Drought assessments of imperiled native trout populations in California

2014

Tulare, Alpine, Mono, Nevada and Placer counties

State of California

Department of Fish and Wildlife

Heritage and Wild Trout Program

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Overview

In 2014, the California Department of Fish and Wildlife, Heritage and Wild Trout Program (HWTP) initiated drought assessments on several waters in California. The Threatened Trout Committee (TTC) and HWTP staff developed a prioritized list of streams with native trout species of high conservation value that may be at risk due to drought conditions. This list was prioritized based on genetic integrity, with a focus on native populations (both within and outside of their respective historic ranges), species on federal and state endangered species lists and perceived threat level. The latter included consideration of slope, aspect, streamflow, water source and surrounding land use activities. In one case, priority was given due to a recent fire which severely burned over several streams known to contain populations of federally listed (threatened) Little Kern golden trout (*Oncorhynchus mykiss whitei*) with high genetic integrity. These drought assessments complemented regional HWTP drought assessments, focusing on species and waters not recently surveyed.

A structured decision-making matrix was created to aid staff in assessing drought conditions, evaluate whether fish rescues were necessary to protect certain populations and identify potential locations for translocations (within the same waterbody, within basin or out-of-basin). The first drought assessments were performed in five tributaries on the eastern side of the Little Kern River drainage in August, 2014. These assessments were used to further refine study methods and were not as comprehensive as subsequent surveys. From October through November, 2014, drought assessments were conducted in ten watersheds supporting Lahontan cutthroat trout (*Oncorhynchus clarkii clarkii*).

Many of the surveys were located in unnamed tributaries and, for the purpose of this report, common stream names were used. Surveys were conducted in the following drainages: Middle Fork Yuba River (Macklin Creek, Austin Meadow Creek and an unnamed tributary to East Fork Creek); North Fork Mokelumne River (Marshall Canyon, Pacific and Milk Ranch creeks); Walker River (Slinkard, By Day, Mill and Wolf creeks); and Truckee River (Pole Creek).

Need

Negative effects from drought on inland native trout populations and their habitats have been historically documented and, in some cases, have led to localized extirpation. Recent drought conditions (2012-present) have been exceptionally severe and related impacts on inland fishes may be further exacerbated by water diversions, presence of barriers (artificial and natural), reduced snowpack, increased summer water temperatures and decreased winter water temperatures, potentially leading to anchor ice formation or entire stream segments freezing solid. Despite negative effects of the drought in California, population persistence and recovery may be expected if habitat conditions improve and/or recolonization from reconnected populations occurs.

Methods

Survey protocols were developed based on parameters outlined in the Drought Response Implementation Plan and Rescue-Translocation Decision Model (Model; Table 1). Key parameters included: streamflow, extent of occupied fish habitat, depth and frequency of pools (or deeper water) and water temperature. Surveys were initiated at the downstream extent of known or assumed distribution of the at-risk population, oftentimes associated with a barrier to upstream fish migration, and proceeded in an upstream direction. Surveys were concluded when one of the following occurred:

1. Surveyors reached the upstream extent of fish distribution or wetted habitat
2. A minimum of 200 age 1+ trout were observed within 2000 meters of connected habitat
3. A quarter mile of dewatered habitat was documented and the likelihood of water farther upstream was low
4. A barrier to year-round fish migration was documented and zero trout were observed within 500 feet of habitat directly upstream
5. Safety or time constraints required the survey to end

Streamflow

Streamflow (cfs) was measured at the start of the survey (if water was present). Where feasible, one to two additional locations were selected to document changes in flow within a waterbody and establish benchmark locations to compare changes over time. Benchmark locations were selected near trail crossings or roads for future ease of access.

Pool Depth

Pools, as identified following Level 2 protocol in the California Salmonid Stream Habitat Restoration Manual (Flosi et al. 1998), were counted. Every fifth pool was measured for maximum water depth (ft). Habitat condition, number of trout observed and other factors were noted. If pools were infrequent (less than five pools in 0.25 miles), all pools were measured. Water temperature (°C) was measured at various locations throughout the survey.

Barriers

Year-round barriers to upstream fish migration were photographed and geo-referenced using hand-held Global Positioning System (GPS) units (North American Datum 1983). Other measured or estimated attributes included: feature length (ft), slope (%), streamflow (cfs), pool maximum depth (ft), pool length (ft) and average wetted width (ft).

Fish counts

Surveyors counted observed trout by species and size class and tallied within continuous wetted habitat reaches. If a dry segment was encountered surveyors ended the tally, recorded geographic coordinates and started a new tally if trout were observed in a separate wetted reach. Size classes were divided into the following categories: young of year (YOY); small (< 6 inches); medium (6-11.9 inches); large (12-17.9 inches) and extra-large (≥ 18 inches). YOY are defined by the HWTP as age 0+ fish, emerged from the gravel in the same year as the survey effort. Depending on species, date of emergence, relative growth rates and habitat conditions, the size of YOY varies greatly, but is generally between zero and three inches in total length. If a trout was observed to be less than six inches in total length but was difficult to determine whether it was an age 0+ or 1+ fish, by default it was classified in the small (< 6 inches) size class.

Stream condition

Using hand-held GPS units (North American Datum 1983), surveyors geo-referenced:

- Survey start and end points
- Wetted, dry and intermittent habitat
- Observed trout distribution
- Unique habitat or land use activities if perceived to impact flow and/or trout persistence (e.g., heavy sedimentation, grazing, mining, water diversions, beaver dams, etc.)
- Tributaries at their confluence with the main-stem
    - If wetted, each tributary was surveyed upstream no more than 2000 feet, trout were counted by size class and flow conditions were documented. If dry at the confluence, the tributary was only surveyed upstream 500 feet.

Observations related to riparian habitat, relative fish densities, perceived threat level and likelihood of anchor ice formation were recorded in field notebooks. Representative photographs of the waterbody and other environmental or habitat features were taken.

Results

Little Kern River

The Little Kern River, tributary to the Kern River, is located in the southern Sierra Nevada Mountains approximately 65 miles northeast of Bakersfield, CA (Tulare County). Little Kern golden trout (*Oncorhynchus mykiss whitei*) are the only native salmonid in this basin. Drought assessments were conducted on Lion, Sheep, No Name, Willow and Tamarack creeks on August 9 and 10, 2014. Streamflow and water temperature were measured at previously benchmarked locations to document potential changes over time. The quantity and quality of available fish habitat in each creek,

including frequency and depth of pools, were noted. Surveyors walked along portions of each creek, mainly in the vicinity of the 32E02 trail crossing, to count trout by size.

In 2014, streamflow (August) was similar but slightly less than 2013 (June-July; Table 2). Water temperature varied across years and was likely the result of diurnal variation. Little Kern golden trout and pool habitat appeared abundant in all tributaries except No Name Creek, which appeared severely impacted by the Lion Fire. This tributary had very low flow, shallow water depths, and little available fish habitat. Surveys conducted in 2012 and 2013 indicated trout density to be low in No Name Creek; due to its small size, it likely never supported a robust population. This tributary is at high risk from both drought conditions and fire impacts. Due to its connectivity with Sheep Creek, trout in No Name Creek may be able to disperse downstream during higher flows to seek refuge.

Little Kern golden trout in Lion, Willow, Sheep, No Name, and Tamarack creeks were determined to be at moderate risk due to drought. Depletion electrofish surveys conducted in 2013 estimated abundance between 30 trout/mi (No Name Creek) and 1148 trout/mi (Tamarack Creek). The HWTP recommends continued monitoring of Little Kern golden trout throughout the entire range in 2015. Consideration should be given to surveying other tributaries in the drainage that have not recently been assessed, such as Rifle, Pistol and Shotgun creeks.

Figure 1. Overview map of the eastern tributaries surveyed in the Little Kern River basin

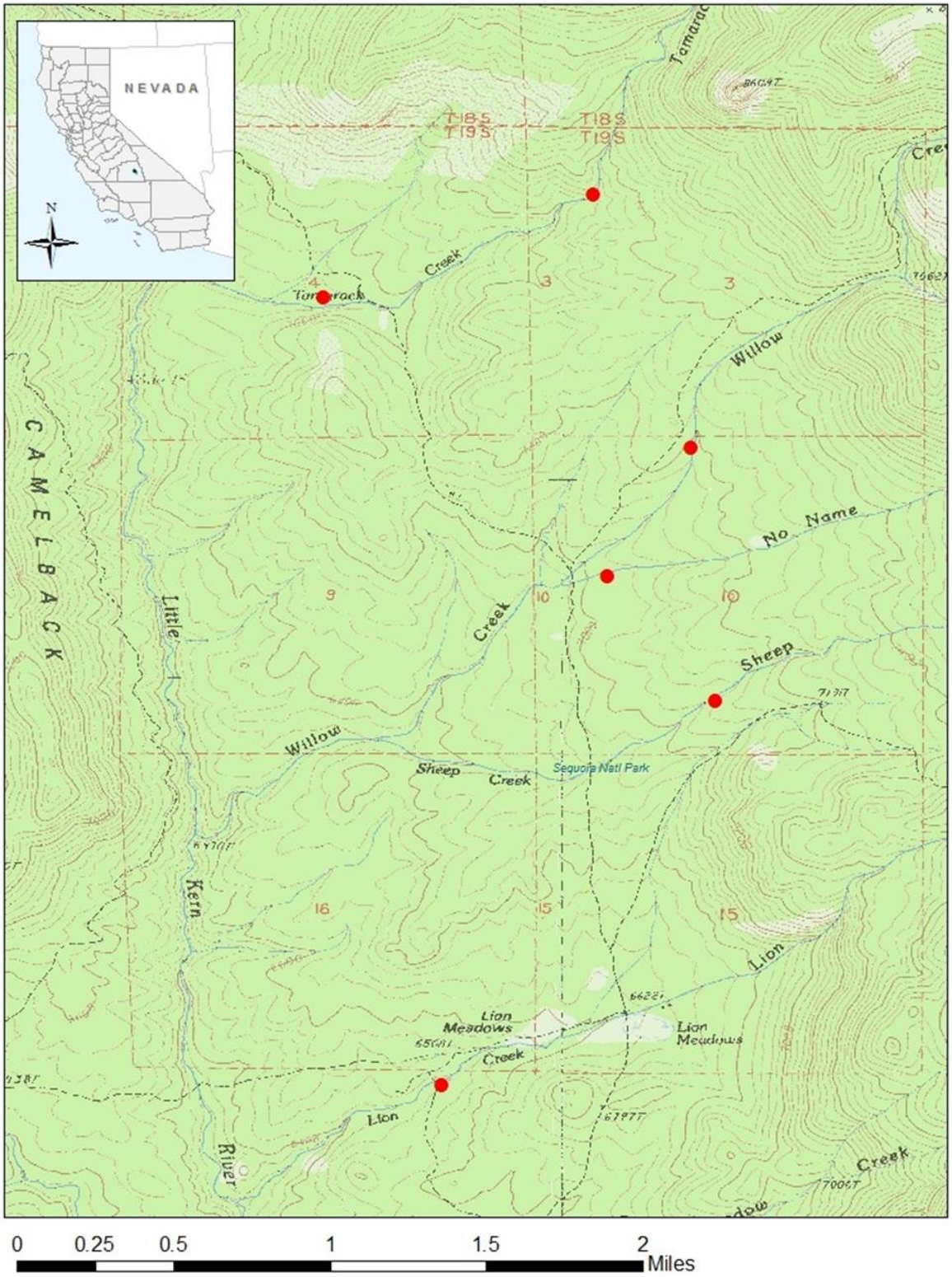


Figure 2. Photographs of Lion Creek in 2013 (left) and 2014 (right)

By-Day Creek

By-Day Creek (Mono County) is located approximately five miles east of Bridgeport, CA and supports the only known naturally distributed Walker-strain Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*) population in the Walker River basin. On October 27th and 28th, 2014 this stream was surveyed from an engineered fish barrier (culvert at USFS Route 017 road crossing) upstream approximately 2.4 miles (Figure 3). Three first-order tributaries (unnamed) in the headwaters of By-Day Creek were also surveyed. The barrier at the survey start was approximately five feet high with an 85% slope (Figure 4). Streamflow measured at two locations was 0.12 (survey start) and 0.06 cfs (survey midpoint). Pools were relatively frequent and 24 were measured with maximum depths between 0.3 and 1.4 feet. Water temperature ranged from 2 to 6 °C. Aside from pool habitat, By-Day Creek was very shallow throughout (< 4 inches).

