MUSSER AND JARVIS WATERSHED ASSESSMENT REPORT

January 24, 2025

Alpine Watershed Group

P.O. Box 296

Markleeville, CA 96120

(530) 694-2327

www.alpinewatershedgroup.org

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Introduction

The purpose of this report is to provide information on work conducted in the Musser and Jarvis watershed following the Tamarack Fire and to make recommendations for future management of the watershed. This report covers:

- Musser and Jarvis watershed conditions and details from US Forest Service assessment following the Tamarack Fire
- Post-fire initial erosion control efforts, including seeding, wattle installation, and tree planting
- Overview of post-fire restoration monitoring and natural revegetation
- Overview of Markleeville Water Company infrastructure and operations pre- and post-fire
- Recommendations to manage forest and watershed health

Musser and Jarvis Creek is in the Humboldt-Toiyabe National Forest and flows into Hot Springs Creek which then flows into Markleeville Creek. Markleeville Creek subsequently flows into the East Fork Carson River north (downstream) of Markleeville. The watershed is located on public lands which are managed by the US Forest Service (USFS), a federal agency. The upper watershed is designated Mokelumne Wilderness, while the lower watershed is within the Humboldt-Toiyabe National Forest. Musser and Jarvis Creek is spring-fed from several springs located near the top of the watershed in the main drainage, with additional flow coming from side canyons. This watershed was impacted by the Tamarack Fire in July of 2021 by both medium-intensity burns and high-intensity crown burns. See Appendix A: Tamarack Fire Soil Burn Severity Map.

The Musser and Jarvis watershed supplies 70% of Markleeville Water Company's (MWC) domestic potable water through an intake on the downstream side of the burn scar, which MWC operates under a Use Permit from the USFS. A major concern after the Tamarack Fire was that the burned area within the Musser and Jarvis watershed would become a significant source of erosion and would increase high-turbidity events in the creek. These events make the water untreatable. To stabilize slopes and prevent sediment from entering the creek, a restoration project took place in November 2021 in the non-wilderness part of the watershed. Alpine Watershed Group (AWG) prepared a monitoring plan for the restoration project (Appendix B) and has been monitoring the site, summarizing data in annual reports (Musser and Jarvis…2024). Because this watershed provides a significant percentage of the local drinking water supply for the town of Markleeville, it is critical infrastructure. Therefore, the creation and implementation of a management plan is vital.

Landscape Overview

Pre-Tamarack Fire

As is common throughout the upper Carson River watershed, prior to the Tamarack Fire the Musser and Jarvis watershed was comprised of a timber overstory/brush understory vegetation type with fairly high fuel loadings. South-facing upland slopes typically consisted of moderately dense Jeffrey pine, with increased tree density on north-facing slopes and in the drainages. The lower portion of the watershed has moderate slopes while the upper portion is characterized by steep slopes, rocky outcroppings, and open ridgelines. Fire history in the area had been rare in recent decades with only a few ignitions and no wildfire of any size since recording began in the 1950s.

There is a lack of monitoring data and photos available for the Musser and Jarvis watershed from before the Tamarack Fire. However, in an unsent letter written by Bill and Mary Young, pre-fire conditions of the Musser and Jarvis watershed are described. In this unsent letter it is noted that the watershed comprises "…a combination of eroded/bare sections of no growth to areas heavily forested with fir, pine and cedar trees along with undergrowth consisting of bitterbrush and manzanita …. The terrain within the watershed consists of steep slopes. Several sections of the watershed are devoid of any growth, mainly along the ridge top, resulting in significant erosion, particularly during the spring runoff." This information is valuable because it is the only record of pre-Tamarack Fire site conditions of the Musser and Jarvis watershed. It is helpful to understand that hillside erosion, due to site conditions, was a noted concern for the Musser and Jarvis watershed before it was impacted by the Tamarack Fire (2020 letter provided to AWG; unreferenced).

Post-Tamarack Fire

The Tamarack Fire burned through the Musser and Jarvis drainage starting on July 16, 2021. The USFS issued the Tamarack Fire Burned-area Report, or BAER, on August 17, 2021, drawing from specialist reports on geologic hazards, soils, and hydrology. The hydrology specialist report noted the following "Fire Impacts on Resource" in the "Resource Condition Assessment" section:

- "Water infiltration was spot checked throughout the burn scar and medium to strong water repellency was observed on the soil surface in areas of moderate and high SBS [soil burn severity]."
- "Potential Future Impacts from Burned Condition: The loss of canopy cover, reduction in ground cover, and decreased infiltration rates within areas of moderate and high soil burn severity are expected to result in significant increases in runoff. This increased runoff can result in temporary water quality degradation as ash and sediment are routed through the stream network and potentially dangerous flash flooding and debris flows, both within and downstream of the burnscar."

In the "Non-Emergency Response Strategy" the hydrology specialist report advised MWC "to investigate the potential for upgrades to and/or relocation of the water diversion structure to reduce exposure to the flash flood and debris flow threat in Musser and Jarvis creek. A further investigation of additional off-channel water sources and an increase in emergency storage capacity are also recommended." It is important to keep in mind that MWC is a small public utility district with limited financial resources operating water supply infrastructure on public lands under a USFS Use Permit. After the fire, MWC sought funding from multiple sources to address the immediate threats to the water supply. MWC found that it was difficult to obtain funding because the critical infrastructure is on public lands (e.g., Natural Resources Conservation Service and California Office of Emergency Services cannot grant money for work on USFS land), and other grant funding for infrastructure improvements (e.g., additional well) was extremely competitive.

Initial Post-fire Restoration Project

Project Description

In November of 2021, a high-priority restoration project was completed in the Musser and Jarvis watershed to mitigate erosion into MWC's intake infrastructure. This was achieved by MWC with help from CAL FIRE, AWG, Alpine Trails Association, Friends of Hope Valley, and community volunteers. MWC sought and received USFS approval for the project. Donations from the Tamarack Fire Recovery Fund were utilized to purchase seed and other materials for this project. In 2022, AWG completed post-restoration monitoring as outlined in the *Musser and Jarvis Watershed Restoration Monitoring Plan* (Appendix B). Subsequently a second and third year of post-project monitoring were completed in 2023 and 2024 (Musser and Jarvis…2024). Photo points and vegetation data were taken semiannually from 2022 through 2024 at 24 locations around the watershed. All 24 points were located within the 15-acre 2021 restoration site; no monitoring was conducted upstream in the Mokelumne Wilderness. The points were chosen to represent the various conditions of the watershed after the Tamarack Fire and the range of treatments that were completed in 2021.

