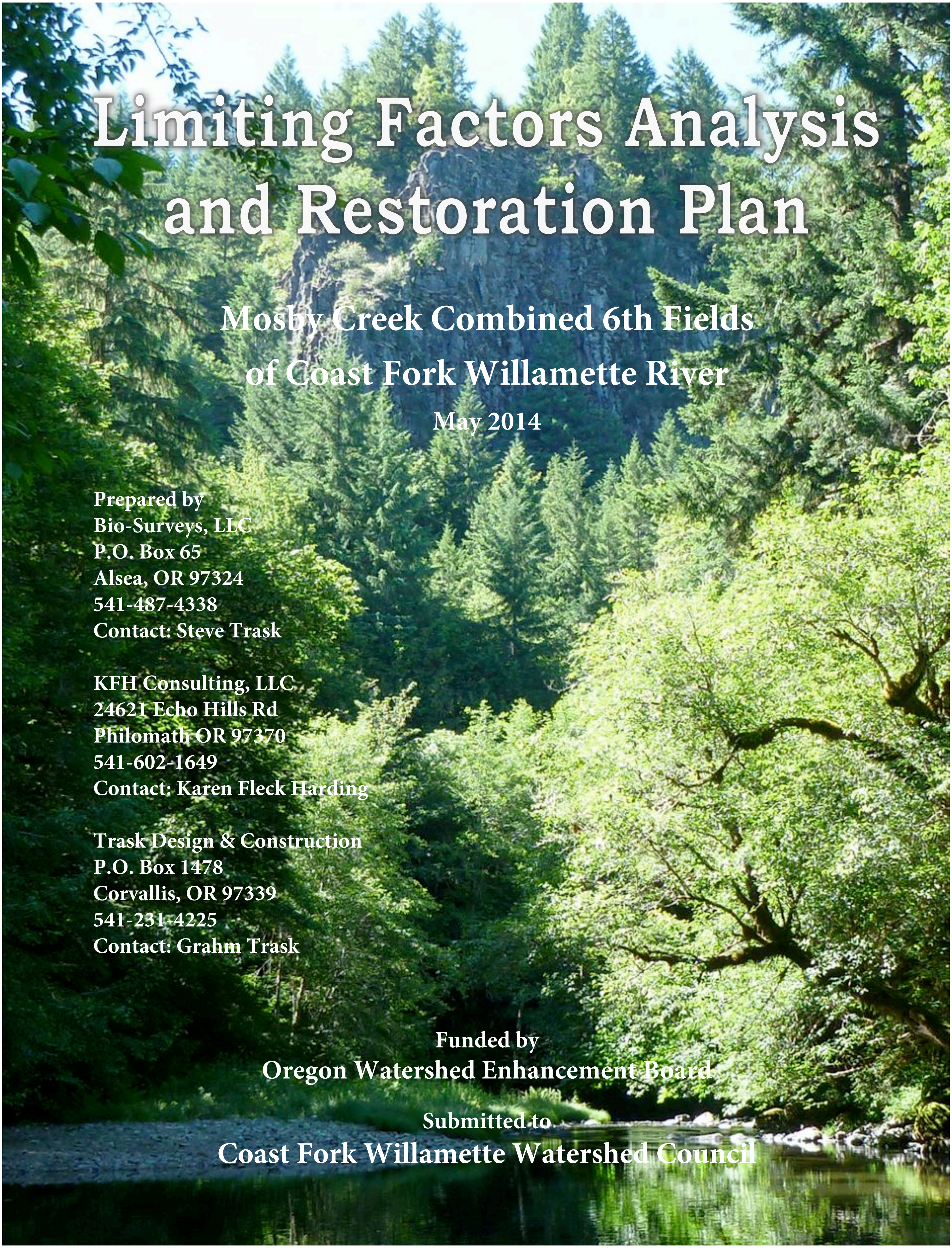

Limiting Factors Analysis and Restoration Plan

Mosby Creek Combined 6th Fields of Coast Fork Willamette River

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Executive Summary
Mosby Cr Limiting Factors Analysis 2013

Purpose
This document identifies the dominant processes and habitat characteristics that currently limit the survival and productivity of salmonids in Mosby Creek, a tributary to the Row River, in the Coast Fork Willamette River subbasin. In addition, the document intends to develop a prioritized list of restoration actions designed to directly address the identified limitation(s).

The Limiting Factors Analysis (LFA) identifies habitat conditions that restrict the success of one or more salmonid life history stages. The plan proposes and prioritizes restoration actions to address these limitations based on the following guiding principles:

- Protect the remnant (core) salmonid populations from extinction.
- Protect the refuge areas that support the core populations.
- Protect life history and genetic diversity.
- Emphasize protection of intact habitats over restoration of degraded habitats.
- Emphasize restoration of ecosystem function over site-specific habitat enhancement.
- Ensure that the habitat needs of all life history phases are supported.
- Ensure connectivity (accessibility) among the habitats needed for all life history stages.
- Ensure that habitat enhancement actions support the natural recovery of the system.

The scale of effort is focused primarily on steelhead / rainbow trout (Oncorhynchus mykiss) and Cutthroat Trout (Oncorhynchus clarki) within a restricted geographic zone, in this case three contiguous 6th field HUCs. The primary attributes evaluated are fish distribution, the abundance and distribution of aquatic habitats, spatial differences in thermal water quality, and historical upslope management activities.

The assessment process relies on responses to a structured set of questions that progressively reveal the status and needs of stream channels in relation to salmonid habitat use. The end product of the analysis is a list of specific needs and actions (prescriptions) prioritized according to their effectiveness at addressing the identified seasonal limitation, urgency, cost, and practicality.

The prescriptions include a mix of strategies involving the recovery or diversification of riparian canopy, passage barrier removal, instream structure placement, supporting beaver dam building activity, sediment reduction, improvements to water quality and protection and conservation strategies.

System overview

Mosby Cr is an undammed headwater tributary of the Row River in the Coast Fork Willamette River watershed. The Mosby Creek sub-basin contains 3 sixth-field HUC's that combine to drain 60,737 acres and contains 22.2 miles of mainstem stream corridor and 28.2 miles of tributary habitat in 30 separate tributary corridors that are utilized by anadromous salmonids (survey did not extend to the end of resident cutthroat habitat) (Figure 1).

The Coast Fork Willamette Watershed has been broadly classified as a Western Cascades geology (Figure 3). The Western Cascades are dominated by deeply weathered, layered, basaltic and andesite lavas and volcaniclastic flows of mostly Miocene age. The steep, highly dissected landscape of the Western Cascades ranges in elevation from 400 to 1800 m and reflects significant erosion by fluvial, glacial, and mass movement processes. The region is typically well-drained, with soils 1–3 m in depth of moderate to high surface hydraulic conductivities grading vertically to shallow subsurface confining layers of clay, saprolite and unweathered bedrock of generally low permeability. Drainage densities are high, averaging 3 km/km2, further reflecting an efficient well-organized drainage system [Wemple et al., 1996]. Western Cascade streams exhibit a much flashier and more variable hydrograph (than High Cascade streams), with winter peak flows that are several orders of magnitude greater than summer base flows. [Tague, C. and G.E.Grant, 2004]

Mosby Cr watershed can be characterized as a pinnate drainage system where many small tributaries join the mainstem at an oblique angle. It also displays a high drainage density, characterized by finely divided networks of streams with short lengths and steep slopes. These small tributaries generally exhibit poor runoff storage capacity, influenced by unfractured competent bedrock substrates. As is typical of drainages dominated by Western Cascades geology, Mosby Cr exhibits winter peak flows that are much greater than summer base flows.

Current stream habitat function is greatly reduced below that of historical levels due to a long list of anthropogenic changes initiated over 150 years ago that continue today. These changes have created a trajectory of channel simplification that will continue without the intervention of upslope and aquatic restoration. Even without a historical reference point for comparing current salmonid abundance, it is safe to conclude that native stocks of anadromous, fluvial and resident salmonids are teetering on the brink of viability in Mosby Cr.

Management practices and flood events

The Mosby Cr subbasin currently functions in response to a long legacy of historical impacts that have shaped its current condition and consequently its future trajectory.

Extended reaches of exposed bedrock in the mainstem of Mosby Cr is a legacy of historical landscape management. A process of anthropogenic events has led to excessive channel simplification in Mosby Cr and resulted in truncating the distribution of aquatic habitats suitable for sustaining robust salmonid populations. It is important to note that the process of simplification began in the mid-19th century when easily accessible old growth riparian conifer was harvested from the entire riparian corridor well into the headwater forks (EF Mosby, MF Mosby). Of all the human caused impacts that have occurred, this would turn out to be the most devastating and have the most long-term crippling impact. The hydraulic processes that eventually unravel aquatic systems were accelerated by the splash damming that removed the ancient wood resources stored anaerobically in deep accumulations of bedload that would have been revealed slowly over time during the process of natural channel meander. When splash damming was used in mainstem Mosby Cr to transport logs to mill sites, large volumes of transient bedload were also whisked out of the system leaving miles of stream corridor scoured to bedrock. To exacerbate the issue of channel degradation, full spanning log jams were removed into the 1970's by federal and state management agencies determined to improve salmonid access to spawning and rearing habitats. It was not until 1971 that the Oregon Forest Practices Act first regulated the removal of riparian timber resources. Prior to this very contemporary law, most riparian corridors continued to be harvested and still only exhibit very young age classes of timber.

The majority of the upper watershed's tributaries (above the confluence of Fall Cr) exhibit a legacy of debris torrents.

Most of the upper Mosby Cr watershed is managed industrial forestland (BLM also has ownership in the upper basin). For the most part, current forest management appears to follow the minimum requirements of the Oregon Forest Practices Act, which do not preserve riparian buffers on Type N (non-fish bearing) streams and limit the regulated buffer width on fish-bearing streams from 50-100 feet, dependent on stream size.

Because proper stream function is highly dependent on the continued contribution of wood resources from just two potential source locations (slope failure or riparian recruitment), the potential exists for upslope harvest activities in Type N streams to deplete the stream corridor of its future large wood resources historically contributed by debris flow. Additionally, alder currently dominates riparian areas once containing mature conifer and there is no economic incentive to reestablish conifer in the riparian corridor. Both of these factors contribute to declining system function because without large conifer pulsing through the aquatic corridor, there are very few other ways that an active channel can remain integrated with its floodplain.

The lower watershed reaches (below the confluence of Fall Cr) are managed for multiple uses including rural residential, agriculture, nursery and woodlot. Management of riparian corridors varies from a mature conifer canopy to fully solar exposed agricultural ownerships. The thermal impacts that dramatically impact the distribution and survival of salmonids in Mosby Cr begin much further upstream and is more tightly linked to the impacts that occurred on managed forest lands in the late 19th and early 20th century than it is to the contemporary impacts of solar exposure in the lower mainstem. Tributaries in the lower mainstem (below the confluence of Fall Cr) are very minor flow contributions during the summer pinch period and are not complicit in exacerbating temperature limitations in the mainstem.

Mosby Cr exhibits a broad channel that is exposed to significant solar influences as it traverses the landscape in a northerly direction. This condition is exacerbated by extensive bedrock exposure that facilitates the exposure and mixing of all water sources (hyporheic, ground water, cool tributary confluences) at every pool tailout. The lack of natural wood in the active channel that would have facilitated bedload storage and protected a hyporheic lens from the influence of direct exposure to air and sunlight ends up being the key missing ingredient from the headwaters to the Row River. The resultant thermal loading accumulates in a downstream progression until portions of the mainstem of Mosby Cr are incapable of rearing salmonid juveniles in the summer because of temperatures that exceed their threshold for growth or survival.

Beaver colonies

Beaver impoundments have the potential to contribute significantly to the restoration of the broken system processes discussed above. They have the capacity to provide thermal refugia in the summer because they are capable of developing a thermocline, they store nutrient rich sediments that support food webs in an otherwise nutrient deficient system, they store water on the floodplain for extended summer release and they alter the gradient in steep mountain streams which results in the retention of spawning gravels. Unfortunately, the role of beaver in the Mosby Cr basin is currently very limited. In 2013, beaver activity was observed in the watershed but the presence of active dams or indications of prior beaver impoundments were observed only on Champion, Smith, Short, and Cow creeks. Legacy beaver flats, particularly on Smith and Short creeks, are not currently being utilized and therefore the regenerative capacity of beaver to restore system function is currently very low. There were only two dams functional and winter stable dams observed all of the Mosby Cr basin, one on Champion Cr and one on Smith Cr.

Status of Fish

Severe temperature limitations documented to RM 18 in the 22.2-mile mainstem reduce the system's capacity for the provision of summer rearing habitat. These conditions create an unquantifiable level of stress on populations of O.mykiss, resident cutthroat and fluvial cutthroat adults migrating to headwater reaches to spawn. The physiological complications associated with spawning and elevated spring temperatures probably exacerbate stress that may impact survival. Both of the field inventories conducted by Bio-Surveys in May and July encountered dead cutthroat (N=10) in mainstem and tributary habitats. This is an unusual encounter during field surveys and worthy of mention in this review. The May encounters involved dead or dying cutthroat of multiple age classes from the 1+ age class to mature adults 4+ and older. Some were pre-spawning mortalities (adults with mature gametes), some were post-spawning mortalities (no gametes and flaccid sperm sacks, observed in the mainstem of Mosby Cr only) and some were not mature spawning individuals (sub adults likely not suffering any reproductive stress).

The most disconcerting mortality observations were the sub adult age classes in tributary habitats with very cool spring flows. There was no obvious explanation for these individuals to be perishing (in one case in Brownie Cr a 1+ cutthroat lying upside down at the bottom of a pool slowly revived when touched). When utilizing the summaries and tools provided by this review you will observe that none of the 30 tributaries exhibited fully seeded or even significant abundances of resident Cutthroat. Even the highest quality habitats in what could be considered reference reaches (Brownie Cr-0.11 cut/sqm, EF Mosby Cr-0.09 cuts/sqm) contained unusually low average densities and an atypical distribution of native cutthroat. There was a total of 593 pools snorkeled during the July 2013 Mosby Cr inventory, just 44% of those pools contained cutthroat. Of the pools that contained cutthroat the average rearing density was just 0.16 fish / sqm of pool surface area. Only 4 of the 262 pools that contained cutthroat exhibited densities near what has been observed as potentially fully seeded densities in many other Willamette basin tributaries (0.7 cuts /sqm). Three of the four fully seeded individual pool densities were observed in pools in Norwegian Cr that displayed a strong upstream temperature dependent migration from the mainstem of Mosby Cr related to elevated summer temperature in the mainstem. There is no doubt that some very atypical vector of stress was at play in the Mosby Cr mainstem and its tributaries that to date is not well understood.

If our brief field surveys encountered this many dead cutthroat (dead fish vanish quickly in a stream environment from scavengers), and the mortalities continued from May through July, then it is likely that the actual cumulative mortalities could be very significant on an annual basis. A baseline inventory such as this Limiting Factor Analysis is designed to highlight dominant processes and significant morphological and biological relationships. In the case of the observed cutthroat mortalities, it would be prudent to conduct supplemental water quality monitoring and / or tissue sampling that targets spring runoff compounds present in, select tributaries.

<u>Steelhead / Rainbow - O.mykiss</u>

No data are available that quantify adult anadromous salmonid escapement into the Mosby Cr basin. However, several pieces of data acquired during the May 2013 foot inventory and the July 2013 snorkel inventory of 50.4 stream miles in Mosby Cr and all of its tributaries shed some light on their current status. A total of 7 winter steelhead redds were documented in the mainstem of Mosby Cr during the May inventory (Figure

10). An adult winter steelhead kelt was also observed at this time. The redds were fresh and averaged 1 sqm in size (Photo 26). It is highly unlikely that these were remnant summer steelhead redds because of their freshness, the May timing and because none of the redds contained any substrate deposition from high winter flow events. During the July 2013 snorkel inventory, 3 summer steelhead adults were observed around RM 9.8 (2 ad clipped, 1 unmarked). This inventory was a 20% sample of all pool habitats and not meant to be an exhaustive effort to quantify adult abundance. In addition, approximately ½ of the high quality deep holding pools that were not encountered in the 20% census were snorkeled (specifically to document adult salmonids) and no other adult salmonids were observed.

Snorkel inventories also encountered a basin wide total of only (87) 1+ and older O.mykiss juveniles in the 20% sample (Figure 14). This observation expanded to a total estimate of 435 pool rearing O.mykiss in 50.4 miles of inventory. To be clear, the snorkel effort did not sample riffle and rapid habitats that would have contained additional O.mykiss. However, when these numbers are compared to almost any other system the Bio-Surveys team has inventoried in 12,000 stream miles, total abundance is so low that the viability of the population is questionable.

In most systems that might contain a native rainbow population, it is common to observe O.mykiss that exceed 200 mm in length (3 yr and older) in the rearing population. There were no O.mykiss that exceeded this size in Mosby Cr. Preliminary indications suggest that the few O.mykiss remaining in the Mosby Cr basin are the progeny of anadromous winter or summer steelhead parentage and not the progeny of resident rainbow. This is not meant to be a definitive analysis of origin but a review of the few clues gleaned from a single years inventory. Additionally, if there had been a well-established resident rainbow population at the time of inventory, there should have been abundant observations of O.mykiss in a wide distribution of high quality habitats that existed in the 30 different tributaries contributing to the mainstem of Mosby Cr. Only 25% of all O.mykiss observed were rearing in tributary habitats. Just 4 of the 30 tributaries (Big Dry, Simpson, Smith and Stell) contained 86% of all tributary rearing O.mykiss. This was a total expanded estimate of 95 O.mykiss parr. O.mykiss juveniles are far less abundant in tributary habitats than in the mainstem. The four tributaries where O.mykiss were observed joined the mainstem of Mosby Cr within its temperature limited reach. Distribution patterns also suggest that upstream temperature dependent migrations from the mainstem were definitively occurring in at least Stell Cr and Smith Cr. Our conclusion based on the abundance and distribution patterns discussed above is that the O.mykiss observed were again, likely the progeny of anadromous summer or winter steelhead spawning in the mainstem.