Substrate in By-Day Creek was mostly cobble and gravel, but was heavily inundated with silt/fine sediment upstream of the culvert for approximately 0.75 miles. Within this area, there were four dewatered segments ranging from 2 to 100 feet long. Silt/fine sediment was also present farther upstream, but in lesser quantities, and the main-stem was wetted throughout. Ice was observed on the surface, particularly near the bank and on overhanging vegetation, but it was not extensive throughout the survey area. No anchor ice was observed. Surrounding habitats included both forest and meadow complexes. The forested areas included aspens and some conifers with abundant pools and flatwater habitats exceeding 0.3 feet in depth. Fewer pools were present in the meadow reaches.

Two tributaries were dry (Trib 1 and 2). The western-most (Trib 3) was surveyed for 0.2 miles along the low gradient reach (see Figure 3). There were zero barriers to upstream fish migration and one pool was observed with a maximum depth of 0.80 feet and water temperature of 0 °C.

Two small-sized Lahontan cutthroat trout were observed in By-Day Creek, one near the confluence of the main-stem and Trib 3 and the other a short distance upstream in Trib

3. One dead Lahontan cutthroat trout (4.8 inches total length) was also observed in a pool in By-Day Creek downstream of where the two live fish were observed. Visual observation was difficult due to aspen and willow leaves on the surface of the water and woody debris; fish detection was likely poor.

The Lahontan cutthroat trout population in By-Day Creek is at risk. Using the drought matrix, it receives a threat level of 4 due to low population size, lack of pool depth and streamflow less than 0.5 cfs. Wetted habitat in excess of 2000 meters was observed, but it is unclear whether trout occupied all available habitat; the two trout observed were in the headwaters. The lower reach of By-Day Creek was intermittent with corresponding siltation and poor habitat conditions. The HWTP recommends initiating a translocation assessment strategy and/or rescue alternatives. Due to presumed poor fish detection during visual surveys, a more thorough method, such as electrofishing, should be considered to evaluate population distribution and abundance.

Figure 3. Map of By-Day Creek 2014 survey area

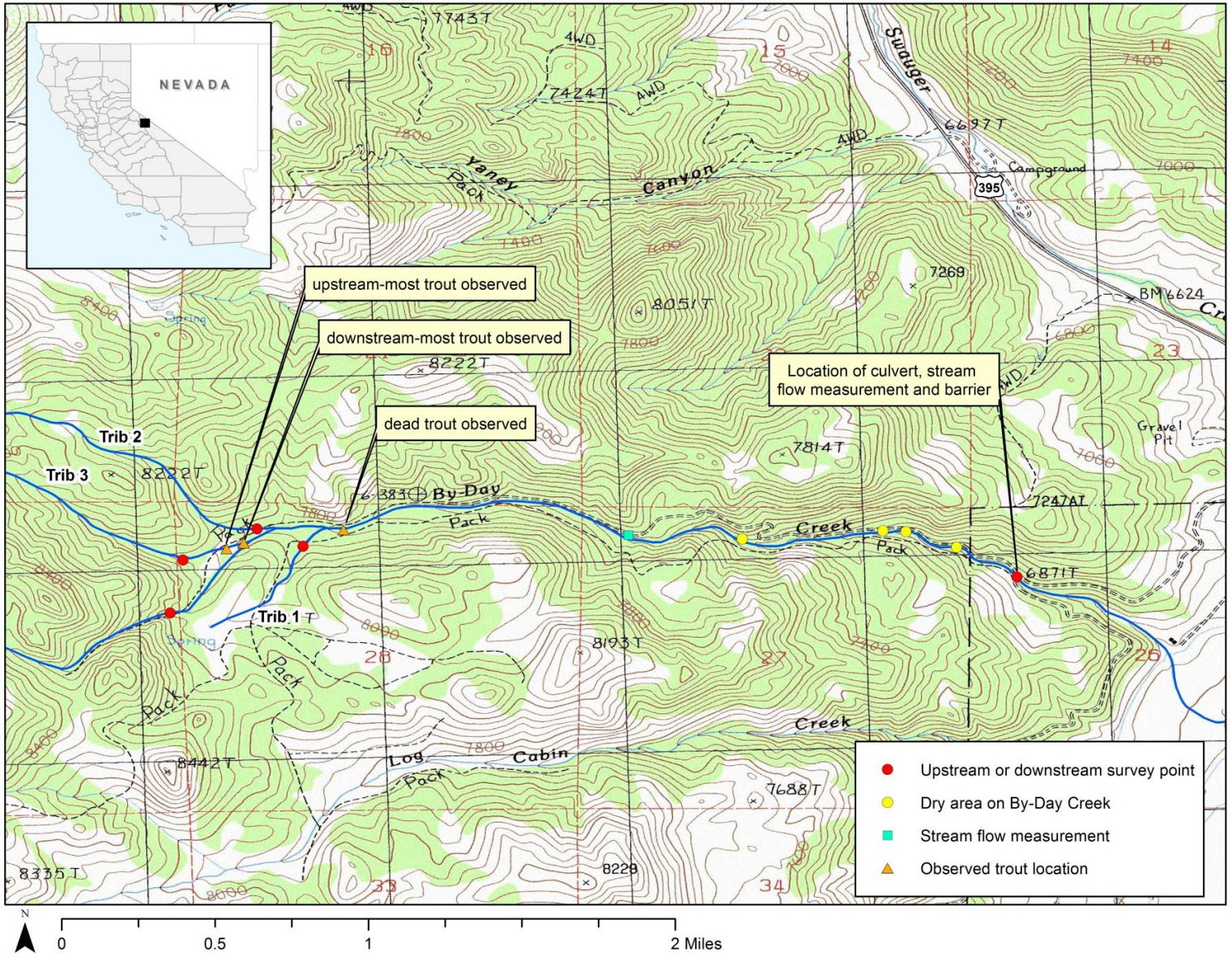


Figure 4. Representative photographs of By-Day Creek in 2014, including (clockwise from top left): fish barrier at survey start, siltation, dewatered reach, forested habitat, meadow habitat and dead Lahontan cutthroat trout

Mill Creek

Mill Creek, near Walker, CA (Mono County) is tributary to the West Walker River and supports a population of Lahontan cutthroat trout in their native range. A barrier to upstream fish migration, located approximately two miles upstream of the West Walker River confluence, limits the movement of non-native trout into Lahontan cutthroat trout habitat. On October 29th, 2014 Mill Creek was surveyed from the barrier upstream 5.2 miles (Figures 5-6). Streamflow was measured at 0.47 cfs at the survey start and 0.32 cfs approximately 1.8 miles upstream.

Directly upstream of the barrier, Mill Creek was surrounded by high-gradient forested habitat with aspen and willows. Willows growing over the creek and numerous fallen trees made surveying this area difficult. A large beaver dam complex extended for 0.8 miles, with beaver dams every 50 to 100 feet. All dams observed within this area appeared active with freshly-cut willows. A combination of dense willow and rose bushes, along with deep sediment along the bank and deep water, precluded thorough surveys in this reach. As feasible, surveyors walked to the water's edge to examine conditions. Beaver dams ranged from 12 to 25 feet long and 2 to 3 feet high, with water depths between 1.5 and 4 feet. Water clarity was one to four feet. All ponds observed had large deposits of silts and fines. Due to poor water clarity, visual observation was difficult and only eight trout were observed within this beaver dam complex.

A second beaver complex, consisting of five dams, was observed along 0.4 miles of the creek. Each was approximately 10 feet long and 3 feet high. Some of these dams were not active; flow was diverting around the sides and depositional pools were not always present. Dams with pools were not as expansive, nor as heavily inundated with sediment, as those in the first complex and it was easier to navigate through this area. Evidence of a wildfire was also present in this area.

Twenty-five pools were measured (every fifth pool) and, with the exception of a three-foot deep pool, maximum pool depths were between 0.4 and 1.0 feet. Water temperature was between 3 and 4 ºC. A total of 31 trout were observed with a size class distribution of 61% small- and 39% medium-sized trout (Table 3). Trout were observed in 2.1 miles of stream habitat. Overhanging willows and woody debris made observing and identifying fish difficult, but some were positively identified as Lahontan cutthroat trout.

On October 30th, 2014 additional surveys were conducted on a short stretch of Mill Creek near the headwaters (3.3 miles upstream from the previous day). This area was dry, except for three isolated pools. Zero fish were observed.

Due to time constraints, a large portion of Mill Creek was not surveyed and it is unknown whether trout are present in the un-surveyed middle reach or where the upstream extent of wetted habitat was located. Based on the low numbers of trout observed, it is possible the population in Mill Creek is small and, therefore, at high risk; however, further surveys should be performed to substantiate this assumption. Streamflow was less than 0.5 cfs and pool depths exceeding one foot were, for the most

part, absent. The beaver dam areas likely provide deeper water refuge habitat and should be further evaluated for fish occupancy. The HWTP recommends continued monitoring of Mill Creek, including a more comprehensive assessment of trout abundance, particularly in the middle reach, to determine risk factors and whether translocations should be evaluated.

Figure 5. Map of 2014 Mill Creek survey area

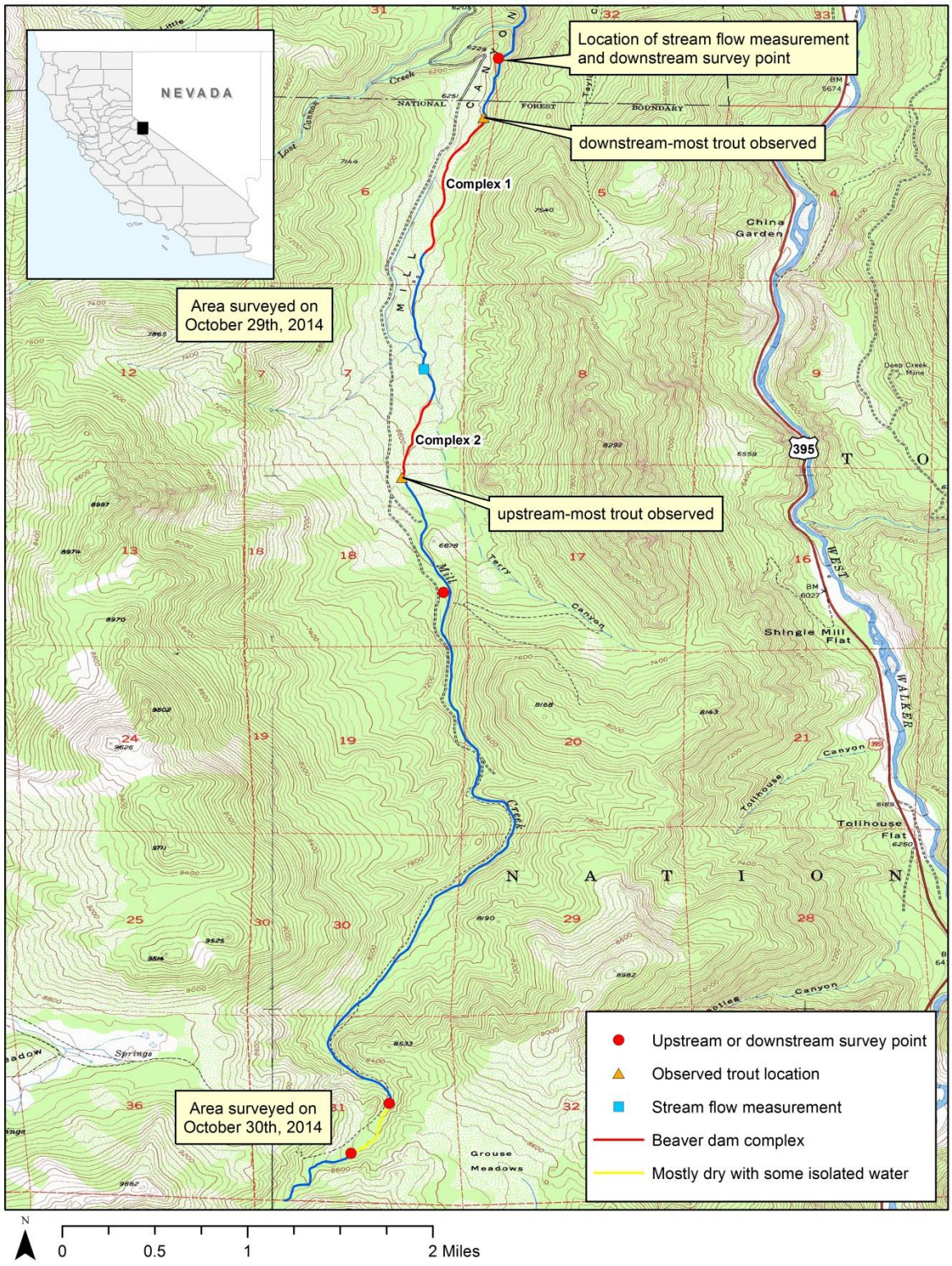


Figure 6. Representative photographs of Mill Creek in 2014 including dry stream segments (bottom)






