Black Canyon Riparian Restoration Plan

A Watershed-Based Plan to Reduce Stream Temperature and Improve Habitat for Gila Trout

Produced by the New Mexico Environment Department in Cooperation with the Upper Gila Watershed Alliance

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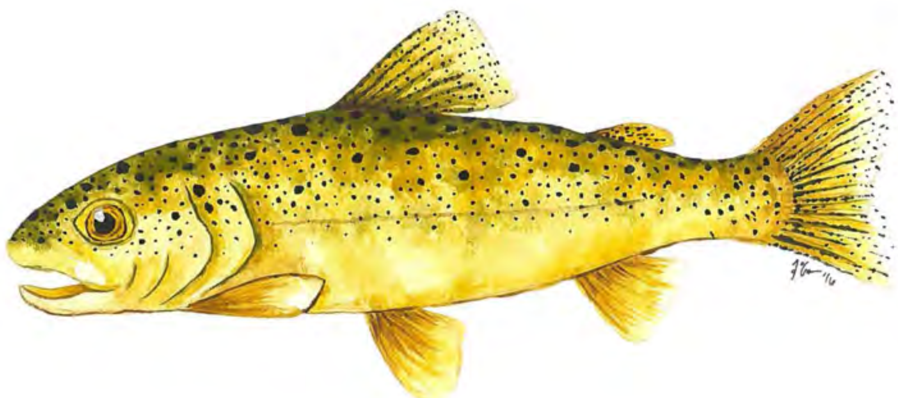

INTRODUCTION

Black Canyon Creek is a small tributary to the East Fork of the Gila River in southwest New Mexico. Over the past 30 years, the watershed has been heavily impacted by livestock grazing and multiple wildfires. This has led to severely degraded conditions in the creek and associated riparian corridor which includes a lack of streamside vegetation, channel incision and widening, and associated loss of floodplain storage capacity. The result has been an increase in water temperature that threatens its status as a quality trout fishery. Based on current New Mexico Water Quality Standards, Black Canyon Creek is impaired for temperature (NMED, 2014). Black Canyon Creek has also been identified as a critical recovery water for the threatened Gila trout (*Oncorhynchus gilae*). This watershed-based plan determines the nature of the causes and sources of increased temperature in Black Canyon Creek and outlines mitigation measures to decrease water temperatures and improve water quality in this vital New Mexico fishery.

Background

Black Canyon Creek is located in Grant County of southwest New Mexico in the Gila National Forest. It emanates from two springs on the western slope of Reeds Peak of the Black Range along the Continental Divide at an elevation of 8,700 feet and flows west about 25 miles to its confluence with the East Fork of the Gila River at an elevation of 5,740 feet (Figure 1). Along the way, it flows through both the Aldo Leopold and Gila Wilderness areas. There is a short segment approximately 1.5 miles long between the two wilderness areas where the river flows through the Diamond Bar Ranch before re-entering the national forest at Black Canyon Campground. It includes two 12 digit HUCs: Headwaters Black Canyon (HUC 150400010702) and Outlet Black Canyon (HUC 150400010704). The watershed area of Black Canyon Creek is 88.47 square miles and is 95% forested and 5% rangeland. Base flow of Black Canyon Creek during the hottest months of the year is approximately 1 cfs (NMED, 2001).

Geology

The Black Range is covered largely with layers of Tertiary volcanic rocks of the Datil-Mogollon lava field that extends into Arizona. This large formation was later lifted as part of an up-thrust block at the western edge of the Rio Grande Rift. Surface rocks exposed within the Black Canyon Watershed include: andesite, rhyolite, tuff, and Gila conglomerate. Perennial natural waters originating in this area are generally cold water streams, low in dissolved solids, and well aerated. Groundwater in the fractured bedrock is near the surface in some locations providing good quality water flowing through permeable breccias and volcano-clastic deposits to seeps and springs near fractures (Ratte et al, 1979).

Gila Trout

The Gila trout (*Oncorhynchus gilae*) is a species of salmonid native to the Gila River Watershed in Arizona and New Mexico. Due to competition, predation and hybridization from non-native trout species such as the brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) their occurrence and range has decreased significantly since the introduction of these non-native fish. This has long been recognized and conservation efforts began in 1923. The Gila trout was listed as endangered under the federal Endangered Species Act in 1973, but was subsequently down-listed from endangered to threatened in 2006. At the time of the listing, Gila trout persisted in only five streams within the Gila National Forest: Iron, Whiskey, and Spruce creeks in the Gila Wilderness, and Main and South Diamond creeks in the Aldo Leopold Wilderness (Wick et al 2014). As part of the conservation effort, a recovery program was developed which included efforts to expand their range beyond the original five streams. Black Canyon Creek was identified as one of the critical

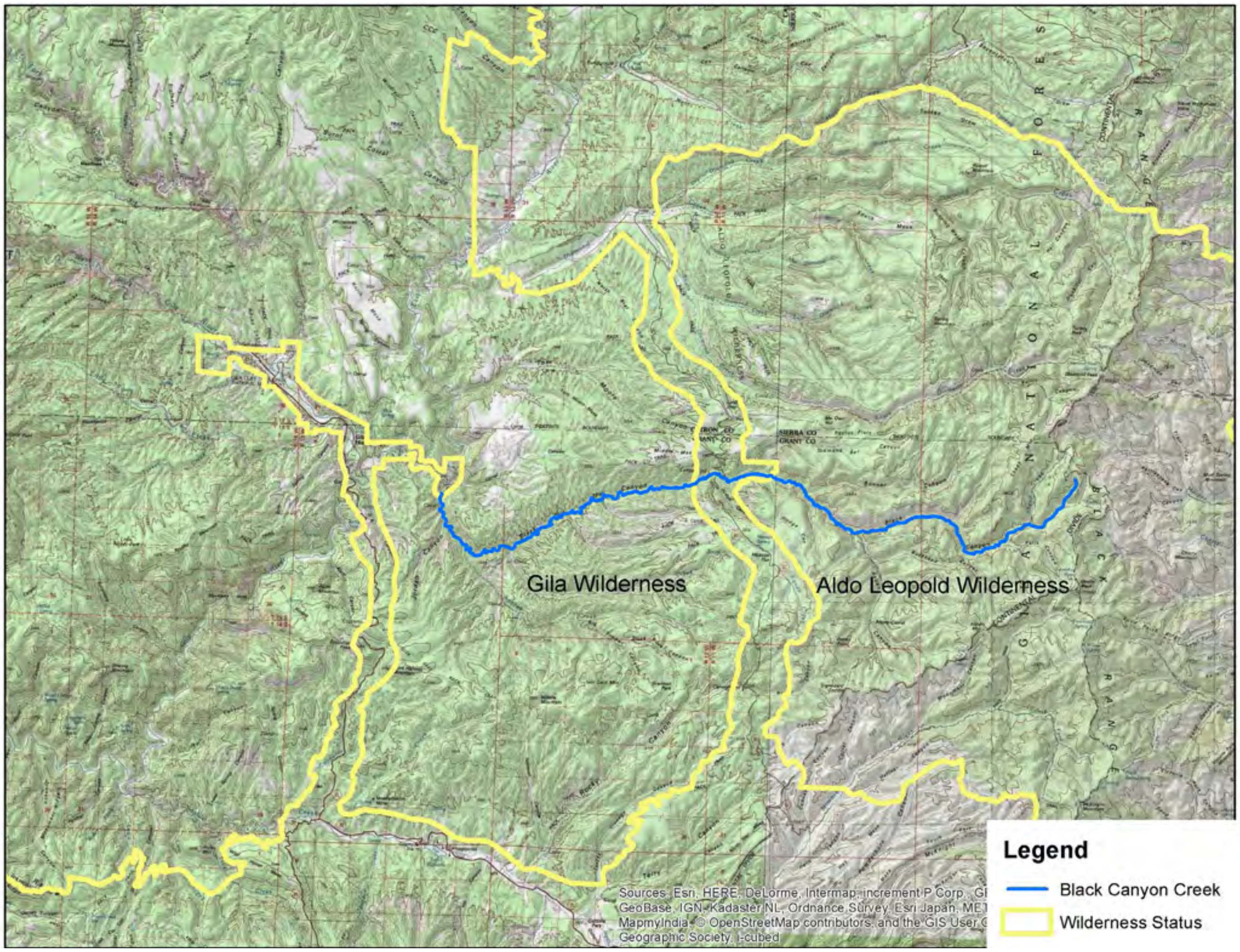

Figure 1. Black Canyon Creek in the Gila National Forest of southwestern New Mexico.

recovery waters under this effort.

Ironically, wildfire has played a significant role in the establishment of Gila trout to Black Canyon Creek. The Bonner Fire in 1995 sent heavy ash flows into the creek killing all fish. This provided an opportunity to bulid a fish barrier to retard upstream movement of non-native fish. Through a cooperative effort between the Gila National Forest, the US Fish and Wildlife Service and the New Mexico Department of Game and Fish, Gila trout were reintroduced above the barrier in 1998. The fish barrier proved to be ineffective in preventing non-native fish from migrating upstream so a new concrete barrier was completed in August 2011 to address the old barrier's flaws (Figure 2). Despite annual

Figure 2. The fish barrier installed in Black Canyon Creek to prevent migration of non-native trout upstream.

mechanical removal efforts to rid the stream of non-native trout, brown trout remained a problem until another wildfire (the Silver Fire) occurred in 2013 (NMDGF, 2014). Subsequent flooding and associated sediment and ash flows following the Silver Fire eliminated all fish above the barrier but also degraded the stream even further.