The restoration project was spearheaded by MWC President Mary Young and her husband Bill Young. The project's main goal was to stabilize the hillsides to prevent further erosion within the Musser and Jarvis watershed. Two types of physical barriers were utilized to slow runoff and store sediment on the hillsides: wattles and chinked trees, which are trees felled across the slope with soil packed on the upslope side to create a sediment barrier. After preparing the area around the creek by raking the soil, a seed mixture comprised of seven native grass species was spread on the ground. The seeds were spread along flat areas near the creek banks, on both sides of the wattles, and on the upslope side of the chinked trees.

Native grass seed species list (from Comstock Seed bag label):

- Mountain brome
- "Pryor" slender wheatgrass
- "Elkton" blue wildrye
- "High Plains" Sandberg bluegrass
- "Sherman" big bluegrass
- "Sodar" streambank wheatgrass
- "Jospeh" Idaho fescue

From November 19 to November 21 of 2021, 115-135 trees were felled and chinked, 900 feet of wattles were installed, and 7-8 acres were seeded over an area of 15 acres. Two CAL FIRE California Conservation Corps (CCC) crews of 15 members each and a total of 49 volunteers worked over this weekend, totaling 284 volunteer work hours. In March of 2022, MWC coordinated with CCC crews to plant 3,000 trees throughout this 15-acre area. The trees were donated by the US Forest Service and included Jeffrey pine (*Pinus jeffreyi*), ponderosa pine (*Pinus ponderosa*), sugar pine (*Pinus lambertiana*), and incense cedar (*Calocedrus decurrens*).

Project Monitoring Results

The *Musser and Jarvis Watershed Restoration 2023 Monitoring Report* (Musser and Jarvis…2024) concludes: "The restoration project was successful in accomplishing the objective of preventing erosion and maintaining improved watershed health." Visual comparisons of key points made in the field and with photo monitoring indicate that the hillsides have remained stable in the watershed. Soil and sediment have successfully settled behind the felled, chinked trees and wattles, which has encouraged seeded graminoid growth (Figures 1-3).

The seeding of native grasses along the creek banks, on both sides of the wattles, and on the upslope of the chinked trees was largely successful in jump-starting the ecological succession of native vegetation. Upland vegetation such as snowbrush ceanothus (*Ceanothus velutinus*) has greatly rebounded post-Tamarack Fire. The seeding along the creek banks has restricted upland vegetation from spreading down onto these flatter areas and dominating the creek banks. Farther upstream, in areas along the creek bank not seeded with the seven native grass species, the creek-side growth (e.g., willow) has rapidly regenerated and makes access to the creek difficult.

From these observations within different treatment areas, it can be inferred that native grass seeding along flat creek banks successfully accelerates succession, increases soil stability on and adjacent to stream banks, and helps capture sediment from adjacent slopes. The seeding on both sides of the wattles was also very successful. The wattles are barely visible three years post-Tamarack Fire. This is due to the amount of sediment the wattles have captured and the vegetation that has grown behind and over them. The seeding behind the chinked trees led to significant graminoid growth which helped to stabilize the hillsides. In conclusion, all the areas that were seeded in the fall after the fire have proven to be successful in promoting growth of native vegetation and seedlings. See the below pictures which demonstrate seeding and erosion control success.

Figure 1: Successful seeding behind a felled tree

Figure 2: A wattle that has successfully captured sediment, with thriving seeded grasses on either side

Figure 3: A wattle that is nearly level with the sediment it has captured

Watershed Condition August 2024

Fuel Loads and Vegetation

A site visit was conducted in preparation for this assessment report on August 22, 2024, with AWG staff, Alpine County Wildfire Project Coordinator Clint Celio, Bill Young, and Mary Young with MWC. The area walked included the restoration project area and a burned area located farther upstream within the Mokelumne Wilderness. The group did not explore the unburned portions of the Mokelumne Wilderness; it is presumed that the vegetation within this area remains largely unchanged from the observations made by Bill and Mary Young prior to the Tamarack Fire. In 2020, the Youngs observed high fuel loads in the unburned portions of the wilderness, consisting of dense tree stands, numerous downed trees, and a thick layer of duff (i.e., pine needles). The rocky and eroded ridgelines which make up most of the unburned area were largely unvegetated and therefore less affected by fire than the vegetated slopes in the wilderness.

During the August 22, 2024, site visit, the group observed that the burned areas within the restoration project boundary have lower fuel loads than the burned portions of the Mokelumne Wilderness. The seeding of native grasses along the flat portions of creek banks jumpstarted the vegetation growth post-Tamarack Fire. This growth has minimized encroachment of upland shrubs and invasive species while also allowing access to the creek as grasses are a less-

restricting riparian species than willow. Areas below the wilderness boundary that were not seeded have larger populations of invasive species and native riparian species, such as willow which has grown in densely and restricts creek access. According to the Youngs, the drier south-facing slopes have more vegetation than they did before the fire (largely invasives) which may have more to do with the wet winter of 2022/2023 rather than the fire.

Within the burned portion of the Mokelumne Wilderness that the group walked, snowbrush ceanothus has visibly begun to overtake much of the bare ground. This is a result of the Tamarack Fire burning the hillsides adjacent to Musser and Jarvis Creek. According to Bill and Mary Young, who walked this reach before the fire, the increased density of this shrub following the Tamarack Fire has made many of their pre-fire walking routes impassable. A large quantity of partially and completely burned trees from the Tamarack Fire are still standing and are now beginning to fall in this area. Figure 4 shows the dense snowbrush ceanothus within standing dead and partially-burned trees in a burned portion of the Musser and Jarvis watershed within the Mokelumne Wilderness.