Wolf Creek

Wolf Creek (Mono County), located approximately 20 miles northwest of Bridgeport, CA, supports a refuge population of Lahontan cutthroat trout in its native range. Wolf Creek flows for approximately six miles, from Wolf Lake near Sonora Pass in the Sierra Nevada Mountains, to its confluence with the West Walker River. Lahontan cutthroat trout are present in approximately 4.5 miles of stream upstream of a natural fish barrier. On October 30th, 2014, a drought assessment was conducted along 1.4 miles of Wolf Creek upstream of the barrier (Figure 7). Surveyors did not measure this barrier; however, other barriers encountered during the survey were documented including a 12-foot high waterfall (Figure 8).

Streamflow was measured at 0.76 cfs and 0.64 cfs. The latter measurement corresponded to a location surveyed in July, 2012, where streamflow was measured at 1.13 cfs (Mehalick et al. 2012). The difference in streamflow from 2012 to 2013 may be due to further reduction in surface flow from long-term drought or difference in the seasonal timing of surveys, or both. A total of 19 pools were measured (every fifth pool observed) with maximum water depths between 1.0 and 2.0 feet. Water temperature was between -2 and 0 °C.

A total of 114 Lahontan cutthroat trout were observed with a size class distribution of 17% YOY, 49% small-, 32% medium- and 2% large-sized fish. Trout were observed throughout the survey area, but appeared to decrease in abundance as the survey progressed upstream. Substrate in Wolf Creek was mostly boulder, cobble and silt/fines. Contiguous wetted habitat existed and no dewatered segments were observed. Surface ice was present in a few areas. Evidence of grazing was noted in meadow habitats. One tributary with surface flow was observed and surveyed for 100 feet; it was approximately four feet deep and two feet wide (Figure 9). Zero fish were observed in this tributary.

The Lahontan cutthroat trout population in Wolf Creek does not appear at risk (threat level 1) due to contiguous flow for 1.4 miles, streamflow exceeding 0.5 cfs (0.70 cfs) and maximum pool depths exceeding one foot. While only 93 adult trout were observed, based on distribution observed in 2012, there was likely an additional one mile of habitat in which fish were present that was not surveyed in 2014 due to time constraints. In 2012, abundance was estimated between 654 and 979 fish/mile (Mehalick et al. 2012).

Figure 7. Map of 2014 Wolf Creek survey area

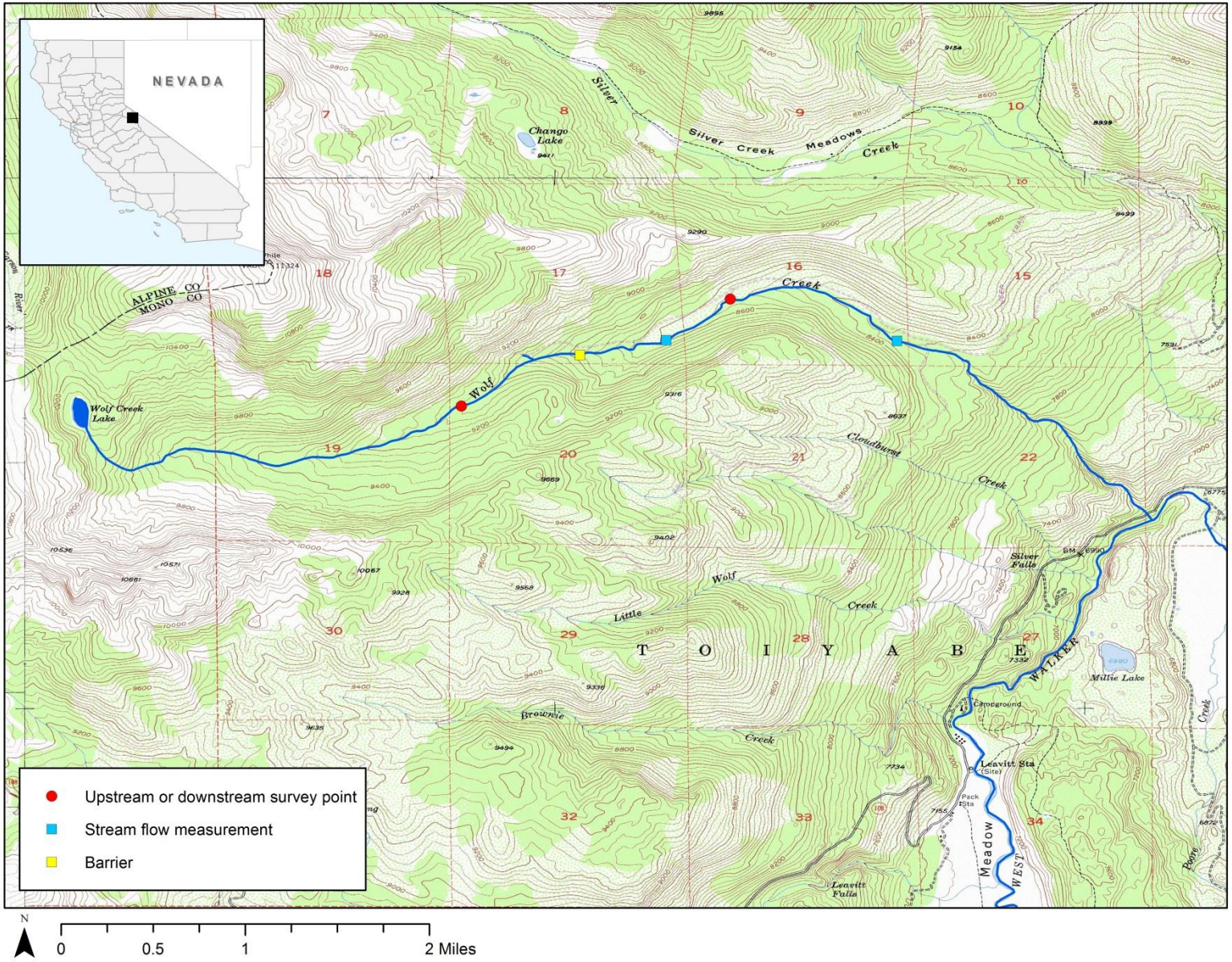


Figure 8. Representative photographs of Wolf Creek in 2014 including fish barrier (top right)

Figure 9. Representative photographs of unnamed Wolf Creek tributary in 2014

Middle Yuba River drainage

Approximately 25 miles northwest of Truckee, CA, East Fork Creek (Nevada County) and two unnamed headwater tributaries within the Middle Yuba River drainage support out-of-basin refuge populations of Lahontan cutthroat trout. One is commonly referred to as Macklin Creek and, for the purposes of this report, the other is the "unnamed tributary to East Fork Creek." The surveyed portion of East Fork Creek flows through Austin Meadow and is often referred to as "Austin Meadow Creek." Each tributary has a natural barrier to upstream fish migration. These barriers protect the Lahontan cutthroat populations from invasion of non-native trout. The Lahontan cutthroat populations are essentially isolated from one another. Drought assessments were conducted on each stream, from the barrier upstream to the headwaters.

East Fork Creek

An initial drought assessment was conducted in East Fork Creek on October 19, 2014 and surveyors documented intermittent streamflow from the barrier upstream to the culvert/road crossing of USFS Route 4 (Figure 10). The downstream barrier consisted of a three-foot drop over bedrock with a 90º slope. The reach between the barrier and culvert had intermittent streamflow and zero fish were observed. The culvert pool was heavily silted with one foot of water visibility. Connected wetted habitat was observed for 15 feet from the culvert downstream, at which point the stream became intermittent. Water temperature was 9 ºC at 1800. East Fork Creek flows through both coniferous forest and meadow habitat. A more thorough evaluation of the meadow habitat was recommended.

The remaining portion of the creek was surveyed on November 3rd, 2014. Streamflow was measured at 0.01 cfs (survey start) and 0.06 cfs (one mile upstream). A total of 13 pools were measured (every fifth pool) with maximum water depths ranging from 0.6 to 2.3 feet. Nearly 50% of the measured pools had depths greater than one foot. Water temperature was between 2 and 3 °C.

Zero trout were observed; however, snow and ice on the surface of the creek limited visibility (Figure 11). Two dry areas were observed, ranging between 25 and 700 feet in length. One dry area had isolated pockets of frozen water. Ice was present throughout most of the survey area, both on the water surface (1-2 inches thick) and as anchor ice. The upper portion of the survey area had more flow and less ice. A braided and shallow channel approximately 0.4 miles in length existed in the meadow.

It is unknown whether Lahontan cutthroat trout exist in East Fork Creek; zero fish were observed during the survey effort. If fish are present, they are likely in low numbers and population viability should be evaluated. It is presumed that less than 200 adult trout are present in East Fork Creek and, therefore, it was assigned a threat level of 4. Poor habitat conditions (dry segments, anchor ice, low water temperatures and low flow) are likely contributing to the decline of this population, although records show the population has likely never been very abundant. The HWTP recommends a more thorough evaluation of the population to determine whether a fish rescue/translocation is

warranted. Potential negative effects from bottlenecking and low genetic diversity should also be evaluated.