Spring Chinook Salmon

ODFW fish distribution data suggests that the historical and current range of Spring Chinook Salmon includes portions of the mainstem of Mosby Cr (Figure 6). Rearing habitat is listed as extending 3 miles upstream to approximately the confluence of Kizer Cr. These are juveniles swimming upstream from the mainstem Row River (Ziller). Historical spawning distribution extends to approximately RM 15 near the confluence of Bark Shanty Cr.

RBA snorkel surveys conducted in mid-July of 2013 included a supplemental effort to dive nearly all the potential adult spring Chinook holding holes from the mouth at the confluence with the Row River to the confluence of WF Mosby Cr where the potential for summer holding pool habitat diminishes. This effort was undertaken independently from the 20% snorkel inventory and included utilizing weight belts and fins to get below thermoclines to determine the presence or absence of adult spring Chinook in the system. Some high quality deep pools exist in the system that presented excellent opportunities for observing resting adults. No spring Chinook adults were observed. A possible sighting of 2 adult spring Chinook was documented within the standard RBA inventory but a return visit to that site with the appropriate dive gear for verification, revealed that the 2 fish observed were actually summer steelhead adults.

There were no 0+ age spring Chinook observed within the confines of the 20% snorkel inventory. Typically, most 0+ age spring Chinook would have migrated out of the system soon after emergence as mainstem temperatures in lower Mosby Cr increased to sub lethal levels. However, where spring Chinook are successfully escaping to spawn in other Willamette River tributaries, there is almost always some residual 0+ age rearing observed in high quality thermal refugia along mainstem corridors (hyporheicly fed side channel habitat). None of this residual life history pattern was observed in the 2013 inventory. Not a single 0+ age Chinook was observed. It is unlikely that there are any significant numbers of adult spring Chinook currently spawning in mainstem Mosby Cr based on the results of the 2013 adult and juvenile surveys.

Cutthroat Trout

Cutthroat Trout were present in all 30 tributaries surveyed and the Mosby Cr mainstem to the confluence of the Row River. 29% of all pool-rearing cutthroat were documented in the mainstem (44% of lineal stream miles surveyed and 85% of all pool habitat). This suggests that the majority of the cutthroat production (71%) currently occurs in the tributary habitats during summer low flow regimes even though just 15% of the total pool surface area for rearing exists in these tributaries. The implications of this observation are significant in a system that exhibits severe life history limitations for the survival of salmonids.

Cutthroat Trout exhibit the most diverse array of life history patterns of any salmonid species. We assume that many of these unique survival strategies exist in Mosby Cr and should be considered very critical components of a successful recovery plan. There is no doubt that a resident life history pattern continues to exist, especially in tributary habitats. This was observed by dissecting 15 cm cutthroat found dead in tributary habitats and finding fully developed gametes. These adult cutthroat have likely not migrated out of these tributaries to attain the size and fecundity of their fluvial relatives that were observed in the mainstem at 35 cm.

The absolute numbers of cutthroat rearing in the 50.4 miles of the Mosby Cr system (mainstem and tributaries), would however be considered extremely low when compared to other east side tributaries of the Willamette River (Figure 15). With densities of 73 pool rearing cutthroat /mile for tributary habitats and 39 cutthroat / mile for the Mosby Cr mainstem, we are looking at what would be classified as low rearing densities. Compare the Mosby Cr densities to the range observed in the Molalla River system with 43-192 fish / mile for mainstem reaches and 250 – 617 fish / mile in high quality tributary reaches without intraspecific competition with O.mykiss.

If we look at the mainstem of Mosby Cr as two distinctly different reaches (temperature limited and not temperature limited), the comparison is more descriptive. The lower 17.4 miles of the mainstem with severe temperature limitations was rearing just 13 cutthroat / mile. The upper 4.8 miles of functional summer habitat was rearing cutthroat at 132 fish / mile. This is a number that fits within the observed range of normal expectation.

The status of cutthroat in Mosby Cr should be considered depressed. Severe habitat limitations associated with temperature, natural and anthropogenic barriers to thermal refugia and a high spring / summer mortality rate (10 dead cutthroat were observed during the May habitat survey and the July snorkel survey) combine to fracture the linkages required for sustaining a robust population.

<u>Pacific Lamprey</u>

There were 473 Pacific lamprey redds documented in the 22.2 miles inventory of the mainstem of Mosby Cr mainstem in 2013 (Figure 11). Nine lamprey redds were observed in the 30 tributaries combined. This was a 100% census during a period where only one live pair of spawning lamprey was observed. This suggests that the number of redds observed is likely to represent the bulk of the spawning that occurred in the system. The count included a broad range of redd age classes but surveyors noted that almost all redds regardless of age class were still visible and not inundated by deposition from late winter storm events.

The super-imposition of redds was not a significant issue in quantifying the abundance of redds because spawning gravel was abundant and widely distributed. This reduced the need for aggregate spawning. Brumo (American Fisheries Society Symposium 72:203–222, 2009) found that in wadeable streams with clear water and low flows, redds /adult ranged from 2.1 – 5.5. This would have resulted in an escapement estimate of 75-187 adult lamprey to the mainstem of Mosby Cr.

Concepts and Approach

This document evaluates the relationships between the physical and biological attributes of the Mosby Creek subbasin that drive system function in the basin. The goal is to identify the dominant processes and habitat characteristics that currently limit the production of salmonids in the basin.

The primary product of the analysis is a prioritized list of actions (prescriptions) for removing the limitations in ways that normalize landscape and stream channel function. This analysis is designed to be salmonid centric, with the assumption that most restoration prescriptions that serve the needs of salmonids will positively affect many other aquatic and inner riparian species.

The concept of Anchor Sites is used to specify project goals and focus effort. This process identifies specific sites and conditions within the aquatic system that support the remnant population by determining how these sites (anchors) function together to allow completion of the salmonid freshwater life history.

The Anchor Sites are those portions of the stream network that provide all the essential habitat features necessary to support the complete salmon freshwater life history, from egg to smolt. The required attributes of an Anchor Site designation include optimal gradient (1-2%), potential for floodplain interaction, and presence of spawning gravels. Such sites typically provide the greatest opportunity for boosting or restoring channel conditions that support all of the habitats required for producing salmon to the smolt stage.

The prioritization process thus relies on identifying a Core Area where the remnant population is sustained during all life history stages (incubation, spring, summer and winter). The Anchor Sites within or near the Core Area become the highest priority for restoration. The overarching goal is to conserve and expand the population within the Core Area and to do this in ways that contribute to normalized landscape and stream function.

Subbasin history and current function

The Mosby Creek subbasin has long been the host of resource extraction activities that have impacted many aspects of watershed function. Exploitation of the watershed over the past 150 years has drastically altered historical habitats in the watershed for fish and wildlife. These land use changes have had a negative impact on system function that has resulted in declining salmon and trout populations. Short rotation industrial timber management describes the primary contemporary use of the watershed.

The riparian corridors exhibiting old growth conifer were the first to feel the impact of road building and timber harvest. Debris torrents originating from steep highly dissected landforms were accelerated by upslope timber harvest as it became feasible to work on steeper and steeper slopes. The old growth riparian conifer that used to truncate the runout of these debris flows and allow for the slow pulse of wood and gravel resources through the stream network were removed and large quantities of forest resources (large woody debris and gravel) reached the mainstem and were whisked away during winter flood events. Splash damming was also utilized in Mosby Creek (Figure 5) where large volumes of logs were cached in the stream channel behind a wooden dam and then released with a wall of water in an effort to forward them downstream to a mill or railhead. This activity was powerfully destructive to the native channel morphology. The wall of logs released smoothed and straightened the channel, removing all roughness, sinuosity, stored bedload and legacy wood complexity. The result was a channel scoured to bedrock with no capacity to recover (Photo 1). These dysfunctional channel forms can still be observed today in the mainstem of Mosby Cr, unchanged since their unraveling.

A legacy of debris torrent events is displayed in almost all Mosby Cr tributaries above RM7.5. Landslides are a natural characteristic of this landform and are required to assure the continued proper function of a stream network. However, in Mosby Cr tributaries the frequency of occurrence has been accelerated by the impacts of road construction and timber harvest. Unfortunately, there is little wood delivered by this important vector anymore and stream corridors have simplified from the lack of large woody debris capable of persisting during winter hydraulics.

Stream clearing was a practice utilized in the Mosby Cr mainstem during the 60's and 70's, designed to remove full spanning log jams that were assumed to be impeding adult migrations. The tactic was especially popular on publicly owned lands within the upper tributaries of East, West and Middle Fork Mosby Creek (Photo 176). This management practice was subsequently recognized as detrimental to stream function and was terminated. However, the results have been long lasting and the recovery of that historic wood complexity nearly unachievable.

All of these actions that removed large wood from the riparian and the active channel have created a serious resource deficit that cannot be replaced near term. Mosby Cr has been on a trajectory that is just nearing its end after 150 years of unraveling. The stream continually portrays a loss of function that is swiftly revealed in the low function observed today and discussed in this document.

Results

Core Area

Field assays that included a review of channel morphology, snorkel inventory, temperature loggers and a relational matrix to rank the importance of tributary habitats have resulted in the identification of a functional Core. The Core extends from RM 10.9

(confluence of Rock Cr) upstream 11.3 miles to the confluence of the EF and MF of Mosby Cr (Figure 7). Reflecting on the definition of the Core area, "the remnant population can be sustained during all life history stages (incubation, spring, summer and winter)". Restoration actions within the Core Area have the highest likelihood of a quantifiable impact on the factors limiting salmonid production.

Anchor Sites

Ten Anchor Sites were identified within the Mosby Cr sub-basin (Figure 7). Nine of these Anchor Sites exist within the identified Core Area, five of which are in the mainstem and four are located within tributaries that contribute to the Core Area -- Palmer Cr (1), Brownie Cr (1) and WF Mosby Cr (2). The remaining anchor outside the Core Area exists in Smith Cr.

Basin-wide limiting factors

This assessment was targeted toward identifying the seasonal habitat resource that currently most limits salmonid production in the larger Mosby Cr basin. Summer stream temperatures in the lower 18 miles of mainstem Mosby Cr exceed ODEQ standards for juvenile salmonids for nearly four consecutive months between June and mid September (Figure 19). With 81% of the mainstem summer pool habitat classified as temperature impaired, it is clear that the primary seasonal habitat limitation for salmonids is the abundance of functional summer pool habitat. This position is strengthened by the fact that many of the 30 contributing tributaries are inaccessible during pinch period summer flows because of natural barriers at their confluence or intermittent stream flows during the summer pinch period.

Habitat inventories conducted by Bio- Surveys, LLC in 2013 have identified four primary causes for summer habitat deficiencies:

1) The lower 18 miles (of 22.2 total miles) mainstem Mosby Cr are temperature impaired due to extensive solar exposure and lack of protected hyporheic flows as a result of the historic events that left miles of mainstem stream corridor scoured to bedrock.
2) The aquatic corridor is deficient in large woody debris that historically retained transient bedload providing a mechanism for protecting hyporheic flows from the influence of air and sun.
3) Mainstem side channels are consistently linked to summer flow with high temperature profiles (this is also a result of the lack of wood complexity that would have formed inlet jams and delinked side channels from the mainstem).
4) Many tributary flows are naturally limited due to their small drainages areas and the underlying geology that displays unfractured competent bedrock with low water storage potential.

Large woody debris (LWD) and beaver dams are the primary mechanisms for trapping, storing, sorting and pulsing gravel resources through a stream network and for building and retaining floodplain interaction. The floodplain storage of winter flows from the channel aggradation initiated by wood and beaver dams extends late season flows, contributing to cooler summer stream temperatures. Gravel bedload and increased channel roughness created by large woody debris increases hyporheic exchanges that dissipate heat through groundwater mixing. Currently, the lack of active beaver dams in the basin reduces the capacity of the system to provide ground water storage and extend summer flow profiles.

The extremely low levels of instream wood are a result of the legacy of splash damming, stream cleaning and the complete exhaustion of riparian old growth wood resources for future recruitment. The riparian corridors of nearly all the important salmonid producing mainstem reaches and tributaries were lost before 1971, when changes in Oregon Forest Practices provided for the retention of riparian buffers.

Site-specific limiting factors

While summer rearing habitat has been identified as the primary seasonal limitation for the Mosby Cr basin as a whole, this limitation does not apply to every stream segment. So to expand the function of the whole it will often require restoration action in areas where summer temperatures are not the primary limitation. Addressing the cumulative impact of the pieces (tributaries) results in shifting the trajectory of the whole (mainstem).

Important examples of site-specific limiting factors are the following:

1) The upper 4.2 miles of mainstem Mosby Cr, is the only contiguous segment of mainstem Mosby Cr that exhibited summer stream temperatures adequate for supporting salmonid rearing during the summers of 2012 and 2013. The RBA snorkel inventory verified that salmonids were concentrated in the mainstem within this zone. Within this reach, the primary seasonal habitat limitation is the lack of spawning gravel, not elevated summer temperatures. So addressing the lack of spawning gravel here in the heart of the Core Area (boulder weirs and wood structures), not only strengthens the stronghold but begins to accumulate the bedload required to protect a cool hyporheic lens progressing downstream (directly addressing the basin scale primary limitation).

    - W Fk and Brownie provide some of the highest quality incubation habitat for native cutthroat.
    - A top-down approach to riparian restoration addresses stream temperatures in an effort to extend the zone of summer habitat as far downstream as possible.
    - Protection of the cold flows that tributaries contribute to this reach to support mainstem temperatures is critical.

- Juvenile barrier above Brownie Cr terminates upstream juvenile migrations to this functional reach.

2) The middle sixth-field of Mosby Cr is the location where the most abundant mainstem spawning gravels are currently located and where it is expected that the highest production of fry would occur. The largest sources of gravel resources contributing to the middle mainstem are originating in several tributaries (Clearing, Cedar, Big Dry and Brownie creeks). Supporting the retention of these resources, by assuring adequate woody debris densities, to allow them to naturally pulse into the system rather than torrent through and out of the mainstem is a priority for the long-term retention of these spawning resources.

   - Given that the mainstem is temperature-limited throughout this reach, access to lower ends of side channels that are receiving hyporheic flows to provide summer refugia, is critical.
   - Delinking side channel habitat from the mainstem provides a foundation for the development of the thermal refugia provided by hyporheic flows.
   - The tributaries in this reach with good summer flow (Rock, Palmer, Cedar, and Stell) play a key role in providing the needed flows to support cooler mainstem temperatures.
   - Beaver impoundments in this reach (Cow, Palmer) play a role in sustaining flows through the pinch period of the summer.

3) Elevated temperatures in the lower mainstem Mosby Cr make this extensive pool habitat unusable during the summer. This habitat disconnect is further complicated by multiple juvenile barriers on the mainstem that exist at RM 2.7, RM 3.7 and RM 8 (Figure 12), effectively stopping temperature dependent upstream juvenile migrations. Higher abundance of the 0+ age class in the lowest tributaries of Mosby indicate that Smith, Perkins and Simpson creeks may be providing refugia for juveniles trapped between these migration barriers. Stream temperatures at the mouth of Simpson Cr were as much as 11 deg F cooler than the mainstem near its confluence during 2013 (Figure 25). Perkins Cr has some of the highest abundance of 0+ trout of all the tributaries, though pinch period flows are relatively low. From a restoration standpoint, Smith, Simpson and Perkins creeks play a key role as the tributaries where salmonids can access summer pool habitats in the lower 10 miles of temperature compromised mainstem Mosby Cr, supporting an alternate life history to migrants that remain in mainstem habitats moving up to 18 miles upstream as stream temperatures rise through the summer. Because the population of salmonids in the Core is so depressed (above the confluence of Rock Cr), encouraging life history diversity in the lower Mosby Cr 6th field has become a secondary priority in terms of restoration actions until the Core can be stabilized.

4) Tributaries with an abundance of gravel bedload resources (particularly Clearing, Cedar, Big Dry, and Brownie creeks) consistently display a lack of well-sorted spawning gravels suitable for cutthroat. This suggests that restoration prescriptions for this important segment of the Core Area should focus on restoration actions that trap and sort mobile substrates to boost gravel retention and protect hyporheic flows.

5) Low summer pinch-period flows resulting in dry channels and bedrock or cobble lifts at the point of entry from the mainstem complicate access to multiple tributaries (Cedar, Brownie, Big Dry, Gray, Shea, Miles creeks) for upstream movement of juveniles seeking cold-water refuge. This suggests that restoration prescriptions that support water storage on the floodplain and boost channel aggradation in the vicinity of these confluences is important for providing access to highly critical thermal refugia. Of the highest importance are those tributaries in the temperature limitation transition zone of mainstem Mosby Cr (Cedar, Brownie, Shea creeks).

Adult escapement and juvenile seeding

Our review of the quantity, quality and distribution of spawning gravels and winter habitat makes it clear that the basin currently provides an abundance of viable spawning and winter rearing habitat. Restoration actions solely focused on providing more of these habitat types will have no impact on current salmonid abundance. There is currently more available than is being utilized.

Adult steelhead escapement is currently so insignificant that even functional habitat segments in the basin are not seeded to capacity. The spawning gravels quantified in the system (Figures 8-9) could currently support approximately 476 spawning pairs assuming a 1:1 male to female ratio and 1.5 redds per female.