Figure 4: Ceanothus carpets the floor of a forest of burned trees in the Mokelumne Wilderness

The dense growth of snowbrush ceanothus depicted in Figure 4 is a stage in forest succession known as the early seral shrub layer. Snowbrush ceanothus growth is prompted by fire,

regenerating from seed that is dormant in the ground until germinated by heat from a fire (Anderson 2001). “Where its seeds are present in soil, snowbrush ceanothus may dominate early seral growth following ‘medium or hot’ fire. Snowbrush ceanothus also sprouts vigorously from the root crown after fire.…Fire creates conditions more favorable for snowbrush ceanothus by removing the overstory…. When conifers overtop the shrublands, snowbrush ceanothus may die out because of reduced light intensities in the forest understory” (Anderson 2001). This suggests that the current increased growth and successful establishment of snowbrush ceanothus within the Musser and Jarvis watershed post-Tamarack Fire is expected and can be considered normal forest succession. It also suggests that as forest succession progresses and overstory canopy develops, this dense shrub layer may begin to die off.

Unfortunately, it can take years for overstory growth to create a sufficiently dense canopy to shade out the snowbrush ceanothus. A potential setback for establishing overstory growth could be that “[i]n high densities, snowbrush ceanothus may compete with conifer seedlings for moisture and nutrients and may shade out intolerant tree species” (Anderson 2001). The current forest condition, alongside the growth of the brush, raises concerns about a secondary burn impacting the area. “Snowbrush ceanothus burns ‘quite hot,’” and will burn at moderate to high intensities depending on the time of year and the weather conditions. “The foliage contains volatile oils that may contribute to fire hazard” (Anderson 2001). While this adaptation is helpful for the species, as seeds are germinated by fire, it is indicative of a potential change for the ecosystem at large. “Vegetation structure and composition of areas that repeatedly burned at high severity are consistent with a transition to persistent shrubland or hardwood forests” (Steel et al. 2021). The possible conversion of mixed-conifer forest to shrubland in the Musser and Jarvis watershed is of significant concern because shrubland does not provide the same ecosystem benefits, nor store as much carbon, as does a mixed-conifer forest. Monitoring of the vegetation within this watershed should continue to verify that conifer growth, both from seedling plantings and natural regeneration, is able to persist above the snowbrush ceanothus.

The heavy fuel loads of standing dead trees and downed burned trees within the Mokelumne Wilderness portion of the Musser and Jarvis watershed pose a significant threat when another wildland fire comes through this portion of the watershed. Research shows that the risk of future high severity fire may be higher in areas that have already burned at high to moderate severity, especially in areas that have a high density of standing snags, surface fuels, and dense cover of regenerating shrubs (Influence of Post-fire…2022). This secondary fire could cause severe impacts on the watershed previously impacted by the 2021 Tamarack Fire (both wilderness and non-wilderness). For these reasons, vegetation management via fuels treatment should be a priority in the lower portions of the Musser and Jarvis watershed in order to ensure that the creek is best protected, as a critical resource and habitat, from a fire that could originate either within the upper wilderness portions or within the lower portions of the Musser and Jarvis watershed.

Invasive Species

Throughout the August 22, 2024, site visit, there was a notable heavy presence of four nonnative species: prickly lettuce *(Lactuca serriola)*, great mullein *(Verbascum thapsus)*, yellow salsify

(Tragopogon dubius), and bull thistle *(Cirsium vulgare)*. There is prolific growth of prickly lettuce throughout the burned portion of the watershed, and it may be limiting the opportunity for regeneration of native vegetation within the burn scar. Yellow salsify is also present throughout the burned portion of the watershed. Great mullein and bull thistle were often found in clusters—significant groupings of these species were observed within both the Mokelumne Wilderness and in the lower portions of the watershed.

"There is a threat of spread of weeds due to fire," the USDA Forest Service Tamarack Fire Burned-area Report (BAER) noted, "especially in high and moderate soil burn severity areas near known infestations and adjacent to transportation system within the burned area. The probability of damage or loss is considered likely, as the fire has rendered approximately 49% (moderate-high severity) of the habitat vulnerable to introduction of new weeds and expansion of existing weeds" (Tamarack Fire Burned-area…2021). The invasive species observed in the high-severity burned portion of the wilderness could travel downstream, increasing the acreage they occupy. The need to address these invasive species in the burn scar is crucial. Invasive species outcompete native vegetation, and nonnative species are often associated with increased fire risk. "[E]xpansion of weeds into areas disturbed by fire suppression and within the burned area [is] likely; potentially increasing fire frequency" (Tamarack Fire Burned-area…2021). The presence of nonnative, invasive plant species usually subsides in the years following a fire, but it should be kept in mind that drought can cause nonnative species to outcompete native species because they can grow faster in dry conditions.

Prickly lettuce *(Lactuca serriola)* Non-wilderness	

Great mullein *(Verbascum thapsus)* Mokelumne Wilderness	
Great mullein *(Verbascum thapsus)* Non-wilderness	
Yellow salsify *(Tragopogon dubius)* Non-wilderness	

Bull thistle *(Cirsium vulgare)* Mokelumne Wilderness	
Bull thistle *(Cirsium vulgare)* Non-wilderness	

Table 1: Invasive Plants in the Musser and Jarvis Watershed

Water Intake Infrastructure

MWC President Mary Young provided the information in this section on operations of the water system intake before and after the Tamarack Fire. The Musser and Jarvis Creek intake provides 70% of the water supply for MWC. See Appendix C for photos of the intake structure.

Pre-Tamarack Fire Intake Condition

Pre-Tamarack Fire, the intake structure on Musser and Jarvis Creek consisted of a dam and a 14" pipe that extended into the upstream pond created by the dam. The pond measured about 30' long x 20' wide x 3' deep (Appendix C, Photo 1). It was excavated annually under a routine maintenance schedule to remove settled materials that had accumulated. The dam itself consisted of a concrete dam with extension boards that could be adjusted to raise or lower the depth of the pond. The creek water in the intake pond either went into the intake pipe or spilled over the dam and proceeded downstream in its natural stream course. The flow control to the water plant was either on or off.

