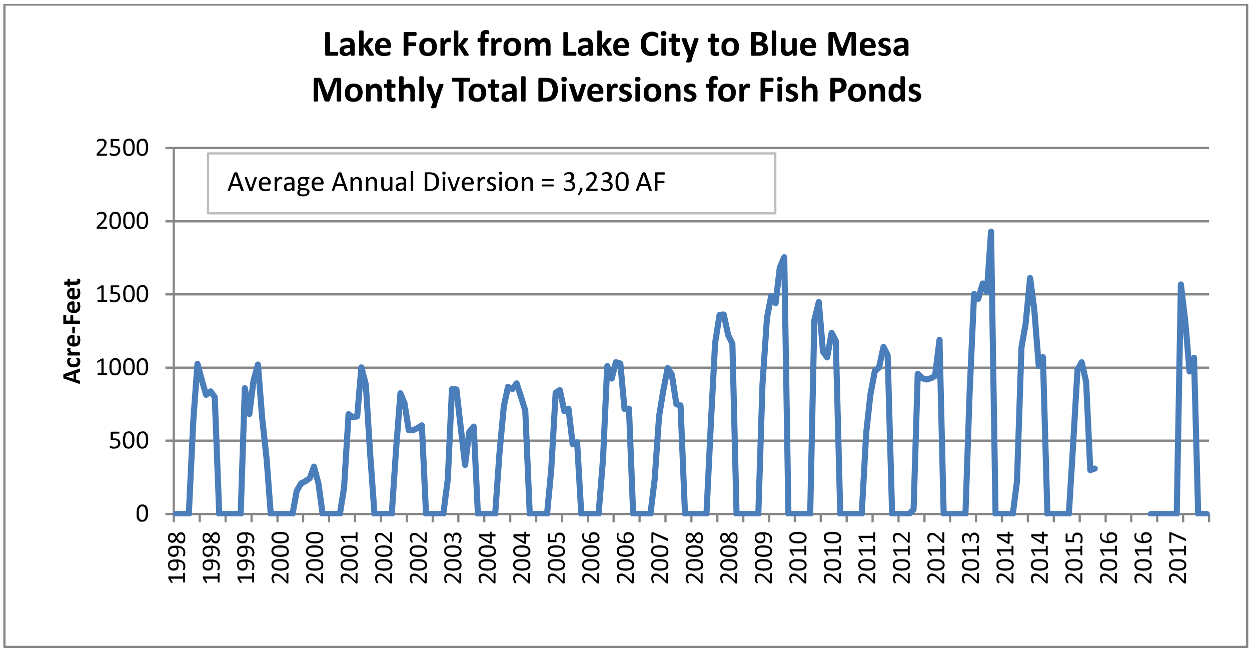


Figure 9-9: Lake Fork from Lake City to Blue Mesa – Measured Diversions for Fish Ponds