Although resident cutthroat are widely dispersed and surviving in the tributary habitats, their meta-population is suffering from the decline of the fluvial life history strategy related to mainstem thermal barriers.

Addressing the constraints

We can summarize the status and needs of the Mosby Creek salmonid populations as follows:

1) Salmonid productivity in the Mosby Cr basin is limited primarily by elevated summer temperature profiles that radically truncate the abundance of usable summer habitat and cripples access to these isolated habitats.
2) Riparian efforts to address this temperature limitation will only be meaningful if they occur in the middle and upper 6^{th} fields (Core Area) and if they are prioritized from the top down.

3) Actions that support and enhance the remnant populations are priority.
4) Restoration efforts should focus within the identified Core Area for achieving quantifiable results.
5) Restoration efforts should focus on the restoration of the most fundamental processes for capturing and storing migratory bedload (boulder weirs, large wood augmentation).
6) Population stability requires genetic diversity. Recognizing and enabling variable life histories (survival strategies) is critical for supporting the salmonid population.

These are the paramount guidelines of a successful recovery plan designed to stabilize the fragile population as long-term restoration work is pursued. Under such a coordinated program, improved smolt production would build a basin-wide salmon population that sustains itself generation to generation.

Using this report

Implementing the prescriptions

Utilizing a basin scale perspective, the report steps through the conditions and constraints that control channel functionality at each anchor site. It then establishes what actions will relieve these constraints in ways that contribute to the expansion of the Core Area and to improvements in whole-system health and functionality.

The prescribed actions are collated into a table of prioritized prescriptions presented in Appendix 5, with locations of the proposed actions presented in map form as well. As more specific information is needed about a prescription, refer to the text that describes the Anchor Site or treatment reach, its problems, and how they may be addressed.

Note that the prescription table can be copied to MS Excel, where sort and filter operations can be used to create organized short-lists of prescriptions.

Complexity and localization of issues

This report examines the physical and biological interactions that form a complex stream system. It assumes that a high level of inter-dependence exists among habitats that extend from the low gradient mainstem to the high gradient headwater reaches. Emphasis is placed on how current and historical conditions have broadly reduced salmonid habitat throughout the system.

It should also be understood that limitations defined for the whole sub-basin are not always those operating at the individual tributary or reach level. Both scales of concern have been considered in defining the prescriptions and their order of implementation. It is the localized conditions that occupied most of the field and analytic work, and which the report documents. The reader should refer to the body of the report to access information about specific sites and prescriptions.

Order of restoration actions

A limiting factor analysis establishes an ordered progression of actions, not a single-effort solution. Once significant progress has been made toward resolving the seasonal limitations addressed by Priority 1 prescriptions, attention to Priority 2 prescriptions should then logically begin. However, it is understood that the orderly process that this suggests may not occur. The realities of landowner cooperation, funds acquisition, and physical constraints may prevent an entirely orderly process. It is also true that the effects of implementing the Priority 1 actions may create responses from the system that lead to re-prioritizing or modifying the remaining prescriptions. Priority levels should be thought of as a strong set of guidelines, and not as a rigid set of directions.

Presentation of data, maps and photographs

All of the data summaries, charts, maps, and photographs are presented within the appendices. Please refer to the appendices listed in the Table of Contents as they are referenced in the text of the report.

Note: In the electronic version of the report, it is possible to use the Table of Contents as a hot link to a topic. Hold the Control key down and left-click the heading listed in the Table of Contents.

Acronyms used

- AQI – Aquatic Habitat Inventory (Oregon Dept of Fish and Wildlife)
- CFWWC – Coast Fork Willamette Watershed Council
- DEQ – Department of Environmental Quality
- DO – Dissolved Oxygen
- ESU – Evolutionarily Significant Unit
- HUC – Hydrologic Unit Code
- LFA – Limiting Factor Analysis
- LWD – Large Woody Debris
- nd – no data
- ODEQ – Oregon Department of Environmental Quality
- ODF – Oregon Department of Forestry
- ODFW – Oregon Department of Fish and Wildlife
- OFP – Oregon Forest Practices
- RBA – Rapid Bio-Assessment Inventory
- RM – River Mile
- SRS – Stratified Random Sample
- USFS – United States Forest Service
- WP – waypoint – describing GPS data point

Table of Contents

Introduction

Goals

This document evaluates the physical and biological attributes of the Mosby Creek basin, which together describe the relationships that drive system function in the basin. The goal of the project is to identify the dominant processes and habitat characteristics that currently limit the production of salmonids in the basin. The approach taken is a Limiting Factors Analysis (LFA) that focuses on the seasonal habitats utilized by both adult and juvenile salmonids. The study is thus a limiting seasonal habitat analysis.

Mosby Cr empties into the Row River, below Dorena Reservoir. Row River joins the Coast Fork Willamette River approximately 5 miles downstream of the confluence with Mosby Cr. Upper Row River, above the confluence with Mosby Cr, is dammed to form Dorena Reservoir. The Coast Fork Willamette River is dammed to form Cottage Grove Reservoir. Mosby Creek is the only free flowing primary tributary to the Coast Fork Willamette River. The basin drains an area of 60,737 acres and comprises 14 percent of the Coast Fork Willamette Watershed. The basin contains 50 miles of stream corridor accessible to anadromous salmonids and an unquantified subset of additional stream miles that exhibit resident cutthroat use only. The study area includes all of mainstem Mosby Cr and its tributaries (Figure 1).

The primary product of the analysis is a prioritized list of actions (prescriptions) for removing habitat limitations in ways that normalize landscape and stream channel function. The LFA protocol was designed to evaluate the seasonal habitat requirements of large anadromous salmonids (steelhead). This was primarily because it is extremely difficult (and highly variable) to attempt to quantify spawning gravel resources for spring Chinook or Cutthroat Trout. Therefore we make the assumption in this analysis that the restoration prescriptions outlined in this review would have positive and not negative effects on the other salmonid species of concern in the Mosby Cr subbasin (spring Chinook, Cutthroat Trout).

The analysis relies heavily on the concepts of Core Area and Anchor Site. These are described in more detail below.

The Limiting Factors Analysis approach

Documentation

The modified LFA restoration and assessment protocols used in developing the plan are adapted from the approach described in "MidCoast Limiting Factors Analysis, A Method for Assessing 6th field Subbasins for Restoration", available at
http://www.midcoastwatershedscouncil.org/Assessments/Methodology.pdf
It is highly recommended that a review of this document accompany the use of the LFA report because it describes the processes and relationships that support the conclusions

developed by the analysis. More specifically, the document provides detailed information on assessment, nomenclature, prioritization rationale and methodology.

This document evaluates the physical and biological attributes of the Mosby Creek subbasin, which together describe the relationships that drive system function in the basin. This analysis combines three separate 6^{th} field HUC subdivisions (Lower, Middle and Upper Mosby Cr) into a single natural geographic subdivision. The subbasin contains approximately 50 miles of stream corridor that was utilized by anadromous salmonids (O.mykiss) during the 2013 RBA snorkel inventory conducted by Bio-Surveys.
The goal is to identify the dominant processes and habitat characteristics that currently limit the production of salmonids in the subbasins using a limiting seasonal habitat analysis (LFA) approach.

The study area includes all of mainstem Mosby Cr and its tributaries above its confluence with the mainstem Row River, at approximately RM 5, near the town of Cottage Grove (Figure 1). The Mosby Creek sub-basin drains an area of 60,737 acres. In this case, the larger geographical area represented by the three combined 6^{th} fields (lower, middle and upper Mosby Cr) represents the type of watershed subunit that the LFA methodology is designed to effectively interpret. These three 6th fields exhibit a complex interactive relationship that corporately supports resident, anadromous and fluvial life history strategies.

Core Area and Anchor Site concepts

The concepts of Core Area and Anchor Site are used to describe and highlight the physical locations of habitats critical for restoring ecosystem function and focus the restoration planning effort. Definitions of these terms direct the investigation in identifying the specific sites and conditions of the aquatic system that support the remnant population by determining how these sites function together to allow completion of the freshwater life history of multiple salmonid species.

Core Area: A contiguous section of stream channel or tributary network where juveniles rear on a consistent (year to year) basis. The assumption is made that habitat linkages exist within the core area that are critical for addressing the fragmentation of habitats observed on the basin scale.

Anchor Site: A smaller subdivision of the Core Area, which provides all the essential habitat features necessary to support the complete freshwater life history of the species. The required attributes of an Anchor Site designation include optimal gradient (1-2%), potential for floodplain interaction, and the presence of spawning gravels. These sites typically provide the greatest opportunity for boosting or restoring channel conditions that support all of the seasonal habitat needs of most salmonid species.

The prioritization process thus relies on identifying the Core Area where the remnant population is sustained, and then identifying the habitats within the Core Area that function as Anchor Sites. The overarching goal is to conserve and expand the population within the Core Area, and to do this in ways that contribute to normalized landscape and stream function.

Data Sources

The limiting habitat approach considers the amount of spawning gravel and the availability of spring, summer, and winter rearing habitats to determine where the bottleneck for salmonid survival and productivity exists.

Data were also obtained from the following sources:

- Rapid Bio Assay snorkel surveys of juvenile salmonids conducted by Bio-Surveys, LLC in July 2013. These surveys also collect physical habitat data.
- Topographic maps, which were used to identify and characterize valley morphologies that create stream habitats suitable for salmon rearing.
- Temperature data collected by the Coast Fork Willamette Watershed Council.
- 2008 ODFW Aquatic Habitat Surveys
- ODFW Oregon Fish Habitat Distribution – Current and Historical Spring Chinook Salmon File Geodatabase Feature Class
- Miller, R (2010) “Is the Past Present? Historical Splash-dam Mapping and Stream Disturbance Detection in the Oregon Coastal Province”.
- Tague, C and Grant, G (2004) A geological framework for interpreting the low-flow regimes of Cascade streams, Willamette River Basin, Oregon.
- Bio-Surveys, LLC physical habitat inventory conducted for the LFA in May2013. This inventory included quantification of all spawning gravel resources (steelhead only) in the mainstem and 30 tributaries of Mosby Cr. This survey also developed a comparative matrix to highlight the differences in rearing potential provided by the many tributaries. It is important to know that the pool surface area calculations presented in this document were derived from stream flows observed in mid-May 2013.

Habitat conditions and summer temperature profiles are compared to an overlay of summer juvenile salmonid distribution. These data layers provide a real world display of interaction between populations and physical habitat variables. These distribution and abundance layers (fish, habitat, gravel and temperature) then form the basis for the decision-making matrix that determines the seasonal habitat limitation.

It is important to clarify that the modified LFA exercise is not capable of evaluating all existing density dependent factors and their impacts on seasonal survival rates. Habitat quality, levels of sedimentation, intra and inter-specific competition and similar potentially important factors are not included in the analysis.

Integrating assessment outputs with other resources

We utilize all of the information consolidated in the assessment to specify both short-term and long-term issues of concern that when addressed are expected to restore functional processes and boost salmonid production. Professional judgment is necessarily used during the process of identifying the most important limiting factors that can be successfully addressed.

Salmon bearing potential of the Mosby Creek Sub-Watershed

Geomorphology and geology

Recognizing the underlying geology of the system assists in understanding the morphology of the basin that drives the location and abundance of seasonal salmonid habitats. The following is provided as a discussion of formative processes that may have influenced the current geomorphology of the Mosby Cr basin.

The underlying geology of the Mosby Cr basin is primarily volcanic tuff with harder rock exposed on ridges as andesite from the Little Butte Volcanic series (Figure 4). The topography of the upper Mosby Cr basin exhibits a highly dissected landform and has generated frequent debris flows in many of the contributing tributaries of Mosby Cr. Terrain of this form can have a greater potential for landslides where slopes are greater than 70%. Removal of the root strength that stabilizes these slopes can accelerate the rate of failure. Over time, the hollows left by a slide slowly refill with soil as rock weathers before they repeat the slide process. Replenishment of this resource can take hundreds of years. An additional source of weathered rock that can deliver to the stream channel is derived from the many exposed rock scarps present on ridge tops and steep hillslopes.

The very low gradient broad floodplain that extends far into the upper mainstem appears to be the result of historic depositions built up behind a mainstem debris blockage that occurred at a downstream pinch point (Cover Photo, just below the confluence of Palmer Cr) as deep-seated earth flows moved across the lower mainstem valley bottom to form the low gradient channel that is exhibited today in the upper reaches of Mosby Cr.

Over time, river flows have carved through this deposition. Naturally occurring instream wood functioned historically to capture bedload and maintain stream channel gradients, thus controlling downcutting of Mosby Creek into this depositional plain. Loss of instream wood has resulted in downcutting, termination of connectivity between mainstem and tributary channels and exposure of bedrock in the main channel (*Personal communication, Karen Bennett, USFS).*

The tributary system

The Mosby Creek sub-watershed contains 22.2 miles of mainstem channel and 28.2 miles within 30 tributaries, that when combined describe the extent of anadromous salmonid distribution within the three Mosby Creek combined 6th fields (Figure 1). These thirty tributaries vary significantly in their capacity to provide spawning and rearing habitats for salmonids. This issue becomes important in the following discussions of system function and how to prioritize actions designed to address the identified limitations. An overarching consideration is that within the tributaries, based on the distribution of salmonids observed in the 2013 RBA, we would be considering habitat enhancement for only Cutthroat Trout.

It is important to inject that actions prescribed in tributary habitats are critical for improving water quantity and quality to the mainstem where summer temperature limitations impact all salmonid species.

There are many additional 1st, 2nd, 3rd and 4th order tributaries that contribute flow to the mainstem at least seasonally, but do not provide significant habitat for salmonids due to their limited habitat capacity, high gradient and/or natural migration barriers.

Subbasin history and current function

Management and high flow effects

The Coast Fork Willamette watershed historically supported spring Chinook, O.mykiss and Cutthroat Trout. It contained a broad diversity of habitats, ranging from small, steep mountain streams to low-gradient stream valleys to the lowland floodplains of the Row and Willamette Rivers. The dramatic decline in all species of salmonids in the watershed is not due to just one or even several independent factors, but rather to a complex interplay of activities that have degraded habitats used at specific times during the life histories of these fish. The Mosby Cr subbasin currently functions in response to a long legacy of historical impacts that have shaped its current condition and consequently its future trajectory.

The extent of exposed bedrock in the mainstem is indicative of the long-term events that have caused channel simplification. It is important to note that the process of simplification began in the mid-19th century with the removal of all riparian old growth conifer. Instream wood resources were continually reduced by the splash damming used to transport logs to mill sites and by the more contemporary effort by federal and state agencies to improve spawning access that removed the remaining full spanning log jams. Riparian corridors didn't receive any protection from harvest until the Oregon Forest Practices Act was enacted in 1971. Stream and riparian corridors in Mosby Cr have been reduced to their simplest form and no longer function to provide the quantity and quality of aquatic habitat required for a supporting a robust population of any salmonid species.

The 2008 ODFW Aquatic Habitat Survey for Mosby Cr documented the quantity of bedrock within the active channel as a percent of all substrates observed. With the exception of a single 0.25-mile reach, all 19 survey reaches (total of 36.5 miles) exhibited between 50% and 100% bedrock. Twelve of the survey reaches exhibited bedrock of 85% or more.

Simultaneously, many upper watershed tributaries (Rock, Palmer, Clearing, Cedar, Big Dry, Dahl, Gray Shea, Lilly) exhibit abundant gravel resources, much of which was deposited by debris torrent events in 1964. These gravel resources are rapidly pulsing out of the system from a lack of adequate woody debris.

In the late 1960's, in response to the debris flows caused by the 1964 floods, state and federal agencies in charge of managing fish resources determined that the massive wood jams recruited to Oregon Coast Range stream channels were having a deleterious effect on anadromous fish populations by denying adult salmon access to their historical range for spawning and rearing. This led to the removal of log jams, a practice that lasted nearly a decade and accelerated the unraveling of functional channel forms. This resulted in the simplified channel conditions that are responsible for a large portion of the temperature limitation observed today (no capacity for bedload storage to protect a cool hyporheic lens). This legacy of "stream-cleaning", removal of large woody debris, is most clearly exhibited on publicly owned lands within the upper tributaries of East, West and Middle Fork Mosby Creek (Photo 176).

The majority (about 90%) of the land within the Mosby Cr watershed is managed for timber. The US Bureau of Land Management manages 30% of the forest resource. A single private industrial ownership manages 65% of this resource land; other private industrial corporations manage about 5% of the resource (Figure 2).

Most of the upper Mosby Cr watershed is managed industrial forestland (BLM also has ownership in the upper basin). For the most part, current forest management appears to follow the minimum requirements of the Oregon Forest Practices Act, which do not preserve riparian buffers on Type N (non-fish bearing) streams and limit the regulated buffer width on fish-bearing streams from 50-100 feet, dependent on stream size.

Because proper stream function is highly dependent on the continued contribution of wood resources from just two potential source locations (slope failure or riparian recruitment), the potential exists for upslope harvest activities in Type N streams to be depleting the stream corridor of its future large wood resources historically contributed by debris flow. Additionally, alder currently dominates riparian areas once containing mature conifer and there is no economic incentive to reestablish conifer in the riparian corridor. Both of these factors contribute to declining system function because without large conifer pulsing through the aquatic corridor, there are very few other ways that an active channel can remain integrated with its floodplain.

The lower watershed reaches (below the confluence of Fall Cr) are managed for multiple uses including rural residential, agriculture, nursery and woodlot. Management of riparian corridors varies from a mature conifer canopy to fully solar exposed agricultural ownerships. The thermal impacts that dramatically affect the distribution and survival of salmonids in Mosby Cr begin much further upstream and are more tightly linked to the impacts that occurred on managed forest lands in the late 19th and early 20th century than to the contemporary impacts of solar exposure in the lower mainstem. Tributaries in the lower mainstem (below the confluence of Fall Cr) are very minor flow contributions during the summer pinch period and are not complicit in exacerbating temperature limitations in the mainstem.