Figure 10. Map of 2014 East Fork Creek survey area

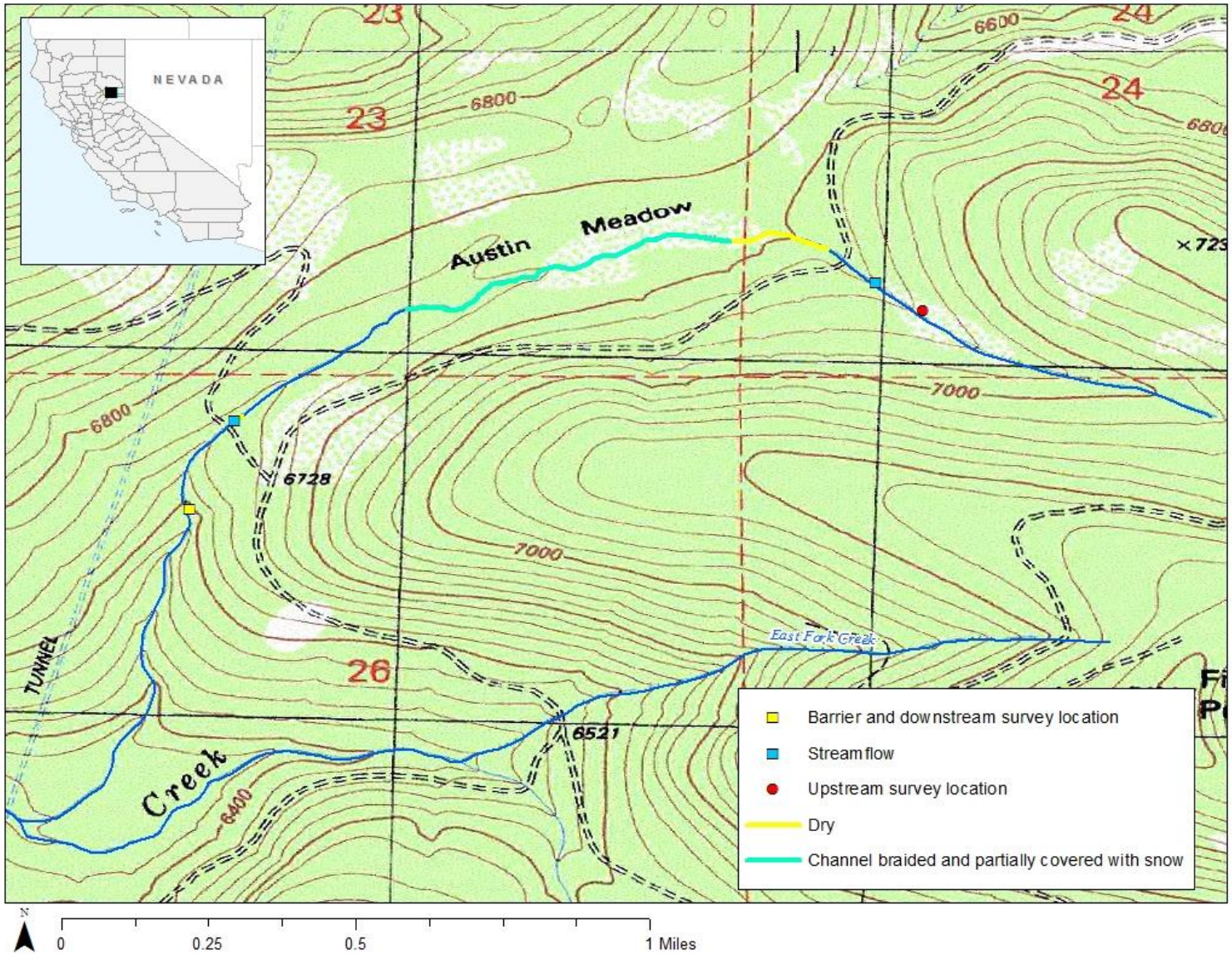


Figure 11. Representative photographs of East Fork Creek in 2014

Macklin Creek

Macklin Creek (Nevada County), tributary to the Middle Yuba River, was surveyed on November 4th and 5th, 2014 along 1.7 miles of habitat in the headwaters (Figures 12-13). Six barriers were observed within two-tenths of a mile of the survey start, although portions of the creek were difficult to access and additional barriers may exist. Those documented ranged from 8 to 45 feet in height (Figure 14). Streamflow was measured at 0.17 and 0.05 cfs. A total of 24 pools were measured (every fifth pool) with maximum pool depths between 0.5 and 1.8 feet. Water temperature was between 3 and 4 °C.

Nineteen trout were observed in 1.3 miles of habitat (assumed to be Lahontan cutthroat trout) with a size class distribution of 21% YOY, 68% small-, and 11% medium-sized fish. Poor light conditions and snow made visual observation difficult. A nine-inch Lahontan cutthroat trout was captured by hand at the upper extent of the survey. No ice was observed. One five-foot dry segment and one area of subsurface flow was observed, both of which were temporary barriers to fish migration. One tributary with minimal flow was present near the survey start in which zero trout were observed. The creek was extensively braided in the middle portion of the survey area (meadow habitat) and zero fish were observed downstream of this area. The majority of trout were observed upstream of the meadow near the end of the USFS road.

Only 15 adult Lahontan cutthroat trout were observed in Macklin Creek and this population was considered to be at-risk and assigned a threat level of 4. While flow was contiguous throughout the surveyed area, the average was only 0.11 cfs and conditions were near freezing. The HWTP recommends a more thorough evaluation of the population earlier in the season (summer to early fall) to determine whether a fish rescue/translocation is warranted. Potential negative effects from bottlenecking and low genetic diversity should also be evaluated.

Figure 12. Map of 2014 Macklin Creek survey area

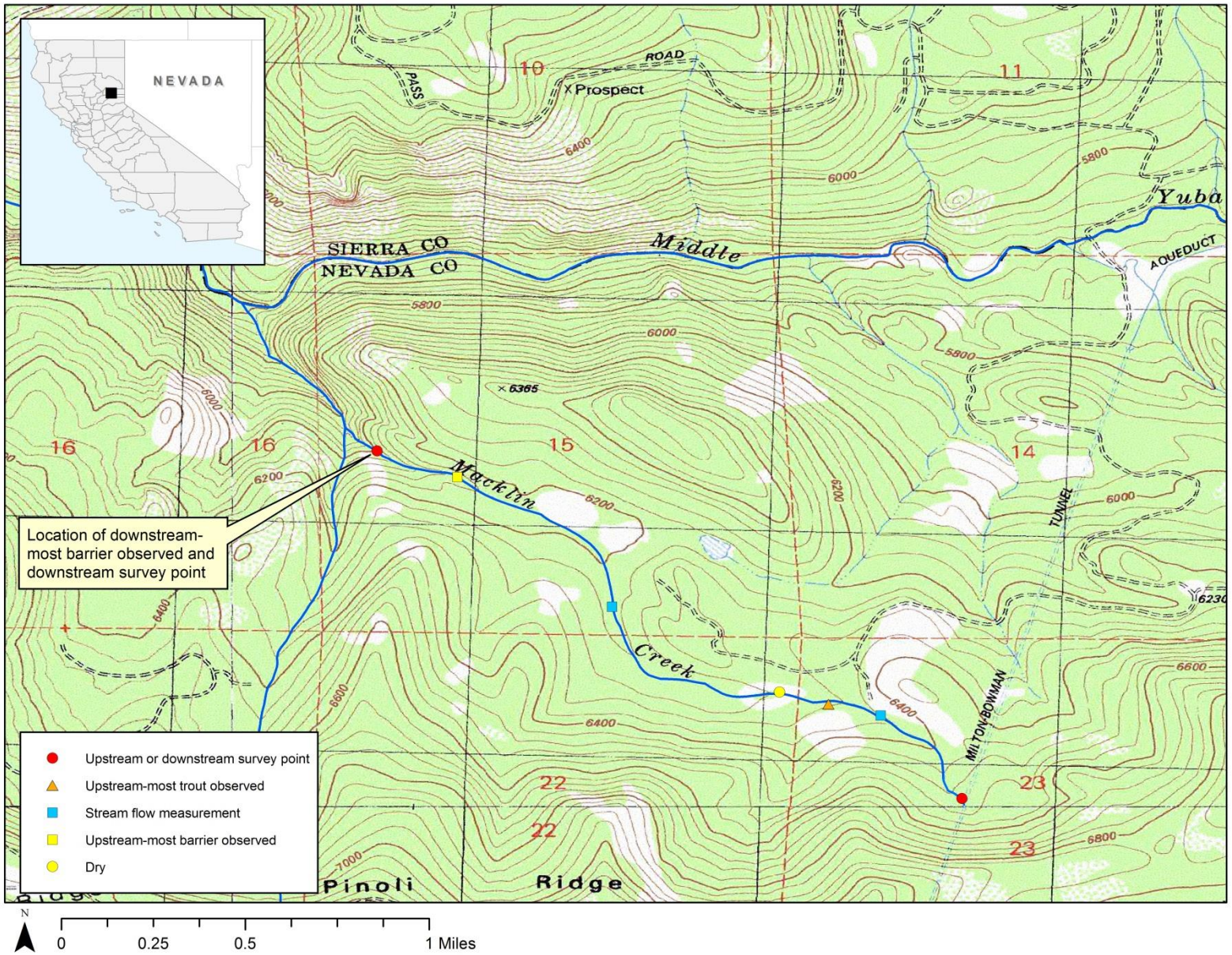


Figure 13. Representative photographs of Macklin Creek in 2014

Figure 14. Barriers observed in Macklin Creek in 2014

Unnamed tributary to East Fork Creek

On November 6th, 2014 an unnamed tributary to East Fork Creek was surveyed along 0.5 miles of habitat (Figures 15-16). Surveyors accessed the creek at the road crossing near the headwaters; no water was present at this location. A spur road was used to access the creek farther downstream (not shown on map) where flow was present. Surveyors initiated the assessment approximately 0.5 miles downstream of this location. A potential barrier to upstream fish migration was observed 0.3 miles upstream of the survey start and consisted of a near-vertical (90% gradient) eight-foot cascade (Figure 17). There was evidence of flow being diverted around the side of the barrier at higher flows and it may not be a complete barrier to upstream fish migration. Streamflow was measured at 0.13 cfs. Seventeen pools were measured (every fifth pool) with an average depth of 1.46 feet. Water temperature was 6 °C at multiple locations.

A total of 15 trout were observed (some were confirmed to be Lahontan cutthroat trout, others were not positively identified but presumed to be Lahontan cutthroat trout) with a size class distribution of 33% small- and 67% medium-sized fish. Trout were observed

throughout the survey area, but dense willow and other riparian vegetation made fish observation difficult. One dead Lahontan cutthroat trout (4 inches in total length) was observed near the survey end, near the lower road crossing. No ice was observed.

The Lahontan cutthroat trout population in the unnamed tributary to East Fork Creek was characterized as at-risk, assuming a small population exists in this stream. A more comprehensive survey, potentially utilizing electrofishers, should be performed to validate this assumption. Observed habitat conditions fall within the threat level 3 classification due to low flow (0.13 cfs), the presence of pool depths exceeding 300 millimeters and connected wetted habitat limited to one-half mile.

