CTWS/BPA Final Project Reporting Outline

1. **Project Narrative, include:**
    a. **Final project summary, what the project accomplished and what problems it addressed**
    b. **Description of the work completed**
    c. **Description of any changes to the original project**
    d. **Lessons learned or recommendations for future implementation**

2. **Camp Creek Headwaters Project 2016**

a) **Final Project Summary.**

b) Camp Creek is one of the Forests Priority/Focus watersheds and has been identified as a high priority stream for steelhead recovery. Mid- Columbia River Steelhead currently utilize Camp Creek but the Habitat was highly departed from desired conditions. Limiting factors identified within the Mid-Columbia River Steelhead Recovery plan (Sept, 30, 2009) include: degraded riparian plant communities, floodplain connectivity and function, channel structure and complexity, water quality (water temperature), and altered hydrology and sediment routing. Water temperature differences of over 8º F have been observed between the upstream and downstream ends of the four mile project reach. Juvenile steelhead mortality due to water temperatures and stress related to low flow conditions have been observed in monitoring data collected since 2011 (ODFW). Because of this, improving juvenile rearing habitat thru creation of pools (over-winter and summer rearing), reconnection of the floodplain (8 miles of abandoned over flow channel-removal of 45 legacy berms), and elevation of water table thru storage, habitat complexity and restoration of riparian hardwood communities (shade) was the focus of the project.

Beaver were historically abundant within the Camp Creek watershed and throughout the John Day basin. Their dams had a strong influence on the vegetative productivity of riparian corridors and on ground and surface water flow regimes. In the 1800s and 1900s, beaver trapping was widespread throughout the John Day basin. The reduction in the beaver population was one factor which led to a loss of floodplain connectivity as well as a loss of channel sinuosity and complexity.

Goal: Increase juvenile rearing habitat (limiting), in proximity of suitable spawning habitat - Mid Columbia River Steelhead

Objectives: <u>Camp Creek Headwaters Project</u>

- Activate abandoned side channels and re-wet abandoned meadows
- Incorporate lessons learned thru Bridge Creek BDA studies, and Camp Creek 2011-2014 work
- Sediment deposition-build streambed and banks (overwidened channel-solar radiation)
- Elevate water table-increase discharge during low flow period
- Establish shade-(limiting) riparian hardwoods-willows

- Increase fish habitat complexity
- Establish Beaver Habitat

The Camp Creek Headwaters Project was designed and built off of lessons learned from aquatic restoration work that occurred from 2011-2014 in lower reaches of Camp Creek and within the project area that included placement of large wood structures, removal of log weirs, excavation of pools, riparian planting and chainsaw cutting sections of weirs out. The write up below summarizes some of the findings from previous work and is a case study included in the Beaver Restoration Guidebook 2015. https://www.fws.gov/oregonfwo/Documents/BeaverRestGBv.1.02.pdf

Stream channels within the reaches where log weirs were located have narrowed and vegetation has colonized exposed stream banks. The majority of pools created through excavation have been maintained by instream wood. Gravel sorting is evident throughout the reaches that were predominantly plane bed with an armor layer of cobble that functioned as a transport reach (slope 0.017). Based on this evidence the project continues to improve Mid-Columbia River Steelhead habitat deficiencies identified within the Camp Creek WRAP.

Unforeseen Benefits

In 2014, beaver moved into a portion of Camp Creek where log weirs were removed, pools were excavated, and wood was added (Figure 1, Figure 2, Figure 3). While historical beaver evidence was present within Camp Creek, transient beaver activity and dams have been noted but no prior large dams, such as those observed in 2014, were documented within lower Camp Creek. Many of the dams that appeared in 2014 were keyed into placed wood or boulders for added stability and persistence (Figure 1). Additionally the beaver dams backwatered the placed wood structures and the excavated pools increased the depth upstream of the dam to over 5 feet in places. Observations indicate beaver are using the wood structure locations as dens and the deep excavated pools as food caches for over wintering. During the spring of 2015, several smaller dams were breached leaving large gravel patches (built by beaver for dam construction). Several steelhead were observed constructing redds in these breached areas. This provides an example of combined salmon/beaver because the same limiting factors affecting salmonids may also be limiting beaver—the two are not exclusive, but share a common beneficiary relationship. Dam's anchored to large wood tended to be taller, had more internal stability and had a larger hydrologic zone of influence (Figure 2 and Figure 3).

The beaver dams mentioned above have persisted for more than 3 years now and an additional 3 beaver dams were observed above this area (Figure 4). Beaver adults require at a minimum 2 years of pond persistence before producing offspring suggesting the beaver colony established in 2014 is expanding.

Also during this time experimentation with beaver dam analogues was occurring on Bridge Creek to facilitate beaver expansion, sediment deposition within incised stream channel, elevate water tables, and reconnect floodplains. Findings from this work are listed below:

- Bouwes, Nicolaas et al. "Ecosystem Experiment Reveals Benefits of Natural and Simulated Beaver Dams to a Threatened Population of Steelhead (*Oncorhynchus Mykiss*)." *Scientific Reports* 6 (2016): 28581. *PMC*. Web. 13 Dec. 2016.

- Pollock, Michael M., et al. "Using beaver dams to restore incised stream ecosystems." *BioScience* 64.4 (2014): 279-290.

- Pollock, M. M., T. J. Beechie, and C. E. Jordan. 2007. Geomorphic changes upstream of beaver dams in Bridge Creek, an incised stream in the interior Columbia River basin. Earth Surface Processes and Landforms **32**:1174-1185.

The Camp Creek Headwaters Project combined the knowledge and lessons learned from USFS work completed on Camp Creek (2011-2014) with that of the knowledge learned from work completed on Bridge Creek in regards to BDAs and beaver habitat/colonization/expansion and applied it to the Camp Creek Headwaters Project. In addition to applying the lessons learned and knowledge gained from ongoing beaver restoration work application of channel spanning wood jams were also utilized as part of the Camp Creek Headwaters project to diversify habitat complexity and support beaver dam analogues as well as activate abandoned over flow channels in conjunction with BDAs. Channel spanning wood jams have a similar function to that of Beaver dam analogues and in the case of Camp Creek appear to be interrelated for success.

- Wohl, Ellen, and Natalie D. Beckman. "Leaky rivers: implications of the loss of longitudinal fluvial disconnectivity in headwater streams." *Geomorphology* 205 (2014): 27-35.