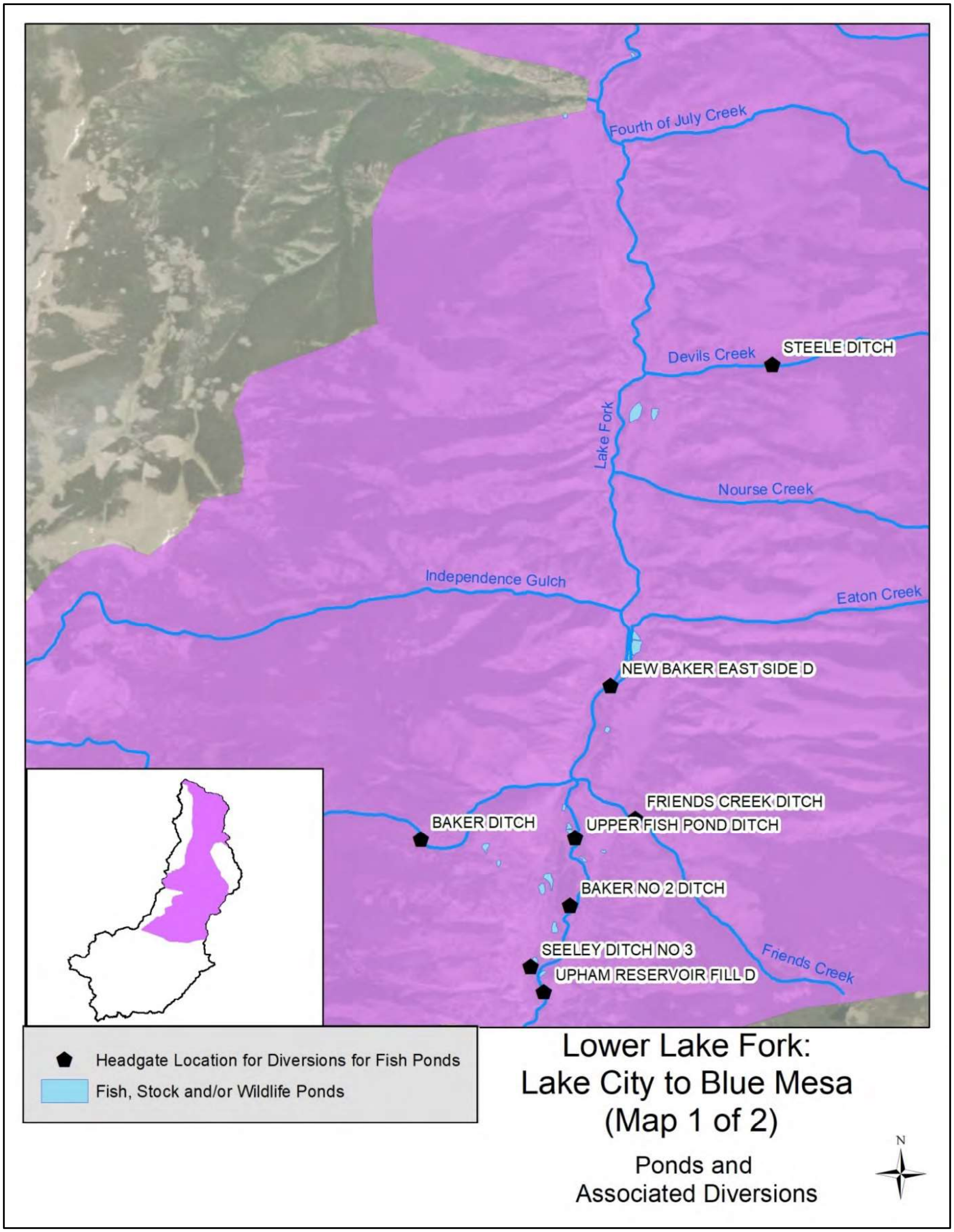


Figure 9-10: Lake Fork from Lake City to Blue Mesa, Fish Pond Diversions, Map 1 of 2

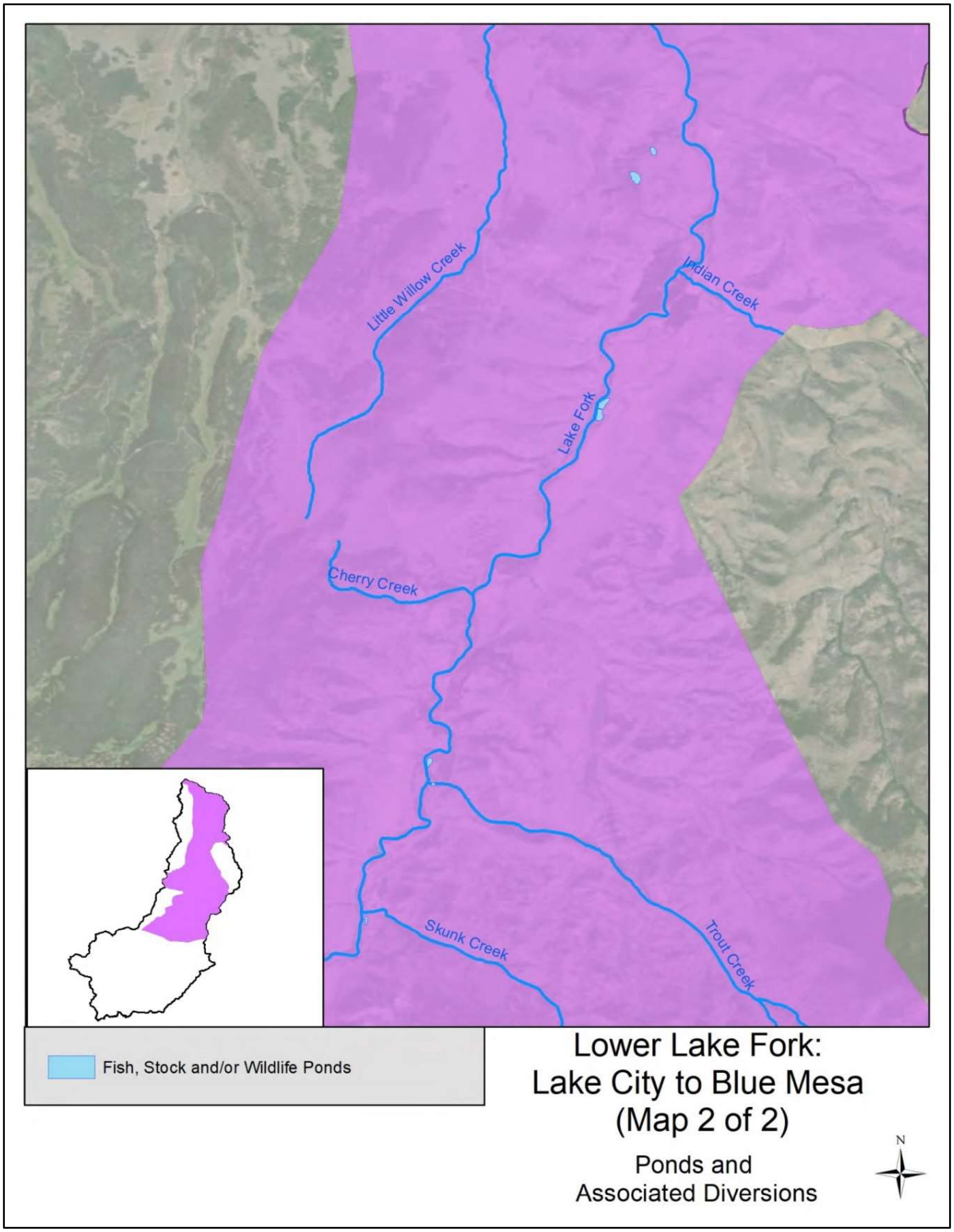


Figure 9-11: Lake Fork from Lake City to Blue Mesa, Fish Pond Diversions, Map 2 of 2

9.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Water quality for household wells.