Post-Tamarack Fire Intake Condition

After the Tamarack Fire, excessive sediment composed of sand and decomposed granite was entrained in the water due to erosion runoff, ultimately depositing in the intake pond. The sediment flow was excessive to the degree that the intake pond would completely fill with sediment within 1-2 weeks. The new level of maintenance was a stark change from the previously required annual excavation. In October of 2021 a flash flood occurred in the Markleeville area including the Musser and Jarvis watershed. Debris from the flash flood covered the dam and intake structure, and sediment filled the intake pipe (Appendix C, Photo 2). This required mechanical removal of the debris and cleaning of the intake pipe. A bypass pipe was installed to allow easier cleaning if the intake pipe filled in the future. After flood cleanup the pond continued to accumulate sediment, and excavating the pond every two weeks was not feasible. It was determined that the pond could not be maintained, and that the intake dam needed modification to permit sediment flow through the dam.

The modifications completed include:

- Allowing the pond to completely fill with sediment and the stream to flow naturally to the dam, protecting the intake pipe from the main stream flow behind a gravel bar
- Modifying the dam boards immediately downstream of the intake pipe by installing three 4-inch pipes with gate valves about 8” below the water surface and at the top of the intake pipe
- Installing a remote camera to monitor the status of the intake
- Installing concrete blocks in the path from the stream to the intake—The purpose of the blocks is to increase and maintain the water velocity to entrain sediment in the water flowing to the three pipes, thereby allowing the sediment to flow through the dam and directing the water with less sediment to flow to the intake pipe.

These solutions significantly improved the operation of the intake (Appendix C, Photo 3). However, during times of high debris flows (e.g., after rainstorms), the three pipes frequently become blocked with sticks and pinecones, preventing sediment and debris from flowing through the dam. During these times, sand and decomposed granite accumulate, blocking the intake pipe within a day. Sometimes this requires maintenance every 1-3 days. As of three years after restoration work, the maintenance required is less frequent, but the entire intake can still become blocked.

Recommendations

The intent of this assessment is to recommend actions needed in the Musser and Jarvis watershed for watershed and forest health. This is important because the watershed is critical infrastructure that provides a significant percentage of the local drinking water supply for the town of Markleeville.

A second site visit was conducted on October 18, 2024, to produce the following list of recommendations. This site visit included AWG staff, Alpine County Wildfire Project

Coordinator Clint Celio, Bill Young, US Forest Service Hydrologist Don Kozlowski, and US Forest Service Forester Ray Lopez. The recommendations put forth are the culmination of this in-field discussion, based on the observations, experience, and expertise of the individuals involved, in addition to AWG staff's experience with the restoration project and subsequent monitoring. This assessment does not represent the recommendations of Markleeville Water Company or any public agency.

Implement Projects to Reduce Future Fire Risk in the Musser and Jarvis Watershed

As noted in the above discussion on fuels loading, a second fire could cause severe impacts on the watershed previously impacted by the 2021 Tamarack Fire. Projects to reduce the risk of fire in the watershed include not only work within the watershed but also projects to reduce the risk of fire on adjacent lands that would likely spread to the watershed.

Reduce Fire Risk on Adjacent Lands by Completing Implementation of the Tamarack Restoration Project

The Tamarack Restoration Project as prepared by the Humboldt-Toiyabe National Forest Carson Ranger District is an approved project whose goals include the following:

- Complete fuels reduction in strategic areas to improve the Agency's ability to manage and control future fuel loading and wildfires, as well as facilitate restoration activities.
- Balance active management with the retention of important attributes of post-fire habitat at the landscape scale and within treatment areas to support the diversity and abundance of plant and wildlife species.

Treatment units for the Tamarack Restoration Project are directly adjacent to and include some area in the lower portion of the Musser and Jarvis watershed. Active management and fuel reduction in these adjacent areas would reduce the risk of a devastating secondary fire within the Musser and Jarvis drainage. The Tamarack Restoration Project has been only partially implemented.

The USFS should either fully implement the Tamarack Restoration Project or provide documentation of rationale for changes to the project scope and details on the new planned actions.

Develop Low Impact Forest Health Improvement Projects on National Forest Lands within Musser and Jarvis Watershed

All of the non-wilderness National Forest land in the Musser and Jarvis watershed should have a target condition that reduces the risk of high intensity future fires. Fuels management work that is conducted within the watershed should be handwork and should be planned to minimize erosion and protect water quality. Projects could include:

- Thinning and hand piling of snags and trees declining in health
- Clearing snowbrush ceanothus and planting other native plants in cleared areas

- Thinning planted and natural regeneration of tree species to achieve desired forest density and fuel loads
- Implementing prescribed fire techniques that would protect saplings
- Planting more tree seedlings in areas that may lack natural regeneration, or which have not been planted before

AWG should work with Alpine County and the USFS to identify funding for planning and implementation of fuels management projects within Musser and Jarvis watershed.

Consider Creating a Fuel Break below Wilderness Boundary

The largest threat to the non-wilderness portion of the Musser and Jarvis watershed is fire in the Mokelumne Wilderness located in the upper portion of the watershed. A fuel break on the non-wilderness, downhill side of the narrows (a geographic feature between the wilderness and non-wilderness area) could be part of the fuels management strategy for the area. This fuel break would provide a defense that could slow or stop the spread of fire from the Mokelumne Wilderness. A fire coming into the watershed from uphill could be fought, preventing the spread downstream into the non-wilderness portion of Musser and Jarvis watershed that was burned by the 2021 Tamarack Fire.

AWG should work with Alpine County and the USFS to identify funding for planning and potential implementation of a fuel break within Musser and Jarvis watershed.

Explore Treatment Techniques and Management Strategies within the Wilderness Area

Almost two-thirds of the Musser and Jarvis watershed is within the area designated as wilderness. Preventing a high intensity fire in the already burned areas of the wilderness is critical to protecting the watershed. Management of wilderness areas through prescribed burns or managed lightning caused burns is now being implemented in some federally designated wilderness areas (Boerigter et al. 2024).

AWG and the USFS should pursue projects that would be feasible within the Mokelumne Wilderness area of the Musser and Jarvis watershed.