- Burchsted, Denise, et al. "The river discontinuum: applying beaver modifications to baseline conditions for restoration of forested headwaters." *BioScience* 60.11 (2010): 908-922.

- Wohl, Ellen, and Daniel N. Scott. "Wood and sediment storage and dynamics in river corridors." *Earth Surface Processes and Landforms* (2016).

- Cluer, B. and Thorne, C. (2014), A STREAM EVOLUTION MODEL INTEGRATING HABITAT AND ECOSYSTEM BENEFITS. River Res. Applic., 30: 135–154. doi:10.1002/rra.2631

Camp Creek Headwaters Project is the first on the Forest or possibly in the region to incorporate channel spanning wood jams in conjunction with beaver dam analogs. These wood jams had several purposes on Camp Creek and are listed below:

1) Activate abandoned over flow channels within floodplain and abandoned meadows
2) Capture gravels and fine sediment
3) Increase fish habitat complexity and pool area for rearing juvenile Mid-Columbia River Steelhead
4) Decrease stream energy above and below beaver dam analogues and create denning areas (cover) for beaver inhabitation and expansion
5) Provide areas for riparian hardwood establishment and expansion

To our knowledge this is the first time channel spanning wood jams have been constructed in conjunction with Beaver dam analogues and the first time sealing of beaver dam analogues has been completed with heavy equipment in the fall. The application of multiple restoration techniques for restoration of fish habitat complexity, beaver habitat restoration, and riparian hardwood species establishment effectively increased habitat complexity, reconnected abandoned floodplains, over flow channels, and created pools within the project area for juvenile MCR Steelhead. It also effectively combined ecological/biological processes with physical/geomorphic processes to produce a product that is likely sustainable into the future.

Depositional features and hardwood establishment success will be monitored as part of the monitoring plan for this project. If successful, establishment of shade providing cottonwoods and willows within the project area would likely address water temperature

issues AND provide a food bank for further beaver expansion into the headwaters of Camp Creek from lower reaches where they are currently persisting and expanding.

Figure 1: Medium size (< 12 inch) diameter ponderosa pine placed in mid-channel in 2011 following log weir removal. Beaver dam has incorporated rootwad into center of dam (6/15/2014).

Figure 2: Beaver dam with rootwad incorporated (12/15/14)

Figure 3: Valley bottom being inundated with moderate flood because of beaver dam influence (12/22/14) **(1)**. Arrow indicates log structure where pool was excavated in 2011. Wood structure and pool immediately following construction 2011 (same as 1) **(3)**. Same area and jam 2015 **(2)**

Figure 4 Example of new beaver dam on Camp Creek approximately 3 miles below Camp Creek Headwaters Project Area that was constructed in 2016 and is assumed to be related to offspring from previous colony that originated in 2014 within 2011 restoration work.

Description of Structures Utilized within Camp Creek Headwaters Project

Beaver dam analogs (BDAs) are porous, channel spanning structures designed to mimic beaver dams and raise the water table upstream of the structure. Beaver dam analogs have willow whips/sedge clumps and other vegetation interwoven between vertical posts driven into the streambed. The structures are sealed with substrate material taken from the streambed (similar to culvert replacement). As the willows take root, they will provide a "live" vegetative base, increasing the life span of the BDAs. The objective of the BDAs is multifold: (1) raise water tables upstream of the BDA to reconnect floodplains and abandoned side channels (2) promote sediment deposition upstream of BDAs to promote growth of riparian vegetation and promote floodplain connectivity, (3) attenuate peak flows to increase water storage later into the summer, (4) provide more miles of high quality juvenile steelhead rearing habitat, (5) provide cover and habitat to facilitate expansion and colonization by beaver of headwater meadow areas (6) decrease stream energy within incised channels allowing deposition to occur.

Figure 5: Beaver dam analog with posts and willow weaves installed prior to sealing. Whole lodgepole trees with rootwad were placed in front of and behind BDA's to dissipate stream energy (flanking of BDA) and provide additional cover for beaver and fish.

Willow planting in BDAs utilize lodgepole on floodplain that have encroached into meadow for posts and stream energy dissipation. Willows were then buried using surrounding substrate and soil to seal the beaver dam analogue, assure ground to stem contact for willow weaves and elevate water table. Primary willow species were Geyer and Coyote willow which expand thru rhizome (roots) and are one of the more prolific willow species that spread thru ground disturbance.

Essentially beaver dam analogues can also act as clusters of willows which once established spread, increasing shading of the stream and possibly expanding upstream and downstream of beaver dam analogs. This can also result in increased nutrient cycling and productivity (leaf fall and aquatic/terrestrial insect biota)

Additionally beaver dam analogues capture fine sediment for deposition, these delta areas of fine sediment are essential for establishment of riparian hardwoods such as willows to be effective.

Channel-spanning large log jams. Log jams occur naturally in many river systems and historically were much more widespread, before the extensive removal of wood from most streams. Channel-spanning log jams retain sediment, create channels with multiple threads, and can even convert bedrock reaches into alluvial reaches. ***In many aspects the benefits of stable channel-spanning log jams can equal or exceed those of beaver dam. Channel spanning wood jams were used in conjunction with beaver dam analogs to dissipate stream energy prior to reaching beaver dam analogs and reentry of overflow channels from floodplain, provide overhead cover for beaver and fish, activation of overflow channels and facilitate floodplain activation***

Channel- spanning over flow (small wood jams). Coarse wood material (dbh < 8 inch) was utilized to "roughen" floodplain and overflow channel prior to activation. These

structures have a similar purpose to that of the channel spanning log jams and allowed utilization/removal of more of the encroaching lodgepole in the abandoned meadows and floodplain. Additionally in several locations beaver dam analogs were also placed on these overflow channels with lodgpole whips weaved in between posts to facilitate beaver dam construction on these channels storing even more water out on the floodplain all the way to the valley toeslope increasing floodplain complexity.

Post Vanes/Rock Vanes. Post vanes and rock vanes were constructed adjacent to eroding banks to facilitate sediment recruitment and increase sinuosity which is anticipated to be captured by beaver dam analogs and channel spanning wood structures thus accelerating deposition and reconnection of floodplain downstream.

Vegetative Planting/Caging/Fencing. Cottonwood planting involved planting of clusters of cottonwood poles (1 -3 inch dbh) and 6-8 feet tall. In general 4-8 stems were planted in each hole. Planting was completed by digging a hole with an excavator bucket until the water table was reached then back-filling the hole. Planting occurred during mid to late October and rain for several days followed the planting therefore pouring water into the hole for stem/soil contact was not necessary. Due to the spacing of cottonwood clusters caging was deemed a better alternative. Approximately 3,500 cottonwood were planted within a ½ mile section of Camp Creek identified as thermally sensitive for solar radiation where stream shade would have the most impact.