Issue: Water supply and water rights in San Juan Ranch Subdivision. The subdivision, one mile north of Lake City, relies on spring fed wells. Some stakeholders are concerned about the effect of senior water rights calls, and others are more generally concerned about overall water supplies.

Issue: Potential to appropriate additional instream flow reaches in the Lower Lake Fork Basin.

Issue: Potential for enlarging the existing instream flow water rights for the Lake Fork River from Lake City to Blue Mesa Reservoir.

Issue: Extent of recreational use, angling and trespass on private land in the Lake Fork River from Lake City to Blue Mesa.

Some residents within this reach are concerned about water supply and augmentation for their wells and ponds, especially as water use and water rights administration increases.

Issue: Follow-up sampling to see if the impaired listing is appropriate for the Lake Fork River in this reach. To date, no TMDLs have been completed for this listing.

Section 10. Reach 6 - Lower Lake Fork Tributaries (Elk Creek, Indian Creek, Willow Creek)

This section describes water use along the three larger tributaries of the Lower Lake Fork that have substantial water rights on them. These were separated from the lower Lake Fork section because they experience more intense water shortage issues than the mainstem of the Lake Fork.

10.1 Agricultural Water Use

There are two irrigation diversions on Indian Creek near the confluence with the Lake Fork. The diversions supply water to irrigated fields that also use water diverted from the Lake Fork mainstem. The use is presented in section 9 - Lower Lake Fork: Lake City to Blue Mesa.

There are five active irrigation diversions on Elk Creek lower tributary to the Lake Fork, serving approximately 365 acres of flood irrigated pasture grass. Table 10-1 shows the total irrigation water rights, combined annual average and range of diversions, crop demands, actual crop consumptive use, and shortage estimates for the 11 ditches in this reach from 1998 to 2017. There was an open water commissioner position in the Lake Fork in 2016 and no diversions were recorded; therefore 2016 was not included the table statistics.

Table 10-1: Agricultural Water Use Statistics – Lake Fork Lower Tributaries (Elk Creek)

Reach Statistics	1998 to 2017 Average excluding 2016	1998-2017 Range excluding 2016
Number of Irrigation Structures	5	n/a
Irrigated Acreage	365	n/a
Water Rights	61.66 cfs	n/a
Diversions	3,210 acre-feet	1,800 – 4,170 acre-feet
Crop Demand	740 acre-feet	580 - 820 acre-feet
Crop CU	690 acre-feet	570 - 790 acre-feet
Shortage/Need	50 acre-feet	10 - 30 acre-feet
Percent Shortage	6%	1% - 11%

Figure 3-11 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. Note that the ditch alignment for the Hunter Elk Creek Ditch could not be identified. All the ditches are unlined and are estimated to lose 10 percent of diverted water during delivery to the irrigated fields. Return flows from these tributaries, estimated to be an average of 2,460 acre-feet per year from 1998 to 2017, accrue to the Lake Fork River, primarily below the confluence with Elk Creek.