Continue Vegetation Monitoring in Musser and Jarvis Watershed

The vegetation and species mix in Musser and Jarvis watershed should continue to be monitored. Specifically, future monitoring should consider observing and tracking the growth of snowbrush ceanothus and its relationship with conifer seedlings as the forest continues to progress through ecological succession post-Tamarack Fire. It is important to monitor the way that this shrub is growing-in post-Tamarack Fire because “[c]onifers established at the same time as snowbrush ceanothus will dominate the snowbrush ceanothus, emerging above the shrub canopy after 10 to 30 years. Snowbrush ceanothus is eventually suppressed by conifers, but the period of dominance by snowbrush ceanothus may determine species composition of the succeeding conifer stand. If snowbrush ceanothus remains dominant for more than 15 years, it will be succeeded primarily by shade tolerant species. Releasing conifers from snowbrush ceanothus

may increase conifer stem diameter and height growth" (Anderson 2001). If the population of snowbrush ceanothus growing in Musser and Jarvis watershed remains the dominant vegetation for more than 15 years following the Tamarack Fire, there is a greater likelihood that shade-tolerant conifer species, such as red/white fir and incense cedar, will dominant the ecosystem. These shade tolerant species are not as adapted to fire as ponderosa pine and Jeffrey pine. As the vegetation is monitored and the growth of snowbrush ceanothus is observed, it may be necessary to prune the shrub back so that the seedlings of fire-resilient trees have an opportunity to grow and shade out the snowbrush ceanothus.

Invasive nonnative species should also continue to be monitored within this watershed to ensure that they do not outcompete native vegetation or significantly restrict its growth. This is because invasive species have the ability to grow faster in drier conditions, and nonnative species are frequently associated with increased fire risk. Populations of prickly lettuce (*Lactuca serriola*), bull thistle (*Cirsium vulgare)*, yellow salsify (*Tragopogon dubius)*, and great mullein *(Verbascum thapsus)* need continued monitoring to determine if occurrence and coverage continue to change. One of the BAER emergency treatment objectives was to treat invasive plants that threaten native ecosystems by minimizing the expansion of existing populations in the burned area, which is vulnerable due to the disturbance from the fire. Ongoing plans for treatment of invasives should be developed based on the monitoring data.

AWG should work with the USFS and other partners to develop a long-term vegetation monitoring protocol which builds on the current surveys while developing consistent metrics over time. Monitoring data should be used to inform land management. Treatment projects should be implemented to reduce large populations of invasive species.

Additional Restoration Projects in Musser and Jarvis Watershed

Implement low-tech, process-based restoration projects to decrease sediment load at the water intake. This watershed is well suited to sediment traps and sediment capture ponds. This would be a feasible restoration project due to the downed trees and woody debris available along Musser and Jarvis Creek. The burned trees may begin to fall across the stream channel on their own, but this could be accelerated by dropping and moving larger pieces of wood into the stream channel by hand, to create a series of check dams and capture ponds that would trap sediment before the water reaches the MWC intake. As sediment is captured in the first pond, water would rise and begin to spill over into the second pond, then the third pond, etc. This would minimize sediment loads at the MWC intake structure downstream. This restoration process would also raise the water table and accelerate the revegetation of the watershed, a feedback loop for water retention. Ideally some groundwater wells could be installed to collect data about the water table prior to future restoration projects so that projects can be assessed for impacts on the water table. The further in advance of future projects that this monitoring program is established, the more understanding can be gained of natural fluctuations in this watershed.

AWG should work with Alpine County and the USFS to identify funding for planning and implementation of a low-tech check dam and capture ponds project within Musser and Jarvis creek, including pre- and post-project groundwater monitoring.

Sediment Analysis Study

A sediment analysis study of this watershed would measure sediment transport and changes in channel morphology. Although it has been three years since the Tamarack Fire, it is going to take several more years for the sediment to settle down in the upper watershed within the burned portion of the Mokelumne Wilderness. This does not account for the effects of a re-burn that could occur during this time. An understanding of the geomorphology of the watershed could inform restoration projects such as additional planting or the check dams and capture ponds described above.

AWG should explore funding sources to conduct a preliminary sediment analysis study of Musser and Jarvis Creek.

Markleeville Water Company Infrastructure Improvement

MWC has been able to manage increased sediment at the intake through low cost infrastructure changes at the intake and increased maintenance. During high-turbidity events, MWC uses well water instead of water from the Musser and Jarvis Creek intake. MWC has been able to meet water demands during extended high turbidity periods by using wells and by water conservation by the systems' users. The recommendations of the BAER report such as expanding off channel water sources (additional wells) and increasing emergency storage are extremely costly and could only be implemented through grant funding given the resources available to MWC. Some lower cost improvements would include:

- Constructing an off-channel intake that would be protected from flash flooding
- Installing a reliable water gauge on Musser and Jarvis Creek that would provide continuous water level data—This could be an additional remote monitoring source supplementing the visual data captured by the camera that is currently installed to monitor the flow at the intake.

MWC and Alpine County should work to identify funding for planning and implementation of both high cost and lower cost infrastructure improvements to improve the resiliency of the MWC water system.

Conclusion

As the local nonprofit environmental organization dedicated to protecting, conserving, and restoring Alpine County's watersheds, AWG hopes to continue as an active partner to improve forest and watershed health in the Musser and Jarvis drainage. Because the drainage holds critical infrastructure for the local drinking water supply, it is crucial to manage the area. The above recommendations outline projects as well as monitoring that can inform additional future

actions. While the recommendations above are specific to the Musser and Jarvis drainage, AWG notes that this is one small area within the Humboldt-Toiyabe National Forest. This area falls under the Toiyabe National Forest Land and Resource Management Plan (Toiyabe National Forest…1986) which dates back to 1986—before the Toiyabe and Humboldt National Forests were merged. AWG continues to urge the USFS to undertake the long overdue update of the Forest Plan that includes this drainage. This report also highlights the fuels load in the Mokelumne Wilderness in the upper Musser and Jarvis watershed. The Wilderness Act dates back to 1964. Fire behavior has changed radically in recent years, and researchers have found that the exclusion of fire from wilderness over the last 120 years has made many fire-adapted wilderness ecosystems less resilient to climate change and more vulnerable to severe wildfires (Boerigter et al. 2024). AWG takes heart that wilderness managers are exploring how prescribed fire might be successfully implemented within federally-designated wilderness areas, and looks forward to seeing what tools might be utilized to help prevent a second, more catastrophic wildfire in this area. We look forward to working with the USFS, MWC, Alpine County, and our community members to be able to implement recommendations made in this report.