Willow planting involved the same procedure as cottonwood however in some patches we were able to use an auger instead of a bucket. Willow planting was not continuous but in specific "patches" identified within the most thermally sensitive areas (Figure 34) in the 4 mile project area where restoration of shade would provide the greatest effect. Structures placed adjacent to these patches specifically were designed to elevate the water table and facilitate deposition thus increasing the likelihood of expansion of the "patches". The willow patches were fenced using hog panels to include multiple clusters of willows.

Monitoring:

- 4 photopoints were established off of upland rock outcrops to capture sections of entire valley.
- 2 PIBO sites are located within the project area
- DMA (Designated monitoring area) for livestock grazing is within project area and will continue to be monitored annually with reporting shared with CTWSRO and participation
- Aerial video (Go Pro) was taken for the entire project area prior to beginning work with helicopter, project area will be re-flown this spring or fall 2017
- Photo points/ markers were established at every BDA (~70) and large wood jam (88) throughout the entire project area.

b) Description of work completed.

Seventy BDAs were constructed on a four mile reach of Camp Creek in conjunction with 88 large wood jams within the active channel, 56 small wood jams within historical flow paths (~8 miles), 8 post vanes, 7 rock vanes, 3500 cottonwoods and 1500 willows were

planted within the floodplain. In addition to traditional planting, a portion of the 10,000 (+/-) willow whips (coyote willow) woven into the BDAs are expected to take root, providing direct shade to the pools created by the BDAs. The project also consisted of legacy structure removal (approximately 45 log weirs) with removal of berms and re-contouring of slope. Approximately 4,000 feet of caging material was used on willow/ cottonwood plantings and another 1,120 feet of 5 ½ ft. hog panel (USFS) was used to construct exclcsures around clusters of willow plantings associated with over flow channel activation.

c) Description of any changes to the Original Project.

- Initial project proposal included the purchase and use of a portable hand held post pounder for beaver dam analog construction. Upon trial of the equipment it was determined that this was not the appropriate piece of equipment for the project due to ground conditions. Because of this an excavator with a compactor head was utilized to drive BDA posts into the ground. The number of beaver dam analogs was not identified in the original proposal and proved to be a significant workload.

- Initial project proposal involved using a USFS fire crew to cut and stage posts for BDA structures. The fire crews were assigned to a different project and therefore felling/ staging was required by fish biologist and technician along with help from CTWSRO crew and ODFW for BDA posts

- Initial project proposal proposed using a log arch and UTV as well as felling to move material into stream for ~50 wood structures. This was deemed not adequate for achieving objectives upon review of LIDAR and site visits to project area.

- Initial project proposal assumed CTWSRO would be doing the contracting for the project. USFS took over contracting duties, and initiated formation of an IDIQ (pool of contractors) for doing aquatic restoration work. Design was completed by USFS internally. Project was completed as a lump sum contract instead of T&M due to thorough design.

- Initial project did not include fencing or post vanes-fencing was completed by USFS, CTWSRO crew and AmeriCorps crew

- Tree tubes were deemed not necessary for riparian hardwoods but were purchased

- Initial project did not involve the use of an excavator (3 excavators were utilized to complete project). One specifically for pounding posts in for Beaver dam analogs

- Initial project did not include activation of abandoned overflow channels nor placement of coarse wood within overflow channels nor did it have the location or number of beaver dam analogues

- Initial project did not involve fall work with beaver dam analog sealing and planting which required an excavator for sealing beaver dam analogues. This was chosen to maximize the effectiveness and survival of riparian hardwoods (near lowest water table, shrubs are dormant, shrubs are immediately utilized upon harvest)

- Removal of log weirs and legacy berms was not in the original proposal (45 were modified/removed) to allow overbank flows to access floodplain. These weirs were cut in the middle with a chainsaw in 2012 however follow up monitoring demonstrated this was

an inadequate method nor did it address the rock berms that were placed along the channel during weir installation.

- Initial funding was $81,162 following purchase of fencing material, tree tubes, and portable post pounder remaining funds were for $60,143. After careful review of the proposal and the transfer of the project to a different USFS fish biologist familiar with the project area it was deemed necessary in order to be effective to utilize heavy equipment. The USFS provided an additional $51,000 in program dollars from fisheries, watershed, and (CFLRP- Collaborative Forest Landscape Restoration Program) monies to cover additional project work not in the original proposal resulting in a more holistic project.

d) Lessons learned or recommendations for future projects:

- Plan accordingly for BDA post harvest and staging. Staging of BDA post prior to any contract work is essential as it reduces costs associated with labor in contract. OR have the post cutting and staging be a part of the contract, we did all of it with chainsaws for this project however there are often pre commercial thinning units adjacent to where we got the lodgpole from lumping pre commercial treatments with post harvesting for BDAs may be an option. Consider the use of a feller buncher or equivalent equipment to increase efficiency of BDA post harvest. Identify post staging areas prior to work if possible lump BDA post- harvest with staging prior to instream work window.

- Sealing the BDA's with an excavator proved to be much more efficient and effective than hand labor. We were able to harvest sedge mats and add additional coarse wood material in proximity of BDAs

- Posts> 6 inch dbh were the most effect for use with an excavator mounted compactor anything less often shattered. Avoid using posts with defects that compromise structural integrity.

- Compactor mounted on excavator is also effective at putting posts out on the floodplain for "locking" in floodplain wood and coarse wood

- Have willow harvest area laid out prior to weaving. Assure willows are dormant. Utilize willow species that expand thru disturbance and primarily expand thru rhizomes

- Weaving lodgepole is also effective in particular in areas that may not have good soil to stem contact or contact with water table

- Excavating and planting clusters of cottonwood and willow where an auger does not work can be effective. Digging takes the guess work out of where the actual water table is on abandoned floodplains

- Plan accordingly for instream work waiver if planting or sealing beaver dam analogs in the fall otherwise delays may occur (we did and had no delays). **This may differ where you have bull trout (spring may be the only option)**

- The window for completing fall planting and instream work is very narrow (generally 2 weeks). Planting in the fall during the wet period prior to freezing assures good soil to stem contact and prevents an early "leafing out" of material.