The Silver fire presented Gila trout recovery efforts with an opportunity to stock the stream above the barrier and establish a population unfettered by competition and cross breeding with non-native trout. Gila trout were stocked in the fall of 2013, 2014, and 2015. The first two years the poor condition of the stream prevented the establishment of a stable breeding population. However, fish surveys in September 2015 showed that some Gila trout are persisting and reproducing. Instream habitats are slowly beginning to recover. As of 2016, a small population of Gila trout has been established in two distinct areas in a 12 mile stretch upstream of the fish barrier to Black Canyon Box. Upstream of the Black Canyon Box to the Continental Divide, the stream is intermittent and no Gila trout occur in the creek.

Past Restoration Activities.

Following the Bonner Fire, subsequent post fire flooding caused extensive bank erosion, stream widening, and loss of riparian vegetation. Between 1997 and 2000 several attempts were made to re-establish riparian woody vegetation by planting willow poles. These efforts were unsuccessful due to the ongoing unstable conditions following the fire, and all plantings were lost to flooding prior to sufficient rooting and establishment (NMED, 2001).

In 2007, CWA 319 funds were awarded to the Grant Soil and Water Conservation District to reduce temperature in Black Canyon Creek resulting from stream over-widening, high sediment loads and a lack of riparian vegetation. The project area was limited to a 4,500 foot reach in the Gila National Forest between Diamond Bar Ranch and the Gila Wilderness boundary. To decrease stream width, 15 rock stream barbs and 16 rock weirs were installed. To increase stream canopy, volunteers from the Mesilla Valley Fly Fishers planted approximately 1,500 cottonwood and willow poles that were harvested locally. The project was a success and increased the measured canopy in the project area from 57% to 74% (Figure 3). Estimated temperature load reductions showed a reduction of approximately 60.45 joules/meter^2/second in the project reach (NMED, 2010).

Figure 3. Black Canyon Creek looking downstream from Black Canyon Campground. The photo on the left was taken in 1999 prior to restoration. The photo on the right was taken in 2016. Note the large pine tree to the upper right of the 1999 photo and center right of the 2016 photo.

In 2011, a state funded River Ecosystem Restoration Initiative project was awarded to the Grant Soil and Water Conservation District to continue the work started under the prior 319 funded project. The project built on the prior project and spanned from the upper end of Black Canyon Campground to the Aldo Leopold Wilderness boundary. The goals of the project were to restore hydrologic resiliency to Black Canyon Creek by improving channel configuration, increasing aquatic habitat diversity, re-establishing riparian vegetation and protecting wetland habitat (NMED 2013). A total of 43 rock structures were constructed from local materials to reduce stream width and increase channel depth. Volunteers from the Mesilla Valley Fly Fishers and the New Mexico Wilderness Alliance planted approximately 1,000 willow and cottonwood poles to increase riparian canopy. Project implementation was successful and was completed in the spring of 2013 six months before the Silver Fire. However, post fire flooding resulted in the loss of many of the structures. No post implementation monitoring for canopy cover was conducted.

Watershed-Based Restoration Planning for Black Canyon Creek

A watershed-based planning approach to address nonpoint source (NPS) water pollution focuses on watershed boundaries defined by drainage basins and sub-watersheds. This approach recognizes that watershed condition is important in determining the causes and sources of waterbody impairment. A good watershed-based plan (WBP) establishes a framework for protecting and restoring watershed health and water quality.

A watershed approach is effective due to the integration of a wide variety of issues between land use, climate, hydrology, drainage, and vegetation within a drainage basin. A WBP provides a non-regulatory voluntary approach to addressing NPS impacts to water quality within a designated watershed. A WBP consists of nine key criteria (USEPA, 2008). They are:

1. Identification of the causes and sources of NPS water pollution that will need to be controlled;
2. An estimation of load reductions expected from the management measures used to achieve water quality goals;
3. A description of the management measures that will need to be implemented to achieve pollution load reductions, i.e., implementation of pollution control and natural resource protection measures;
4. Technical and funding needs to support the implementation and maintenance of restoration measures;
5. The public outreach method(s) and structure that will be used to engage and maintain public and governmental involvement including local, state, federal, and tribal governments;
6. A schedule for implementation of needed restoration measures and identification of appropriate lead agencies to oversee implementation, maintenance, monitoring, and evaluation;
7. A description of interim, measurable milestones for the actions to be taken and desired water quality goals and outcomes;
8. A set of criteria that can be used to determine whether load reductions are being achieved over time and substantial progress is being made towards achieving water quality standards;
9. A monitoring component to evaluate the effectiveness of implementation and assess progress towards achieving water quality goals.

In 2012, CWA 319 funds were awarded to the Upper Gila Watershed Alliance to develop a WBP that addressed the temperature impairment in Black Canyon Creek from Black Canyon Campground to the headwaters. Proposed data collection included installation of temperature loggers in several locations from the headwaters to the Gila Wilderness boundary downstream of Black Canyon Campground, completion of one Rosgen Level II stream survey and the collection of stream canopy measurements at the temperature logger deployment sites.

Initial analysis in the fall of 2012 revealed the water temperature directly upstream of the prior restoration project areas at the Aldo Leopold Wilderness boundary was not meeting the New Mexico water quality (WQ) standard. Since the prior restoration projects that focused their efforts downstream of the Aldo Leopold Wilderness were successful in establishing canopy, a decision was made to focus planning efforts upstream of the prior projects. In addition, data collected under the initial work plan for this project was insufficient to prescribe mitigation measures upstream of Aspen Canyon. As a result, this WBP covers Black Canyon Creek upstream of the Aldo Leopold Wilderness boundary to the confluence with Aspen Canyon (Figure 4).

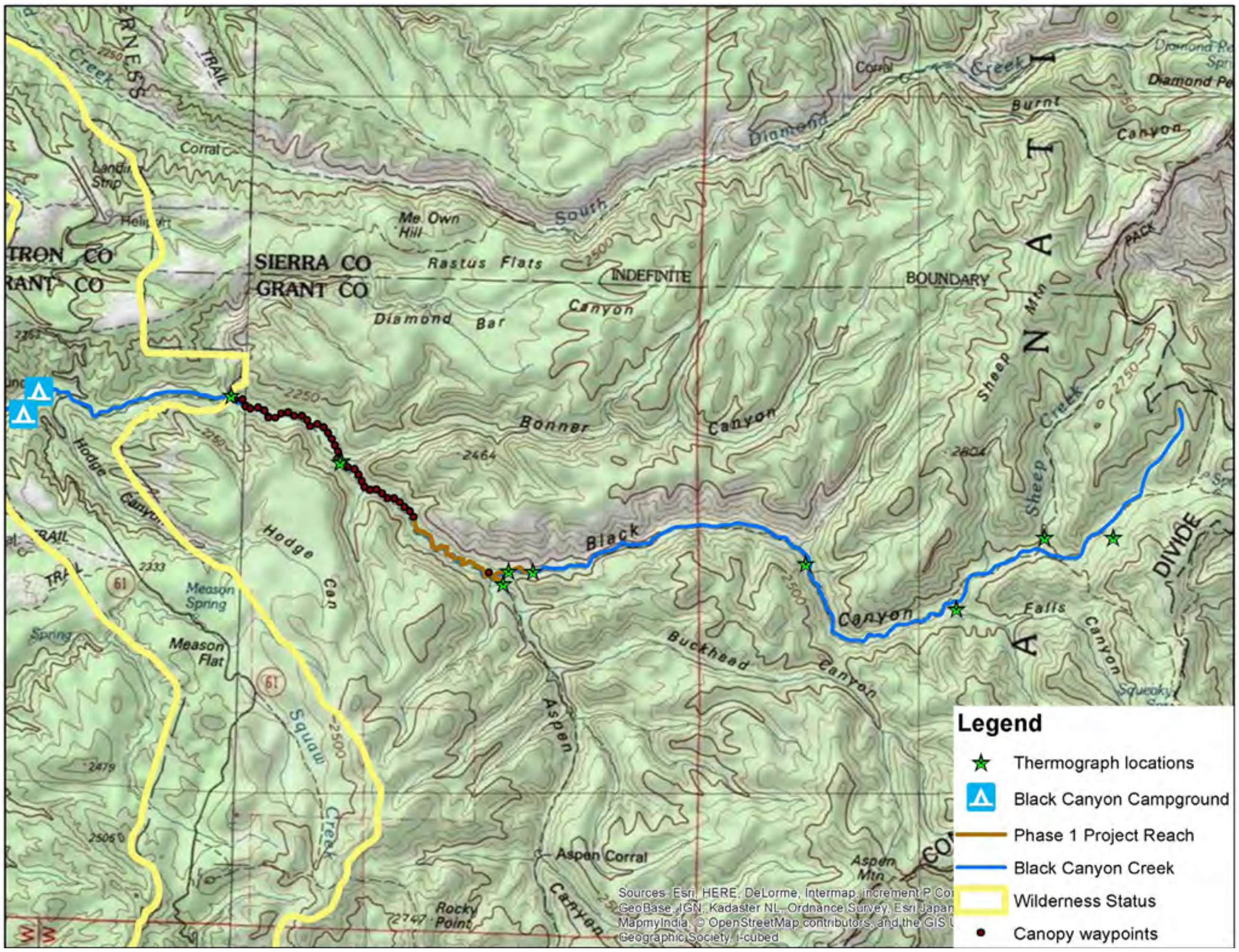

Figure 4. The Black Canyon Creek watershed planning area.