Acknowledgements

Thank you to Sierra Nevada Conservancy for providing funding through the Regional Forest and Fire Capacity Program (RFFCP) to assess post-fire Musser and Jarvis restoration activities to inform long-term management needs for watershed and forest health. The Whitebark Institute graciously agreed to administer the RFFCP subcontract to Alpine Watershed Group to complete this assessment.

Thank you to all of the volunteers that helped with the 2021 restoration project; Alpine County Chamber of Commerce, who funded the restoration project through the Tamarack Fire GoFundMe effort, and the many people who donated to the fund; Brian Hansen of the US Forest Service, who obtained approval for the project; Andy Lovell and Alpine Trails Association, who donated their time and tools; Debbi Waldear and Friends of Hope Valley, who volunteered and helped recruit additional volunteers; Jed Gains of CAL FIRE, who organized and led the CCC efforts; Richard Burchell of Markleevillage, who helped to organize the work and brought in CAL FIRE CCC; and Mary and Bill Young, who obtained the funding, planned the project, and have worked tirelessly to help heal this landscape. AWG is grateful to past AWG staff for their work on this project: Sierra Nevada AmeriCorps Partnership (SNAP) Member Sierra Riker for assisting with restoration project implementation, development of the monitoring plan, the initial rounds of monitoring, and the 2022 Monitoring Report; and AWG's first Forest Health Coordinator Wes Mosley for finalizing the 2022 Monitoring Report and leading 2023 data collection.

California Climate Action Corps (CCAC) Fellow Isabella Kurtz was the lead writer of this assessment, with support from Fellow Kaitlyn Garber. During their tenure with AWG, Kaitlyn and Bella have also continued to implement the monitoring plan and taken the lead on the annual monitoring reports. AWG is indebted to the CCAC program for the increased capacity it has

given our organization. We are so grateful that Bella and Kaitlyn have chosen to serve two terms with AWG.

Finally, this assessment has much benefited from review and input from Mary and Bill Young, and Clint Celio. Thank you!

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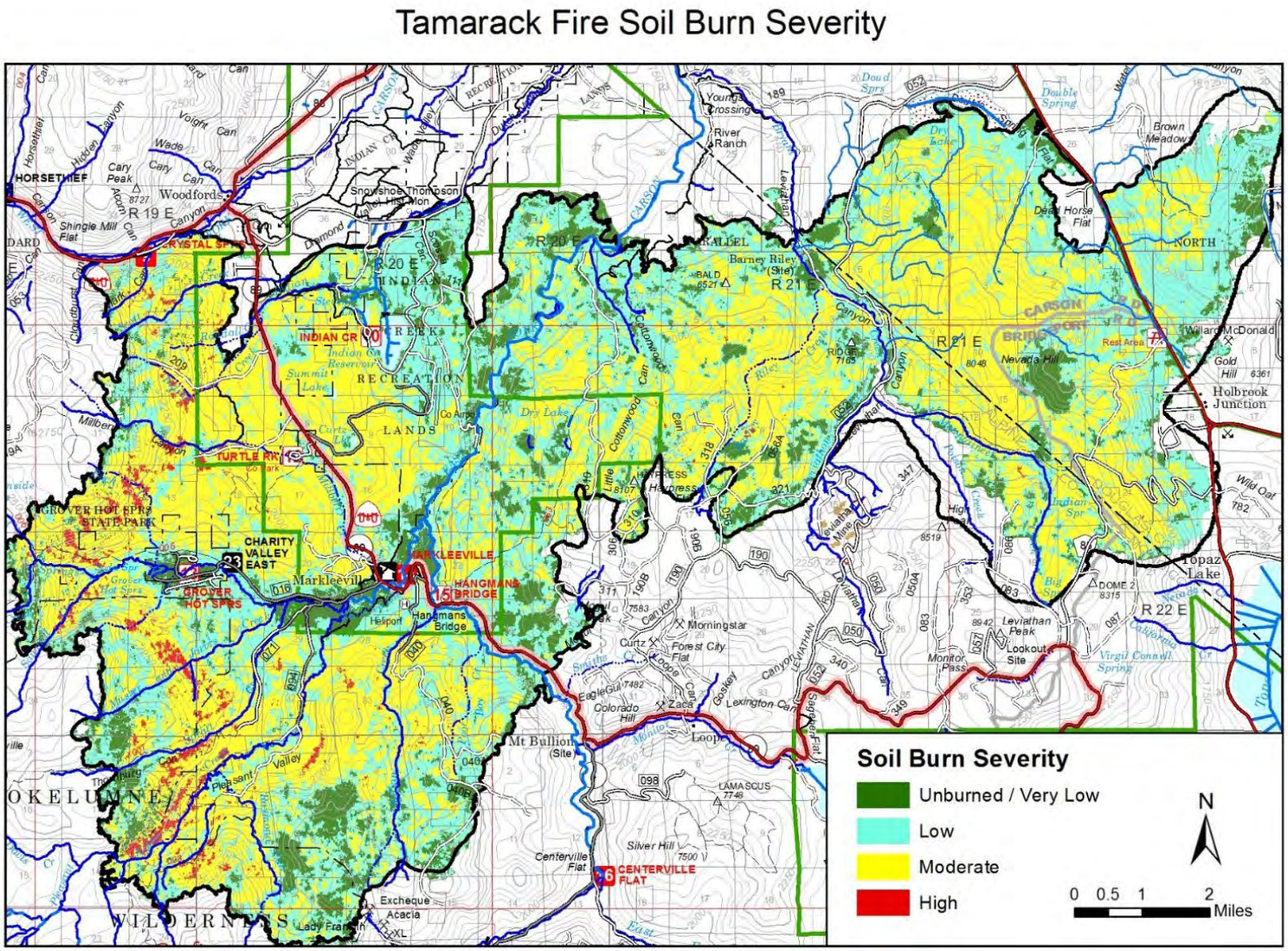
Appendix A: Tamarack Fire Soil Burn Severity Map