Mosby Cr exhibits a broad channel that is exposed to significant solar influences as it traverses the landscape in a northerly direction. This condition is exacerbated by a bedrock-dominated channel that facilitates the exposure and mixing of all water sources (hyporheic, ground water, cool tributary confluences) at every pool tailout. The lack of natural wood in the active channel that would have facilitated bedload storage and protected a hyporheic lens from the influence of direct exposure to air and sunlight ends up being the key ingredient missing from the headwaters down to the Row River. The resultant thermal loading accumulates in a downstream progression until portions of the mainstem of Mosby Cr are incapable of rearing salmonid juveniles in the summer because of temperatures that exceed their threshold for growth or survival.

In a simplified stream network lacking instream wood complexity, high winter flows typically limit over-winter survival of salmonid parr. However, in the Coast Fork Willamette complex of streams that includes Mosby Cr, well-distributed low gradient winter rearing habitat exists in a complex of anchor habitats within the identified Core area. For species such as the Pacific lamprey and fluvial cutthroat, off channel habitats in the Row and Coast Fk Willamette rivers act as a sink for juveniles displaced from upstream reaches during high winter flow events. This vast area of potential winter habitat is situated within 22 miles or less of headwater reaches.

Based on this information, we believe that the abundance of functional winter habitat currently plays a relatively minor role in controlling the survival of salmonids produced within Mosby Cr. This conclusion does not imply that efforts to improve winter habitats within the Mosby Cr basin would be of no value. Our ultimate focus should be on creating conditions within the Mosby Creek subbasin that support a complete life history pattern adapted to the subbasin's physical and climatological characteristics. The focus in this document is to address the primary seasonal habitat limitation first.

Settlement and related human effects

The Mosby Creek subbasin has long been the host of resource extraction activities that have impacted its lands and waters. European settlement and exploitation of the watershed over the past 150 years has included logging, road building, erosion control, flood protection, gravel mining, small-scale farming, and residential development. All of these uses have resulted in simplification of the stream corridor. These activities have drastically altered historical stream and floodplain habitats in the watershed for both fish and wildlife, and are at least partially responsible for the low abundances of salmonids rearing in the system today.

A legacy of splash damming on mainstem Mosby Cr was documented in the 2010 thesis prepared by Rebecca R. Miller in the mid-reach of Mosby Cr near the Palmer Cr confluence (Figure 5). Splash damming is suggested to have an immediate and legacy effect on channel incision, less wood and severe gravel scouring downstream of the dam due to high magnitude and frequent flood flows from splash damming activity that increased erosion and wood transport. *International Pacific Salmon Fisheries*

Commission 1966, Napolitano 1998.

Historically, and contemporarily, timber extraction is the primary land use within the Mosby Cr watershed. Early timber harvests were focused in the valley bottoms where access was easiest. Around the 1950's, it became more feasible to work on steeper slopes and the harvest extended to the upper reaches of the watershed. Debris torrents originating from the steep, highly dissected landscape in the upper watershed was accelerated by these harvests.

Prior to enactment of the Oregon Forest Practices Act in 1971, there was no regulation on timber harvest within riparian corridors. Most of the old western red cedar and Douglas fir that once dominated riparian corridors in the watershed was removed. The BLM owned reach in EF Mosby Cr provides a reference for the historic condition that used to exist in the upper watershed (Photo 185). Most other riparian areas naturally regenerated to deciduous vegetation with higher growth rates that crowded out the regeneration of conifer species. Historic riparian harvest has left stream corridors with no persistent wood resource to recruit to the active channel to maintain a complex channel form and retain mobile bedload.

Beaver colonies

The pinnate stream morphology and the underlying geology of this basin suggest that beaver probably played a limited historic role in the provision of ponded habitat for summer and winter rearing of salmonids. Beaver ponds are the only other form of channel complexity (other than LWD) capable of storing nutrient-rich sediments, storing water on the floodplain and increasing floodplain connectivity.

The role of beaver in the Mosby Cr basin is currently very limited. In 2013, a total of only six beaver dams were observed within the Mosby Cr system. Beaver activity was observed in other reaches of the watershed but the presence of active dams or indications of prior beaver impoundments were observed only on Champion, Smith, Short, and Cow creeks. Legacy beaver flats, particularly on Smith and Short creeks, are not currently fully utilized and dams are not sufficiently winter stable to impound large surface areas capable of storing winter rains on floodplain terraces for extended delivery into the summer. Brownie Cr displays the channel morphology that beaver would be expected to occupy. However, no beaver activity was observed in this drainage.

Current status of salmonids

<u>Steelhead / Rainbow - O.mykiss</u>

No data are available that quantify adult anadromous salmonid escapement into the Mosby Cr basin. However, several pieces of data acquired during the May 2013 foot inventory and the July 2013 snorkel inventory of 50.4 stream miles in Mosby Cr and all of its tributaries shed some light on their current status. A total of 7 winter steelhead redds were documented in the mainstem of Mosby Cr during the May inventory (Figure

10). An adult winter steelhead kelt was also observed at this time. The redds were fresh and averaged 1 sqm in size (Photo 26). It is highly unlikely that these were remnant summer steelhead redds because of their freshness, the May timing and because none of the redds contained any substrate deposition from high winter flow events. During the July 2013 snorkel inventory, 3 summer steelhead adults were observed around RM 9.8 (2 ad clipped, 1 unmarked). This inventory was a 20% sample of all pool habitats and not meant to be an exhaustive effort to quantify adult abundance. In addition, approximately ½ of the high quality deep holding pools were snorkeled that were not encountered in the 20% sample (specifically to document adult salmonids) and no other adult salmonids were observed.

Snorkel inventories also encountered a basin wide total of only 87 1+ and older O.mykiss juveniles in the 20% inventory (Figure 14). This was an expanded estimate of 435 pool rearing O.mykiss in 50.4 miles of inventory. To be clear, the snorkel effort did not sample riffle and rapid habitats that would have contained additional O.mykiss but when these numbers are compared to almost any other system the Bio-Surveys team has inventoried in 12,000 stream miles, total abundance is so low, that the viability of the population is questionable.

In most systems that might contain a native rainbow population, it is common to observe O.mykiss that exceed 200 mm in length (3 yr and older) in the rearing population. There were no O.mykiss that exceeded this size in Mosby Cr. Preliminary indications suggest that the few O.mykiss remaining in the Mosby Cr basin are the progeny of anadromous winter or summer steelhead parentage and not the progeny of resident rainbow. This is not meant to be a definitive analysis of origin but a review of the few clues gleaned from a single years inventory. Additionally, if there had been a well-established resident rainbow population at the time of inventory, there should have been abundant observations of O.mykiss in a wide distribution of high quality habitats that existed in the 30 different tributaries contributing to the mainstem of Mosby Cr. Only 25% of all O.mykiss observed were rearing in tributary habitats. Just 4 of the 30 tributaries (Big Dry, Simpson, Smith and Stell) contained 86% of all tributary rearing O.mykiss. This was a total expanded pool estimate of just 95 O.mykiss parr. This suggests that O.mykiss juveniles are much poorly represented in tributary habitats than in the mainstem. The four tributaries where O.mykiss were observed joined the mainstem of Mosby Cr within it temperature limited reach. Distribution patterns also suggest that upstream temperature dependent migrations from the mainstem were definitively occurring in at least Stell Cr and Smith Cr. Our conclusion based on the abundance and distribution patterns discussed above is that the O.mykiss observed were again, likely the progeny of anadromous summer or winter steelhead spawning in the mainstem.

Spring Chinook Salmon

ODFW fish distribution data suggests that the historical and current range of Spring Chinook Salmon includes portions of the mainstem of Mosby Cr (Figure 6). Rearing habitat is listed as extending 3 miles upstream to approximately the confluence of Kizer Cr. These are juveniles swimming upstream from the mainstem Row River (Ziller). Historical spawning distribution extends to approximately RM 15 near the confluence of Bark Shanty Cr.

RBA snorkel surveys conducted in mid-July of 2013 included a supplemental effort to dive nearly all the potential adult spring Chinook holding holes from the mouth at the confluence with the Row River to the confluence of WF Mosby Cr where the potential for summer holding pool habitat diminishes. This effort was undertaken independently from the 20% snorkel inventory and included utilizing weight belts and fins to get below thermoclines to determine the presence or absence of adult spring Chinook in the system. Some high quality deep pools exist in the system that presented excellent opportunities for observing resting adults. No spring Chinook adults were observed. A possible sighting of 2 adult spring Chinook was documented within the standard RBA inventory but a return visit to that site with the appropriate dive gear for verification, revealed that the 2 fish observed were actually summer steelhead adults.

There were no 0+ age spring Chinook observed within the confines of the 20% snorkel inventory. Typically, most 0+ age spring Chinook would have migrated out of the system soon after emergence as mainstem temperatures in lower Mosby Cr increased to sub lethal levels. However, where spring Chinook are successfully escaping to spawn in other Willamette River tributaries, there is almost always some residual 0+ age rearing observed in high quality thermal refugia along mainstem corridors (hyporheicly fed side channel habitat). None of this residual life history pattern was observed in the 2013 inventory. Not a single 0+ age Chinook was observed. It is unlikely that there are any significant numbers of adult spring Chinook currently spawning in Mainstem Mosby Cr based on the results of the 2013 adult and juvenile surveys.

Cutthroat Trout

Cutthroat Trout were present in all 30 tributaries surveyed and the Mosby Cr mainstem to the confluence of the Row River. 29% of all pool-rearing cutthroat were documented in the mainstem (44% of lineal stream miles surveyed and 85% of all pool habitat). This suggests that the majority of the cutthroat production (71%) currently occurs in the tributary habitats during summer low flow regimes even though just 15% of the total pool surface area for rearing exists in these tributaries. The implications of this observation are significant in a system that exhibits severe life history limitations for the survival of salmonids.

Cutthroat Trout exhibit the most diverse array of life history patterns of any salmonid species. We assume that many of these unique survival strategies exist in Mosby Cr and should be considered very critical components of a successful recovery plan. There is no doubt that a resident life history pattern continues to thrive especially in tributary habitats. This was observed by dissecting 15 cm cutthroat found dead in tributary habitats and finding fully developed gametes. These adult cutthroat have likely not migrated out of these tributaries to attain the size and fecundity of their fluvial relatives that were observed in the mainstem at 35 cm.

The absolute numbers of cutthroat rearing in the 50.4 miles of the Mosby Cr system (mainstem and tributaries), would however be considered extremely low when compared to other east side tributaries of the Willamette River (Figure 15). With densities of 73 pool rearing cutthroat /mile for tributary habitats and 39 cutthroat / mile for the Mosby Cr mainstem, we are looking at what would be classified as low rearing densities. Compare the Mosby Cr densities to the range observed in the Molalla River system with 43-192 fish / mile for mainstem reaches and 250 – 617 fish / mile in high quality tributary reaches without interspecific competition with O.mykiss.

If we look at the mainstem of Mosby Cr as two distinctly different reaches (temperature limited and not temperature limited), the comparison is more descriptive. The lower 17.4 miles of the mainstem with severe temperature limitations was rearing just 13 cutthroat / mile. The upper 4.8 miles of functional summer habitat was rearing cutthroat at 132 fish/mile. This is a number that fits within the observed range of normal expectation.

The status of cutthroat in Mosby Cr should be considered depressed. Severe habitat limitations associated with temperature, natural and anthropogenic barriers to thermal refugia and a high spring/summer mortality rate (many dead cutthroat were observed during both the May habitat survey and the July snorkel survey) combine to fracture the linkages required for sustaining a robust population.

Other fish species

Pacific Lamprey

There were 473 Pacific lamprey redds documented in the 22.2 miles inventory of the mainstem of Mosby Cr mainstem in 2013 and 9 in all 30 tributaries inventoried (Figure 11). This was a 100% census during a period where only one live pair of spawning lamprey was observed. A video of this activity can be viewed at:
https://www.youtube.com/watch?v=vp74991OrI4
This suggests that the number of redds observed is likely to represent the bulk of the spawning that occurred in the system. The count included a broad range of redd age classes but surveyors noted that almost all redds regardless of age class were still visible and not inundated by deposition from late winter storm events.

The super imposition of redds was not a significant issue in quantifying the abundance of redds because spawning gravel was abundant and widely distributed. This reduced the need for aggregate spawning. Brumo (American Fisheries Society Symposium 72:203–222, 2009) found that in wadeable streams with clear water and low flows, redds /adult ranged from 2.1 – 5.5. This would have resulted in an escapement estimate of 88-230 adult lamprey to the Mosby Cr subbasin.

Redds were distributed throughout 20 miles of mainstem Mosby Cr with the highest concentration of redds within the middle 6th field reach, where mainstem spawning gravels are highest in abundance. It is assumed that Pacific lamprey adults, utilizing the same high quality spawning gravels utilized by winter steelhead are not compromising the egg-to-fry survival rates of the few observed winter steelhead redds (N=7). Restoration prescriptions identified within this document that consequently provide for the storage and sorting of spawning gravels would simultaneously benefit the Pacific lamprey.

"Spawning occurs between March and July depending upon location within their range. The degree of homing is unknown, but adult lampreys cue in on ammocoete areas that release pheromones that are thought to aid adult migration and spawning location. Both sexes construct the nests, often moving stones with their mouth. After the eggs are deposited and fertilized, the adults typically die within 3 to 36 days after spawning. Embryos hatch in approximately 19 days at 59° Fahrenheit (F) and the ammocoetes drift downstream to areas of low velocity and fine substrates where they burrow, grow and live as filter feeders for 3 to 7 years and feed primarily on diatoms and algae. Several generations and age classes of ammocoetes may occur in high densities. Ammocoetes move downstream as they age and during high flow events. We know little about movement and locations of ammocoetes within the substrates. Anecdotal information suggests that they may occur within the hyporheic zone and may move laterally through stream substrates." *(USFWS Jan. 2008 B. Streif – USFWS Portland OR)*

The Mosby Creek 6th field Core Area

The Core Area describes the spatial boundaries of a stream network that are currently functioning to support a remnant population. Portions of the stream network outside the Core area may contain rearing salmonids but the seasonal habitat linkages to the meta population for that species are fragmented.

Describe the Core Area

Describe what parts of the mainstem and its tributaries are included in the Core Area. Refer to river mile, tributary junctions, and other map features that identify end points. Present a map that shows the Core Area.

The Core area for the Mosby Cr 6th field extends from the confluence of Rock Cr at RM 10.9 to the end point of salmonid distribution in the mainstem at RM 22.2 (Figure 7). In addition, the Core includes all of the tributaries above and including Rock Cr to the end of anadromous potential. Ten tributaries below the confluence of Rock Cr are excluded from the Core area (Garoutte, Champion, Kizer, Sisson, Perkins, Smith, Fall, Blue, Simpson and Lewis). The Rapid Bio-Assessment surveys conducted in 2013 observed low summer rearing densities of all salmonids throughout the Core area. The lower 18 miles of mainstem Mosby Cr can currently be classified as summer limited for juvenile salmonids because of elevated summer temperatures.

Mosby Creek Mainstem Assessment

Mosby Cr is the only major tributary of the Row River located below Dorena Reservoir making it a primary target for anadromous use within the Row Basin. Mosby Cr enters the Row River approximately 3.5 RM above its Confluence with the Coast Fork Willamette River and extends upstream approximately 22.2 RM.

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

From the confluence with the Row River to RM 7.5 (Kennedy Cr confluence), the land use is primarily rural residential and small farm use. Riparian buffers tend to be thin bands of mixed conifer and deciduous species that have been retained for multiple generations. Buffers exhibited a wide range of age classes but mature Douglas fir was common. The mixed nature of the riparian seems to be consistent throughout the mainstem with only minor exceptions. The uniform age classes associated with industrial use were not present. Large conifers capable of making an impact in the aquatic corridor were present but only in low densities. In several locations it was noted that large conifer had recruited naturally to the stream channel but had been subsequently removed from the stream. This action is typical of rural residential areas where concerns for impacts to infrastructure are often identified by landowners as rational for removal. Canopy closure ranged in this reach from 20-60% but was averaged approximately 40%. The valley floor is wide and flat, and the active stream channel is relatively wide. This type of geomorphology is predisposed to solar exposure even when mature conifers are present in the riparian.

Extending above RM 7.5, ownership changes to exclusive large industrial forest blocks. There is also a change in underlying valley form and channel morphology. The system displays a transition from a broad open valley to a tighter canyon, and the stream becomes more hillslope confined. Exposure decreases but persists at a significant level up to RM 15. Reaches of exposure are primarily the result of young mixed riparian buffers and a wide stream channel (ACW 70ft). Riparian species are mixed with alder dominating the inner riparian and Douglas fir the outer riparian. Cottonwood, Ash and Maple are present. Canopy closure ranges from 20-85% but averaged 55% in this reach. Upslope of the young riparian is almost entirely industrial conifer forest at different points in a short harvest rotation. The age class of riparian buffers average 30-40 years with several short reaches of BLM ownership that contained second growth conifer. Some older age class conifer was present throughout the reach but infrequently. The historical legacy of complete riparian harvest prior to Oregon Forest Practices guidelines established riparian buffer widths removed all potential for significant wood recruitment. This condition will impact channel and floodplain function for another half century until the standing wood in the RMA is old enough to recruit and persist in the active channel.