3. Project Location/Metadata:

Project Type	Metrics	Planned	Actual
Install Fence	**Number of acres of habitat protected by fencing**		
	Number of miles of fence installed in the riparian area	**Not identified in original proposal**	4,000 feet (cages) Exclosure 1,120 feet (hog panel) USFS
	Number of miles of left stream bank fenced		
	Number of miles of right stream bank fenced		
	Start date of lease (mm/dd/yyyy)		
	End date of lease (mm/dd/yyyy)		
	Start Latitude of treated stream reach		
	End Latitude of treated stream reach		
	Start Longitude of treated stream reach		
	Start Longitude of treated stream reach		
	Average Buffer width		
Remove/Install Diversion	**Number of push-up or diversion full passage barriers removed**		
	Number of miles of habitat accessed to the next upstream barrier or likely limit of habitable range	**Not identified in original proposal**	45 log weirs removal with associated legacy berms for floodplain reconnection
	Number of screens addressed		
Install Fish Passage Structure	**Number of natural stream crossings installed**		
	If installing a ladder does it meet NOAA specifications for attraction flow, pool dimensions, jump height, etc.		
	Number of miles of habitat accessed to the next upstream barrier or likely limit of habitable range		
Install Pipeline	**Number of miles of primary stream reach improvement**		
	Number of miles of total stream reach improvement in acre-feet/year		
	Amount of unprotected water flow returned to the stream in cubic-feet/second		
Increase instream habitat complexity	**Number of pools created for Complexity, Stabilization, or both (be specific)**	**Number not identified in original proposal**	**70** Beaver dam analogues

	Number of unanchored individual log structures (not logjams) installed for Complexity, Stabilization, or both (be specific)	**Not in original proposal**	**56** small wood structures on abandoned over flow channels (4-8 trees/structure)
	Number of anchored individual log structures (not logjams) installed for Complexity, Stabilization, or both (be specific)		
	Number of logjams installed for Complexity, Stabilization, or both (be specific)	**56**	**88** large log jams
	Number of anchored rocks/boulder structures installed for Complexity, Stabilization, or both (be specific)	**none**	**7** Rock vanes, **8** Post vanes
	Start latitude of treated stream reach		44º 35' 12.735" N
	End latitude of treated stream reach		118º 52' 17.233" W
	Start longitude of treated stream reach		44º 34' 1.526" N
	End longitude of treated stream reach		118º 50' 34.324 W
	Number of miles of stream with improved Complexity, Stabilization, or both (be specific)		4 miles, **8** miles of abandoned over flow channel
	Number of miles of stream treated with spawning gravel		
Develop Alternative Water Source	**Number of alternative water sources installed**		
Maintain/Remove Vegetation	**Number of acres of upland habitat treated**		
	Number of acres of riparian habitat treated	**Remove lodgepole**	51 acres
	Number of acres of freshwater habitat treated		
	Number of riparian miles treated	**Remove lodgepole**	4 miles
	Number of freshwater miles treated		
	Biological plant removal (Yes/No)		
	Herbicide plant removal (Yes/No)		
	Mechanical plant removal (Yes/No)	**Yes**	
	Conduct controlled burn (Yes/No)		
	Number of acres maintained		
	Number of years treated		
Plant Vegetation	**Number of acres of riparian habitat treated**	**Not identified in original prioposal**	8 Acres cottonwood, 51 acres willow (includes beaver dam analogs)

	Number of riparian miles treated	**4**	2 (3500 cottonwood, 1,500 willow and ~8,000-10,000 willows weaved in BDA structures)
Outreach and Education	**Target Audience (general public, students, teachers)**		Tours with Morgrass grazing association, ONDA, Blue Mountain Eagle Article, AmeriCorps USFS Public Announcement Release Website, coordinated with Blue Mountain Community College to start up a field course on aquatic restoration (application pending), currently putting together an aquatic restoration pamphlet describing purpose of activities used on Camp Creek for distribution to public, Project was featured in regional accomplishment report for Malheur National Forest
	Number of target audience reached		Permittees, John Day and surrounding communities

4. **Budget Summary, include:**
    a. **Budget Table**
    b. **Source and amount of match funds**

	Budget Categories	CTWS Funding	USFS Match Funding (Cash and In-Kind)	Total Expenditures
a	Personnel	$24,500	$31,000	$55,500
b	Travel			
c	Supplies/Equipment	$21,809	$24,875	$46,684
d	Subcontracts	$63,413	$51,000	$114,413
e	Other			
f	TOTAL	$109,722	$106,875	$216,597

5. **Photographs/Map, include:**
    a. **Color photos of before and after project implementation, with photo point documentation**
    b. **Map of project location**

Figure 6 : Camp Creek within project area in 1970s.