CAUSES AND SOURCES OF IMPAIRMENT

Cause of Impairment

In New Mexico, all waterbodies have associated designated uses which determine the WQ standards appropriate for the waterbody. According to the *2012-2014 State of New Mexico CWA §303(d)/§305(b) Integrated Report* the water in Black Canyon Creek has the following designated uses: domestic water supply, high quality coldwater aquatic life (HQCWAL), irrigation, livestock watering, wildlife habitat and primary contact. Data collected by the New Mexico Environment Department determined Black Canyon to be impaired for temperature and its inclusion in the *State of New Mexico CWA §303(d)/§305(b) Integrated Report – List of Assessed Surface Waters* goes back over 20 years. An intensive water quality survey from 1999-2000 showed the temperature criterion was exceeded 37% of the time and that Black Canyon Creek was not supporting the designated use for HQCWAL. The New Mexico WQ standard for HQCWAL is not to exceed 20 ºC for 4 hours or more in a 24 hour period for 3 consecutive days (“4T3”) or a single maximum of 23 ºC. (68 ºF and 73.4 ºF respectively). Temperature was retained as the cause of impairment and a total maximum daily load (TMDL) was calculated for temperature and the associated planning document, *Total Maximum Daily Load for Temperature on Black Canyon Creek*, was prepared in 2001 and approved by the USEPA in 2002 (NMED, 2002).

Sources of Impairment

While the *Total Maximum Daily Load for Temperature on Black Canyon Creek* provides examples of sources that can cause temperature impairment such as alterations to geomorpholgy, loss of riparian vegetation and streambank destabilization, it does not specifically identify sources of impairment. According to the *2012-2014 State of New Mexico CWA §303(d)/§305(b) Integrated Report* the sources of impairment are:

- Habitat modification - other than hydromodification
- Loss of riparian habitat
- Off-road vehicles
- Rangeland grazing
- Silviculture, fire suppression

During the course of conducting the watershed analysis for this WBP the sources of impairment were determined to be:

- Past intensive rangeland grazing
- Wildfire
- Loss of riparian vegetation
- Altered geomorphology

Grazing has had a substantial impact on the watershed. Much of the watershed was historically grazed by domestic livestock; about 75% of the Black Canyon watershed (and 100% of the upper watershed) is within the boundary of the Diamond Bar allotment of the Gila National Forest. Poor management of the grazing allotment led to highly degraded conditions especially in the riparian corridor. In 1996, the Diamond Bar’s grazing permit expired and was not renewed due to unresolved disputes over grazing management between the United States Forest Service (USFS) and the permittees. It took ten years to get the cattle removed from the allotment and it has remained ungrazed by domestic livestock since 2006.

Wildfire has also had a significant impact on the watershed. Wildland fire is evaluated in terms of burn severity on the landscape and the potential to increase runoff, flooding and erosion. There have been six substantial wildfires in the watershed since 1995 (Figure 5). Most of the fires burned relatively low acreage and at low to moderate severity. However, the Rocky and Meason fires burned in the riparian area in the lower portion of the watershed and destroyed some of the larger cottonwoods and much of the riparian vegetation. While the Bonner and Silver fires also burned in the riparian area, the fire severity in the riparian area was low and caused no direct damage. But the recurrent incidence of fire combined with the burn severity of these two fires has led to a repeatedly disturbed watershed.

The high and moderate severity burn in both the Bonner and Silver fires occurred primarily on the steep slopes of the upper watershed. The impact of this was evident following the Silver Fire when post fire monsoon rains delivered sufficient sediment to cover the entire length of the stream to the Aldo Leopold Wilderness boundary with fine sediment, filling pools and reducing stream channel topography to an essentially planar sand bed form. The stream bed is still recovering.

The combined effects of rangeland grazing and wildfire are directly responsible for the loss of riparian vegetation and altered geomorphology. The intensive grazing of the riparian area subjected the channel and floodplain to both increased erosion and increased impacts from flooding. Burning of the upper watershed increased surface runoff and flood intensity and dramatically increased the sediment load to the stream. The

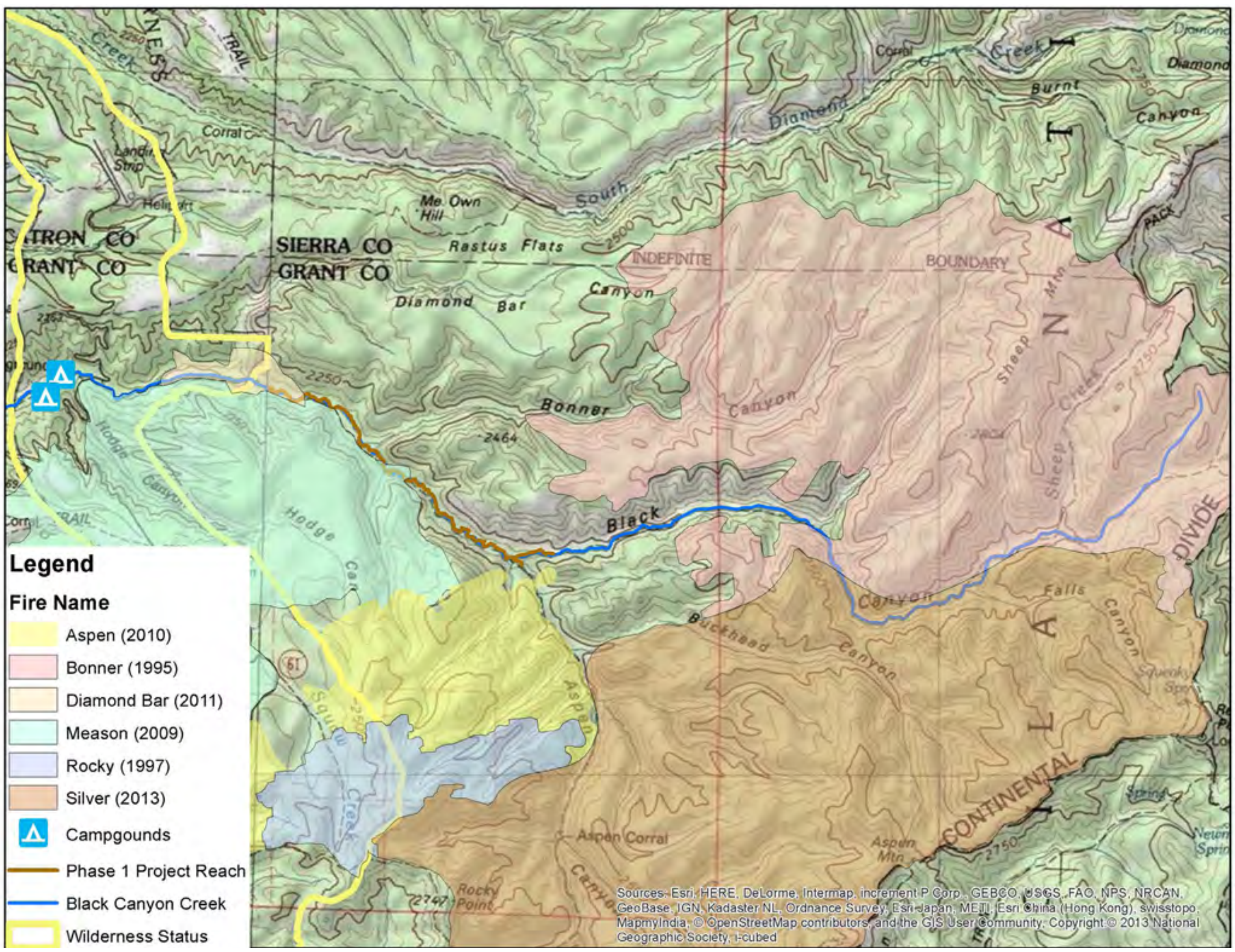

Figure 5. Major fires in the Black Canyon Watershed since 1995.

subsequent impacts to the riparian corridor and stream channel further increased the loss of riparian vegetation and caused streambank destabilization, channel widening, and channel incision.

Literature Review and Data Analysis from Prior Studies

The Gila River Watershed Improvement Plan and Strategies - 2009 Update, and the *Total Maximum Daily Load for Temperature on Black Canyon Creek* and the final project reports*: The Black Canyon Creek: Temperature Impairment Remediation Project* and the *Black Canyon Creek River Habitat Restoration River Project* were reviewed for potential data and information on causes and sources of impairment.

The two project reports contained descriptions of work completed that included select photo points demonstrating changes to conditions in the riparian corridor. As mentioned in the Introduction, the *Black Canyon Creek: Temperature Impairment Remediation Project* reported an increase of riparian canopy cover of 17% along Black Canyon Creek in the implementation area. The report also provided a snapshot in possible efficacy of potential future restoration efforts that use the same techniques.

Review of the TMDL and associated data provided useful information on how target loading values were derived. The data that was used in the development of the TMDL was collected from April 28 to October 3, 2000 at a station located just below Black Canyon Campground which is downstream of the project area delineated for this WBP. The mean temperature was 19.4 ºC nnd the maximum temperature recorded was 25.1 ºC, which exceeds the HQCWAL WQ standard.