Canopy closure increases nearing the headwaters as a function of the reduction in active channel width and hillslope. The improvement in canopy closure is not related to any change in riparian stocking rates or increase in age class. Buffers remain young continuing up canyon (20-40 age class). Alder becomes more dominant. Cottonwood and ash are no longer present. Upslope land use continues to be defined by industrial forestry utilizing short rotations. Canopy closure averages 70% but several reaches of severe solar exposure were noted at WP 563, 576, 602, 609, corresponding RM 21.7, 21, 18, 17.5 (Photos 1, 3, 14).

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Contemporary recruitment from the first 7.5 RM of the Mosby Cr riparian is limited to storm event recruitment from a mixed deciduous and low density conifer buffer. There are large conifers present but the frequency of recruitment is extremely low and broadly spaced both spatially and temporally. The rural residential land use and the confinement of the mainstem channel by roads and other infrastructure continually lead to the removal of recently recruited LWD. Any potential for the delivery and retention of woody material from the riparian in this reach depends heavily on the public's willingness to embrace the concept that a healthy stream needs to gather and store wood resources. To achieve a change in perception, a significant educational outreach component would have to accompany restoration planning. Land use practices in this reach have resulted in the retention of only thin buffers in many areas. Several high-density stands of mature conifer were noted at waypoint 732 and 725 (RM 1.7 and 2.5).

Above RM 7.5 the stream is almost entirely industrial forestland. The current recruitment potential in this reach is limited to deciduous and younger conifer growing within the 100 ft no harvest buffer. Prior to forest practice changes no riparian buffer was left during harvest. This has resulted in a 20-40 year old riparian throughout the majority of the reach. Trees of this age class are not large enough to be retained in the high flow winter channel of mainstem Mosby. Recruitment potential in this reach will remain low for another 50 years. In reaches where the stream was functioning at a high level (i.e. channel meander within identified anchor sites) the standard 100ft riparian buffer would be classified as largely inadequate (Photos 2, 14). Multiple locations were documented where active channel meander has recruited the entire riparian buffer leaving it exposed in a recent harvest unit. This condition exacerbates an already temperature limited mainstem profile by increasing solar exposure. Several locations of mature conifer capable of making an immediate impact were located throughout the industrial use reach: located at or close to waypoints 597,617,650, 656, 678, and 705 (Corresponding RM 18.2, 16.7, 14.3, 14, 12.7 11.3). These locations are almost exclusively associated with BLM ownership.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

Temperature data collected by CFWWC in 2012 and 2013 (Figures 17-18) indicates severe summer temperature limitations exist in mainstem Mosby Cr that begin at the mouth and extend upstream to the Shea Cr confluence (RM 18.3). This represents approximately 82% of the lineal mainstem distance. The elevated temperatures recorded in the mainstem are the result of many contributing factors associated with both geology and land use practices in the basin. Riparian exposure related to early seral riparian condition is exacerbated by the dysfunction of no wood retention in the active channel that has allowed the stream to scour to bedrock. Highly resistant and unfractured bedrock layers express rain off the landscape rapidly resulting in extremely low summer flows in most contributing tributaries (a natural lack of ground water storage based on underlying geology). This exposure and rapidly receding summer flows from the headwaters down, including that occurring within tributaries, cumulatively contribute to severely elevated temperatures observed in the lower mainstem.

Multiple locations of extreme solar exposure are present in Mosby Cr. These exposures mixed with an overly wide active channel (splash damming) and the lack of bedload retention accumulate solar impacts on the aquatic corridor as the stream leaves its protected public lands headwaters and progresses downstream. Some of the most severe exposure rapidly accumulates impacts wherever bedrock is exposed. In these areas, there is no potential for protecting a percentage of the stream in a subsurface hyporheic lens from the impact of air and direct solar exposure (Photos 1, 3). The extensive clear cutting within the basin and its tributaries also plays a role in cumulative temperature impacts. It is likely that temperature limitations occurring in the lower Mosby Cr mainstem would be more effectively addressed by prioritizing riparian restoration actions with a top down strategy to extend the zone of habitable stream habitats currently existing (above Shea Cr) to stream miles below Shea Cr. The lower reaches of Mosby Cr (below RM 7.5) will always be predisposed to summer temperature limitations for salmonids because of natural geologic formations that do not store water, a broad channel and valley floor and the lack of significant tributary contribution for mitigating elevated mainstem summer temperature profiles.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

A series of seven juvenile passage barriers were encountered throughout the Mosby Cr mainstem (Figure 12). The first barrier encountered was at RM 2.7 just downstream of Champion Cr (WP 727). This barrier was a 3 ft cascade falls that was likely a juvenile and possibly an adult cutthroat barrier during summer flows. The second barrier encountered was located at RM 3.7 - a significant bedrock intrusion splits the flow into multiple small chutes and is likely a significant juvenile barrier during critical summer flows. These two barriers were located in the zone where summer temperatures remain above 64 deg F for the majority of the summer. The third barrier encountered was a high velocity chute between Fall Cr and Blue Cr (WP 722). This location exhibits a potential juvenile barrier and is also within a temperature limited reach. The fourth barrier noted was located 1,000 ft downstream from Bark Shanty Cr (RM 14.5). This barrier was noted as a 2 ft vertical bedrock falls and was located in a zone that continues to exceed DEQ standards for water quality.

Barrier five was located 1,000 ft upstream of Dahl Cr and was a restoration sill log that exhibited a 2 ft perch (Photo 4). While this location was documented as a juvenile barrier during the 2013 RBA survey, it was observed that this barrier may be ephemeral and capable of changing from year to year based on alterations in bedload accumulations. This location is very near the transition from temperature limited to no temperature limitation.

Barrier six and seven were located in short succession above and below the confluence of Brownie Cr. Both were bedrock intrusions that formed cascade falls (Photo 5, 16). Both locations were also near the upper end of the mainstem temperature limitation. Neither location was a definitive juvenile barrier but both locations exhibited high 0+ pool counts directly below. This is an indication that each location posed passage problems for the young of the year age class during Bio-Survey's RBA snorkel inventory.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

Based on temperature data collected by the CFWWC, severe temperature limitations exist in Mosby Cr that far exceed DEQ standards for 303d listing (Figures 17-21). Temperatures were recorded above 64 deg F as far up in the system as RM 18.5 increasing in severity and duration downstream. The elevated temperatures documented below multiple juvenile barriers are problematic for nomadic juveniles and in some cases adult salmonids unable to pass these barriers to locate thermal refugia located upstream. Year to year comparisons of temperature variation collected for two contiguous years establishes the existence of this primary limitation for salmonids (elevated summer temperatures above the known threshold for juvenile salmonids).

In 2012, the temperature probe in Mosby Cr (MOS011) at the Shea Cr confluence was the highest temperature data logger placed in the mainstem. In 2012 the seven-day average max remained at or below 64deg F for the majority of the summer with a short stint reaching 64.3 deg F. In 2013, temperatures were warmer across the board and a seven-day average max of 67.8 deg F was recorded at this same location. Temperatures at this location in 2013 exceeded 64 deg F for the entire month of July, and then remained near 64 deg F for the remainder of the summer. Fish distribution patterns for the same year indicated a temperature limited upstream migration in this location.

However, two substantial juvenile barriers exist directly upstream from this location (above and below Brownie Cr) restricting juvenile access to thermal refugia in the headwaters. While these temperatures are likely not lethal, they continue to present environmental stress for summer rearing juveniles that is known to impact their survival. In 2013, additional data loggers were placed approximately 2.5 RM upstream of the confluence of Shea Cr that recorded a seven-day average maximum of 62.2 deg F during the same July 2013 time period. This increase of 5.6 deg F indicates two things. First, Shea Cr is likely close to the upstream extent of temperature limitations. Second, the rapid increase over only 2.5 RM indicates the existence of a major heat contribution source in this reach contributing to system dysfunction. The major tributaries joining the mainstem here were not sampled for temperature and their contribution is unknown. It was noted however, that a ½ RM reach above Shea Cr was severely scoured to bedrock, exhibited sheet flow, and was likely the source of the rapid elevation in stream temperatures (Photo 1). It was observed that boulder weir restoration locations were highly effective in recruiting bedload and restoring function in the highly scoured reaches (Photos 6 & 11). The primary objective being the retention of migratory bedload to protect a hyporheic lens from solar and air exposure.

From the confluence of Shea Cr extending downstream to the confluence of Lewis Cr, stream temperatures remained above 64 deg F for the majority of the summer in both 2012 and 2013. Temperatures peaked both sample years near the confluence of Cedar Cr (MOS008), and then cooled downstream at the Lewis Cr location (MOS006). In 2013 a seven-day average max of 72.8 deg F was recorded at Cedar Cr (MOS008) in mid-August. During the same time period MOS006, approximately 3 RM downstream, recorded a max average of 69.2 deg F. Temperatures remained 1-5 deg F cooler at location MOS006 for the entire summer, showing increased divergence during periods of peak temperatures. This cooling trend is precipitated by the massive bedload storage observed in Anchors 4 and 5 and the introduction of several cold-water tributaries. Temperature monitoring designed to identify hyporheic refugia existing in the side channels associated with these two anchor locations, indicated substantial cool water sources emanating from delinked side channel habitats (no upstream summer flow connection). It is likely that the increased ground water storage facilitated by increased bedload in these locations is cooling stream temperatures and reducing solar exposure (narrowing active channel widths within the braided channel zone). Temperatures at MSC001, located in the largest side channel within Anchor 5, recorded a very constant 60-61 deg F for the majority of the summer (Figure 22). This location was sampling hyporheic flow contributing from the outlet end of a side channel. In addition, the cold water contribution of Cedar Cr, Clearing Cr, Palmer Cr and Rock Cr each assist in cooling the mainstem.

Below Lewis Cr temperatures far exceed DEQ standards for the entire summer. Temperatures range from the low to high 70s for long periods of the summer. These temperature ranges approach or exceed lethal conditions for juvenile salmonids with extreme sub lethal stress that also reduces survival and growth (growth stops around 20 deg C / 68 deg F). Several juvenile barriers exist in this reach RM 2.7, RM3.7, RM 8 (Figure 12), effectively terminating temperature dependent upstream migrations to headwater or tributary thermal refugia. Essentially, summer habitats currently do not exist for long enough periods in this stream reach for any substantial salmonid survival to occur.

It is possible that nomadic components of the native cutthroat population (fluvial life history strategy) have developed the genetic memory to drop out of the Mosby Cr mainstem to seek thermal refugia in the cooler mainstem Row River. Our assessment was not capable of identifying the presence or absence of this potential survival strategy.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

Mainstem Mosby Cr contained more spawning gravel than any other stream segment inventoried during the 2013 LFA (Figures 8-9). A total of 584 sqm of spawning gravel appropriate for large anadromous salmonids (steelhead) was distributed from the confluence with Row River to the confluence of East and Middle Fork Mosby Cr. All inventoried gravels were classified as good (not fair or poor which would have indicated high sediment loading). The high gradient basaltic geology of the system keeps mobile gravels clean and well sorted providing the potential for excellent oxygenation during incubation, resulting in high egg/fry survival rates. Of all the available spawning gravel documented in Mosby Cr and all of its tributaries, 82% was located within the mainstem.

Gravel accumulations in approximately the first 8 RM of mainstem Mosby Cr were typically associated with gradient changes and bedrock intrusions. This reach of Mosby had very little channel complexity and only sorted spawning gravels when hydraulics decreased below the average or a grade control was present (bedrock intrusion). Wood and other channel roughness was not a factor in the provision of these two conditions. This condition is a result of the background gradient and channel confinement in this lower reach. It was noted that the lower mile of the mainstem was not as confined and some sinuosity was present. This reach did have some wood complexity capable contributing to gravel storage. Approximately 23%, (129 sqm) of the mainstem spawning gravel total was located in this 8-mile reach (35% of the lineal distance).

By far the most gravel rich reach of the Mosby mainstem was from RM 8 to RM 17. This reach included four of the five mainstem anchor locations and the majority of the boulder weir restoration sites (Photo 6). 377 sqm of good quality spawning gravel was documented here. This represents 66% of the total spawning gravel observed in mainstem Mosby (40% of the lineal distance). The boulder weir restoration locations were major contributors in the trapping and sorting of a substantial amount of the inventoried spawning gravel within this reach. Approximately 130 sqm was directly associated with boulder placement, this represents 34% of the reach total (Compare Photo 6 & 7). The anchor locations accounted for 177 sqm of the reach total, approximately 47% (Photo 25). The remaining 70 sqm was spread throughout the reach but primarily in the lower half of the 9-mile reach where gradients were more suited to gravel sorting.

The remaining 61 sqm, (11%) of spawning gravel inventoried in the mainstem was located above RM 17. Gravel in this reach was associated with channel roughness that created channel complexity (Photo 9) or significant bedrock intrusions. Much of the reach however, was highly simplified (Photo 10). This reach was incidentally holding over 70% of the inventoried salmonid population during the 2013 RBA.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Summer rearing habitat was identified to be the number one limiting factor for the Mosby Cr mainstem. This is primarily due to the lower 17 RM of the system being temperature limited to varying degrees. During the 2013 RBA inventory an average pool complexity score of 1.9 was calculated for the entire 22.5 miles of mainstem. This scale is based on the total percent of pool surface area (2 is 1-25%, 3 is 25-50%) that is associated with some form of structural complexity capable of providing cover, such as overhanging vegetation, large substrate, wood or undercut bank. In general, an average score of 1.9 is considered low. When the stream reaches are broken down so that the anchor locations and the side channels associated with them are excluded the average score drops to around 1.8. The average complexity score within the anchor locations and their associated side channels boasts an average complexity score of 2.3.

For the purpose of clarity, we'll discuss system function in mainstem Mosby Cr in three unique sections. Reach one includes the rural residential reach extending from the confluence with the Row River to approximately Kennedy Cr (RM 7.5). Reach two extends from Kennedy Cr to the confluence of Dahl Cr (RM 17) and is almost exclusively industrial forestland. Reach three is also industrial forest ownership and extends from Dahl Cr to the end of the Mosby mainstem (confluence of EF and MF Mosby Cr).

In reach one, the stream is large and the habitat is dominated by a pool/riffle channel form (Photo 12). Much of the pool habitat is well developed (deep scour and hydraulic control) and offers extensive rearing area. The average gradient in this reach was 0.5%-0.7%, allowing for streamside vegetation growth and some small side oriented cover. However, it was noted during the 2013 LFA that downed large woody debris contributed from the riparian had been removed. The average complexity score was 2 (1%-25% of the pool surface area offers cover). Several locations are confined by roads. Bank stabilization was noted when the stream comes into conflict with residential use or roads. This reach is characterized by extensive pool surface area with minimal summer cover and rearing habitats exhibit elevated summer water temperatures exceeding thresholds for salmonids for long periods.

Reach two, much like reach one, offers extensive pool habitat and has a pool complexity score of 1.9. Gradient increases through this reach from approximately 0.6% to 1.5%. There was a marked decrease in bank stabilization and other residential conflicts. Many pools are well formed and have good depth. The pool/riffle complex still dominates channel form but reaches of bedrock exposure and long highly simplified glide habitats become more prevalent (Photos 3 & 13). Within the anchor locations the complexity and abundance of summer habitat vastly improves. Four of the five mainstem anchor sites were located within this reach. Sinuosity and horizontal erosion is much higher increasing wood and substrate recruitment from the adjacent riparian terraces. Woody debris recruited from the riparian is more frequently retained at the location of entry, further encouraging gravel recruitment and retention (Photos 2, 9, 14). The increased bedload observed in these locations provides a platform the development of deep pool scour (providing significant pool depth). Despite the high quality summer rearing habitat found within the identified anchor sites, much of the reach is still temperature limited and therefore incapable of currently providing significant summer habitat.

Reach three contains a single anchor site (#1) that expresses habitat qualities similar to those described in Reach 2. Within the anchor alone, the stream exhibits all the qualities of good summer rearing habitat (this is discussed extensively in the Anchor 1 section). The remainder of this reach is riffle and rapid dominated with no wood complexity. The stream is lacking pool depth and pool complexity with long reaches of highly simplified channel. The lack of channel complexity has lead to vertical scour and reaches of exposed bedrock with poor pool formation. This reach is only minimally temperature limited. There is evidence in the reach of a recent debris flow event that exacerbated channel scour and left behind large amounts of alluvium that have formed inner terraces that are currently not classified as interactive.

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Winter cover is often expressed in terms of wood density and the presence of complex channel forms. In addition, the relationship between the active channel and its floodplain terraces are also critical for the provision of winter cover. Much of the channel form and function in mainstem Mosby Cr that historically provided complex winter habitat has been lost or altered in the last 150 years as a result of harvest, settlement and the development of a road network. Mosby Cr can be characterized in its current state as having poor winter rearing in most locations excluding the 5 identified mainstem anchor sites.

In the first 11 RM the majority of the complex channel forms associated with high quality winter refugia are located low in the system within the influence of the Row River floodplain. In this lower reach there is some channel braiding and floodplain interaction that allows for wood retention and exhibits the characteristics of adequate winter habitat. Aside from this there is very little winter refugia in the confines of the deeply entrenched mainstem channel. Wood densities were low and remain low because of the lack of large wood in the riparian, residential infrastructure conflicts and the hydraulic potential of winter flows. 150 years of road building, erosion control, flood protection and a loss of floodplain access for the stream have led to over simplification of the stream corridor. The stream is no longer capable of the horizontal erosion necessary to create the complex channel forms (meander) associated with high quality winter refugia and wood retention remains very low because of the channel simplification and the resulting winter velocities.