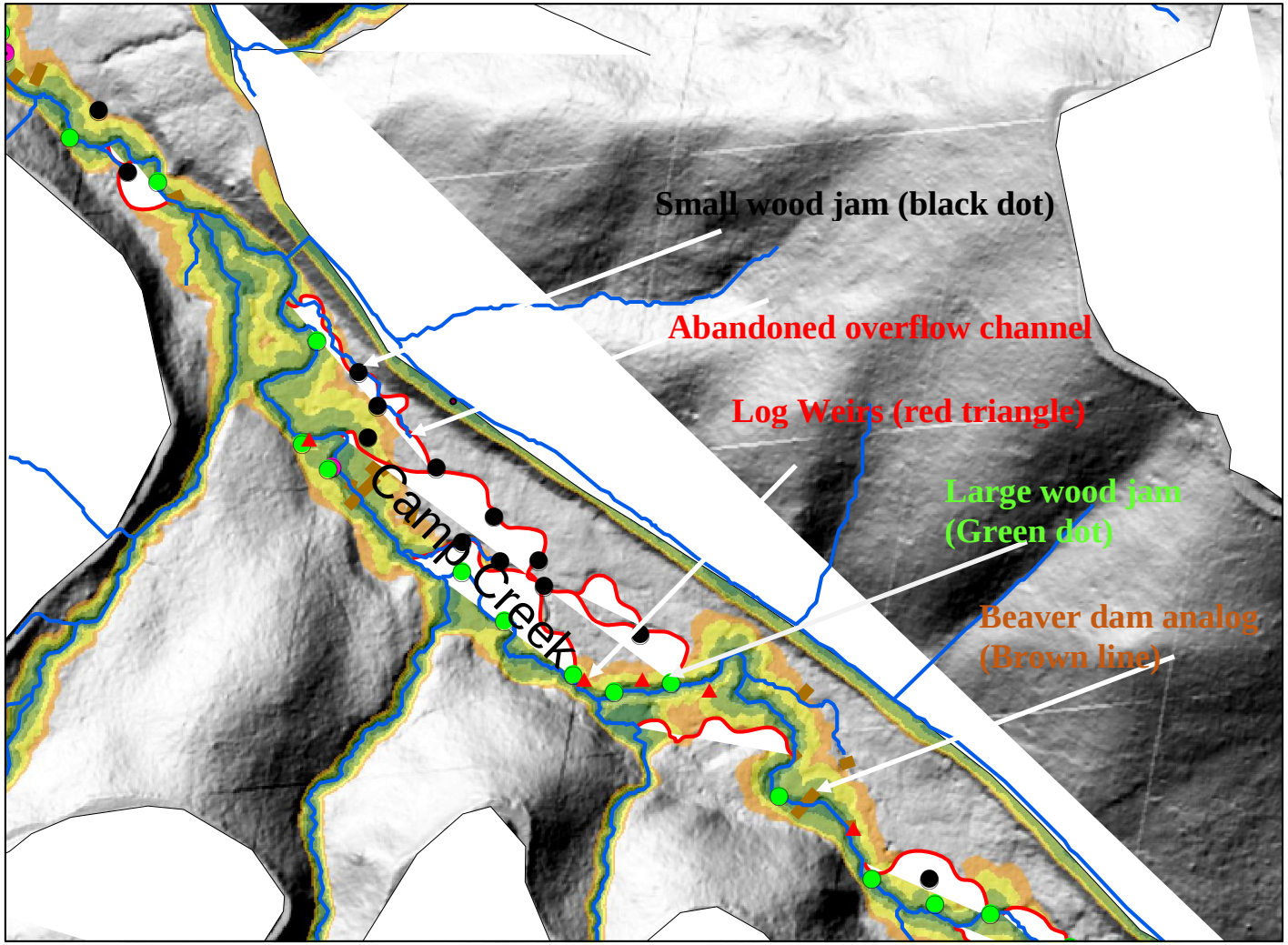

Figure 7: Example of Design layout as built for reactivation of abandoned over flow channels and floodplain reconnection for meadow within Camp Creek Headwaters Project. Colored areas represent height (feet) above channel (green 0-1), yellow (1-2), orange (2-3). BDAs were placed to maximize inundation of floodplain based on floodplain height above the channel.

Figure 8: Removing log weirs and re-contouring legacy berms on right river bank (notice how high excavator is sitting in photos)

Figure 9: finished product from figure 6 with log weirs removed/modified, legacy berm recontoured and beaver dam analog constructed with wood placement

Figure 10: A beaver dam analog after posts have been driven into the streambed and willows woven through posts**.** Existing sedge clumps were also used to cover willow bundles and seal BDA

Figure 11: The same BDA complex impounding water after it was sealed with stream substrate material.

Figure 12: Example of Post Vane with AmeriCorps crew- direct flow towards cut bank and activate over flow channel by pooling water during high flows (Where group is standing), brown dashed line represents deposition area-point bar

Figure 13: Example of historic flow path with small wood jam. Lodgepole were also felled and staged in overflow channel above structures

Figure 14: Example of Large Wood Structure with spawning gravel tailout (primary fish habitat)

Figure 15: Example of channel spanning wood jam and historical flow path activation (rock was removed from log weir). When built log weir effectively cut off over flow path

Figure 16: Same structure as figure 15 following fall rains, notice water already percolating thru substrate on right side into 1/4 mile of abandoned over flow channel