The Stream Segment Temperature Model (SSTEMP) was used in developing the TMDL for Black Canyon Creek to determine solar load allocation based on current conditions and the load reduction that would be required to reach WQ standards. SSTEMP is a mechanistic model that simulates the heat budget of a stream and predicts maximum, minimum and mean daily stream temperatures for a given stream segment. It requires input of variables such as stream geometry, hydrology, solar radiation, average daily air temperature and shading. Since shading is the variable most easily manipulated, the model is primarily used to determine the percent shading (riparian vegetation) required for stream temperature to fall within a certain range or in this case, the WQ standard. The model defines solar load in joules/meter^2/second. By design, the SSTEMP model considers percent shade over the entire stream segment and does not attribute load allocations to specific sources. The solar load calculated from the temperature data was determined to be 142.2 joules/meter^2/second. The solar load necessary to maintain the water temperature within WQ standards was calculated to be 46.2 joules/meter^2/second. This requires an overall load reduction of 96.0 joules/meter^2/second. A value of 87% shade was estimated to be the amount of shade needed to bring the water temperature within WQ standards. As a result, the TMDL prescribes 87% shade for the entire stream length to reduce the solar load by 96.0 joules/meter^2/second in order to reach the TMDL of 46.2 joules/meter^2/second.

Data Collected for Development of the Watershed-Based Plan

The initial data collection effort included aerial photography, one Rosgen Level II geomorphic stream survey, deployment of temperature loggers from the headwaters to just below the Black Canyon Campground and collecting canopy measurements at the temperature logger deployment sites. In addition, canopy measurements were collected in September 2015.

The aerial photography provided a big picture view of the stream pattern and riparian conditions. Comparing the resultant photographs with historical imagery showed that the stream has evolved over time, straightening and reducing belt width. It also revealed the impacts of fire on the riparian tree community, especially mature cottonwoods.

A cross section was conducted in May 2012 about midway between the confluence with Aspen Canyon and the Black Canyon Box to obtain an initial geomorphic assessment. A second cross section in conjunction with a Rosgen Level II stream survey was planned for the summer of 2013, but access was prohibited initially due to the potential extreme fire danger and then subsequently, the Silver Fire. Due to the extraordinary sedimentation from post-fire flooding from the Silver Fire in the fall of 2013, and the rapidly evolving conditions in the watershed, the survey was cancelled and was not conducted as part of this planning effort.

Nine temperature loggers were deployed in mid-May 2012 at select sites from the NMED monitoring station downstream of Black Canyon Campground to approximately one half mile below the headwaters in Reeds Meadow (Figure 4). Site location was determined based on the following criteria: bracketing potential tributary inflow, shading, and spatial distribution. Initial data from these temperature loggers was retrieved in November 2012. Canopy measurements were also collected at the time of deployment.

All mainstem temperature loggers deployed in 2012 exceeded the WQ standard (Table 1). The loggers at Reeds Meadow and Above the Cross Section were meeting the WQ standard until the first part of June, when maximum water temperatures above the maximum air temperature at Bonner Canyon indicate these

Table 1. Results of temperature loggers deployed May through November 2012.

Logger Deployment Site	Exceeds Standard	Main stem or Tributary	Comments
Gila Wilderness Boundary	yes	Mainstem	Max temperature of 41.1 ^{o}C on June 30.
Aldo Leopold Wilderness Boundary	yes	Mainstem	Max temperature of 28.9 ^{o}C on June 27.
Black Canyon above Aspen Canyon	yes	Mainstem	Max temperature of 27.8 ^{o}C on June 26.
Black Canyon above X-section	yes	Mainstem	Max temperature of 42.8 ^{o}C on June 20.
Black Canyon @ Reeds	yes	Mainstem	Max temperature of 32.8 ^{o}C on June 20.
Bonner Canyon	yes	Tributary	Max temp of 45.6 ^{o}C on June 28.
Aspen Canyon	no	Tributary	Max temp of 20.6 ^{o}C on June 28. The temp did not exceed 20 ^{o}C for four consecutive hours for three consecutive days.
Falls Canyon	yes	Tributary	Max temp of 45.6 ^{o}C on June 26.
Sheep Creek	yes	Tributary	Max temp of 31.1 ^{o}C on June 20.
Air Thermo @ Bonner Canyon	NA	NA	Logger recorded max temp of 35.0 ^{o}C on June 20

loggers were no longer wet and the stream was dry. Sunlight hitting the dark casing of the dry logger probably accounts for the very high temperatures recorded. Similarly, it is assumed the tributaries Bonner Canyon and Falls Canyon also went dry as indicated by recorded water temperatures. Aspen Canyon did not exceed the WQ standard. Although Aspen Canyon did exceed 20 ºC it did not exceed the 4T3 condition of the WQ standard (four hours or more for three consecutive days). Unfortunately Aspen Canyon is intermittent and does not contribute enough flow to positively impact the temperature in Black Canyon Creek. The temperature loggers were redeployed and left in place by the contractor and all but three of them were lost in the summer of 2013 during post Silver Fire flooding prior to further data retrieval. NMED personnel deployed additional temperature loggers in 2015 and 2016 in an attempt to fill in the data gaps left by the loggers that were lost.

Temperature loggers were deployed at Black Canyon above Aspen Canyon and at Bonner Canyon from June 10 to September 30, 2015. The water temperature was recorded every 15 minutes for the duration of deployment. Both loggers exceeded the WQ standard shortly after deployment. The temperature logger deployed at Black Canyon above Aspen Canyon showed the WQ standard was exceeded multiple times in June and July, but the water began to cool down by late July (Figure 6). The cause of the dramatic drop in water temperature in late August is unknown but is attributed to the onset of summer monsoon rains.

Black Canyon Creek was surveyed in the fall of 2015 to collect canopy measurements and select po-

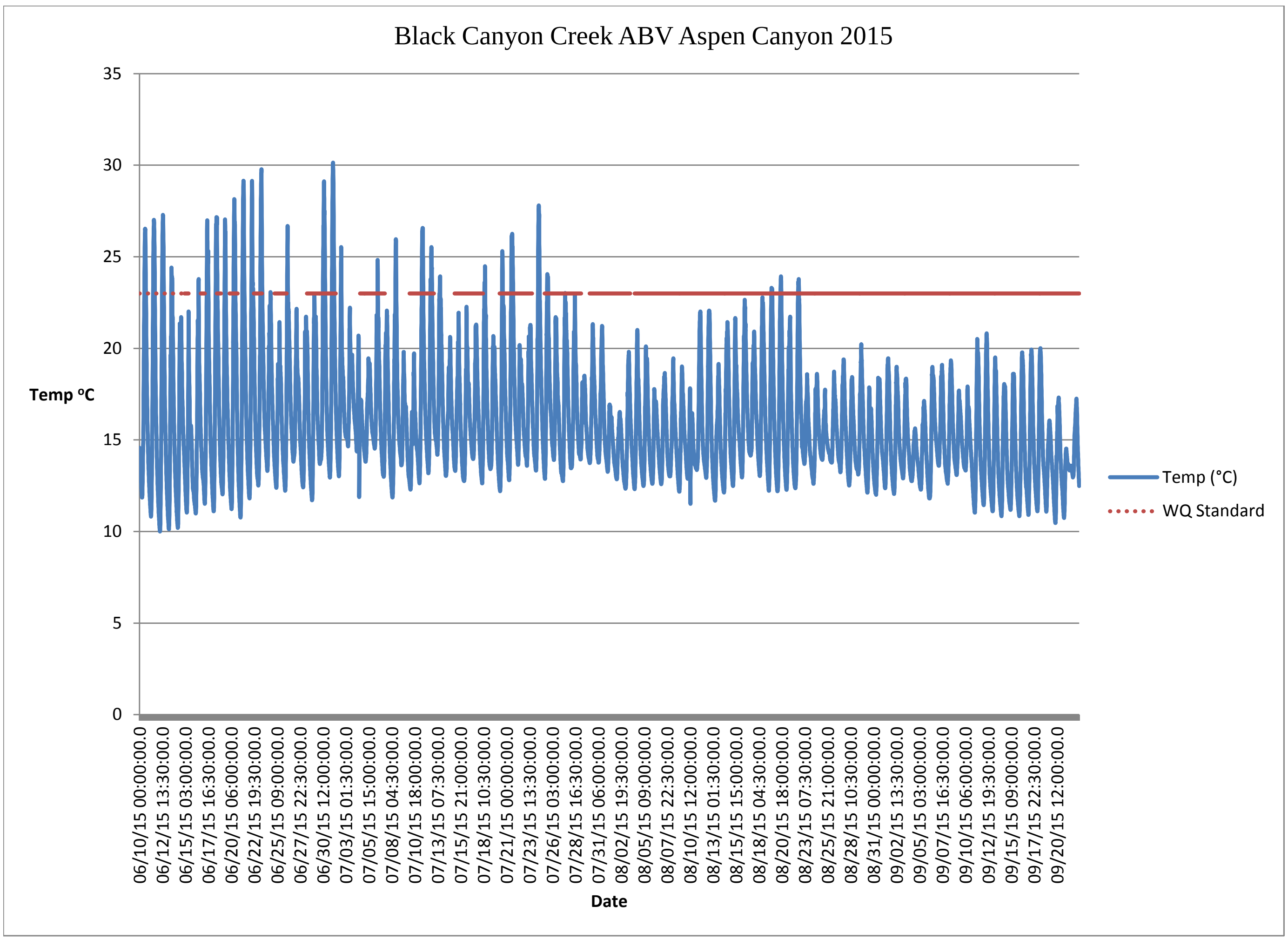

Figure 6. Temperature recorded every 15 minutes in Black Canyon Creek above the confluence with Aspen Canyon June 10, 2015 – September 30, 2015. The WQ standard depicted is the single max of 23 ºC. The 4T3 20 ºC standard was also exceeded on most days throughout June and July.

tential mitigation sites. Canopy measurements were collected every 200 feet along a 1.5 mile stretch of the river from the Aldo Leopold boundary to approximately one mile downstream of the confluence with Aspen canyon (Figure 4). The canopy cover ranged from 100% to 0% with an average of 49%.