Figure 15. Map of 2014 unnamed tributary to East Fork Creek survey

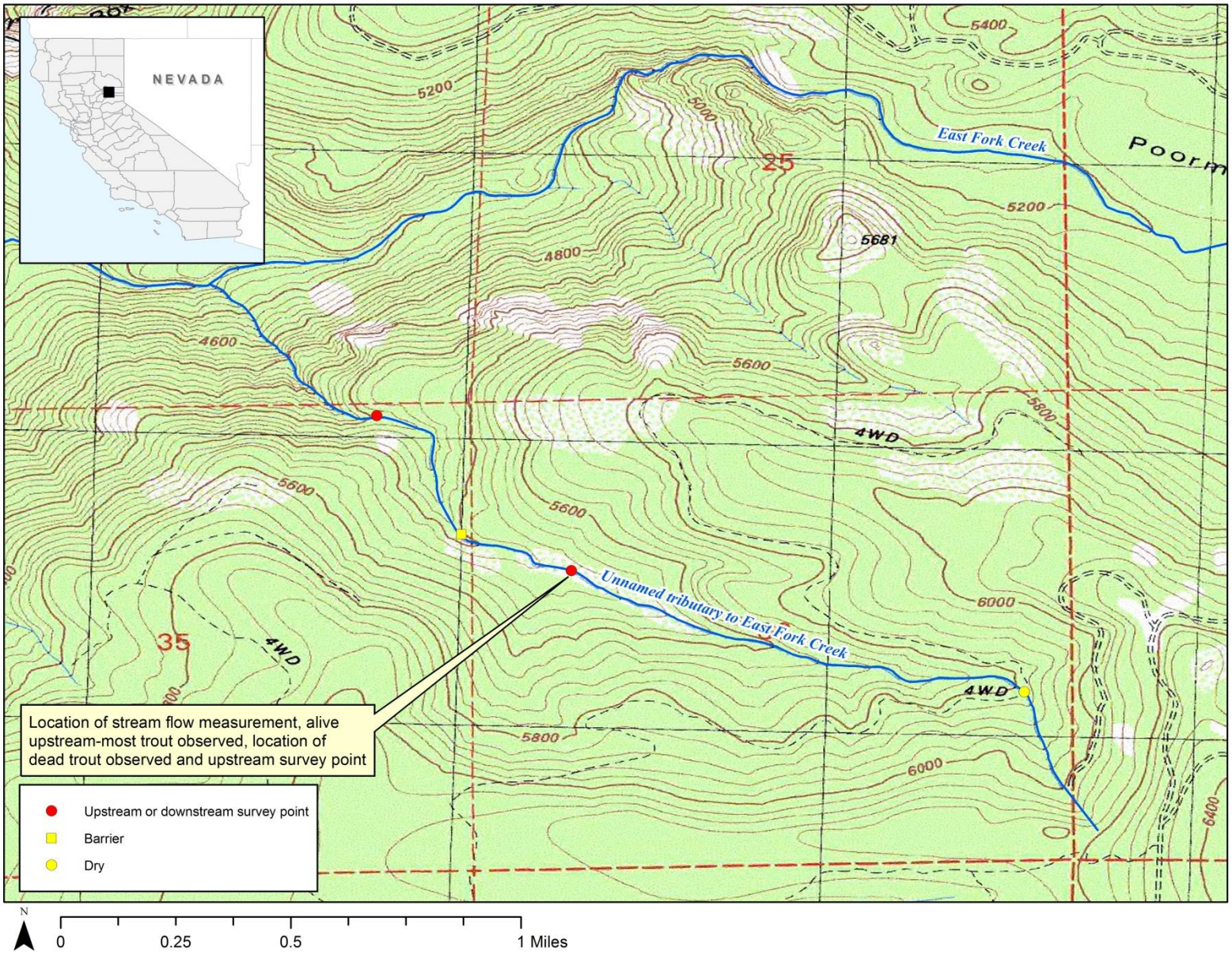
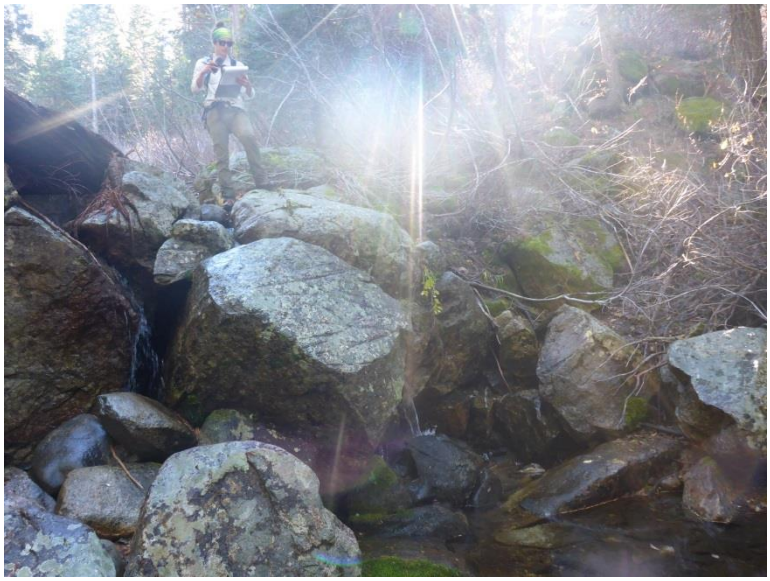


Figure 16. Representative photographs of unnamed tributary to East Fork Creek in 2014

Figure 17. Photograph of potential barrier to upstream fish migration observed on unnamed tributary to East Fork Creek in 2014



Raymond Meadows Creek

Raymond Meadows Creek, tributary to Silver Creek in the East Fork Carson River drainage, is located approximately eight miles south of Markleeville, CA (Alpine County). This creek was stocked with Lahontan cutthroat trout in 1982 upstream of a natural fish barrier. A drought assessment was conducted on November 10th, 2014 along 1.2 miles of habitat and the survey start corresponded with a ten-foot near-vertical drop, which is likely a barrier to upstream fish migration at low to moderate flows (Bar 1; Figures 18-19). There was evidence of flow around the sides during high water events. In the vicinity of the survey start, pools were frequent and separated by riffles (Figure 20). Substrate was mostly cobble and gravel with large deposits of silt along the stream margin and pool tail-outs. The creek was medium-gradient and surrounding canopy was fairly open, with some willows present along the riparian corridor. Moderate shading is likely during summer months. Snow was present in shaded areas and there was evidence of a recent scour event. Farther upstream, Raymond Meadows Creek was high-gradient and two additional barriers were documented. One was a vertical drop of seven feet over boulders and bedrock with evidence of high flows diverting around the sides (Bar 2). The other was sheer vertical drop of 16 feet and was likely a year-round barrier to upstream fish migration (Bar 3). In this reach, steep-walled slopes composed of loose, unstable gravels confined the creek. Pools were numerous. The upper reach flowed through a low-gradient meadow and was open and shallow (< 2 inches). Zero pools were observed and fish habitat was poor. The upper meadow had evidence of a recent large scour event; the channel was deeply incised with two large head cuts. Substrate was predominantly silt and gravel.

Streamflow, measured at the survey start, was 0.11 cfs and water temperature was between 0 and 1 °C. Twelve pools were measured (every fifth pool) in the survey area. Maximum pools depths were between 0.7 and 1.2 feet. The survey was ended where flows ceased at the upper end of the creek. One flowing tributary was present; it was surveyed for approximately 400 feet and zero fish were observed (Figure 21).

Zero trout were observed in Raymond Meadows Creek; the water was clear and shallow during the survey effort with presumably good conditions for direct observation. The entire 1.3 miles surveyed had continuous flow.

Previous single-pass electrofish surveys conducted in Raymond Meadows Creek in 1995 captured six Lahontan cutthroat trout. Based on this finding and conditions documented during the 2014 drought assessment, it is likely that Raymond Meadows Creek no longer supports a viable trout population.

Figure 18. Map of 2014 Raymond Meadows Creek survey

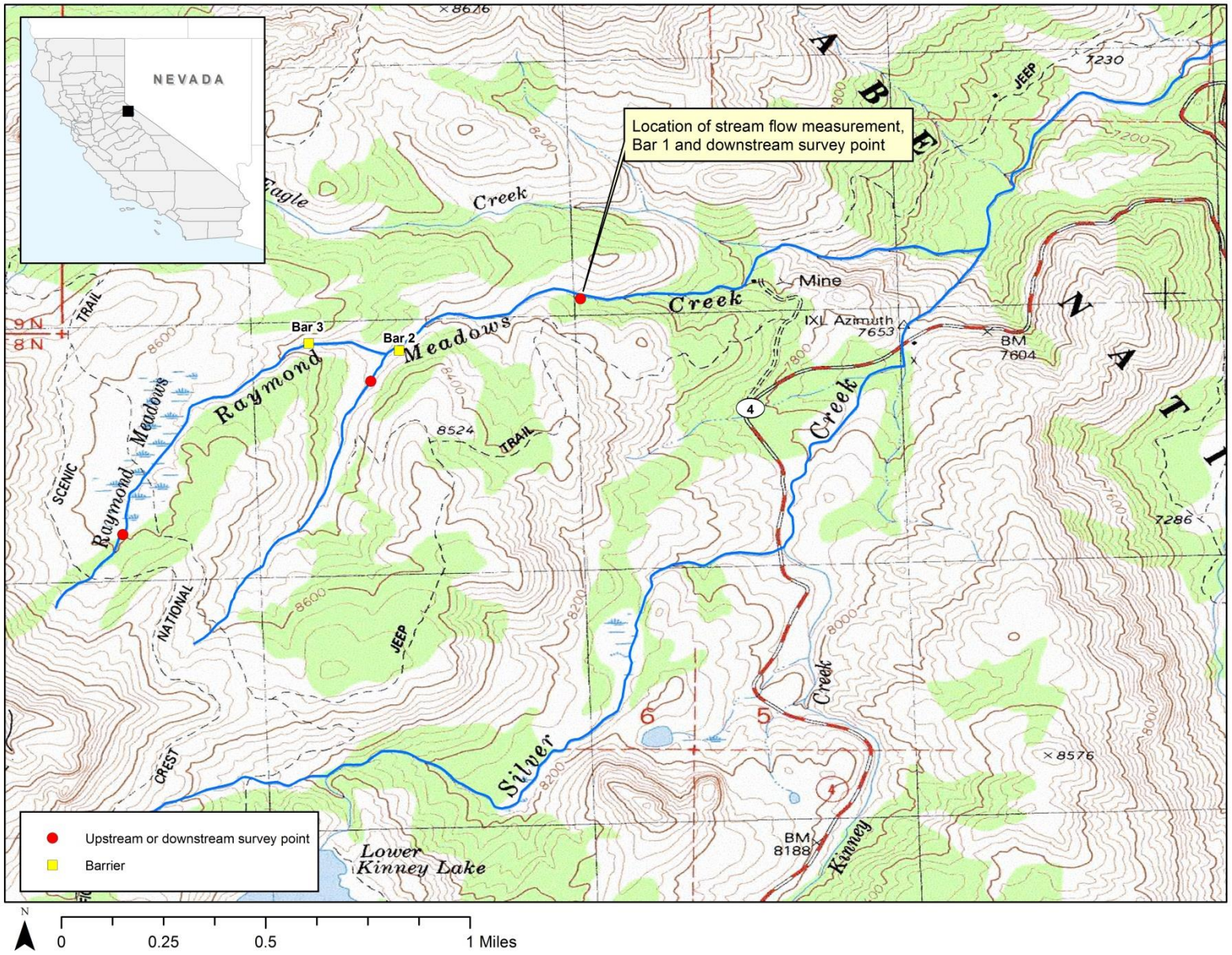


Figure 19. Fish barriers observed on Raymond Meadows Creek in 2014

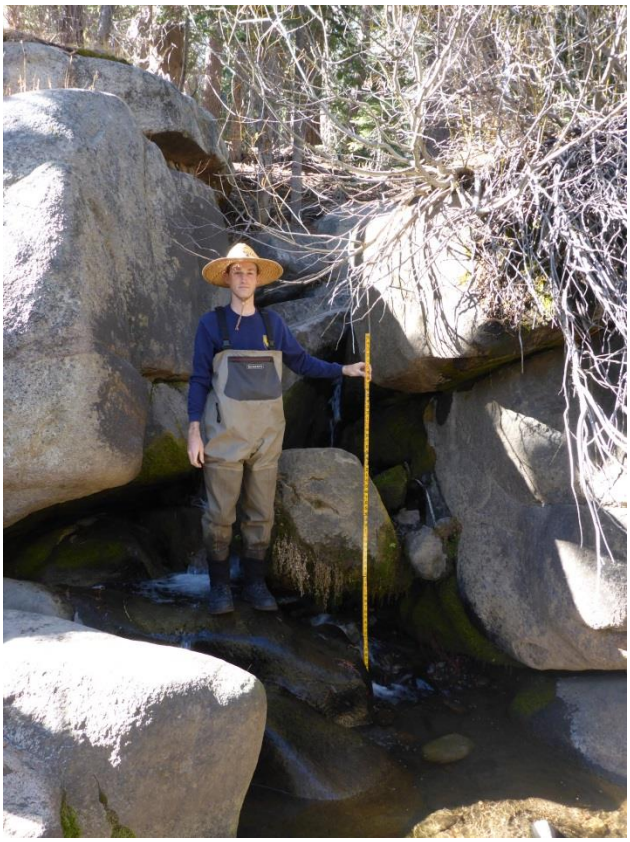


Figure 20. Representative photographs of Raymond Meadows Creek in 2014

Figure 21. Representative photographs of Raymond Meadows Creek tributary in 2014

Marshall Canyon Creek

Marshall Canyon Creek (Alpine County), tributary to Pacific Creek in the North Fork Mokelumne River drainage, is located approximately 14 miles southwest of Markleeville, CA. An out-of-basin population of Lahontan cutthroat trout was established in Marshall Canyon and Pacific Valley creeks, the origin of which is unknown. Natural barriers isolate the upper portions of each stream, protecting the Lahontan cutthroat population from upstream invasion by other salmonids. On November 11th, 2014 Marshall Canyon Creek and tributaries were surveyed from the barrier upstream 0.6 miles (Figure 22). The barrier consisted of a sheer bedrock drop with a feature height of 12 feet (Figure 23). Downstream of this location, the creek flowed through a relatively steep and constricted canyon. Streamflow directly upstream of the barrier was 0.06 cfs. Five pools were encountered within 0.1 mile of the barrier, after which gradient lessened and large expanses of decomposed granite were encountered. One tributary was surveyed in this reach, which entered on the northern side of Marshall Canyon creek; there was flow for approximately 500 feet to the trail crossing and neither pools nor fish were observed (Figure 24). This tributary was approximately 1 foot wide and 0.1 feet deep. A dry channel was documented in the meadow area on the south side of the creek.