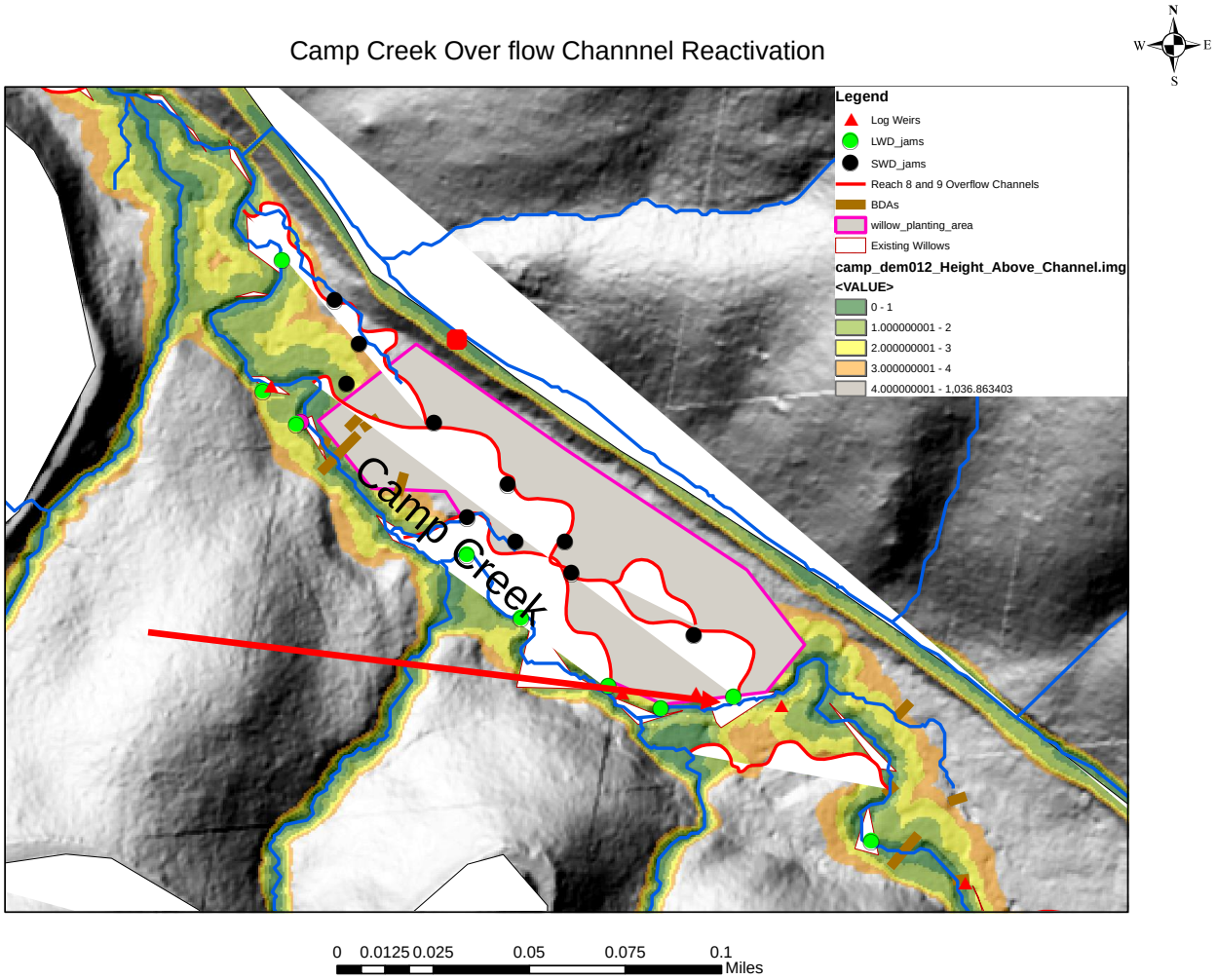

Figure 17: Location of wood jam and over flow channel in figure 16 above

Figure 18: Log weirs with portions cut with chainsaw 2012, red arrow indicates 2-4 foot elevation change (berm)

Figure 19: Log weir modified and legacy berm removed 2016

Figure 20: BDA with willows woven through posts.

Figure 21: BDA with willows and substrate material sealing it.

Figure 22: BDA fully sealed and impounding water. Large wood was added near bank to deter livestock and wildlife access to sprouting willows as well as to provide fish habitat complexity and beaver habitat.

Figure 23: BDA complex and large wood jam during construction.

Figure 24: BDA complex with large wood jam just upstream after BDA sealing was completed. Combination of channel spanning wood jam (activate three overflow channels/dissipate stream energy/fish habitat/elevate water table) with BDA series (elevate water table/sediment deposition/pool habitat/ riparian shrub expansion). Wood jam is inundated as well as over flow channels reentry by BDA complex. Blue lines indicate over flow channels

Figure 25: Excavator placing small wood (lodgepole) within over flow channel (1)**,** Excavator with compactor head driving posts for BDA structure (2**),** Excavator with wide bucket for scraping sedge mats, substrate and soil related to BDA sealing over willow weaves (3), BDA with willow weaves prior to sealing (4).

Figure 26: BDA with associated wood jam prior to sealing (Figure 27 below)

Figure 27: Completed beaver dam analogue with wood jam (below) and trees with root wads locked into BDA posts. BDA locations were determined by valley pinch points and height of floodplain above channel (level of inundation) by BDA

Figure 28: point bars and elevated bars associated with abandoned over flow channels (covered by mesic grasses) were scraped in several locations to facilitate recruitment of gravels and fine sediment during high discharge events

Figure 29: Three excavators were utilized for project. One excavator operator focused on tipping and small wood jams on over flow channels, other operator and excavator focused on tipping trees and large wood jams/legacy berm removal log weirs. The third smallest excavator was utilized solely for putting in BDA posts and was later brought back to complete BDA sealing and planting.

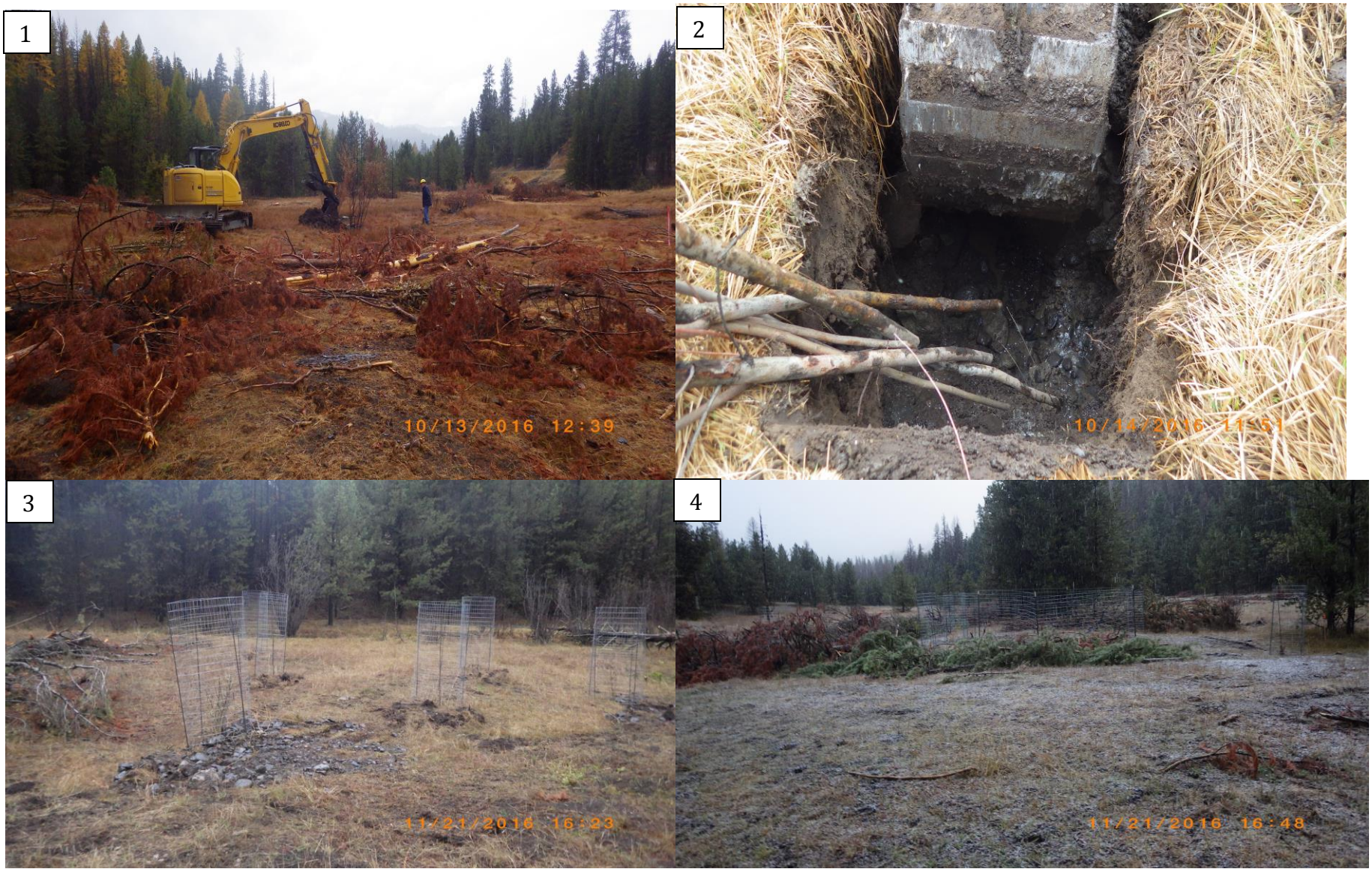

Figure 30: Planting willow clusters with an excavator bucket (1), close up view of bucket reaching water table (2), caged cottonwood clusters (3), Fenced willow "patch" with over flow channel (4)