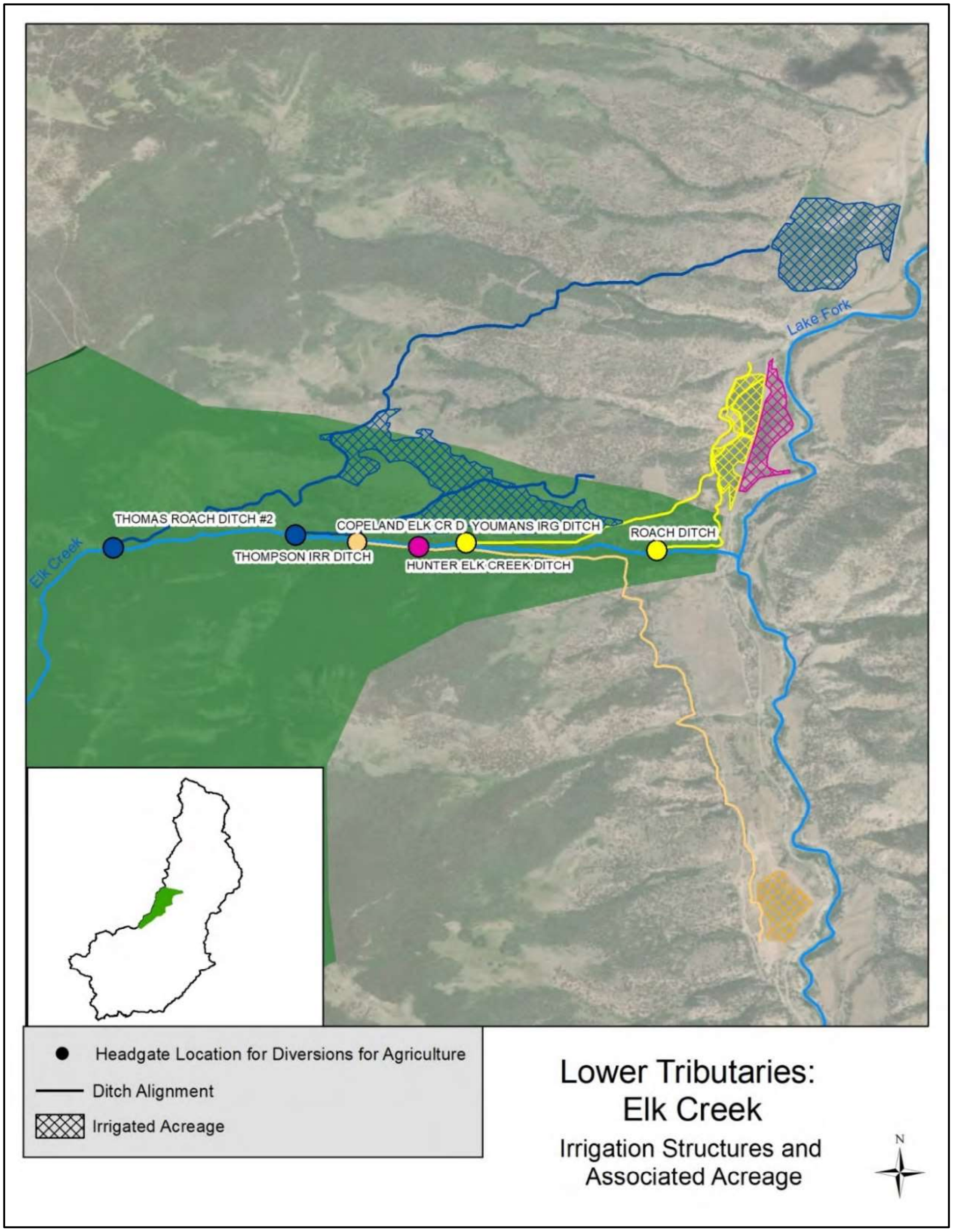
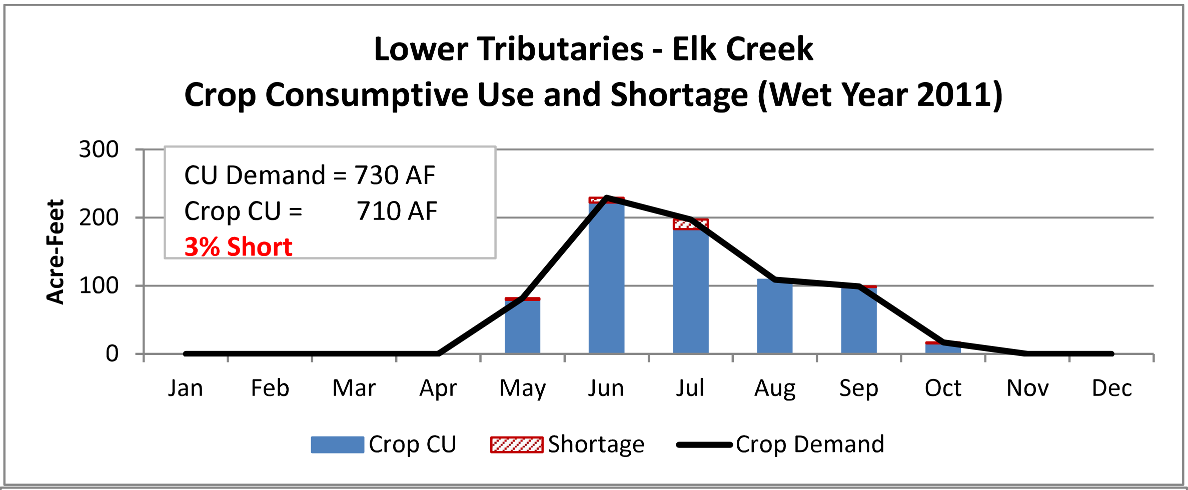
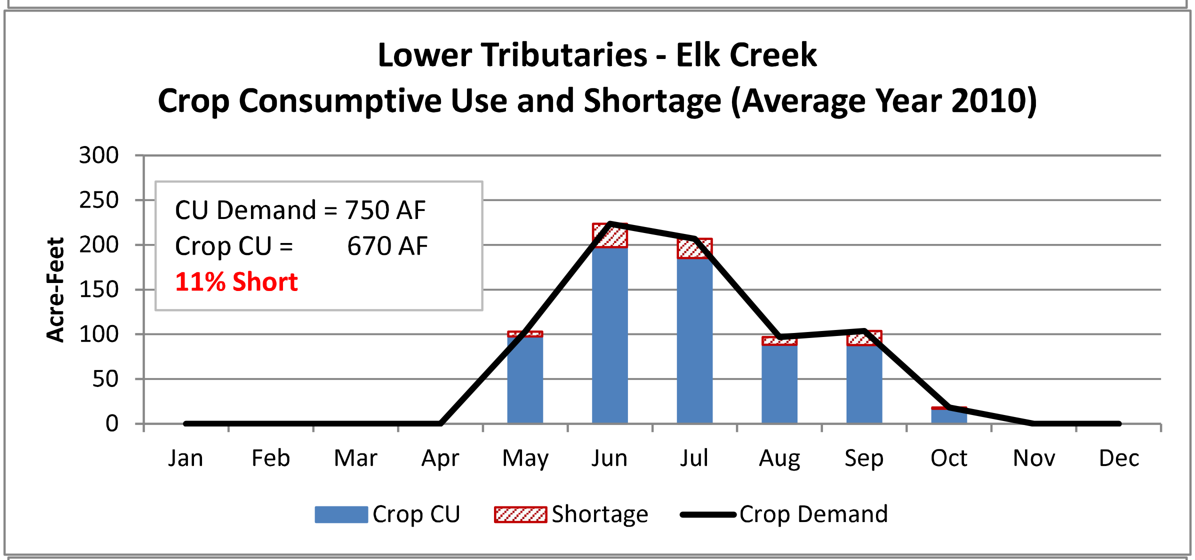