Above RM 11, the majority of functional winter habitats are found within the five identified anchor locations (Figure 7). Outside these locations terraces were generally high and not interactive during average winter flow regimes. The lack of complex off-channel forms for the provision of low velocity refugia confines winter rearing salmonids to the increased hydraulics of the mainstem channel. The large wood complexity required to initiate impoundment, aggrade bedload and lift the active channel to the floodplain are not present. Some boulder complexity was present outside of the anchor locations but had not developed winter rearing habitat at the time of survey. The broad and low velocity habitat provided by beaver impoundment also is not present and not attainable in the mainstem Mosby Cr except within anchor sites or side channels.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Channel form and floodplain interaction has changed dramatically over the last 150 years in the Mosby Cr Mainstem. Land use practices that include timber harvest, road building, residential infrastructure within the floodplain, agriculture and stream cleaning have led to channel incision, simplification and isolation from historical floodplain terraces. The once horizontally mobile channel is permanently confined and most secondary channels no longer function. These alterations in channel form have dramatically reduced the ability of the system to function for salmonids during all seasons of the year.

From the Row River confluence extending a short distance upstream Mosby Cr traverses a broad, intact and interactive floodplain that exists within the greater valley floor width defined by the Row River floodplain. The average gradient is less than 1% and sinuosity is good in reaches that have not been confined by development or road construction. Some channel braiding and floodplain interaction is present. Again at RM 3.5 a large oxbow exhibits some floodplain interaction and channel braiding across a 200ft wide inner terrace. This morphology at this location however, is very atypical. Beyond these two locations, the stream is more typically isolated from its floodplain during average winter flow regimes. The stream is primarily terrace confined becoming alternating hillslope terrace confined further up in the reach. Multiple locations are confined by the presence of roads and or residential infrastructure. This extends upstream to approximately RM 11. The active channel width ranges between 60-80 ft.

Above RM 11 and extending to the end of the mainstem, the gradient increases but does not typically exceed 2.7%. Terraces in this reach are also isolated from mean winter flows and average 5-8 ft in height. The stream is primarily alternating hillslope and terrace confined. However, some reaches are terrace confinement in a broad valley and some exhibit hillslope confinement in a canyon type setting. Essentially both forms are functioning the same way with no potential for floodplain linkage. The active channel width is 65 ft narrowing to 35 ft in the upper mainstem. Floodplain width varies greatly in this reach from 100-400 ft and is primarily a function of geomorphology rather than stream size. High frequency floodplain interaction is found only within the identified anchor sites (Photo 15).

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The locations identified in this document as Anchor Sites (Figure 7) are not only currently the highest functioning areas but also offer the most potential for boosting complexity and creating complex channel forms. These locations are discussed individually later in this document.

From the confluence with the Row River to approximately Fall Cr the stream does not offer significant opportunity for the development of complex channel forms. There are also residential use conflicts that restrict the type and scope of restoration that can occur here. There are several locations however that offer some potential for increasing function and channel complexity. These locations are individually discussed in the prescription table (Figure 31).

Above the Fall Cr confluence there is great potential for increasing channel complexity and function. Increased wood densities and boulder placement would considerably boost resource storage, aggrade the incised channel and improve floodplain interaction. This would also directly address the identified temperature limitations (lack of ground water storage and hyporheic flow) and provide increased rearing capacity.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) The lack of full spanning wood jams or other significant channel roughness limits the streams ability to trap and store transient substrates that lift the active channel to historical floodplain elevations.
2) Diminishing bedload and channel isolation.
3) The lack of mature conifer in the riparian corridor capable of being retained during winter flow regimes.
4) Land use guidelines (current forest practices) and residential/industrial infrastructure are hindering the natural function of the stream.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Yes. The introduction of LWD and boulder structures throughout the system in select locations.

2) Yes. Protecting, enhancing and reestablishing riparian buffers throughout the system. Including combating invasive species to promote a natural seral progression to woody vegetation. Protect and enhance beaver populations throughout the upper reaches, especially in identified anchor sites.
3) Yes. Establish expanded buffer zones in high priority anchor sites where large wood has a chance of being maintained in the active channel because of the current high level of function observed there.
4) Yes. Work with landowners to develop solutions and restoration strategies that minimize human impact on the stream corridor while not jeopardizing landowner needs or rights. Prioritize conservation zones as a target for getting expanded buffer widths in the places that will be the most beneficial long term (identified anchor sites).

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

During the 2013 RBA inventory, there were 2,256 0+ age juvenile cutthroat and O.mykiss observed in pools within the Mosby Cr mainstem (Appendix 3). This represents 25% of all the 0+ age class observed in pool habitats in the Mosby Cr basin (including all its tributaries). In addition, an estimated 871 cutthroat and 325 O.mykiss were observed in pool habitats for the total lineal distance of the mainstem (these do not represent population estimates because only pool habitats were sampled). The total and relative abundance estimates are the key observation here. The expanded values represent 30% of all cutthroat and 75% of all O.mykiss observed in the basin. When comparing the available surface area of rearing habitat in the mainstem of Mosby Cr to the actual standing crop of salmonids utilizing these habitats, it is apparent that all species of salmonid (resident or anadromous) are in crisis. Based on the 412 lamprey redds documented during the 2012 LFA survey of the mainstem (Figure 11), the Pacific lamprey is the most abundant species utilizing the mainstem of Mosby Cr for incubation and rearing.

The distribution and abundance of salmonids rearing within the mainstem of Mosby Cr is clearly linked to the summer temperature limitation documented within the system. Based on temperature data collected by the CFWWC, temperatures were elevated above desirable levels for salmonids as high in the system as Shea Cr, RM 18 (81% of the total lineal distance existing in the mainstem, 22.2 miles). The severity and duration increased extending downstream with one exception just downstream of Rock Cr (see temperature limitations section). Fish distribution closely mirrored this temperature profile. Of the mainstem fish totals, 76% of the 0+ population, 69% of the O.mykiss population, and 74% of the cutthroat population were rearing above RM 16.5 leaving the majority (74%) of the mainstem river corridor largely dysfunctional for the provision of summer habitat.

Within the 0+ population above RM 16.5 there was a strong upstream temperature dependent migration signal observed. Significant numbers of 0+ juveniles were documented below the barriers located on either side of the Brownie Cr confluence. In addition, a significant influx of juveniles was present in lower Brownie Cr. This type of behavior is indicative of temperature dependent movement in search of thermal refugia. The other tributaries within this zone, Dahl Cr and Shea Cr did not exhibit the same upstream temperature dependent migration signal.

Another important reach in the relationship between temperature and salmonid distribution was from RM 10 to RM 13 (this is approximately between Lewis Cr and Cedar Cr). This reach encompasses both Anchors 1 and 2. Of the remaining 24% of summer rearing 0+ (not found above RM 16.5), 19% were located within this reach of the mainstem and its associated Anchor Site side channels. This concentration of juveniles appears to also be linked to temperature patterns that describe the presence of thermal refugia (further discussion in temperature limitations section). Despite the mainstem in this reach still being temperature limited, the cooling provided by the increased hyporheic flow and the introduction of multiple cool tributaries is providing temperature refugia capable of sustaining juveniles during summer pinch periods. The same population concentration was not seen in older age class fish in this reach. However, the abundance of older age class salmonids was so low in Mosby Cr in general that conclusions based on 1+ O.mykiss or cutthroat are not definitive. It did appear that older age classes were seeking out cold water refugia within the temperature limited reach of the mainstem based on their concentrations at or very near cold water tributary confluences.

It is unknown at this time what the distribution of juvenile lamprey looks like during summer months. The depositions of fine sediment utilized by lamprey ammocoetes for rearing are not abundant in the mainstem. Lamprey redds were documented in the system as high as the Middle Fork and East Fork of Mosby (Figure 11). Extensive fine sediment deposition is present in the Row River below the confluence of Mosby Cr and may be a rearing destination for larval lamprey emerging from incubation sites further up the Mosby Cr mainstem.

Anchor Site 1

Location and length

Describe the location and length of this Anchor Site. Identify location by river mile, tributary junctions, and other map features.

Anchor 1 begins at approximately RM 19.5 directly above the confluence of Brownie Cr and extends upstream 1.1 RM, ending near the confluence of Tom Cr (Figure 7).

Channel structure

Describe channel form in terms of meander, braiding, side channel, alcove, backwater and other complex channel structures.

Anchor 1 is the highest identified anchor site in the Mosby Cr mainstem. Habitat within the anchor reach is starkly different from the surrounding habitat both up and down stream. It is characterized by lower gradient (approximately 1.2%), a wide floodplain (150 ft - 350 ft) and low interactive terraces (2 ft – 5 ft) (Photo 15). Bankfull width ranged from 40 to 55 ft within the anchor. The existence of this anchor is directly related to a series of bedrock intrusions that function as grade controls (Photos 16, 18). The grade controls are not allowing channel incision and the resultant isolation of the stream channel from the surrounding floodplain. In addition, they maintain a low gradient that allows for the deposition of substrate and the development of complex channel forms. One bedrock control is located at the bottom of the anchor and the second and smaller of the two, is located approximately 2/3 from the bottom of the anchor.

In comparison with the adjacent reaches upstream and downstream, sinuosity was high within the anchor. Active wood recruitment from the adjacent riparian was observed as a result of lateral scour (Photo 9). Active side channels where observed throughout the entire reach. Side channels where in various states of function. Some being connected during summer flow regimes and all exhibiting signs of connection during winter flow regimes (Photo 17). Mid channel bars and braiding were also observed, usually associated with wood complexity. In stream wood complexity was initiating and maintaining complex channel features.

Floodplain structure and interactivity

Describe the floodplain terrace structure in relation to channel level and complexity. Explain how these allow or restrict high flood access to the floodplain.

The channel complexity in this anchor was directly related to a decrease in gradient caused by channel morphology and the presence of several bedrock intrusions. Terraces were 2-5 ft and the floodplain width was in excess of 300 ft in some portions of the anchor. Terraces were composed of a gravel/cobble foundation with a fine depositional layer on top (indication of frequent over topping flows). The stream was actively recruiting gravels and wood complexity from the terrace as horizontal channel meander created new erosion (exhibits high function). Terraces showed signs of frequent overtopping events. Terrace canopy was young mixed alder and conifer not typically exceeding 30 years of age. Willow was the primary species in areas of disturbance such as mid channel bars or deposition plains.

The wood currently being recruited from the riparian is too young/small to have a lasting impact in the reach and is highly mobile. Large wood in the riparian is severely lacking. Several reaches of wood placement were observed both in the primary channel and within the side channels. Several side oriented large wood structures where noted in the main channel but only the most aggressive (occupying at least 50% of the active stream channel) where effective at creating complex habitats (Photo 19, 20). The LWD structures within the side channel were an excellent example of effective habitat restoration. They provided pool scour, winter refugia / cover and increased side channel complexity (Photo 17). The side channels observed without wood treatment were lacking pool depth and complexity.

Rearing contribution

Describe how the Anchor Site contributes to spawning, incubation, summer rearing, and winter rearing.

Because Anchor 1 is located above the temperature limited segment of mainstem Mosby Cr and exhibits such high quality channel complexity, it could be considered the single most functional stream segment within mainstem Mosby. The only significant accumulation of spawning gravel between Brownie Cr and the East Fork, Middle Fork confluence was encountered in Anchor 1 (15 sqm, representing approximately 3% of the mainstem total). In addition, it was noted that the lower velocities and flow within the side channels were sorting spawning gravels suitable for resident and fluvial cutthroat (totals not quantified). All gravels within the anchor were considered good quality. Given the location above temperature limitations and the highly interactive nature of the floodplain within the reach, Anchor 1 is a prime location for both summer and winter rearing. The physical habitat should be considered capable of supporting all life history stages of all salmonid species (incubation, spring, summer and winter). This reach also exhibited the highest density (redds / mile) of lamprey redds within the Mosby mainstem.

Anchor 1, while being a highly functional location, should also be considered a high priority zone for both active restoration and passive conservation measures. This caliber of habitat is rare within the mainstem of Mosby Cr. The channel morphology and location in the basin make Anchor 1 a high priority for improving and maintaining current function. Some specific initiatives are discussed in the following section.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) The primary habitat limitation within Anchor 1 is a lack of large mature conifer resources in the riparian that can be effective in sustaining long term channel roughness to encourage, support and maintain channel complexity.
2) A lack of pool complexity and scour. Much of the pool habitat does not offer high quality cover for rearing salmonids for predator avoidance during summer flow regimes. This is a zone where avian predation is extremely effective because large pool sizes allow the group hunting of the common merganser to occur.

3) Long lasting large wood complexity capable of ensuring continued function. Much of the in stream wood complexity is highly transient and/or susceptible to rapid decomposition (i.e. young Alder).
4) The narrow confinement of the active channel within a 100 ft riparian buffer does not allow the development of a broad meander belt within the anchor.

Addressing the limitations

List and rank the restoration work at the site that would most effectively improve rearing conditions within the Anchor Site and stabilize the core population at a higher base level.

1) Riparian planting within the anchor focus on conifer for long-term recruitment potential to the active channel. Work with local landowner to establish and protect a broader riparian meander belt than required by current forest practices. (i.e. conservation easement). The target zone would be best delineated by utilizing a LIDAR projection for identifying legacy channel forms on the 350 ft wide historical floodplain.
2) The addition of LWD complexity would be beneficial to increase floodplain interaction and develop complex channel forms. Given magnitude of winter flow aggressive side oriented wood complexity would likely be more feasible than full spanning log structures in the mainstem. Side channel wood treatment is also recommended in untreated reaches.

Anchor Site 2

Location and length

Describe the location and length of this Anchor Site. Identify location by river mile, tributary junctions, and other map features.

Anchor 2 begins at approximately RM 16.5 and extends upstream 2,500 ft to the confluence of Dahl Cr (Figure 7). It is the smallest anchor site in terms of linear distance.

Channel structure

Describe channel form in terms of meander, braiding, side channel, alcove, backwater and other complex channel structures.

All the fundamental characteristics of an anchor are present within this reach but the lineal distance is relatively short. The presence of channel roughness (i.e. boulders and/or large woody debris) is decidedly lacking. Some floodplain interaction in small off channel habitats is present, but terraces are not regularly inundated during winter flow regimes. Sinuosity and meander is moderate in the anchor and complex off channel linkages do not exist on the scale observed in other mainstem Mosby anchor locations. There were multiple mid channel bars and channel braids. Pools were well developed but lacked complex cover in most cases. The average gradient throughout the anchor is

0.9% and the bankfull width averaged 58 ft. The primary reason for the anchor appeared to be hillslope morphology that constricted the channel at the bottom of the anchor. The current level of function would be ranked as low when contrasted with the high level of function observed in Anchor 1.

Floodplain structure and interactivity

Describe the floodplain terrace structure in relation to channel level and complexity. Explain how these allow or restrict high flood access to the floodplain.

Terraces were composed of highly erodible sediments on top of a deep gravel lens. Terrace height was 2-5 ft with a 100-300 ft floodplain width. The riparian was mixed maple, alder, fir, and some cedar. The age class was primarily 30-40 years and offered good future wood recruitment potential. Some second growth conifer was present on a small section of BLM ownership in the lower anchor. This was the only wood capable of making a significant immediate impact. Willow was the dominant species on areas of disturbance such as inner channel gravel bars. It was noted that high water channels were present on the terraces, unlike side channels found in other anchor locations, these were only connected during peak winter flow regimes. The lack of significant channel roughness appeared to be the primary reason for limited terrace interaction. Grade control seems to be provided by the channel constriction noted in the lower anchor and likely the presence of a deep-seated bedrock intrusion. However, the later was not conclusively present during observation of the location.

It was noted that there was a small pond located on the east side of the stream. The pond appeared to be old excavation, likely historic gravel extraction. There was a man-made berm of spoils between the pond locations and the active channel of Mosby Cr. It appeared that the pond was fed primarily by hyporheic or ground water sources and not connected with the Mosby mainstem at any flow level. Solar exposure was not excessive. It is possible that the existing pond location could provide an opportunity for the development of off channel habitat. A baseline topographic survey would be required to establish the feasibility of linkage.

Rearing contribution

Describe how the Anchor Site contributes to spawning, incubation, summer rearing, and winter rearing.

The spatial location of Anchor 2 is important as it relates to mainstem temperature limitations. It is located in the zone where summer temperatures exceed DEQ standards for juvenile salmonids. This severely limits the capacity of the anchor for the provision of functional summer rearing habitat. However, it is located near the upper end of mainstem temperature limitations. An analysis of the RBA fish data and temperature probe data supports this conclusion. Mainstem Mosby juvenile salmonid numbers drastically increased at and above the confluence of Dahl Cr (approximately RM 16.7). Approximately 76% of Mainstem Mosby's summer rearing juveniles were located above

Dahl. In addition, the thermister located at the Shea Cr confluence, only 1.5 RM above Anchor 2, registered a seven-day average max of 64.4 deg F in 2012 and 67.8deg F in 2013, essentially the top end of desirable stream temperatures.

Given the temperature limitation of Anchor 2, the primary rearing contributions are spawning, incubation, and winter rearing. Sixteen square meters of high quality spawning gravel were located in Anchor 2 (3% of the mainstem total). Thirty lamprey redds were noted in this same reach (6.5% of the mainstem total). Anchor 2 exhibits the complex channel characteristics required for the provision of winter habitat. However, not to the level of the other four mainstem anchors, making it the least functional anchor site for the provision of winter habitat. The 2013 RBA data collected by Bio-Surveys indicated summer rearing was very limited (0+, 20. - O.mykiss, 5. – cutthroat, 5). These are critically low abundance estimates and a direct reflection of the habitats inability to provide functional summer habitat.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) Summer temperature limitations (Channel dysfunction upstream of the anchor exposing shallow summer flows on sheets of bedrock).
2) Low pool complexity and a lack of aquatic cover (lack of functional LWD).
3) The lack of future wood recruitment from the surrounding riparian corridor (low conifer stocking rates).
4) Low abundance of complex off channel habitats for the provision of winter refugia (lack of functional LWD).
5) A lack of channel roughness capable of impounding the active channel, creating aggradation and initiating extensive floodplain interaction (lack of functional LWD).