The *Total Maximum Daily Load for Temperature on Black Canyon Creek* only modeled the shading and solar loading of the reach downstream of the project area. In addition to providing spatial and temporal water temperature trends that clearly documented exceedance of the WQ standard, the temperature logger data and the canopy data from the project were used to re-calculate the target load reductions for Black Canyon Creek from the Aldo Leopold Wilderness boundary to the headwaters. The solar load allocation and necessary reductions to meet the WQ standard for the project reach were determined by re-running the SSTEMP model with the new input variables. The solar load under current conditions (49% canopy) was determined to be 157.12 joules/meter^2/second. The solar load necessary to maintain the water temperature within at the 43T 20 ºC WQ standard was calculated to be 67.68 joules/meter^2/second. This is the target that was used to develop the TMDL and requires an overall load reduction of 89.52 joules/meter^2/second. A value of 78% shade was estimated to be the amount of shade needed to bring the water temperature within the WQ standard. As a result, this watershed plan prescribes 78% shade to achieve a temperature under 20 ºC and reduce the solar load by 89.52 joules/meter^2/second in order to reach the target load of 67.68 joules/meter^2/second (Figure 7).

On June 21, 2016, real time “grab” temperature data was recorded at select locations from the tem-

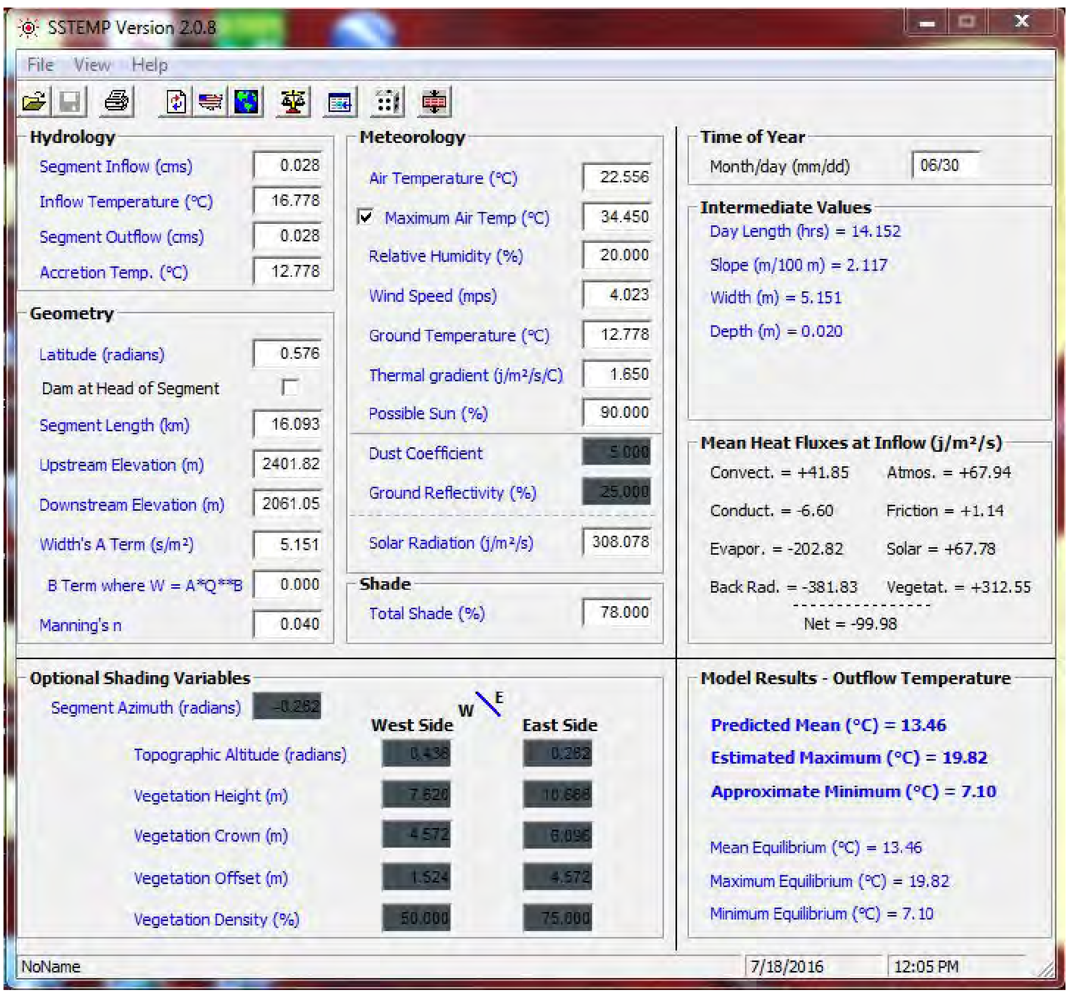

Figure 7. The SSTEMP model run for the target load of 78% canopy on Black Canyon Creek.

perature logger deployment site at the Aldo Leopold Wilderness boundary to the site just above the confluence with Aspen Canyon. This consisted of taking single point measurements with a hand held probe, and collecting temperature data from the mainstem of Black Canyon Creek, three adjacent springs, Aspen Canyon above the confluence with Black Canyon and the outflow of the one remaining beaver dam in the project reach. Water temperatures in Black Canyon Creek ranged from a low of 18.5 ºC at the start of a gaining reach to a high of 31.2 ºC just upstream of where the stream dried out (Table 2). This analysis provides a greater level of detail than either the TMDL or the thermograph data gathered as part of this planning effort.

Table 2. "Grab" temperature readings along Black Canyon Creek and associated springs and tributaries June 21, 2016. Data are presented from upstream to downstream.

Location	Mainstem, Spring or Tributary	Temperature (˚C)	Comments
33.16379 -107.95675	Mainstem	22.6	Black Canyon Creek logger deployment site above confluence with Aspen.
33.162784 -107.961478	Tributary	19.1	Small tributary entering Aspen Creek just above confluence with Black Canyon.
33.162333 -107.960355	Tributary	19.0	Aspen Creek ¼ mile above confluence with Black Canyon.
33.164086 -107.963179	Mainstem	27.6	Potential bank planting of *Carex sp*.
33.164974 -107.964957	Mainstem	30.5	Bank planting site.
33.165318 -107.966175	Spring	13.0	Wetland spring adjacent to Black Canyon Creek
33.165385 -107.966997	Mainstem	23.7	Directly below wetland spring.
33.166736 -107.969095	Spring	13.9	Small spring adjacent to Black Canyon Creek.
33.166790 -107.969149	Mainstem	19.9	Temperature taken just downstream of the inflow of the small spring above.
33.169247 -107.973549	Mainstem	31.1	Temperature taken just above where the stream dried out and went underground.
33.173268 -107.977447	Mainstem	18.5	Temperature taken just downstream of where the stream began to flow below the dry reach.
33.174051 -107.98075	Mainstem	22.1	Deep plunge (18") pool where logger was deployed.
33.181909 -107.990542	Mainstem	27.7	Pool against large rock.
33.1843 -108.000056	Mainstem	22.5	Outflow @ beaver dam.

Management Measures and Expected Load Reductions

A healthy watershed and associated riparian corridor are essential to maintaining stream temperature. Healthy uplands provide maximum infiltration of precipitation, reduce surface runoff, and minimize erosion. A healthy riparian corridor and associated floodplain helps mitigate flooding, recharges the shallow groundwater table helping to maintain baseflow, and provides a buffer between the uplands and the stream channel that reduces pollutant loading. The stream channel plays an important role in maintaining the functions found in the riparian corridor. The dimension, pattern and profile of a stream channel are critical to maintaining channel stability, floodplain connectivity and riparian vegetation. The most effective management measures to mitigate elevated temperatures are directed at improving or maintaining channel integrity and riparian function. These include restoration of uplands, protecting or maintaining the riparian area, installing instream structures to restore dimension, pattern and profile, and planting of riparian plants.

The wilderness status prohibits the use of heavy equipment which would facilitate placement of instream structures to mitigate channel incision and improve geomorphology. Smaller hand built structures could be implemented without the use of heavy equipment but it is unclear if clearances could be obtained to conduct this work within the wilderness area. The end of this section includes a recommendation to use natural channel design stream restoration techniques that could be implemented to aid in returning the stream to the appropriate dimension, pattern and profile. Due to the remoteness of the area and potential constraints in working in a wilderness area only three management measures are prescribed.

Management Measures

Leaving the Diamond Bar Allotment at Rest

Following a protracted dispute between the Gila National Forest (GNF) and the leasees of the Diamond Bar allotment, cattle were removed from the watershed in 2006 and the grazing permit has not been renewed. Although the permit is up for renewal in 2017, the GNF has no plans to re-issue the permit at this time. It is critical to the recovery of the riparian area and mitigation of the temperature impairment that the Diamond Bar grazing allotment remain at rest until the riparian area reaches a more stable condition.