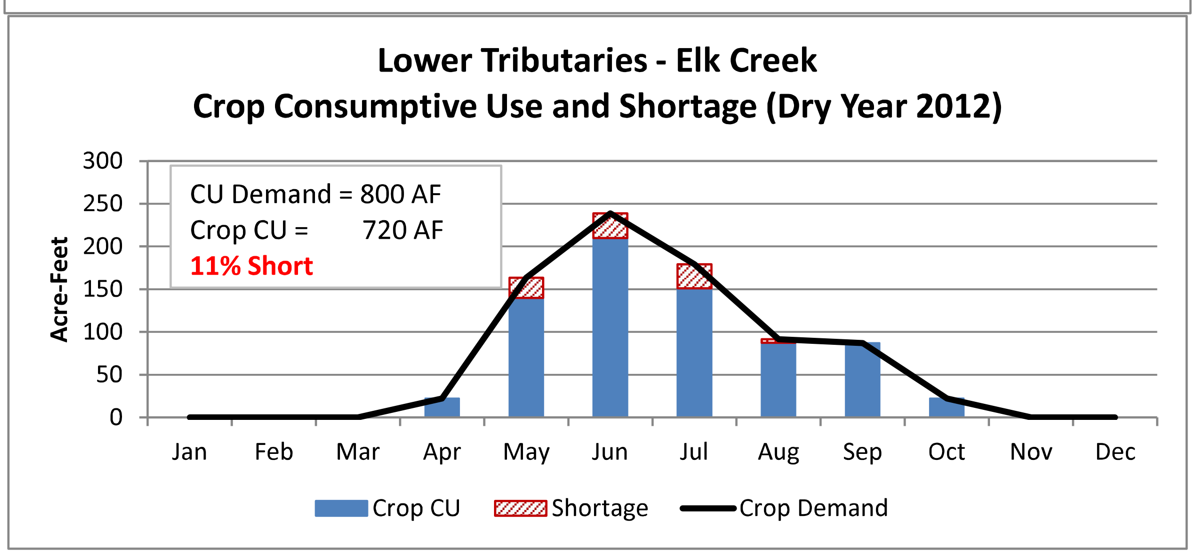
Figure 10-1: Lake Fork Lower Tributaries, Irrigation Structures and Acreage (Elk Creek)

Figure 10-2 shows the monthly crop demands, crop consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). There were minimal shortages during the representative wet year and, as shown, shortages were largest in the representative dry year in May, June and July.

Figure 10-2: Lake Fork Lower Tributaries (Elk Creek) – Crop Consumptive Use and Shortage







There is one active irrigation diversion on Willow Creek that irrigates approximately 140 acres of pasture grass near Blue Mesa Reservoir. Table 10-2 shows the total irrigation water rights, combined annual average and range of diversions, crop demands, actual crop consumptive use, and shortage estimates for the ditch in this reach from 1998 to 2017.

Table 10-2: Agricultural Water Use Statistics – Lake Fork Lower Tributaries (Willow Creek)

Reach Statistics	1998 to 2017 Average	1998-2017 Range
Number of Irrigation Structures	1	n/a
Irrigated Acreage	140	n/a
Water Rights	11.71 cfs	n/a
Diversions	1,100 acre-feet	0 – 2,310 acre-feet
Crop Demand	310 acre-feet	260 - 340 acre-feet
Crop CU	280 acre-feet	50 - 340 acre-feet
Shortage/Need	30 acre-feet	210 - 0 acre-feet
Percent Shortage	2%	0% - 21%

Figure 10-3 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. The ditch is unlined and is estimated to lose 10 percent of diverted water during delivery to the irrigated fields. Return flows from the diversion, estimated to be an average of 920 acre-feet per year from 1998 to 2017, accrue to Blue Mesa Reservoir.