Marshall Canyon Creek was wetted a short distance farther upstream, to a point where another tributary entered from the north (Trib 3; Figures 25-26). This area was heavily grazed and had large deposits of decomposed granite. The presence of detritus and pine cones in the creek bed indicated flow had not recently occurred. Surveyors continued up the main channel and did not observe any water; total wetted habitat in Marshall Canyon Creek was approximately 1/4 mile. Water temperature was measured at -2 and 2 °C. Where Marshall Canyon Creek went dry, another tributary entered from the west and appeared to be the main channel (contradictory to the GPS unit and map). It was wetted for 0.4 miles and habitat appeared good. Stream gradient was medium to high and boulders composed the majority of the substrate. The channel became braided, shallow and covered with algae. Zero fish were observed in Marshall Canyon Creek or its tributaries and it may no longer support a viable population of Lahontan cutthroat trout. The HWTP recommends initiating electrofish surveys to better assess the presence or absence and relative abundance of trout in this stream. If Lahontan cutthroat trout are still present, the threat level would be assigned a 4, due to small population size, potential for bottlenecking and inbreeding depression and poor habitat conditions, including: limited wetted habitat, lack of pool depth, streamflow less than 1 cfs and below-freezing water temperatures.

Figure 22. Map of 2014 Marshall Canyon Creek survey

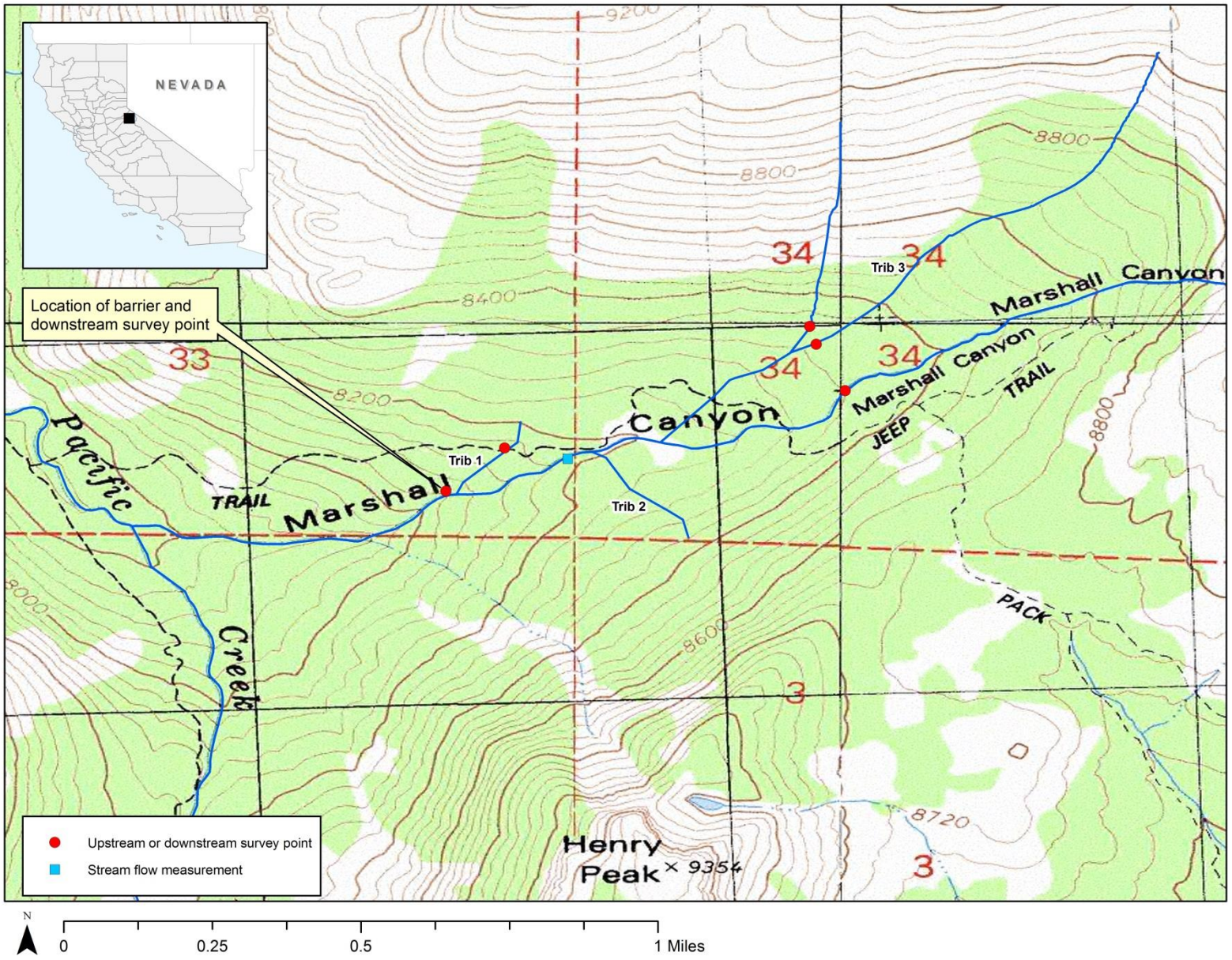


Figure 23. Fish barrier on Marshall Canyon Creek in 2014

Figure 24. Representative photographs of Trib 1 on Marshall Canyon Creek in 2014

Figure 25. Representative photographs of Marshall Canyon Creek in 2014

Figure 26. Representative photographs of Trib 3 on Marshall Canyon Creek in 2014

Pacific Creek

After completing the Marshall Canyon Creek survey, Pacific Creek was assessed by HWTP staff, from the trail crossing downstream to Pacific Creek Campground (Figure 27). Flow near the trail crossing was intermittent and isolated pools were often covered in ice (Figure 28). Flows and connected wetted habitat increased as surveyors progressed downstream. Due to time constraints and poor light conditions, fish were not comprehensively counted throughout the survey area and pool measurements were limited in favor of documenting wetted versus dry habitat. Surveyors did not know which portion(s) of Pacific Creek contained Lahontan cutthroat trout and the survey was limited to opportunistic visual counts during the hike back to the vehicle. The survey was conducted along 1.6 miles of habitat and, other than dewatered segments, zero fish barriers were observed. Streamflow measured adjacent to the campground was 0.15 cfs. In the lower portion of the survey area, pools were frequent and ranged from three to six feet deep. Water temperature was between -1 and 1 °C.

A total of 16 trout were observed with a size class distribution of 87.5% small- and 12.5% medium-sized fish. Most trout were not identified to species due to their small size (most were less than three inches total length) and poor light conditions, although some were believed to be brown trout (*Salmo trutta*). The surrounding meadow was heavily grazed with cattle tracks in the streambed.

It was later verified that surveys in Pacific Creek were conducted outside of the Lahontan cutthroat trout habitat (Somer, personal communication, November 2014); however, based on intermittent flow and isolated pools, further surveys are warranted to assess drought condition and potential impacts to the cutthroat population farther upstream.

Figure 27. Map of 2014 Pacific Creek survey area

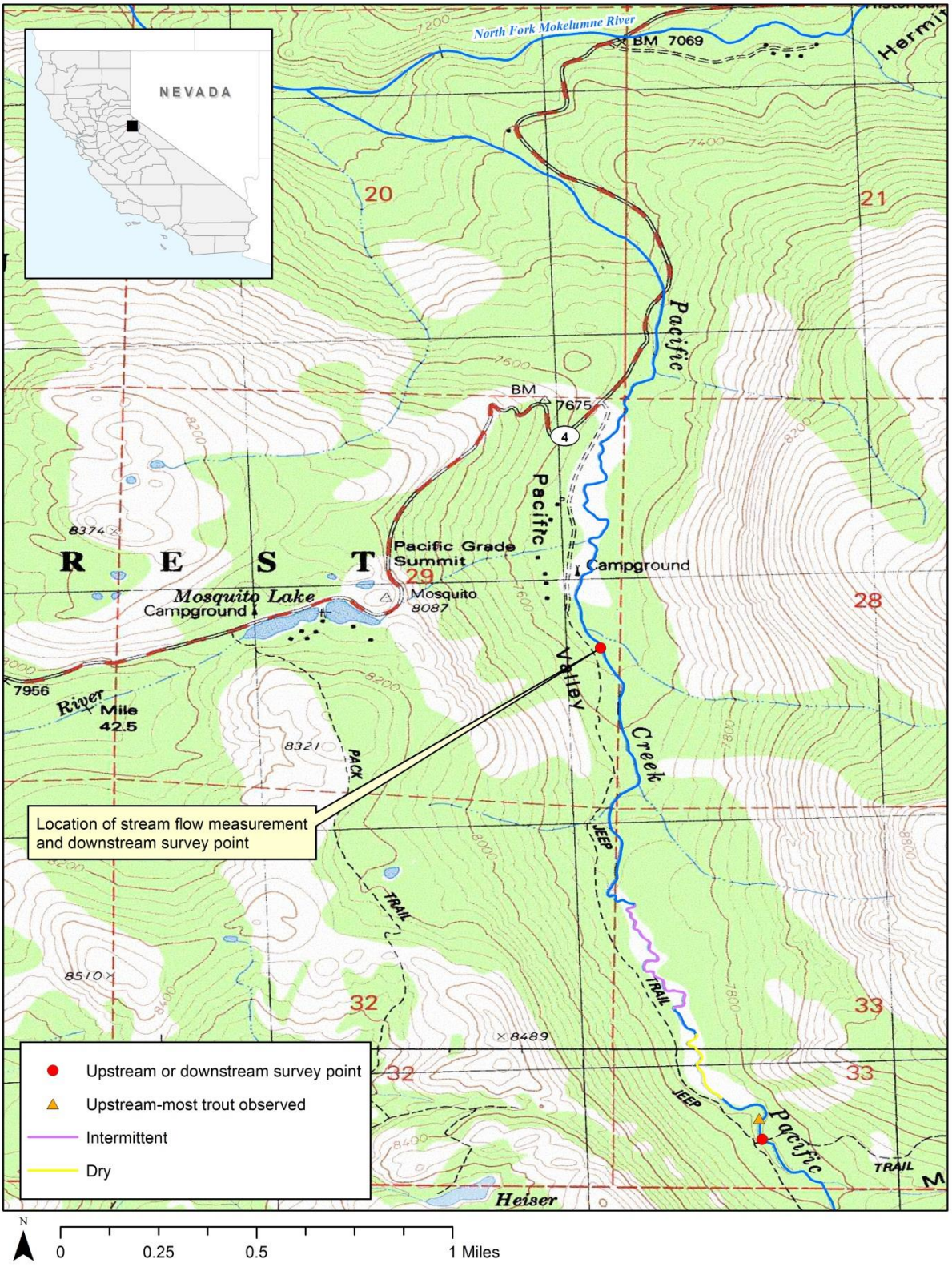


Figure 28. Representative photographs of Pacific Creek in 2014

Milk Ranch Meadow Creek

Milk Ranch Meadow Creek (Alpine County) is approximately 11 miles south of Markleeville, CA and contains an out-of-basin population of Lahontan cutthroat trout. A natural fish barrier isolates the upper portion of creek and, on November 12th, 2014, this stream was surveyed from the barrier upstream to the headwaters (1.5 miles; Figures 29-30). The barrier was a sheer bedrock drop at least 50 feet high. A second, smaller barrier was located approximately 500 feet upstream; water flowed over a sheer drop (6 ft) through constricted bedrock. Streamflow was 0.01 cfs. The survey was initiated in high-gradient habitat; pools were numerous, with maximum depths ranging from 0.6 to 2.3 feet. Zero trout were observed in this reach. Farther upstream, the creek flows through Milk Ranch Meadow (low-gradient). Only eight pools were present in the upper one mile of habitat. These pools had maximum water depths between 0.7 and 1.8 feet. Water temperature ranged from -3 to 0 °C throughout the entire survey area.