Addressing the limitations

List and rank the restoration work at the site that would most effectively improve rearing conditions within the Anchor Site and stabilize the core population at a higher base level.

1) Prioritizing any restoration actions to address mainstem temperature limitations within the system using a top down strategy could easily extend the range of functional summer habitat into and below the location of Anchor 2 (fastest and largest bang for the buck).
2) The addition of LWD complexity and/or boulder complexes would increase floodplain interaction, increase pool complexity and create complex channel forms. Maintaining sinuosity and channel meander is important for all current function to continue and improve.

3) A conservation easement to protect a broader band of riparian assets throughout the lineal extent of the identified anchor location.
4) Connection of the off channel pond existing on the terrace within the anchor to the active winter channel could improve the abundance of low velocity winter refugia. Add LWD structures.
5) Add both full spanning and edge oriented LWD structures.

Anchor Site 3

Location and length

Describe the location and length of this Anchor Site. Identify location by river mile, tributary junctions, and other map features.

Anchor 3 begins at approximately RM 15.6 and extends upstream 3,500ft (Figure 7). The anchor terminates approximately 1,000 ft above the confluence of Little Dry Cr.

Channel structure

Describe channel form in terms of meander, braiding, side channel, alcove, backwater and other complex channel structures.

Anchor 3 exhibited a high level of function from a channel structure viewpoint. Sinuosity was high in the anchor leading to significant horizontal erosion of the floodplain terraces (highly desirable) and dissipating the hydraulic potential during winter flow regimes. Horizontal erosion was recruiting large quantities of substrate and wood from the riparian (Photo 21, 14). Abandoned legacy channels had become significant side channels and were activated the entire lineal distance of the anchor. Side channels were alternating (either side of the main channel) and provided habitat diversity and different levels of function. All side channels were connected during moderate winter flow regimes and provided good high water refugia for juvenile salmonids. The largest and upper most side channel was fully accessible during summer flows from the outlet end. Summer flows were emanating from a substantial hyporheic lens (preferred summer scenario, no linkage to mainstem on inlet end). Backwater habitat was present, primarily expressed in side channels and associated with wood complexity.

High levels of riparian wood recruitment coupled with dispersed winter flows (a function of channel braiding) allowed for high wood retention and the resultant bedload accumulation. The trickle down process that starts with wood to build bedload continues to the formation of deep complex pools because there is bedload to scour that ends up expressing thermal refugia as a result of the hyporheic storage in these deep accumulations of bedload. Flows became noticeably consolidated going from a wetted channel width of 45 ft above the anchor to 20 ft within the anchor. It was noted that the visible flow decreased 30% within the anchor (the 30% calculation based on observation). Bankfull width averaged 56 ft and the average stream gradient was 0.9%.

This decrease in surface flow is the desired outcome for all priority restoration strategies, put the stream in a gravel lens and keep it there as long as possible in a contiguous process that starts from the top down.

Floodplain structure and interactivity

Describe the floodplain terrace structure in relation to channel level and complexity. Explain how these allow or restrict high flood access to the floodplain.

The floodplain terraces within Anchor 3 are much wider than previous anchors and consisted of two distinct levels. The inner terrace was 2-5 ft in height and 100-300ft wide. It was frequently inundated by winter flows, consisted of primarily cobble and gravel covered with a deposition layer of fine sediment. The primary canopy was alder and willow. The inner terrace was highly active and contained all of the channel complexity referred to in the previous section. The outer terrace was 6-7ft by 500-1,000ft wide and was only inundated by the highest winter flood events (100 yr. frequency). Both sides of the outer terrace had recently been harvested. The riparian buffer was mixed maple, alder, and fir in the 30-40 year age class. The horizontal erosion and resultant wood recruitment taking place in this reach was primarily from the outer terrace. In multiple locations, the harvest buffer had already been completely recruited to the active channel and the stream was beginning to migrate into the harvest unit (Photo 14).

In this location the standard riparian buffer is not sufficient. Continued high function in this reach is predicated on the streams ability to migrate and recruit wood from the surrounding riparian. Wood recruitment maintains and encourages the streams capacity to wander horizontally. Without regular wood recruitment to the active channel within the broad anchor, the channel would decrease in sinuosity by finding the path of least resistance and continue to simplify until each of the anchor sites looked morphologically like the rest of mainstem Mosby Cr. To maintain high function within the limited number of anchor sites, a different approach would be required to restore the relationship between the stream and its riparian corridor than establishing a static 100 ft harvest buffer (see Conservation easement strategy in list of final prescriptions).

Rearing contribution

Describe how the Anchor Site contributes to spawning, incubation, summer rearing, and winter rearing.

Anchor 3 has most of the characteristics required for completing the fresh water life history of salmonids. The only current limitation is elevated stream temperatures that exceed DEQ standards for adult and juvenile salmonids during pinch period summer flows. This severely limits the capacity of the habitat to provide any summer rearing. This is supported by 2013 RBA snorkel data and temperature profiles. According to data collected by MFWWC, the thermistor located at the Shea Cr confluence, roughly 2.5 RM above Anchor 3, registered a seven-day average max of 64.4 deg F in 2012 and 67.8 deg

F in 2013, essentially the top end of usable aquatic habitats for salmonids in Mosby Cr during the summer. The next downstream thermistor located near the confluence Cedar Cr, approximately 2.8 RM downstream from Anchor 3, registered a seven-day average max of 69.1 deg F in 2012 and 72.8 deg F in 2013 (Figures 17-18). Despite well-formed pools with good complexity in the anchor, fish numbers were very low in the mainstem channel. An expanded pool estimate of 35 0+, 15 cutthroat, and 3 O.mykiss were present. The largest of the side channels was accessible at the outlet during the RBA survey and was fed by hyporheic flow. It was noted to be cooler that the mainstem. A total of 34 0+, and 3 Cutthroat were documented in the side channel.

Given the temperature limitation of Anchor 3, the primary rearing contributions are currently only spawning / incubation and winter rearing. 43 square meters of high quality spawning gravel was documented in Anchor 3 (8% of the mainstem total). 27 lamprey redds were noted in this same reach (6% of the mainstem total). Anchor 3 exhibits the complex channel characteristics that provide high quality winter habitat and is an ideal spawning location for anadromous salmonids.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) Summer temperature limitations (cumulative effects originating above the anchor).
2) Future wood recruitment from the surrounding riparian (inadequate buffer width for a highly mobile active channel).
3) Riparian corridor not protected from harvest rotations across the full width of the historical meander belt within the anchor (static policy guidelines that don't recognize that unique riparian buffer requirements are necessary for restoring natural function. One size does not fit every riparian / floodplain application).

Addressing the limitations

List and rank the restoration work at the site that would most effectively improve rearing conditions within the Anchor Site and stabilize the core population at a higher base level.

1) Address temperature limitations systematically from the top down.
2) The addition of LWD complexity and/or boulder complexes would be beneficial to increase floodplain interaction, increase pool complexity and create complex channel forms. Maintaining sinuosity and channel meander is important for all current function to continue.
3) A conservation easement to protect a broader riparian meander belt within the anchor site only.

Anchor Site 4

Location and length

Describe the location and length of this Anchor Site. Identify location by river mile, tributary junctions, and other map features.

Anchor 4 begins close to the Cedar Cr confluence and extends upstream 2,500 ft (Figure 7).

Channel structure

Describe channel form in terms of meander, braiding, side channel, alcove, backwater and other complex channel structures.

Much like Anchor 3, this anchor exhibited a high level of function that extends for only a short lineal distance. The anchor exhibits dissipated hydraulic potential and was eroding horizontally rather than vertically (highly desirable and an indicator of high function). Sinuosity was moderate and was encouraging erosion of floodplain terraces and active recruitment of the riparian buffer. Horizontal erosion was also recruiting large volumes of stored bedload to the active channel within the anchor (Photo 22). Abandoned legacy channels had become significant side channels and were present for the entire lineal distance of the anchor. All side channels were connected during moderate winter flow regimes and provided good backwater habitat for juvenile salmonids during all but the peak winter flows. The upper most side channel had been treated with LWD that had created excellent side oriented winter cover (Photo 23). Both side channels were fully accessible during summer flows from the outlet end and were being fed by hyporheic flow.

The dissipated flows from channel braiding increased retained wood densities and a highly effective boulder weir placement within the anchor has resulted in well-formed pools with moderate cover and the protection and storage of hyporheic flows. Much like Anchor 3, flows became noticeably consolidated from increased aggregation of substrate. It was observed that the visible flow decreased 20% within the anchor (the 20% calculation is based on observation). Bankfull width was 65-75 ft and the average stream gradient was less than 1%.

Floodplain structure and interactivity

Describe the floodplain terrace structure in relation to channel level and complexity. Explain how these allow or restrict high flood access to the floodplain.

The floodplain terrace within Anchor 4 was extensive and varied. Terrace height ranged from 2-5 ft and 200-700 ft in width. Lower terraces and inner channel bars were frequently inundated by winter flows exhibiting a high level of function. Terraces consisted of primarily cobble and gravel covered with fine sediment deposition. The primary canopy was alder, cottonwood and maple in the inner riparian and high-density plantation fir in the outer riparian. Willow was the dominant species on areas of disturbance (mid-channel bars). The higher terraces within the broad interactive anchor were being utilized for industrial forestry. The horizontal erosion and wood recruitment taking place in this reach was primarily from the higher terraces, making the preservation of future wood recruitment extremely high priority. As with the other anchor locations the standard 100 ft riparian buffer is not sufficient. Continued high function in this reach is predicated on the streams ability to migrate and recruit wood from the surrounding riparian. Wood recruitment maintains and encourages the streams capacity to wander horizontally. Without future wood recruitment, the channel will incise and trend toward simplification.

Rearing contribution

Describe how the Anchor Site contributes to spawning, incubation, summer rearing, and winter rearing.

Anchor 4 is a highly functional stream segment providing all seasonal habitats for salmonids. The only current limitation is elevated stream temperatures in the mainstem corridor that exceed DEQ standards for juveniles. This severely limits the rearing function of the anchor during the warm summer months but does not terminate it as observed in Anchors 2 and 3. 2013 RBA snorkel data collected by Bio-Surveys indicated that this anchor is being utilized by summer rearing juveniles despite the mainstem temperature limitation. However, numbers and densities were far below what the available habitat could support. Thermistor MOS008 located near the confluence Cedar Cr, within the anchor, registered a seven-day average max of 72.8 deg F during the RBA survey year (Figure 17). Temperatures remained above 64 deg F for two consecutive months from mid-July through mid-September (Figure 19-20).

Given the temperature limitation of Anchor 4, the primary rearing contributions are spawning, incubation, and winter rearing. Gravel abundance was high, 96 sqm of high quality spawning gravel was located in Anchor 4 (17% of the mainstem total). 32 lamprey redds were noted in this same reach (8% of the mainstem total). An expanded estimate of 160 0+, 0 cutthroat, and 10 O.mykiss were present. Fish distribution in this reach is further discussed in the Summer Juvenile Distribution and Temperature Limitation sections and is part of a significant trend that continues into Anchor 5.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) Summer temperature limitations (cumulative effects originating above the anchor).
2) Future wood recruitment from the surrounding riparian (inadequate buffer width for a highly mobile active channel).

3) Riparian corridor not protected from harvest rotations across the full width of the historical meander belt within the anchor (static policy guidelines that don't recognize that unique riparian buffer requirements are necessary for restoring natural function. One size does not fit every riparian / floodplain application).

Addressing the limitations

List and rank the restoration work at the site that would most effectively improve rearing conditions within the Anchor Site and stabilize the core population at a higher base level.

1) Address temperature limitations systematically from the top down.
2) The addition of LWD complexity and/or boulder complexes would be beneficial to increase floodplain interaction, increase pool complexity and create complex channel forms. Maintaining sinuosity and channel meander is important for all current function to continue.
3) A conservation easement to protect a broader riparian meander belt within the anchor site only.

Anchor Site 5

Location and length

Describe the location and length of this Anchor Site. Identify location by river mile, tributary junctions, and other map features.

Anchor 5 begins at the Palmer Cr confluence and extends upstream 1.2 RM (Figure 7). It is the largest and most complex anchor site identified in the Mosby Cr mainstem.

Channel structure

Describe channel form in terms of meander, braiding, side channel, alcove, backwater and other complex channel structures.

Anchor 5 is the lowest identified anchor in the Mosby Cr mainstem. Habitat within the anchor is classified as exhibiting high function. Sinuosity was high in the wide low terrace reach. Active wood recruitment from the adjacent riparian was observed as a result of lateral scour (Photo 9). Active side channels where observed throughout the entire reach. Side channels where in various states of function. Some being connected during summer flow regimes and all exhibiting signs of connection during winter flow regimes (Photo 17). Mid channel bars and channel braiding were also observed. As winter flows dissipate with channel braiding, transient wood sources are retained at a higher within the anchor than in mainstem Mosby Cr outside the anchor. Accumulations were common on the point bar at the head of side channels. In stream wood complexity dramatically boosts pool complexity and habitat diversity within the anchor.

The reach is characterized by a gradient less than 1%, a wide floodplain (200 ft-950 ft) and low interactive terraces (2 ft-6 ft) (Photo 15). Bankfull width ranged from 60 ft-75 ft within the anchor. The anchor was created by the existence of a major bedrock intrusion several hundred feet above the confluence of Palmer Cr. This bedrock intrusion is the contemporary grade control that defines upstream gradients. The much larger geological formation that is responsible for what we perceive as a very wide historical floodplain above the confluence of Palmer Cr (900 ft) was formed by the basaltic intrusion (pictured on the cover Photo) that pinched the valley floor and was responsible for the large-scale deposition that formed the Palmer Cr flat. There may have historically been ephemeral grade control near this basaltic outcropping (Cover Photo) in the form of a wood and debris jam that dictated the expanse of the 100 yr floodplain above the confluence of Palmer Cr.

Floodplain structure and interactivity

Describe the floodplain terrace structure in relation to channel level and complexity. Explain how these allow or restrict high flood access to the floodplain.

The channel complexity in this anchor is directly related to the decrease in gradient and broad floodplain caused by ancient geological process and the continued presence of a channel spanning bedrock intrusion above the confluence of Palmer Cr. Terraces were 2-6 ft and the floodplain width was in excess of 900 ft in some portions of the anchor. Terraces were composed of a gravel/cobble foundation with fine depositional layer on top. The stream was actively recruiting gravels and wood complexity from the terrace as horizontal channel meander maintains an erosive process (exhibiting high function, Photo 8). Terraces exhibited signs of frequent overtopping events and secondary channel formation. There was evidence of an old road/RR grade on the Eastern side of the stream that continues to hinder channel migration (diking and compaction). The grade has been breached by the active channel in several locations however and may continue to unravel. On the East side of the stream at the top of the anchor riprap was present (Photo 24). This was also hindering natural channel migration and has been recommended for removal.

The canopy on the dominant floodplain terrace was highly varied. Portions of the floodplain consisted of young plantation stands of Douglas fir, there was a significant acreage of early seral meadow habitat (100 acres west side) and the remainder of the floodplain within the anchor exhibited a mixed deciduous canopy of alder, maple and cottonwood. Willow was common within the lower inner terraces that contained legacy channels and active channel braids. The wood currently being recruited from the riparian was young and will not have a significant foot print within the anchor for the development of channel complexity. Large wood for future recruitment in the riparian is severely lacking (except the occasional large cottonwood). It was noted that Himalayan Blackberry had arrested seral progression on the old homestead site on the east bank just above the confluence of Palmer Cr.

The conservation of the entire Palmer Cr Flat (described most accurately with a LIDAR projection) would be highly beneficial to the continued function of this reach and the overall health of the Mosby Cr system.

Rearing contribution

Describe how the Anchor Site contributes to spawning, incubation, summer rearing, and winter rearing.

Anchor 5 was one of the highest functioning reaches within the Mosby Cr mainstem from a physical habitat perspective. As with other mainstem anchor locations the primary limitation is elevated stream temperatures that exceed DEQ standards for juveniles. This severely limits the rearing function of the anchor during warm summer months. However, the 2013 RBA snorkel data collected by Bio-Surveys indicated that this reach was being utilized by a small population of summer rearing juveniles and was part of a broader trend observation for mainstem rearing. There appears to be a cooling trend within anchor 5 that is providing thermal refugia for salmonids and also mitigating for impacts occurring higher in the system. Temperature data collected by MFWWC indicates that the stream, while continuing to be classified as temperature limited, was undergoing a cooling trend as it progressed through Anchor 5.

We are hypothesizing that the deep accumulations of mobile bedload stored within the anchor are protecting and cooling a lens of hyporheic stream flow that is expressed as thermal refugia as it rises to meet the dominant bedrock intrusion near the bottom of this anchor. This is the same bedrock intrusion that holds the entire Palmer Cr flat intact and protects it from head cutting and channel incision. It is likely that this hyporheic lens becomes accessible near the outlet of side channel habitats in the form of backwater pools that are developing a thermocline. These unique microhabitats are providing accessible refugia within the confines of a temperature-limited mainstem. This phenomenon is discussed in depth in the Summer Juvenile Distribution and Temperature Limitation sections.