Encourage Beaver Activity

Beaver (*Castor Canadensis*) build dams that can provide a variety of ecological services. In recent years facilitating beaver activity to restore watersheds has become a recognized tool to address problems of channel incision, loss of riparian habitat, and impaired water quality including temperature. The water impounded behind a beaver dam raises the shallow groundwater table and sub-irrigates the surrounding area. The increase in available water promotes riparian plant growth which increases canopy cover and shade. The deeper water of the pond also increases hyporheic exchange and raises the water table. Although larger ponded areas will be subjected to greater solar radiation, these ponds are often deeper and undergo minor thermal stratification which provides cooler water at the bottom and along the banks where shading and groundwater exchange is greatest. Additional benefits include: maintaining baseflow, moderating flood flows, capturing sediment, reconnecting floodplains, creating wetlands, providing both terrestrial and aquatic habitat, and increasing complexity of riparian habitats (Pollock et al, 2015).

When a dam is constructed across an incised reach, stream power is reduced and both the suspended load and bed load drop out and begin to accumulate causing the stream bed to aggrade. The aggradation materials will contain a variety of particle sizes including woody debris and not just fine sediments. When a dam is abandoned or breached not all the entrained materials will wash downstream. The varying particle sizes in combination with increased riparian vegetation and associated vast root systems hold the materials together reducing erosion. In this manner beaver ponds can restore incised reaches and reconnect the floodplain even after abandonment (Pollock, 2014).

There is a small population of beaver in Black Canyon and four beaver ponds were observed during the data collection efforts conducted as part of this planning effort. Two ponds located just downstream of the Diamond Bar Ranch were blown out during the flooding following the Silver Fire and were not rebuilt. A third dam was constructed just downstream of this area between the fish barrier and Forest Road 150 that was lost to flooding in 2015. It is uncertain if these beavers were removed, or if they have moved to another location. The fourth pond was located about two miles upstream in the Aldo Leopold Wilderness and was built in the fall of 2013 after the initial post-fire flooding (Fig 8).

The dam breached in the fall of 2015, but was being rebuilt in the spring-summer of 2016. On June 21, 2016 the outflow temperature at 5:00 in the afternoon from the beaver dam was 22.5 ºC which is only 0.4 ºC warmer that the lowest temperature recorded along the mainstem that day. That demonstrates the ability of the beaver pond to moderate water temperatures, despite the fact that the dam was incomplete with only half the dam height and pond depth of the previous year.

Figure 8. Beaver dam in Black Canyon Creek, July 2015.

Successful implementation of a program to enhance beaver activity requires only three things- beavers, available water, and a sustainable supply of food and materials for dam building. The presence of beavers indicates that all these requirements are met for the locations in which dams were built. The limiting factor to increase beaver activity is the lack of available riparian plants. Increased riparian vegetation is the key to enhancing beaver activity.

Planting Riparian Vegetation

For a variety of reasons, one of the most common management measures to reduce stream temperature is planting riparian vegetation. Riparian vegetation can often be harvested in close proximity to the project site, projects can be implemented by relatively unskilled labor, implementation is generally conducted without the use of heavy equipment and implementation can be conducted in remote areas where other methods may be impractical or restricted. Implemented in an effective manner, planting riparian vegetation will increase shading, capture sediment, provide streambank stability, decrease stream width to depth ratio, and improve both terrestrial and aquatic habitat. Planting riparian vegetation to increase canopy cover is also the one variable in the SSTEMP model (% shade) with the greatest sensitivity to affect a change in water temperature and the primary variable that can be impacted by human activity. Since the model is used to determine the TMDL for solar radiation, implementation results (increase in % shade) can be directly correlated to improvements toward meeting the TMDL targets.

The canopy measurements collected in the fall of 2015 showed the riparian vegetation was concentrated in pockets with entire sections of the stream populated with little woody vegetation and primarily upland plants. The prescriptive treatment is to expand riparian vegetation beyond these pockets to include the entire perennial portions of the stream.

Several field visits were conducted during periods of low flow between spring runoff and the rainy season in late summer. Even without taking any flow measurements it was apparent that there were gaining and losing reaches of the stream and one segment that dried up entirely. This information was critical in determining potential efficacy of project implementation based on available water. The temperature data collected June 21, 2016 provided information on which areas had the coolest water temperatures and the greatest potential to meet WQ standards. Using the information from these efforts eight distinct reaches for planting riparian vegetation were selected (Figure 9).

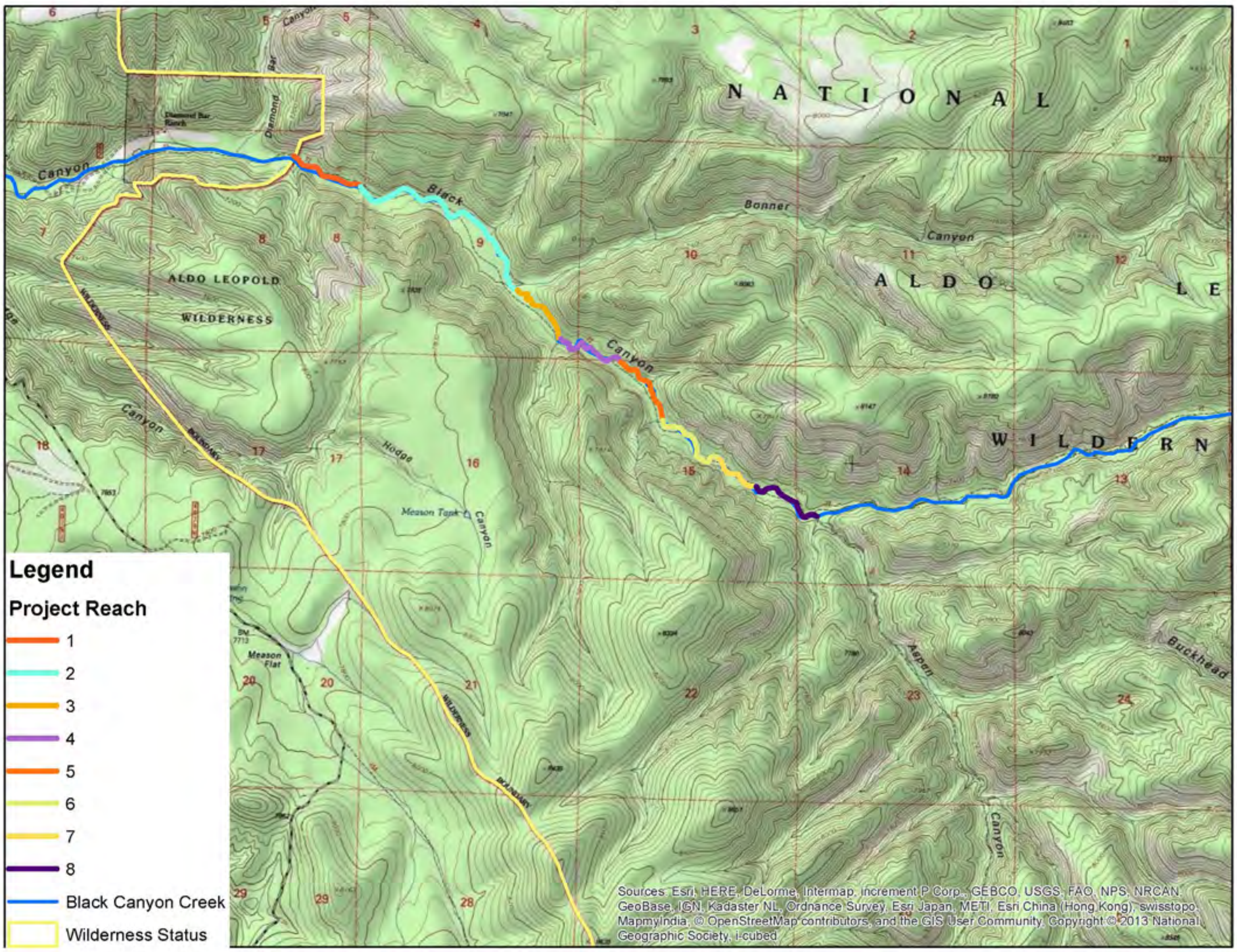

Figure 9. The eight reaches selected for riparian plantings to reduce stream temperature along Black Canyon Creek in the Aldo Leopold Wilderness.

Plant materials including cottonwood, willow and native *Carex sp.* will be harvested from areas along Black Canyon Creek in close proximity to the implementation sites. Purchasing riparian planting stock is not anticipated at this time. Riparian planting prescibed in this WBP will occur during a series of annual workshops designed to educate participants on the significance of temperature as a water quality impairment, the importance of a healthy riparian corridor with a focus on shade to mitigate water temperature, and to promote mitigation measures to reduce temperature and maintain a healthy watershed. It is anticipated that approximately 500-1000 poles could be planted during each workshop with between 10 to 20 particiapants.