Sixteen Lahontan cutthroat trout were observed with a size class distribution of 87.5% small- and 12.5% medium-sized fish. Trout were only observed in a few pools within 0.2 mile of habitat. Flow decreased incrementally upstream until the channel was either completely frozen or dry.

Three tributaries were documented during the survey effort. Two were dry at the confluence and were not surveyed. One was wetted (Trib 2) for approximately 100 feet (Figure 32). There was no connectivity to the pond complex in the upper portion of the meadow (Figure 33).

Although wetted habitat in Milk Ranch Creek exceeded 2000 meters, fish were only observed in a small portion of available habitat, habitat was degraded, pools were lacking and stream temperatures were at or below freezing. Due to poor habitat and small population size, Milk Ranch Creek was assigned a high risk rating (threat level 4).

Figure 29. Map of 2014 Milk Ranch Meadow Creek survey area

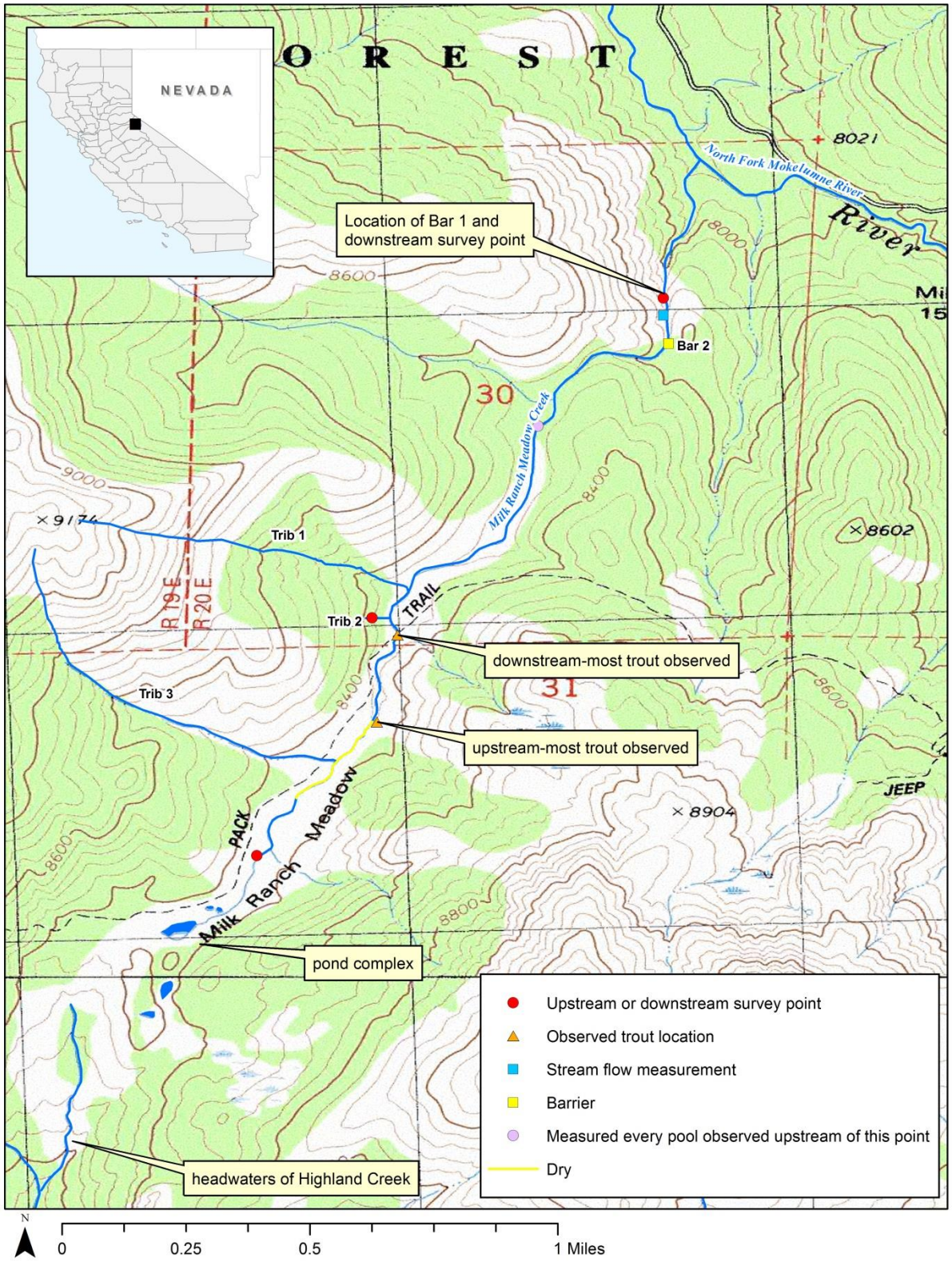


Figure 30. Representative photographs of Milk Ranch Meadow Creek in 2014

Figure 31. Fish barriers observed on Milk Ranch Meadow Creek in 2014

Figure 32. Representative photographs of Trib 2 in Milk Ranch Meadow Creek in 2014

Figure 33. Representative photographs of pond complex near headwaters of Milk Ranch Meadow Creek in 2014

Slinkard Creek

Slinkard Creek (Mono County) is approximately 13 miles southeast of Markleeville, CA. In 1987, an artificial gabion barrier was constructed to isolate a transplanted population of Lahontan cutthroat trout; brook trout (*Salvelinus fontinalis*) and Lahontan cutthroat trout are sympatric downstream of the barrier. The HWTP Inland Desserts Region is removing brook trout in Slinkard Creek to restore Lahontan cutthroat. To facilitate this project, a temporary weir was installed approximately 0.1 miles downstream of the gabion structure. A drought assessment was conducted on November 18th, 2014 along 1.4 miles of stream habitat and included portions both downstream and upstream of the gabion barrier (Figures 34-35).

Streamflow was measured at 0.95 and 0.91 cfs. Pools were relatively infrequent and had maximum depths between 0.9 and 2.1 feet. Although pools were limited in number, flatwater habitats with depths greater than one foot were prevalent (Figure 36). Water temperature was measured three times and was between 8 and 12 °C. Habitat appeared in good condition and, with the exception of a braided area with intermittent flow, wetted habitat was connected throughout.

A total of 28 unknown trout (68% small and 32% medium) and 3 brook trout (33% small and 67% medium) were observed downstream of the temporary weir. An additional 24 unknown trout (96% small and 4% medium) and 1 medium-sized Lahontan cutthroat trout were observed upstream of the weir. Brook trout may have been present in the relatively short reach between the weir and gabion structure; however, it is assumed all trout upstream of the gabion were cutthroat trout, as no brook trout have been documented above the barrier to date. Visual observation in Slinkard Creek was very difficult due to dense aquatic and riparian vegetation. One dry tributary was observed.

Lahontan cutthroat trout in Slinkard Creek were assigned a moderate risk level (2) based on potentially small population size, although this may be a function of survey bias and limitations associated with visual observation in this stream. Habitat appeared relatively intact, with deeper water areas and good cover. The HWTP recommends continued monitoring to ensure this population persists over time.

Figure 34. Map of 2014 Slinkard Creek survey area

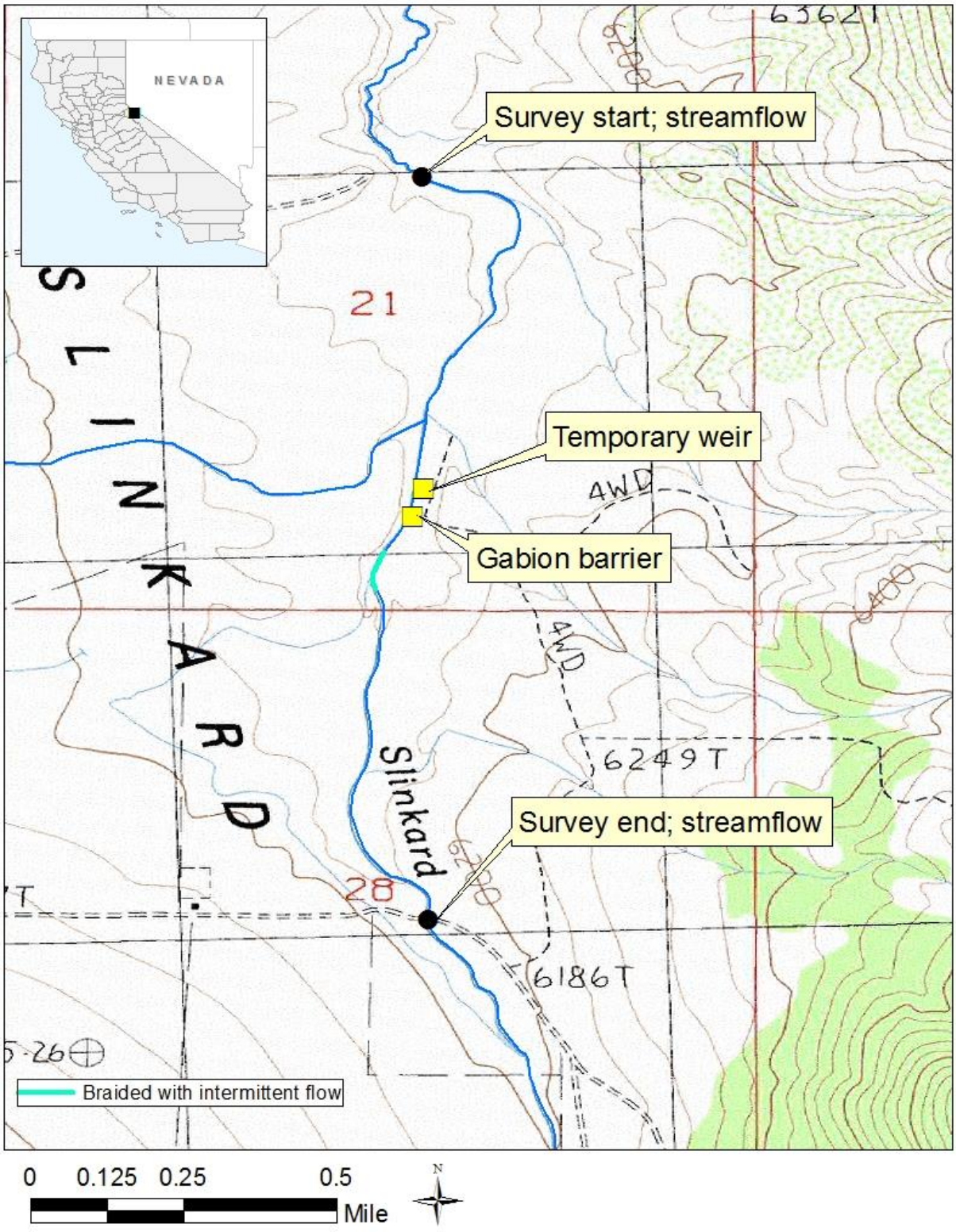


Figure 35. Artificial barriers on Slinkard Creek in 2014

Figure 36. Representative photographs of Slinkard Creek in 2014






Pole Creek

Pole Creek (Placer County), tributary to the Truckee River, is located approximately six miles south of Truckee, CA and supports a population of Lahontan cutthroat trout within their native range. An artificial barrier (gabion structure and boulders) is located approximately ½ mile upstream of the Truckee River confluence, which isolates this population from upstream invasion of non-native trout. Drought assessments were conducted on November 19th, 2014 from the barrier upstream one mile (Figures 37-39). Flow was restricted to the boulder portion of the barrier; the gabion was dry. Streamflow was measured at three locations, all of which were less than 0.2 cfs. Pools were relatively frequent and had maximum depths between 1.1 and 2.9 feet. Water temperature was 2°C.