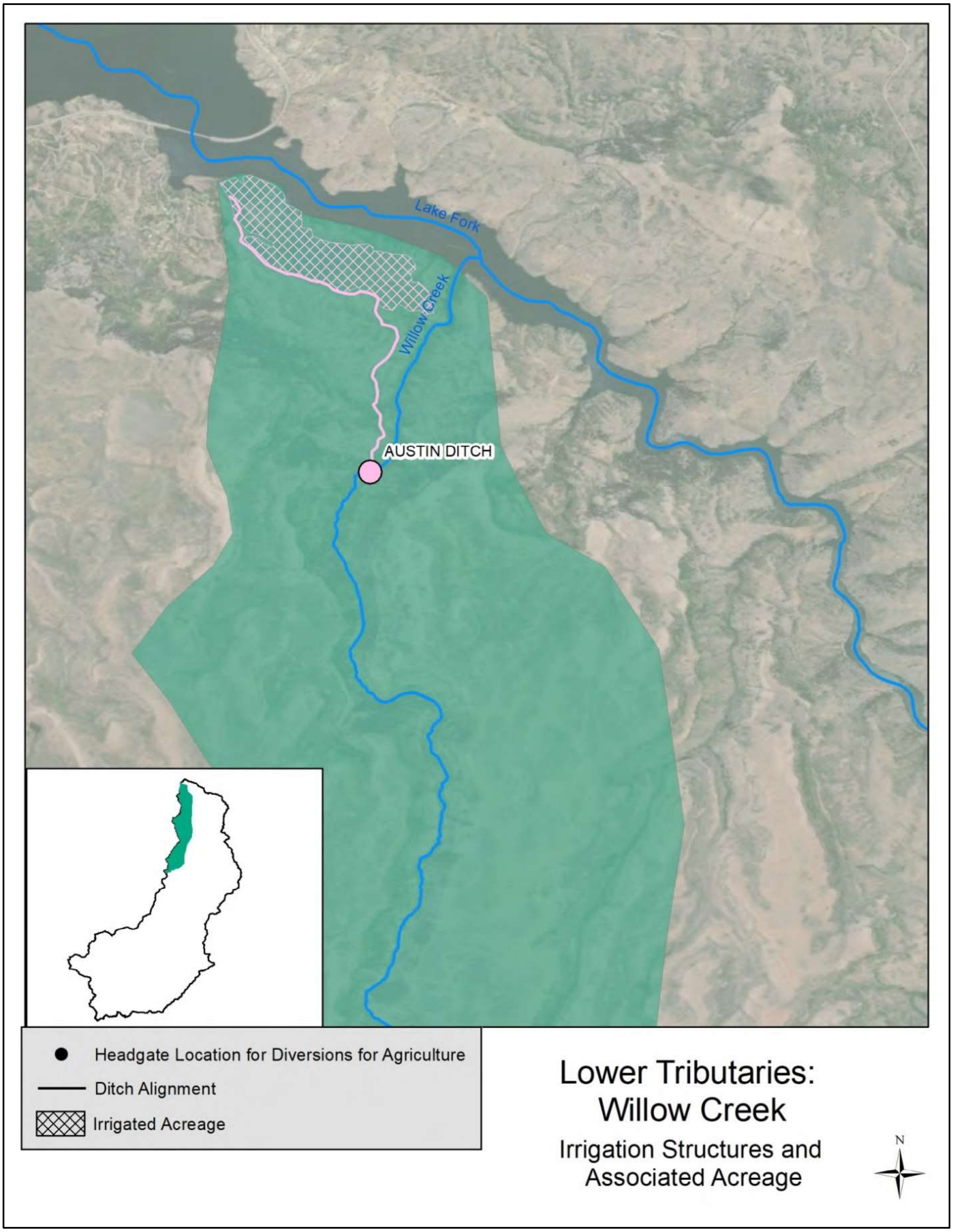
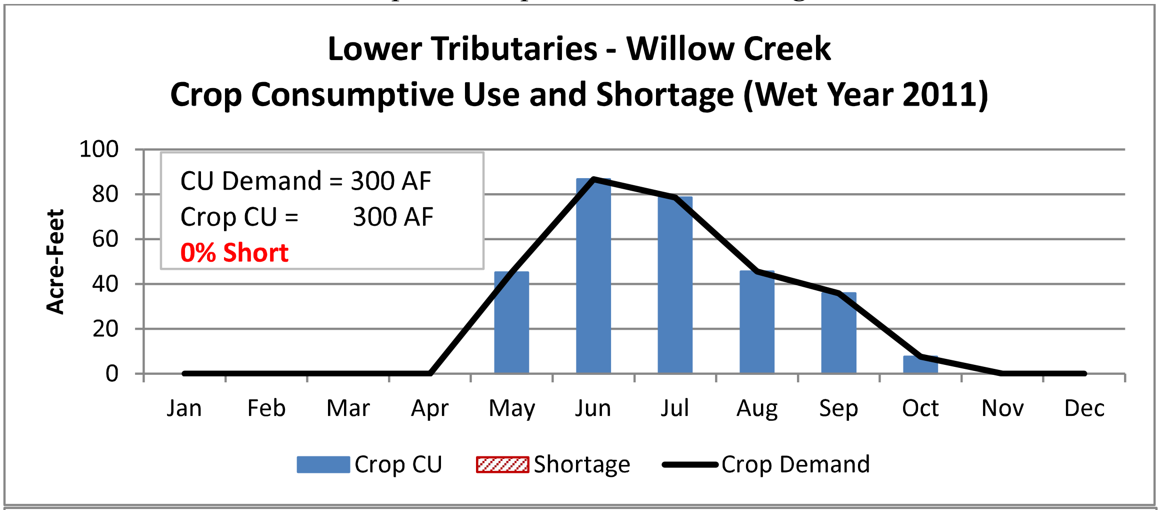
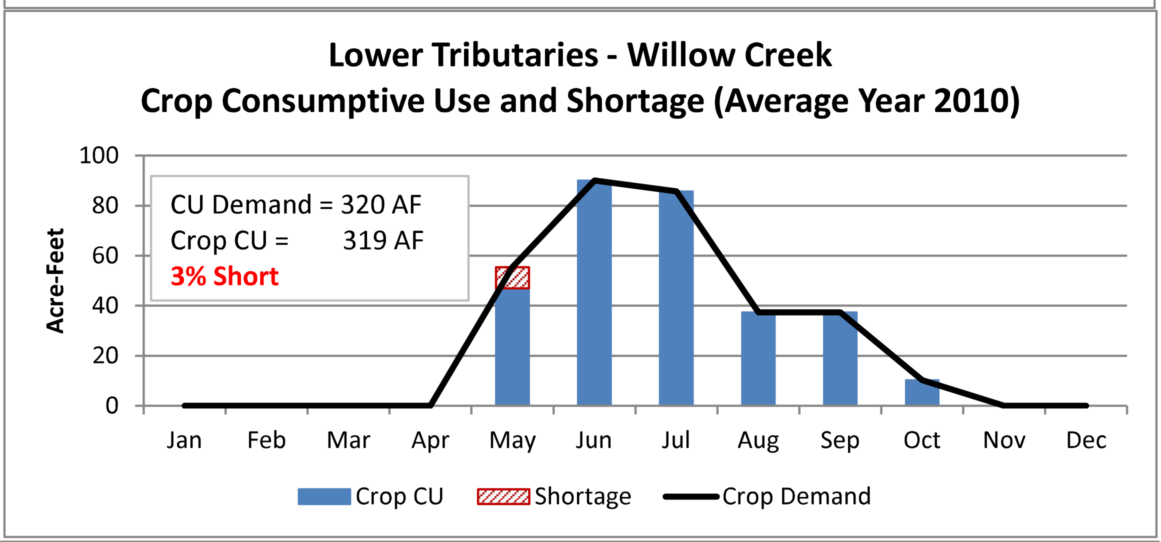