Pole planting will primarily consist of willow, and cottonwood. Planting sites have been determined and prioritized based on the potential for establishment and long term success. Since the stream generally runs east-west, planting the south bank of the river at each restoration site will be most effective at producing shade and will also be prioritized where appropriate. *Carex sp.* is very common above the confluence with Aspen Canyon and contributes to streambank stability, shading and sediment removal. The increased streambank stability helps the stream maintain an appropriate width and minimizes the impacts of flooding that can create a wide, shallow channel (Figure 10). *Carex sp.* seeds could potentially be harvested for propagation by a native plant specialist or local *Carex sp.* could be harvested and used on an experimental basis as streambank stabilization to reduce stream width where canopy may not be the primary issue or an appropriate or effective treatment.

The Two Pronged Restoration Approach

Increasing riparian vegetation that increases canopy and the percent shade is not enough to achieve the reduction in temperature necessary to meet WQ standards. Channel incision and disconnection from the floodplain has drastically reduced water storage in the riparian area and reduced baseflow. Early summer baseflow is minimal (≈1 cfs). Expanding riparian vegetation to include more stream miles will not only increase canopy but provide the materials necessary for beavers to expand their range and provide the ecosystem benefits associated with dam building that will improve habitat and reduce water temperatures. It is anticipated that this two pronged restoration approach will sufficiently reduce temperatures to meet WQ standards initially along stream segments with high potential for success and then expanding over time to include more stream miles.

Recommendation for Instream Structures

Natural channel design considers the "natural" dimension, pattern and profile of a stream within a given watershed based on a sound geomorphic characterization developed from the collection of stream survey data. The process begins with a thorough geomorphological stream survey to determine the appropriate stream type based on the hydrology and physical characteristics of the watershed (Rosgen, 1996). The stream

Figure 10. Black Canyon Creek above (left photo) and below the confluence with Aspen Canyon (right photo). *Carex sp.* would be used to vegetate the gravel bar to stabilize the bank and narrow the stream width in the right photo.

can then be evaluated for deviations from the ideal form. Implementation sites can be indentified and appropriate instream structures can be chosen to improve channel morphology. In a setting such as a wilderness area, structures can be designed and implemented using local materials with the goal of creating minimal or no aesthetic impacts. With proper implementation, the structures would blend into the landscape and not be discernable to the untrained eye. Instream structures to mitigate some of the incision in Black Canyon Creek are recommended for future consideration if the appropriate clearances and permitting could be attained.

Expected Load Reductions

Estimating load reductions for leaving the grazing allotment at rest and enhancing beaver activity were not calculated due to the indirect impact that these measures will have and the inability to predict the outcome. Load reductions were estimated for riparian planting along 8 distinct project reaches of Black Canyon Creek from the Aldo Leopold Wilderness boundary to the confluence with Aspen Canyon using the SSTEMP model and canopy measurements collected in the field. Stream reaches were prioritized based on the potential for success in moderating temperatures and not on percent canopy alone. The potential for success was predicted by a combination of factors including water temperature within the reach, groundwater inflow/outflow and baseline canopy conditions. The goal of this prioritization is to target those areas that are close to meeting the temperature standard and would benefit from expansion of shading to maintain lower water temperature for a greater distance along the stream (Table 3).

Table 3. Current shade, target shade and expected load reductions from pole planting along select reaches of Black Canyon Creek. WP = canopy waypoint.

Reach	Priority Rating	Length (meters)	Current Shade (%)	Target Shade (%)	Load Reduction ($j/m^2/s$)	Comments
1	2	366	55	78	70.86	Aldo Leopold Wilderness boundary to WP 4 (beaver dam).
2	2	853	53	78	77.02	WP 5 to WP 22 (Bonner Canyon).
3	2	305	38	78	123.23	WP 23-27.
4	1	305	53	78	77.02	WP 27-32.
5	4	305	41	78	113.99	WP 32-37. Intermittent reach no treatment recommended.
6	3	362	41	78	113.99	Top of intermittent reach to meander bend just below lower spring.
7	1	483	49	78	89.34	This reach brackets both spring inputs.
8	3	501	41	78	113.99	Upper spring to confluence.

In general, priority reaches 1 and 2 have cooler temperatures and groundwater inflow (gaining reach) and riparian canopy to expand on, while priority reaches 3 have high temperatures with outflow to groundwater (loosing reach) and little current riparian canopy. Priority rating 2 was assigned to reaches with stable water flow and canopy to expand on.

This approach considers the high variability in temperatures along the stream primarily as a result of groundwater inflow or outflow during low flow periods and the potential to maintain the lower water temperatures of gaining reaches and the reach directly downstream with stable flow. Reach 5 goes dry during the low baseflow between spring runoff and the summer monsoons and was given a priority of 4 and is not recommended for planting unless the water table rises enough to maintain baseflow along the reach year round.

TECHNICAL AND FINANCIAL ASSISTANCE

Technical expertise has already been attained during the process of developing this WBP. It consists of fisheries biologists, botanists, hydrologists and watershed restoration specialists. At the core of this effort are members of the Gila Trout and Chihuahua Chub Recovery Team which is comprised of a multi-disciplinary team from the United States Fish and Wildlife Service, United States Forest Service, New Mexico Department of Game and Fish, Bureau of Land Mangement and University of New Mexico. In addition, the following specific individuals have been identified to provide further technical assistance.

Technical Assistance

Technical Advisors

Jerry Monzingo
Wildlife, Fish and Rare Plant Program Manager
Gila National Forest

Dustin Meyers
Fish Biologist
Gila National Forest

Rachelle Huddleston-Lorton
District Ranger, Wilderness Ranger District
Gila National Forest

Jill Wick
Fish Biologist
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Chris Canavan
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NMED, Las Cruces

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NM CoOp Fish and Wildlife Research Unit
New Mexico State University

John Moeny
Project Officer
NMED, Silver City

Van Clothier
Watershed Restoration Consultant
Stream Dynamics, Silver City, NM

Carolyn Koury
Forest Hydrologist
Gila National Forest

Angel Montoya
Partners for Fish and Wildlife Program
U.S. Fish and Wildlife Service

Jennifer Frey
Mammalian Diversity and Conservation Laboratory
New Mexico State University

Jeff Arterburn
President
Rio Grande Chapter, Trout Unlimited

The Gila National Forest is a partner in implementing the program from contributing to the WBP to potentially assisting in project implementation. The New Mexico Department of Game and Fish is stocking the stream with native Gila trout and monitoring stocking success and population density and distribution. The Gila Trout and Chihuahua Chub Recovery Team is providing guidance with the Gila Trout recovery efforts in New Mexico and Arizona. The New Mexico Department of Game and Fish and the Gila National Forest are both members of the recovery team and are partnering to implement the Gila trout recovery efforts in the project area. During the course of developing the WBP they were engaged to assure that restoration efforts would also meet the goals of the Gila trout recovery effort. This level of involvement will continue throughout implementation of this WBP.

Financial Assistance

Potential Funding Sources and Associated Budget

USFS Operational Funds
CWA Section 319
USFWS Partners for Fish and Wildlife
NM River Stewardship Program
Trout Unlimited Grants
Western Trout Initiative Small Grants Program
Private Foundations

Table 4. Estimated financial assistance needed to implement the Black Canyon WBP.

Budget Category	Unit Description and # of Units	Unit cost	Total Cost (4 years)
Project Management			
Project coordinator- includes implementation project oversight and fiscal and reporting responsibilities.	240 hours/year @ $40/hr	9,600	38,400
Coordinator for WQ Monitoring (includes deployment and data analysis).	24 hours/month for 6 months @ $40/hr	5,760	23,040
Project Implementation			
Pole planting workshops	Four workshops	4,000	16,000
Pack animal rental	Support for workshops	1,225	4,900
Labor	10 x 18/hr x 8 hours x 12 days	1,440	17,280
WQ monitoring assistant	24 hours/month for 6 months @ $20/hr	2,880	11,520
Outreach			
Host annual fishing derby at Lake Roberts	Fishing Derby for four years	1,500	6,000
Banner for fishing Derby	1 (4' x 8') banner	179	179
Display for fishing Derby	1 display	500	500
Educational Brochures	1,000 brochures	1.20	1,200
General outreach materials	Event giveaways	1,000	1,000
MVFF webpage for Gila trout	Webpage design and maintenance	1,000	1,000
Miscellaneous			
Mileage	0.51/mile x 1,600	0.51	816
Per diem	16 days @ 85/day	85	1,360
Temperature loggers	6 loggers	110	660
Temperature/conductivity loggers	2 loggers	750	1,500
Total			**$125,355**

OUTREACH

The Outreach Program was developed with consideration of the remoteness of the site and sparse population. As noted in the Introduction, this segment of Black Canyon Creek is located primarily in wilderness area. The only road and access point is located between the Gila and Aldo Leopold Wilderness areas, and is approximately 18 miles from the nearest paved road and 25 miles from the nearest small rural community. There is one private inholding and the nearest neighbor is 10 miles away. As a result, outreach has been directed at the stakeholders who have the greatest vested interest in the area and success of the project. These stakeholders include:

- The USFS Gila National Forest
- New Mexico Department of Game and Fish
- Gila Trout and Chihuahua Chub Recovery Team
- Mesilla Valley Fly Fishers
- Gila/Rio Grande chapter of Trout Unlimited

Outreach will be primarily directed at conservation organizations, outdoor enthusiasts and recreational anglers such as the Mesilla Valley Fly Fishers and the Gila/Rio Grande Chapter of Trout Unlimited. The primary outreach componant will consist of four annual riparian planting workshops. Participants will learn the significance of temperature as a water quality impairment, the nature of the water quality impairment in Black Canyon Creek and the need to reduce temperatures to meet water quality standards, the importance of a healthy riparian corridor with a focus on shade to mitigate water temperature and mitigation measures to reduce temperature to maintain a healthy watershed.