A total of 66 trout were observed with a size class distribution of 85% small- and 15% medium-sized fish. Trout were observed throughout the survey area and some trout were positively identified as Lahontan cutthroat trout. Ice on the water surface was noted in some areas. One small dead Lahontan cutthroat trout was observed in the survey area under ice.

The Lahontan cutthroat trout population in Pole Creek was determined to be at moderate risk (threat level 3) due to low streamflow. The HWTP recommends more comprehensive (earlier in the season) assessments in 2015.

Figure 37. Map of 2014 Pole Creek survey area

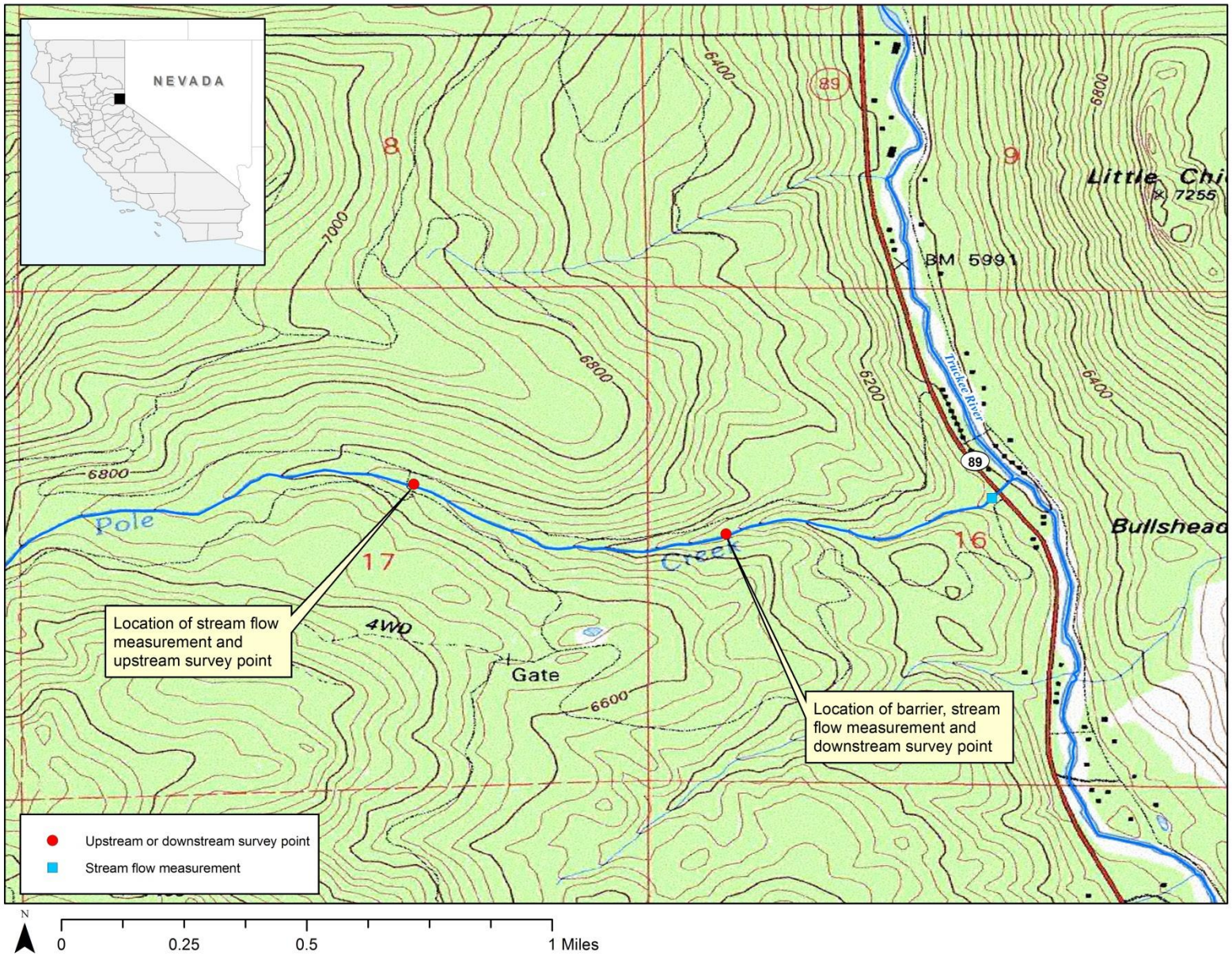


Figure 38. Representative photographs of Pole Creek in 2014

Figure 39. Fish barrier on Pole Creek in 2014

Literature Cited

Flosi, G., S. Downie, J. Hopelain, M. Bird, R. Coey and B. Collins. 1998. California Salmonid Stream Habitat Restoration Manual. 3rd Edition. Vol. 1. State of California Resources Agency. Department of Fish and Game. Inland Fisheries Division.

Mehalick, S. and C. Zuber. 2012. Wolf Creek 2012 summary report. State of California Natural Resources Agency. Department of Fish and Wildlife. Heritage and Wild Trout Program.

Table 1. Drought Response Implementation Plan and Rescue-Translocation Decision Model

Assessment effort	Observed conditions	Threat Level (1 to 4, 4 being the highest risk)	Response
Delineate connected and non-connected wetted habitat, document barriers, count and measure mean/maximum pool depth, gather stream temp, measure discharge, estimate population size by size class, and document water source.	Instream water quality is sufficient to maintain biological function and fish health, flow is contiguous and is >.5 cfs, pool habitat exists which exceeds 300mm in depth, population exceeds 200 adults, and wetted habitat is > 2000 meters	1	Document conditions/status, make recommendations on monitoring schedule,
Delineate connected and non-connected wetted habitat, document barriers, count and measure mean/maximum pool depth, gather stream temp, estimate discharge, and estimate population size by size class.	Instream water quality is sufficient to maintain biological function and fish health, flow is not contiguous and is <.5 cfs, pool habitat exists which exceeds 300mm in depth, population exceeds 200 adults, and although wetted habitat is not contiguous it is > 2000 meters	2	Document conditions/status, make recommendations on monitoring schedule, and identify a reference location for future measurements and comparisons.
Delineate connected and non-connected wetted habitat, document barriers, count and measure mean/maximum pool depth, gather stream temp, estimate discharge, and estimate population size by size class.	Instream water quality is sufficient to maintain biological function and fish health, flow is contiguous and is <.5 cfs, pool habitat does not exist which exceeds 300mm in depth, population exceeds 200 adults, and wetted habitat is contiguous for > 2000 meters	2	Document conditions/status, make recommendations on monitoring schedule, and identify a reference location for future measurements and comparisons.

Delineate connected and non-connected wetted habitat, document barriers, count and measure mean/maximum pool depth, gather stream temp, estimate discharge, and estimate population size by size class.	Instream water quality is sufficient to maintain biological function and fish health, flow is not contiguous and is <.5 cfs, pool habitat exists which exceeds 300mm in depth, population is below 200 adults, and although wetted habitat is not contiguous it is > 2000 meters	2	Document conditions/status, make recommendations on monitoring schedule, and identify a reference location for future measurements and comparisons.
Delineate connected and non-connected wetted habitat, document barriers, count and measure mean/maximum pool depth, gather stream temp, estimate discharge, and estimate population size by size class.	Instream water quality is sufficient to maintain biological function and fish health, flow is not contiguous and is <.5 cfs, pool habitat exists which exceeds 300mm in depth, population is > 200 adults, and wetted habitat is < 2000 meters	2	Document conditions/status, make recommendations on monitoring schedule, and identify a reference location for future measurements and comparisons.
Delineate connected and non-connected wetted habitat, document barriers, count and measure mean/maximum pool depth, gather stream temp, estimate discharge, and estimate population size by size class.	Instream water quality is sufficient to maintain biological function and fish health, flow is not contiguous and is <.5 cfs, pool habitat exists which exceeds 300mm in depth, population is below 200 adults, and wetted habitat is < 2000 meters	3	Initiate translocation assessment strategy and or rescue alternatives and formulate plan
Delineate connected and non-connected wetted habitat, document barriers, count and measure mean/maximum pool depth, gather stream temp, estimate discharge, and estimate population size by size class.	Instream water quality is sufficient to maintain biological function and fish health, flow is contiguous and is <.5 cfs, pool habitat exceeding 300mm in depth does not exist, population is < 200 adults, and wetted habitat is contiguous for > 2000 meters	3	Initiate translocation assessment strategy and or rescue alternatives and formulate plan

Delineate connected and non-connected wetted habitat, document barriers, count and measure mean/maximum pool depth, gather stream temp, estimate discharge, and estimate population size by size class.	Instream water quality is not sufficient to maintain biological function and fish health, flow is contiguous and is >.5 cfs, pool habitat exceeding 300mm in depth does not exist, population exceeds 200 adults, and wetted habitat is > 2000 meters	4	Initiate translocation assessment strategy and or rescue alternatives and formulate plan
Delineate connected and non-connected wetted habitat, document barriers, count and measure mean/maximum pool depth, gather stream temp, estimate discharge, and estimate population size by size class.	Instream water quality is sufficient to maintain biological function and fish health, flow is not contiguous and is <.5 cfs, pool habitat exceeding 300mm in depth does not exist, population is < 200 adults, and wetted habitat is < 2000 meters	4	Initiate translocation assessment strategy and or rescue alternatives and formulate plan

Table 2. Comparison of streamflow and water temperature in Little Kern River tributaries from 2013 to 2014

Water	Date	Streamflow (cfs)	Water temperature (ºC)
Lion Creek	6/29/2013	0.14	15.2
	8/9/2014	0.1	18
Sheep Creek	6/29/2013	0.55	11.9
	8/10/2014	0.49	10
Tamarack Creek-lower	7/15/2013	0.7	11.3
	8/10/214	0.6	12
Tamarack Creek-upper	7/12/2013	0.69	10.4
	8/10/2014	0.49	15
No Name	6/30/2013	0.22	15
	8/10/2014	0.02	13
Willow Creek	7/14/2013	0.66	11.5
	8/10/2014	0.42	10

Table 3. Number of fish observed by size during 2014 drought assessments

Water	Species	Number of trout observed			
		YOY	Small	Medium	Total
			< 6"	6"-11.9"	
Austin Meadow Creek	-	0	0	0	0
By-Day Creek	unknown trout	0	2	0	2
Macklin Creek	unknown trout	4	13	2	19
Mill Creek	unknown trout	0	19	12	31
Pacific Creek	unknown trout	0	14	2	16
Pole Creek	unknown trout	0	56	10	66
Raymond Meadows Creek	-	0	0	0	0
Slinkard Creek	brook trout	0	1	2	3
	Lahontan cutthroat trout	0	1	0	1
	unknown trout	0	42	10	52
Unnamed tributary to East Fork Creek	unknown trout	0	5	10	15
Milk Ranch Meadow Creek	Lahontan cutthroat trout	0	14	2	16
Marshall Canyon Creek	-	0	0	0	0
Wolf Creek	Lahontan cutthroat trout	19	56	37	112