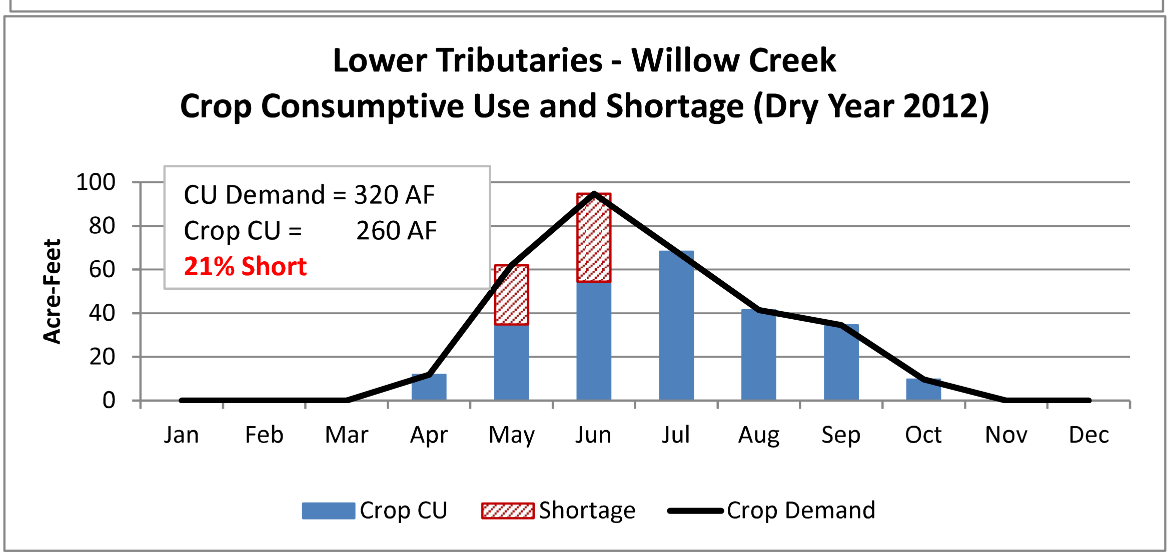
Figure 10-3: Lake Fork Lower Tributaries (Willow Creek), Irrigation Structures and Acreage

Figure 10-4 shows the monthly crop demands, crop consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). The ditch received a full supply in the representative wet year and had minimal shortages in the representative average year. As shown, shortages were largest in the representative dry year in May and June.

Figure 10-4: Lake Fork Lower Tributaries (Willow Creek)
Crop Consumptive Use and Shortage







10.2 Domestic Water Use

There are a handful of homes on the lower portion of Elk Creek, a reservation with multiple homes near Willow Creek. These homes rely on wells for household use and individual onsite wastewater treatment systems.

10.3 Environmental Water Use

10.3.1 Stream and Riparian Characteristics

The headwaters of Elk Creek are nestled between mesas at over 12,000 feet. Dense forests cover north-facing slopes, while sage parks are common on south-facing slopes. Aside from a few diversion structures and the area near Highway 149, Elk Creek's riparian corridor supports undisturbed native vegetation. Diversions from lower Elk Creek, likely prevent the creek from flowing into the Lake Fork River during most times of the year.

The headwaters of Willow Creek form on the southern edge of the Alpine Plateau. The north-facing headwaters are forested. The riparian corridor is largely undisturbed and supports native riparian vegetation. Sagebrush parks and wet meadow vegetation occur on the lower reaches of Willow Creek. Willow Creek meanders freely from the headwaters to the confluence with the Lake Fork River.

Like Elk and Willow creeks, the headwaters of Indian Creek are forested on north-facing slopes and sage brush parks are common on south-facing slopes. In selected areas, the valley confines riparian vegetation to areas immediately adjacent to the stream channel. Where the valley is broader, Indian Creek meanders and supports a larger riparian area with a mixture of willows and wet meadow vegetation. There are a handful of abandoned diversion structures along Indian Creek. The riparian vegetation is less robust in formerly irrigated areas. Near Highway 149, the Indian Creek Irrigation Ditch diverts nearly all of Indian Creek to irrigate lands southwest of Highway 149. Additional diversions remove water from Indian Creek. Aside from runoff season, Indian Creek is unlikely to reach the Lake Fork River.