Tamarack Fire – Burned Area Emergency Response Soil Resource Report
Eric Nicita, Forest Soil Scientist, Eldorado NF, eric.nicita@usda.gov,
USDA Forest Service, August 11, 2021

Musser and Jarvis Watershed Restoration Monitoring Plan

Comments received from Mary and Bill Young on February 16, 2022; incorporated into next draft; and recirculated to Mary Young for Markleeville Water Company Board of Directors on May 12, 2022
Reviewed and Approved by Carson Ranger District, Humboldt-Toiyabe National Forest on June 16, 2022
Finalized by Alpine Watershed Group on August 12, 2022
Updated by Alpine Watershed Group on January 23, 2024, to reflect July monitoring

Introduction

Project Background

Musser and Jarvis Creek is in the Humboldt-Toiyabe National Forest and flows into Markleeville Creek, which flows into the East Fork Carson River north of Markleeville. This area was impacted by the Tamarack Fire in July of 2021 by both medium-intensity burns and high-intensity crown burns. The Musser and Jarvis watershed supplies 70% of Markleeville's water through an intake on the downstream side of the burn scar, which is leased from the U.S. Forest Service by Markleeville Water Company (MWC). Because of the fire, the banks have become unstable and the hillsides are eroding into the stream. This is negatively impacting water quality, and the intake infrastructure has clogged repeatedly. This restoration project, spearheaded by Markleeville Water Company President Mary Young and her husband Bill Young, aims to stabilize the hillsides to prevent further erosion. The work described in the Project Description took place on November 19–21, 2021.

Location

The Musser and Jarvis watershed can be accessed through Markleevillage. The access road is located at the end of Sawmill Road, and is locally known as the access route for Thornburg Canyon Trail. The dirt road goes through private property and over Spratt Creek. Shortly after crossing the creek, the road forks, with one fork continuing straight up Thornburg Canyon while the other turns sharply to the right and goes up a steep hill to a gate, beyond which is U.S. Forest Service land. There is a gate with a U.S. Forest Service lock, which restricts access. Access will be coordinated with Markleeville Water Company. After approximately a mile, the road enters the forest and widens out. This is where vehicles should park. See the reference binder for a map of the access area.

If parking at the intake is necessary, prior to going to the intake, phone Mary Young, Kris Hartnett, or another MWC Board Member to let MWC know when you will be parked at the intake. Keep vehicles on existing gravel and dirt roadways. Parking at the MWC intake requires driving along the existing road through a section of private property, which should be respected

and used for access only. Park the vehicle in a position where other vehicles can access and turn around at the intake site. Place a note on the vehicle identifying AWG so MWC personnel will know why the vehicle is parked at the intake. The creek should not be entered near or within 100 yards upstream of the intake structure and MWC facilities or equipment at the intake should not be disturbed.

The restoration work initially did not include the area immediately around the intake structure, but began about 100 yards upstream, moving upstream on both the north and south slopes. The first photo point is near two large boulders upstream of the water intake infrastructure. The restoration area begins about 100 yards upstream of the intake and extends upstream to shortly before the "narrows," which is the approximate border of Mokelumne Wilderness Area. The photo locations were created by traversing a loop starting on the downstream, south side of the creek and proceeding upstream on the south side of the creek. At the westernmost edge of the restoration area (near the wilderness boundary), the numbering transferred to the north side of the creek and returned downstream. The creek will need to crossed at least twice when completing monitoring.

Project Description

Seeding

Seed from seven native grass species was spread along the flatter areas near the creek banks, on both sides of the wattles, and on the upslope side of the felled trees. These grasses should help to slow surface runoff, allowing water to infiltrate into the ground and nutrients, pollutants, and sediment to settle. These nutrients and pollutants then can be taken up by plants, decay, get metabolized by microbes, or absorbed into soil particles, thereby preventing sediment from flowing into the stream and negatively impacting water quality. The roots from the grasses will stabilize the soil and hold the banks and hillsides in place.

The species list includes mountain brome (*Bromus marginatus*), "Pryor" slender wheatgrass (*Elymus trachycaulus*), "Elkton" blue wildrye (*Elymus glaucus*), High Plains Sandberg bluegrass (*Poa secunda*), "Sherman" big bluegrass (*Poa ampla*), "Sodar" streambank wheatgrass (*Elymus lanceolatus*), and "Joseph" Idaho fescue (*Festuca idahoensis*).

Physical Erosion Control Barriers

The two types of physical barriers used were focused on slowing runoff and storing sediment on the hillsides. The first barrier type was wattles, which are 25-foot burlap tubes filled with straw. Wattles were staked into the ground to block the passage of runoff, and they were placed at the foot of the hill for the highest effectiveness. The other barriers were felled and chinked trees. The trees were felled perpendicular to the slope. Chinking is when the soil upslope from a felled tree is packed against the log to create a barrier. Both barriers serve to block and slow high-velocity surface runoff.

Accomplishments

Over three days, 115–135 trees were felled and chinked, 900 feet of wattles were installed, and 7–8 acres were seeded over an area of 15 acres. Thirty volunteers assisted on Saturday, November 20, 2022 and nineteen volunteers assisted on Sunday, November 21, 2022, totaling 284 volunteer work hours. Two CAL FIRE California Conservation Corps (CCC) crews of 15 worked Friday, November 19, 2022 through Sunday, November 21, 2022. The volunteer crews seeded around the wattles, behind the felled trees, and on the flat areas near the stream; they also helped with chinking. The CCC crews installed the wattles, felled the trees, and chinked trees.