Figure 31 : Aerial overview of Camp Creel Headwaters 2016 project area. The entire project areas was flown by helicopter prior to beginning instream work and video taken with a Go Pro Camera of specific areas. Tracks visible in meadow are from moving/staging BDA posts with UTV. The entire project area will be re-flown during spring 2017 during high flows

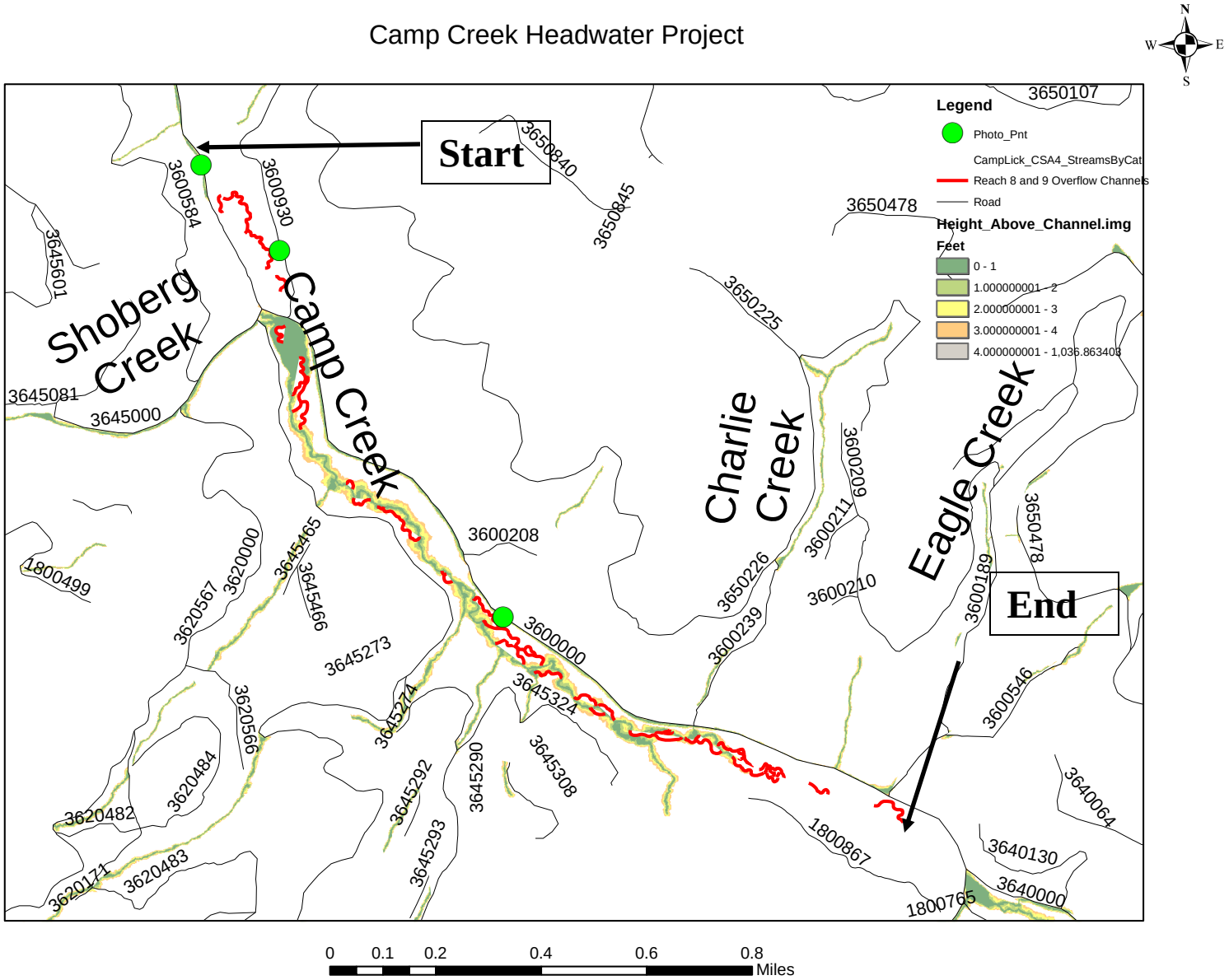

Figure 32: Map depicting the Camp Creek Headwaters Project Area

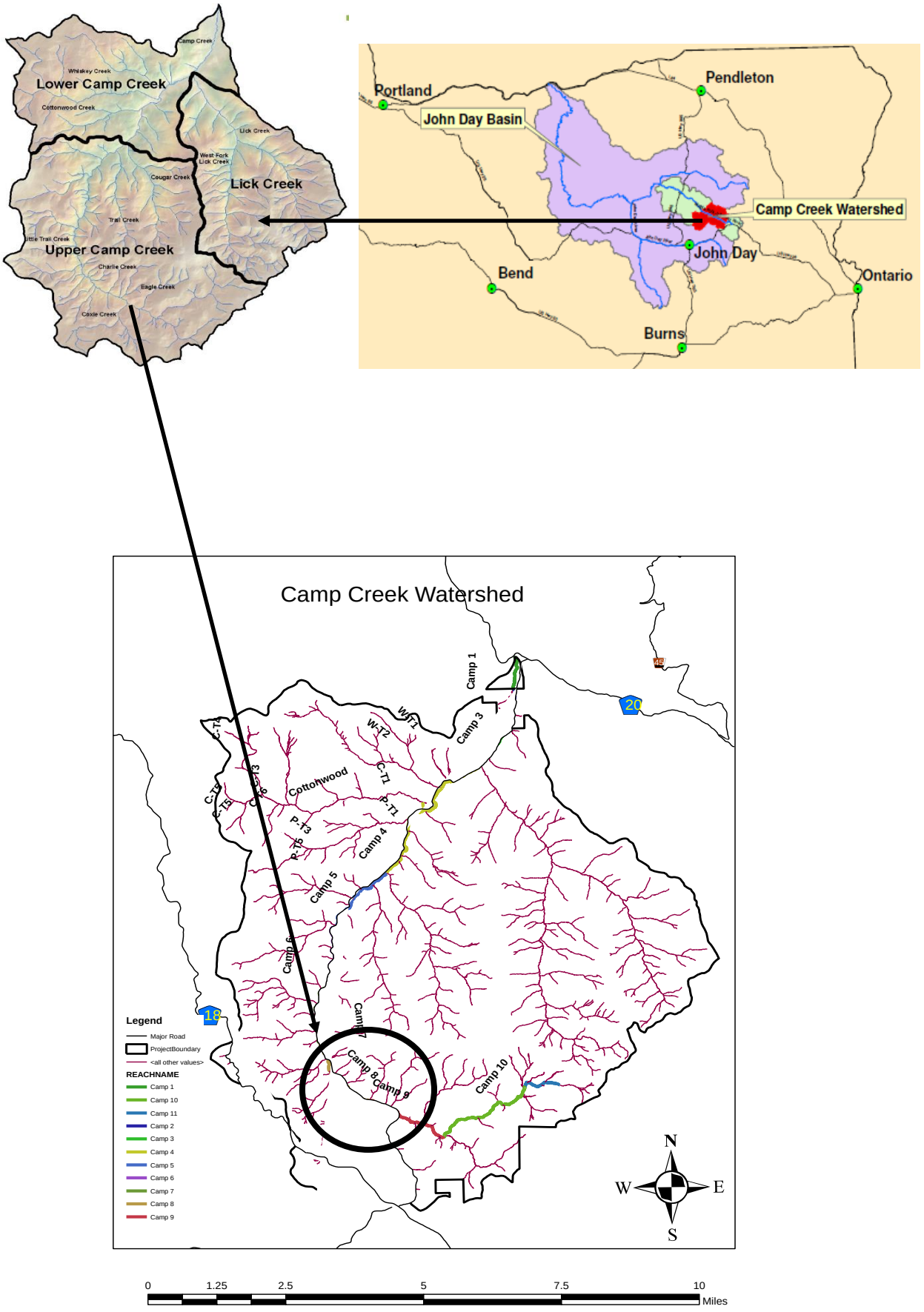