10.3.2 Aquatic Life

Each of these tributaries to the Lake Fork River have the potential to support a robust aquatic life community. No macroinvertebrate sampling and fish surveys are known to have occurred in Elk Creek, Willow Creek or Indian Creek.

10.3.3 Water Quality

No water quality samples are known to have been collected from Elk Creek, Willow Creek, or Indian Creek. Elk Creek, Willow Creek, and Indian Creek are a part of a segment that is listed for impairment of the water supply use for arsenic.

10.3.4 Water Temperature

No water temperatures are known to have been measured in Elk Creek, Willow Creek, or Indian Creek. Addressing this data gap is not currently a priority.

10.3.5 Existing Instream Flows

Both Elk Creek and Willow Creek have year-round flat rate instream flows that were established in 1980, shown in Figure 10-5. Observations from late fall 2018 suggest that the instream flow rate for Elk Creek could potentially be increased. Indian Creek lacks an instream flow water right.

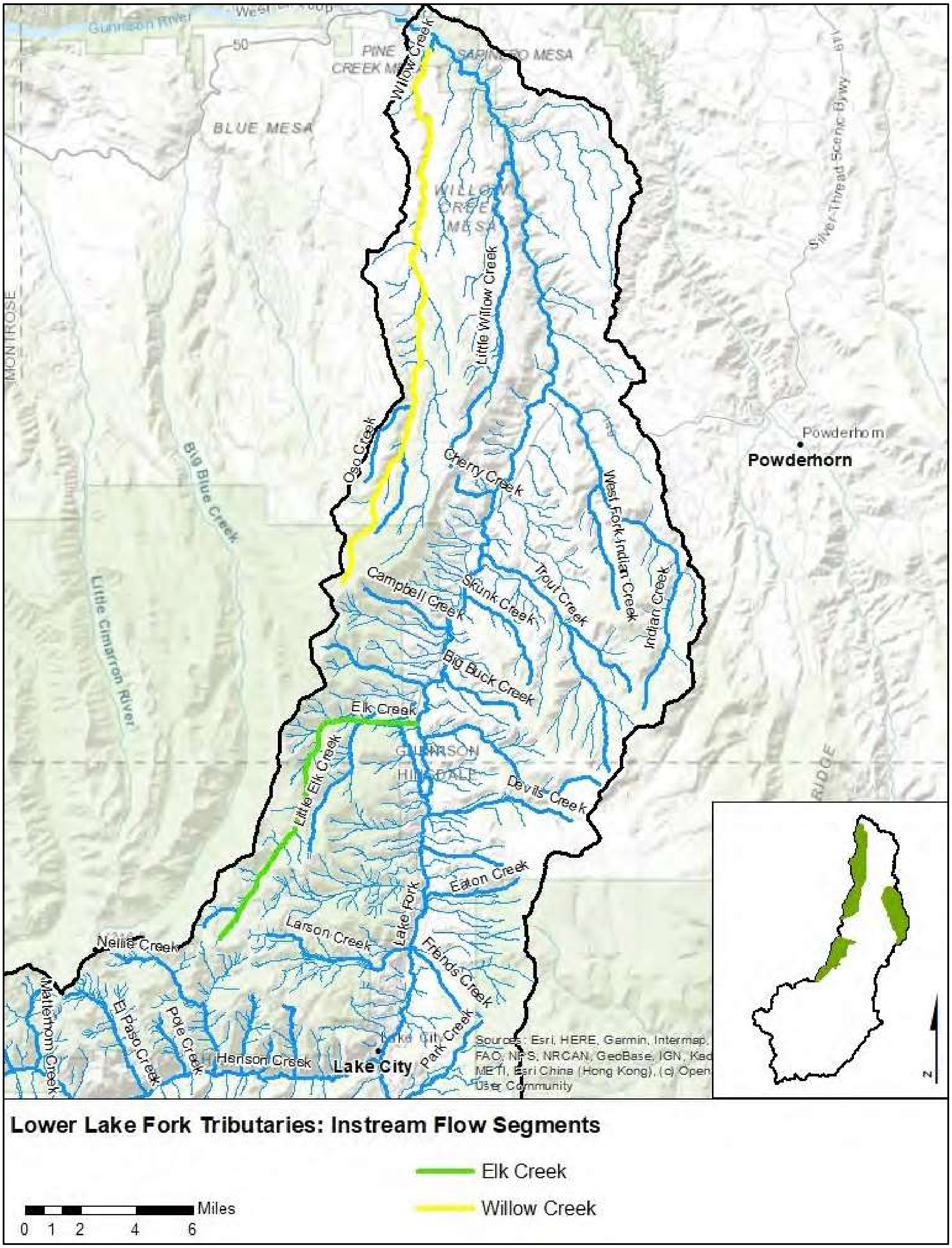


Figure 10-5: Instream flow reaches in the lower Lake Fork tributaries.

10.4 Recreational Water Use

Limited fly fishing may occur in Elk, Willow, and Indian creeks. All three creeks are too small for floating based recreation use. To date, recreation use needs have not been identified.

10.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Water quality for household wells. Elk Creek, Willow Creek, and Indian Creek are a part of a segment that is listed for impairment of the water supply use for arsenic.

Issue: Potential for appropriation of an instream flow water right for Indian Creek.

Issue: Potential for enlarging the existing instream flow water rights for Elk Creek.