The following additional activities have been identified as part of an integrated Outreach Program.

- Support hosting of an annual fishing derby at Lake Roberts with a booth emphasizing the significance of temperature as a water quality impairment and the need to reduce temperatures to meet water quality standards.
- Develop educational brochures that discuss the importance of temperature with respect to water quality and healthy fisheries.
- Distribute brochures to local conservation organizations such as the Mesilla Valley Fly Fishers, the Gila/Rio Grande chapter of Trout Unlimited and the New Mexico Consolidated Sportsmen, and at events such as the Lake Roberts fishing derby, the Natural History of the Gila Symposium and the Gila River Festival.
- Submit abstracts to the Natural History of the Gila River Symposium and other appropriate meetings on temperature as a water quality impairment and the restoration of Black Canyon Creek.
- Attend meetings such as the Southwest Native Trout Meeting and the AZ-NM American Fisheries Society.
- Maintain a webpage on the Mesilla Valley Fly Fishers website providing updates on the status of the Gila Trout, the significance of the temperature impairment and Black Canyon Creek restoration activities.
- Prepare and submit articles to various conservation organization newsletters including: Trout Unlimited, The Western Native Trout Initiative and the AZ-NM American Fisheries Society.
- Present a progress report at the Gila Trout and Chihuahua Chub Recovery Team annual meeting.

IMPLEMENTATION SCHEDULE

The following schedule was developed to encompass the primary tasks to implement this WBP. It includes a series of action items to prepare for implementation, implementation of projects and disseminate information. Each activity or task has a set timeframe to gauge progress and determine if objectives are being met or if modifications to the schedule need to be adopted.

Table 5. Implementation Schedule.

Action	2016	2017	2018	2019	2020	2021
Pre Implementation Planning						
Conduct environmental analysis as needed.	x	x	x			
Apply for necessary permits	x	x				
Implementation						
Select specific implementation sites from WBP	x	x	x	x	x	
Secure funding.		x	x	x	x	
Conduct riparian pole planting workshops to increase stream canopy.			x	x	x	x
Monitoring						
Deploy thermographs to monitor stream temperature.	x	x	x	x	x	x
Monitor stream canopy for project effectiveness.			x	x	x	x
Tentative year NMED will conduct the greater Gila Watershed Water Quality Survey				x		
Monitor implementation schedule for progress and make adjustments as necessary.		x	x	x	x	x
Outreach and Stakeholder Engagement						
Work with the USFWS CoOp unit at NMSU in continued temperature data collection efforts.	x	x	x	x	x	x
Re-engage owners of the Diamond Bar Ranch in cooperation with USFWS Partners Program.		x				
Continue to attend Mesilla Valley Fly Fishers and Gila/Rio Grande Chapter of Trout Unlimited and make an annual report and presentation.	x	x	x	x	x	x
Hold volunteer stream habitat improvement project work weekends conducting pole plantings.			x	x	x	x
Attend Gila Trout and Chihuahuan Chub Recovery Team meetings annually to present progress report.	x	x	x	x	x	x

PROJECT MILESTONE SCHEDULE

In addition to the Implementation Schedule a set of measurable milestones were developed to assure implementation of management measures adheres to the schedule and achieves the management objectives. The milestones may also be used to develop corrective actions in the event the proposed Implementation Schedule needs adjustment or is ineffective.

Table 6. Schedule of measureable milestones to track project activities.

Milestone	2016	2017	2018	2019	2020	2021
Pre- Project planning						
Type of NEPA analysis is determined.	x					
Initiate further NEPA analysis if needed.	x	x				
Required permits have been obtained.		x				
Implementation						
Two planting sites completed annually.			x	x	x	x
Stream length planted annually (approx. 120 m).			x	x	x	x
Volunteer planting workshops scheduled each January for the coming field season.			x	x	x	x
Conduct one pole planting workshop each spring. Minimum of 500 poles planted pr/workshop.			x	x	x	x
Monitoring						
Deploy thermographs in April each year.	x	x	x	x	x	x
Download then redeploy thermographs in early July prior to summer rains.	x	x	x	x	x	x
Retrieve thermographs in late September or early October.	x	x	x	x	x	x
Analyze thermograph data annually post data collection.	x	x	x	x	x	x
Assess pole planting viability mid-summer and fall following current year implementation.			x	x	x	x
Assess change in canopy/shading annually beginning the first season following implementation.				x	x	x
Evaluate WBP implementation efficacy.			x	x	x	
Outreach and Stakeholder Engagement						
Develop educational brochures for distribution at outreach events.		x				
Annual participation in the Lake Roberts Fishing Derby.		x	x	x	x	x
Design and then maintain a webpage on the MVFF website regarding the temperature impairment and the status of restoration activities.		x	x	x	x	x
NMED staff will attend Mesilla Valley Fly Fishers and Gila/Rio Grande Chapter of Trout Unlimited meetings at least twice annually and present annual progress report.	x	x	x	x	x	x
NMED staff will attend Gila Trout and Chihuahuan Chub Recovery Team meetings and report progress annually.	x	x	x	x	x	x

EVALUATION CRITERIA

Prior to developing a successful monitoring plan WQ objectives need to be determined and a set of criteria need to be developed. The criteria should be quantifiable and of sufficient resolution to detect changes and trends over time resulting from implementation of management measures that address the WQ impairment. Temperature is a unique WQ impairment in that it is generally the result of changes to stream geomorphology, streamside vegetation and riparian habitat rather than a direct input of a pollutant. As such, preliminary monitoring criteria involve tracking changes to riparian canopy and subsequent shading. In this manner, progress can be tracked prior to detecting a temperature response in the stream. Although a measurable response may not be seen for several years, ultimately temperature monitoring criteria will determine if implementation has been successful. As a result, criteria were developed to assess preliminary progress as it relates to improvement in canopy and shading and long term progress as it relates to stream temperature. If the monitoring criteria demonstrate deficiencies in implementation or identify problems with the prescribed management measures, alternative approaches will be considered and the plan modified to improve results.

Criteria to Assess Canopy and Shading:

- Annual assessment of pole planting viability expressed as percent mortality.
- Annual assessment of change in canopy/shading at each implementation site expressed as percent shade.
- Annual assessment of change in canopy/shading over project area expressed as percent shade.

Criteria to Assess Geomorphic Changes:

- Pre-implementation assessment of width to depth (w/d) ratios at implementation sites expressed as w/d.
- Post implementation assessment of width to depth ratios beginning two years after implementation expressed as w/d.

Criteria to Assess Water Temperature:

- Assess changes to water temperature over time as recorded by thermographs deployed annually.
- Demonstrate WQ improvement for temperature by the NMED WQ survey tentatively scheduled for 2025.

If Black Canyon Creek does not meet the WQ standard for temperature by the next NMED rotational WQ survey tentatively scheduled for 2025, the data will be used to develop additional strategies to address the water quality impairment.

MONITORING

A monitoring program will be developed to accompany the evaluation criteria and will be designed to examine both short term and long term efficacy of implementation. An integral part of that process will be to develop a detailed sampling plan and a Quality Assurance Project Plan (QAPP) to assure sufficient data are collected to evaluate efficacy of implementing the WBP. Baseline monitoring has already begun and the data is being held internally at NMED in accordance with the SWQB QAPP guidelines. All future monitoring conducted by NMED will be processed and entered into the SWQB database in accordance with the SWQB QAPP. Future monitoring that is conducted under contract will be submitted annually to NMED with the annual project progress report. The data will become part of the permanant project file and uploaded into the SWQB database.

Baseline data have already been collected for both canopy and temperature as part of the development of this WBP. NMED will continue to collect temperature and canopy data in 2016 and 2017 in accordance with the Surface Water Quality Bureau's Quality Assurance Project Plan for Water Quality Management Programs.

Temperature loggers will be deployed in Black Canyon Creek at the Aldo Leopold Wilderness boundary and upstream of the confluence with Aspen Canyon to evaluate effectiveness of implementation toward reducing temperature. Pole planting viability will be evaluated mid-summer and fall to assess the current year implementation to determine if those procedures are working as intended. The year following implementation at a given site, canopy will be monitored in the fall to document the increase in canopy/shading and track progress toward meeting the % shade goal of the implementation site. In addition, changes in stream width to depth ratios and floodplain connectivity will be assessed at each implementation site using the New Mexico Rapid Assessment Method for Montane Riverine Wetlands (NMRAM). The monitoring program will adhere to the following monitoring schedule:

Table 7. The monitoring schedule to evaluate the effectiveness of project implementation.

Monitoring Schedule	2016	2017	2018	2019	2020	2021
Deploy thermographs in April each year.	x	x	x	x	x	x
Download then redeploy thermographs in early July prior to summer rains.	x	x	x	x	x	x
Retrieve thermographs in late September early October.	x	x	x	x	x	x
Analyze thermograph data annually post data collection.	x	x	x	x	x	x
Collect baseline NMRAM data at implementation sites.		x	x	x	x	
Collect NMRAM data post implementation.			x	x	x	x
Assess pole planting viability mid-summer and fall following current year implementation.			x	x	x	x
Assess change in canopy/shading annually beginning the first season following implementation.			x	x	x	x

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