Figure 33: Map depicting location of Camp Creek watershed within the John Day Basin and project location

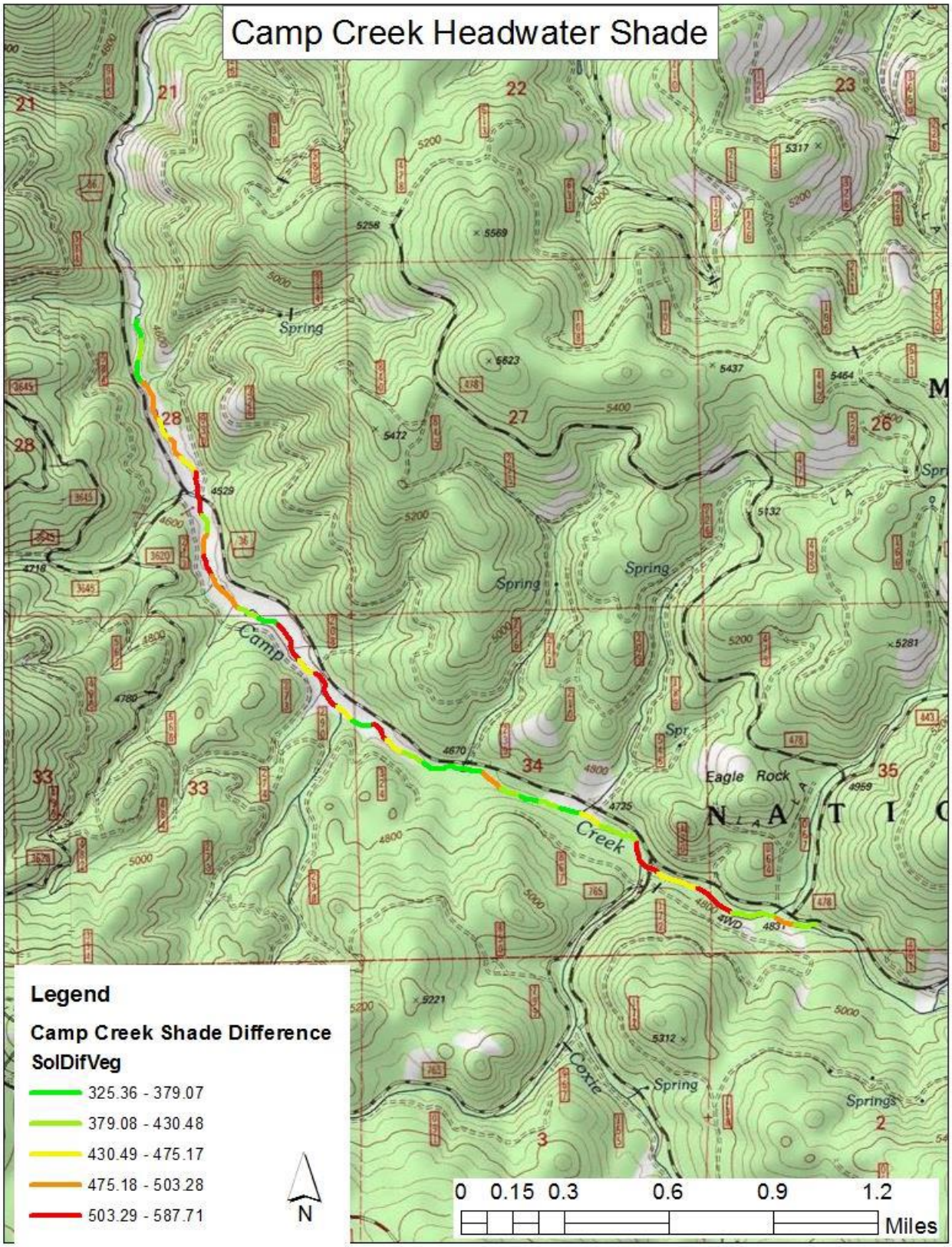

Figure 34: Solar radiation from a desired willow future condition minus topographical shade to illustrate areas where vegetative shade would have the most effect within Camp Creek Headwaters Project Area (red areas). These areas were focused on for hardwood planting/sediment deposition and riparian hardwood expansion.