Goals

Research Questions

- How effective were seeding, tree felling/chinking, and wattle treatments in preventing erosion?
- How does seeding impact the ratio of native/nonnative species that grow post-fire?
- What species were most successful for post-fire seeding? (if monitors can identify individual species)

Purpose of Monitoring

Ongoing monitoring will record the effectiveness of the treatments in the post-fire burn area. Photo point monitoring can be used to visually detect changes in the slope of the hillside and the degree of erosion that occurs, as well as provide a visual reference for post-fire revegetation over time. The vegetation monitoring will determine what seeded species were successful at germinating and reproducing. The monitoring may also suggest whether seeding is effective at preventing nonnative species from inhabiting a disturbed area. Through vegetation monitoring, the spread of invasive species after native seeding can be identified and compared to other restoration sites. Success of revegetation in the different treatment areas as shown by photo point monitoring and vegetation monitoring might suggest the success of a specific treatment type at preventing erosion.

Limitations

- As described above, vehicle access to the project site depends on having the key to unlock the gate.
- The area is remote and steep.
- The lack of human presence makes the relatively pristine area ideal as a drinking water source. Therefore, aside from necessary crossings, the stream should be disturbed as little as possible. No analytical water quality sampling/monitoring should occur, however visual records of the stream should be recorded in the observation box on the data sheet.
- Due to the area's remote and pristine nature, replicability or project application in other areas may be difficult.

- Identification of grass species is very challenging, especially in their early stages of development, however native vs. nonnative will be identified.
- Relocating photo point locations can be very difficult due to the nature of thelandscape, as we are not able to place permanent markers for the points. Alpine Watershed Group (AWG) does not have a high-end GPS. The GPS device AWG owns and GPS-enabled smartphones can be off by several meters, making locating by GPS not alwaysaccurate.

Additional restoration projects or correctional actions to the current project could be difficult because of these limitations.

To assist with consistent, high-quality monitoring, AWG staff has created a reference binder.

Methods

Plot Selection Rationale

The project was brought to AWG's attention one week before the restoration project commenced. No pre-fire photos exist. Baseline photo monitoring was conducted the day before the project started (November 18, 2021). Twenty-four points were chosen within the 15-acre worksite. Photo points were chosen to best represent the various conditions of the watershed (e.g., medium and high burn severity) and the range of treatments, including:

- lack of any alterations (as a control)
- just tree felling and chinking (including seeding the chinked area)
- just seeding
- both tree felling and chinking and seeding

Monitoring Descriptions

Photo Monitoring

Each location was marked with a neon orange flag; locations were also noted with GPS in case flags disappear. Locations will be marked with a stake at a later date. The first flag starts at the top of the hill overlooking the second flat section upstream of the water intake on the south side of the creek. The rest of the photo points occur along the flat areas next to the stream. After photo point 16, photo point 17 is across the steam on the north side. Remaining photo points continue downstream until reaching photo point 23. Photo point 24 is across the stream looking toward the water intake. GPS coordinates for all photo points are included in the reference binder. The reference binder also includes maps and direction guides for photos points. Each photo point should have two portrait and two landscape photos taken.

The photos should be taken two times per year: July and September. For the best quality photos, the survey should be performed in the late morning to mid-afternoon (around 11 a.m. - 2 p.m.).

Much earlier or later than that, the sun may decrease the quality of the photos. Avoid sun glare, shadows, and presence of people in photos as much as possible.

If something of interest is seen, such as alterations in stream flow, wildlife sightings, animal tracks, etc., a photo should be taken for documentation. The data sheet also includes a box for observations.

Vegetation Monitoring

Each vegetation monitoring site corresponds to the photo point monitoring sites. A 1-meter by 1-meter square made from PVC pipe will determine where to monitor around the photo point. From the flag, throw the PVC square in an upstream/downstream direction or away from stream/toward stream direction. The direction the PVC square is thrown should be the same between each point during the monitoring day and alternated between each monitoring session.

Species name, type, and abundance should be measured. Use the identification sheet to determine the species present. Notate if the species is a forb, grass, shrub, etc. Lastly, determine percent cover first by species, then by type. Use the Visual % Cover Comparison Chart, Plant Reference sheet, and USFS Life Form Definitions documents in the reference binder. If you cannot identify a species, notate the species as unknown.

Identify the species using the Plant Reference sheet, which includes all the grass species that were seeded during restoration, as well as native and nonnative grasses, forbs, shrubs, and trees common to the area. If the species is unknown, mark it as such on the sheet.

Notations should be done using standard U.S. Forest Service acronyms. This includes:

- TR - Woody Tree
- SH - Woody Shrub
- FB - Herbaceous forb/herb
- GR - Herbaceous graminoid
- HB - Herbs
- AL - Algae
- LC - Lichen
- SS - Woody subshrub/half shrub
- NP - Nonvascular plant
- UN – Unknown
- VP – All vascular plants

See the Life Form Definitions Memo in the reference binder for more information about each type and how to classify plants.

Vegetation should be monitored in July and September. This allows the data to represent the entire growing season without impacting early growth.

Gear List

- 4WD vehicle
- GPS and extra batteries
- Camera (AWG's camera or a phone) and extra battery
- 1-meter x 1-meter PVC Square
- Work gloves
- Close-toed (preferably waterproof) shoes
- Long pants and long sleeves
- Hard hat
- Sunscreen
- Binder with data sheets and guides
- Pencils
- Water and snacks
- Tape measure
- WAG bags – All waste needs to be packed out of the watershed.

Reporting

Stakeholders of the project, specifically Markleeville Water Company and the U.S. Forest Service, should be kept informed of developments. No official report is required by any agency, however, a report should be completed at the end of each monitoring season as AWG staffing allows. This would serve as a reference for other similar projects after a large-scale wildfire.

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Appendix C: Photos of Markleeville Water Company's Intake Structure

Photo 1: Pre-Tamarack Fire, the intake structure on Musser and Jarvis Creek consisted of a dam and a 14" pipe that extended into the upstream pond created by the dam. The pond measured about 30' long x 20' wide x 3' deep. Photo from BAER Report.

Appendix C: Photos of Markleeville Water Company's Intake Structure

Photo 2: In October of 2021 a flash flood occurred in the Markleeville area including the Musser and Jarvis watershed. Debris from the flash flood covered the dam and intake structure, and sediment filled the intake pipe.

Appendix C: Photos of Markleeville Water Company's Intake Structure

Photo 3: Image of MWC's intake structure from September 26, 2024, depicting modifications that have been made to the intake dam following the 2021 Tamarack Fire.