Given the documented summer temperature limitation in Anchor 5, the primary rearing contributions are spawning, incubation, and winter rearing. Gravel abundance was high, 110 sqm of high quality spawning gravel were located in Anchor 5 (19% of the mainstem total). 74 lamprey redds were noted in this same reach (18% of the mainstem total). An expanded estimate of 130 0+, 10 Cutthroat, and 10 O.mykiss were also present. Fish distribution in this reach is further discussed in Summer Juvenile Distribution and Temperature Limitation sections and is part of a significant trend that continues both up and downstream of this location.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) Summer temperature limitations (cumulative effects originating above the anchor).
2) Future wood recruitment from the surrounding riparian (inadequate buffer width for a highly mobile active channel).
3) Riparian corridor not protected from harvest rotations across the full width of the historical meander belt within the anchor (static policy guidelines that don't recognize that unique riparian buffer requirements are necessary for restoring natural function. One size does not fit every riparian / floodplain application).
4) Lack of mobile large wood to protect inlet end of primary side channel habitat from evulsion. Side channels linked to summer mainstem flow on inlet end.

Addressing the limitations

List and rank the restoration work at the site that would most effectively improve rearing conditions within the Anchor Site and stabilize the core population at a higher base level.

1) Address temperature limitations systematically from the top down.
2) The addition of LWD complexity and/or boulder complexes would be beneficial to increase floodplain interaction, increase pool complexity and create complex channel forms. Maintaining sinuosity and channel meander is important for all current function to continue.
3) A conservation easement to protect a broader riparian meander belt within the anchor site only.
4) Protect inlet end of functional side channels with full spanning woody debris. This builds bedload above the point bar, delinks the side channel from summer flow and allows the expression of hyporheic thermal refugia near the outlet end (requires specific design criteria to generate deep pool scour).

Anchor Site rankings

Function

Rank the identified anchor sites in terms of current function (1= best).

1) 1
2) 5
3) 4
4) 3
5) 2

Restoration potential

Rank the identified anchor sites in terms of restoration potential.

1) 1
2) 1
3) 3
4) 3
5) 2

*Clarification: All anchor sites are ranked high priority for restoration. However, the Limiting Factors questionnaire was designed to tease out a prioritized strategy for restoration with the understanding that it may take decades to achieve completion. With this concept in mind we chose to utilize 3 different ranking levels. Level 1 takes the most functional anchor site (Anchor 1) and maximizes its capacity for providing both summer and winter habitat. Without a protected and enhanced stronghold (core) long-term success may be unachievable. Level 1 also included Anchor 2, which is directly downstream from the upstream extent of summer temperature limitations in the mainstem. This anchor has the highest likelihood of achieving success if a top down strategy for addressing temperature issues is utilized as a guiding restoration principle.

Level 2 included Anchor 5 that currently functions to mitigate for the poor water quality delivered to it (creates a cooling trend and provides a rare thermal oasis in a temperature limited mainstem). Working here second has significant ramifications for cumulative impacts downstream and for expanding and taking advantage of high quality hyporheic flows for improving salmonid distribution and survival.

Level 3 projects in Anchors 3 and 4 are all going to be required to successfully tie level 1 and 2 actions together. Without fully expanding treatments to all of the identified anchors, there will still be segments of mainstem Mosby Cr that function to disrupt the connectivity of salmonid habitats.

Mosby Creek Tributary Assessments

Garoutte Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The lower 0.3 miles of Garoutte has good riparian canopy cover as it passes through a privately owned forest stand. Upstream of this reach, Garoutte Cr passes through approximately 0.75 miles of residential/agricultural lands where the riparian buffer is minimal to non-existent.

Approximately 0.85 miles up Garoutte Rd, in the vicinity of the mapped stream crossing (WP 904 & 905), two large patches of Japanese knotweed were observed (100'X10' and 20'X20' in size) (Photo 27). It is likely that additional patches of knotweed are present in the stream channel downstream from this location.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Within the rural residential/agricultural lands on Garoutte Cr (1st 0.75 miles), a future source of large wood is unavailable.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

Due to very low summer flows in Garoutte Cr, the extensive solar exposure on the agricultural lands that border the stream likely does not contribute significantly to mainstem temperatures.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

The passage status of a crossing located approximately 300 ft from the mouth is unknown (no landowner access).

At approximately river mile 0.3, a driveway crossing on Garoutte Cr has an undersized corrugated metal pipe with a 6" perch (Photo 28).

Approximately 0.5 miles upstream of the mouth (0.85 miles up Garoutte Rd), a 30" concrete pipe is undersized for the 5' channel width (WP 905).

Two other culverts and a bridge exist between the 0.3 and 0.5 mile crossings – passage status for these crossings is unknown (no landowner access).

The crossing at stream mile 0.85 (WP 906) is a 5' pipe with a 20" perch (Photo 29) that would terminate at least the summer migration of juvenile salmonids.

Garoutte Cr is low priority for addressing fish passage barriers due to very low summer flows that preclude the provision of summer rearing habitat.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

No temperature data was collected by the CFW Watershed Council for Garoutte Creek.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

During the 2013 field inventory, no spawning gravels suitable for O.mykiss were observed in Garoutte Creek. Garoutte Creek has no potential for recruiting spawning gravels due to low hydraulic capacity and a lack of gravel resources.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Not assessed.

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Not assessed.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Garoutte Creek is a low gradient stream (ranked 4 of 5). Bankfull channel width is approximately 5'. Stream flow was very low in early May 2013 and insignificant by July.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Low hydraulic potential (small watershed area) limits the ability of Garoutte Creek to develop channel complexity.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Low hydraulic potential.
2) Narrow active stream channel.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

These limitations cannot be effectively addressed by restoration actions. No prescriptions are recommended for Garoutte Cr.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

Garoutte Creek was not surveyed in the July 2013 RBA snorkel inventory conducted by BioSurveys LLC due to lack of flow at the time of the survey.

Champion Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The lower end of Champion Cr has good riparian cover with a mix of mature cottonwood, maple, conifer, alder, and young planted cedar. An exception to this is approximately 0.25 miles upstream of the mouth, where an active beaver impoundment (WP 890) has little vegetative cover, exposing the shallow impoundment to solar influence (Photo 30).

Upstream of the old railroad grade, for approximately 250’, the stream is highly exposed to solar radiation on both sides (Photo 32). Current vegetation in this reach is dominated by blackberry, snowberry and reed canary grass on the inner riparian.

On the Century Farm above the railroad grade, a legacy of livestock use has left the stream highly exposed, lacking any seral development, for about 350 ft (Photo 33), before reentering a more closed canopy of blackberry and aging alder. A few cows (the farm has downsized) access the creek for their water source at a low water/livestock crossing (WP 896) that would benefit from fencing to restrict access.

Upstream of the pasture reach is a forested wetland within a broad deciduous canopy. A large reed canary grass swamp on the terrace upstream of the Century Farm property may be indicative of a legacy beaver terrace where the natural succession to woody vegetation has been interrupted by this invasive grass.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Potential to recruit conifer to the stream channel exists to a very limited degree, primarily in the lowest 0.25 mile reach where conifer and recently planted western red cedar are present. However, recruitment is likely 50-75 years out. Champion Cr lacks the hydraulic potential to recruit and transport conifer from its upper forested reach to the lower mainstem.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

Solar exposure of the low-gradient stream channel with a lack of riparian cover in the vicinity of the beaver dam, railroad grade and throughout the pasture reach of the Century Farm lead to thermal conditions that negatively impact the mainstem Mosby Cr temperature profile.

The impoundment behind the beaver dam is shallow and exposed to solar radiation. However, it appears that most of the spill is flowing through and not over the existing dam boards, which could temper the effects of solar radiation on the broad surface area of the pond. It may have the potential of a positive effect on downstream cooling if sufficient stratification occurs (unknown). Additional temperature monitoring both above and below the beaver pond and pasture reach would assist in determining the factors that influence stream temperatures.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

Ninety feet above the mouth of Champion Cr (WP 888), a 2ft bedrock step followed by a 4 ft cascade with an overhang on the lower end terminates juvenile passage (Photo 34). The 2013 RBA snorkel inventory confirmed that this barrier terminates upstream temperature dependent migration during summer flows.

The culvert where the railroad grade crosses the stream has been removed. The associated riprap remains in place but is fully passable.

On the Century Farm, a slotted dam board structure underneath a farm bridge (WP 893) presents a permanent barrier to all anadromous and resident salmonids as well as lamprey, 0.5 miles upstream of the mouth. There is a 12” perch below the concrete apron and a 36” perch at the dam boards (Photo 35-36). This is the dam that forms the historical lake observed on maps. The bridge currently lacks functional approaches and likely sees little use. Addressing this barrier is a high priority project within the Champion Cr subbasin. It has been ranked low priority as part of the basin wide recovery strategy because it exists outside the spatial bounds of the Core Area.

A graded riffle structure below the apron could address the 12” perch. Removing the dam boards would solve the rest. If removing the dam boards permanently is not an option for the landowner, then negotiating a spawning window would be the next best alternative: no dam boards between Nov 1 and June 1. This would allow summer ponding that could actually benefit the summer temperature profile of Champion Cr downstream if flows were released from the bottom of the pond to capture the cooling effects of stratification.

An ephemeral barrier of logs exists in an alder pinch .7 miles above the mouth (WP 895) (Photo 37). This structure is holding bedload above it. This barrier likely blocks upstream migration of juveniles in the summer; however, it overtops the right terrace (1’) in high flows, providing access for migrating adults.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

Data collected by CFWWC indicates that stream temperatures at the mouth of Champion Cr exceeded the DEQ threshold for salmonid rearing on a total of 41 days in the summer of 2012 and 56 days in 2013 (Figure 23). This temperature profile would severely limit salmonid use of Champion Cr for summer rearing. However, the 4’ bedrock cascade within 90 ft of the mouth renders Champion Cr inaccessible for temperature dependent upstream migration of juvenile salmonids.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

The field inventory identified 3.1 square meters of spawning gravel suitable for anadromous O.mykiss in the lower 1.25 miles of Champion Creek (Figure 8). Potential for recruiting additional spawning gravel is relatively low. Fresh water mussels were observed near the railroad grade indicating a stable bedload condition.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The pool surface area (sq ft) of the first ten pools of this creek were measured during the field inventory as part of a comparison with other tributaries of the Mosby Cr subbasin to assess their capacity to support summer rearing salmonids. Champion Cr had an average of 259 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr. This ten-pool reach did not include the beaver dam impoundment that adds significant pool surface area to Champion Cr for summer rearing habitat.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 1.9 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover). In general an average score of 1.9 would be considered low.

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Winter cover on Champion Cr is available within the beaver impoundment and the interactive floodplain terraces of the upper forested wetland that offers extensive slack water refuge at high flows.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The bankfull width of Champion Cr is about 11 ft. Flows are relatively low (rank 2 of 5) compared to other Mosby tributaries. The lower reach of Champion Cr is incised with the exception of the beaver impoundment area. A three-foot beaver dam, the most significant beaver dam encountered in the field inventory (Photo 30-31) is located approximately 1200' above the mouth of Champion Cr (WP 890).

At approximately river mile 1.0, upstream of the pasture reach and the uppermost culvert crossing (WP 897), the channel character changes to exhibit low floodplain terraces, 150 ft in width, through a forested wetland (Photo 38-39) that has a high level of connectivity to the stream. Floodplain terraces alternate from 1 to 3 ft in height with a 9.5 ft bankfull width. The wetland floodplain extends about 400 ft upstream to a nick point where the channel becomes hillslope confined. A 4-wheel track has been developed in the wetland causing significant disturbance (Photo 40).

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Potential for increased channel complexity in lower Champion Cr would be most affected by impoundments created by beaver dam building. Within the forested wetland, above river mile 1.0, potential for channel complexity is high given the low terraces and broad interactive floodplain.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

Lack of in-channel woody debris limits the stream channel's ability to scour and develop meander across the floodplain.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

Addition of large wood to the stream channel within the forested wetland would encourage increased channel complexity.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

The RBA snorkel inventory implemented in the summer of 2013 by BioSurveys LLC was incomplete due to a denial of access that removed approximately 6000 ft from the 7800 ft survey reach. The inventory did confirm the lower bedrock cascade near the mouth of Champion Cr as a juvenile barrier. No O.mykiss and very low densities of cutthroat were present (Appendix 3). An expanded estimate of only 10 cutthroat were observed. Low densities of 0+ age class trout (expanded estimate of 35 fish) were observed in the 2800 ft reach that was surveyed. Surveyors reported that flows at the time of the survey were medium, relative to other Mosby Cr tributaries. Champion Cr is not the target of upstream temperature dependent migrations of juvenile salmonids seeking cool summer refugia.

Kizer Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The riparian buffer on the lower end of Kizer Cr is narrow. The overstory vegetation is composed primarily of deciduous trees with some western red cedar, but is heavily occupied by blackberry. Because Kizer Cr has a narrow active channel (8 ft), the blackberry does an adequate job of sheltering the stream from solar exposure.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Limited numbers of western red cedar will be available in the long term in the lower reach of Kizer Cr. However the creek lacks the hydraulic potential to recruit these conifer to the mainstem. The stream benefits more directly from the canopy litter recruited during winter storm events.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

A streamside pond, located in upper Kizer Cr, near the trib split, is exposed to high solar radiation. However, none of the three vertical outflow pipes exhibited flow in May 2013. There may however be cold hyporheic flow contributing to the creek, possibly seeping out at the pond bottom across the bedrock (unverified).

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

The crossing at the lower end of the stream, approximately 350' above the mouth (WP 902) has two 36" pipes. One is not perched and receives half the flow. The second is set higher and perched 12". Both have rotted bottoms, such that the stream flows under the pipe. As the flows decrease, most of the flow will go under the pipe (Photo 44), blocking fish passage for summer migration.

At the driveway crossing for 34612 Kizer Cr Rd, two 30" culverts are perched 24", creating a barrier to juvenile passage (Photo 41).

The driveway crossing at 34770 Kizer Cr Rd has two culverts 30" and 24" with fully rotted bottoms that have eroded into perches of 4-6", posing a summer migration barrier. These are smooth steel pipes (Photo 42).

The Mosby Cr Rd crossing (Photo 43) has a 36" concrete pipe with a 15" perch dropping onto rock with a very large scour pool below. This pipe is a barrier to summer migration.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

Data collected by CFWWC indicates that stream temperatures at the mouth of Kizer Cr exceeded the DEQ threshold for salmonid rearing (64 deg F) for a total of only 9 days in the summer of 2012. During the warmer summer of 2013, temperatures exceeded the DEQ threshold for a total of 38 days (Figure 23). A large wetland located about a mile upstream of the mouth may be contributing to moderating temperatures.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

No large anadromous spawning gravels were observed in Kizer Cr during the 2013 field inventory.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Quantified data is not available on pool surface area for Kizer Cr. The Kizer Cr channel is 8 ft in width, allowing for extensive cover from overhanging shrubby vegetation, particularly blackberry.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.6 on a scale of 1-5. This scale is based on the total percent of pool

surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover). This is the highest average pool complexity score observed on all of the tributaries.

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Channel incision on Kizer Cr restricts floodplain access and makes winter cover generally unavailable.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Kizer Cr is a low gradient stream with a bankfull width of 8 ft. On the lower reach of Kizer Cr, the stream channel is incised about 5 ft. Summer flows are some of the lowest among all the Mosby Cr tributaries. The channel is broadly sinuous in nature due to its low gradient. About a mile upstream of the mouth, the stream passes through a broad shallow wetland.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Channel complexity potential is low due to channel incision.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Channel incision.
2) Narrow active stream channel.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

These limitations cannot be addressed effectively through restoration.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

The RBA snorkel inventory implemented in the summer of 2013 by BioSurveys LLC was incomplete due to restricted access, poor visibility and low flows. No O.mykiss and very low densities of cutthroat were present. An expanded estimate of (15) cutthroat and (45) 0+ age trout were observed in the 0.6-mile reach that was surveyed, beginning 0.7 miles above the mouth (Appendix 3).

Sisson Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

Reed canary grass is the dominant riparian vegetation downstream of the railroad grade where the stream traverses a low flat to reach the mainstem of Mosby Creek (Photo 45). About 350 ft above the mouth, the vegetation changes to overhanging vine maple providing good shade cover that extends to the road crossing. Japanese knotweed is present in at least 5 small patches (WP 864-866).

Upstream of the road crossing, large maple, alder, and 40 year old western red cedar (with some intrusions of dense blackberry patches) fully protect the stream from solar exposure.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Conifer are present upstream of the road crossing that may recruit to the adjacent stream channel in the 50 year time scale. However, the low gradient, constrained stream crossing and limited hydraulic potential of Sisson Cr would restrict transport of this wood resource downstream.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

Due to the narrow channel and overhanging nature of the riparian vegetation, no thermal problems are expected to exist on Sisson Cr. Riparian planting within the reed canary grass above and below the lower culvert would not have much thermal benefit as summer flows are low, the channel is narrow and incised and the existing vegetation provides adequate cover.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

The culvert on the old farm access road in the lower pasture below the railroad grade (Photo 46) is 5 ft wide X 5 ft long and is fully passable for adults and juveniles.

The Blue Mountain School Rd crossing has twin 3' concrete pipes with one pipe half full of bedload (Photo 47). This is not a passage issue for adult or juvenile salmonids, but it is a definite maintenance issue for the County. It is likely to plug and overtop the road in a 10 yr frequency flow event.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

No stream temperature data is available for Sisson Cr. This stream has low summer flows that would have little influence on downstream temperatures.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

Substrates of Sisson Cr are sandstone dominated and range from fine silt particles to quarter sized gravels to cobble. No gravels suitable for anadromous O.mykiss spawning were observed in the 2013 field inventory. However, spawning gravels suitable for cutthroat are abundant in every riffle and pool tailout within this low gradient creek from the railroad grade up to the road crossing. Above the road crossing, substrate size increases to gravel/cobble with cobble up to 6". Fresh water mussels were observed in the lower end of the creek, indicating a stable bedload.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The Sisson Cr channel is 8 ft wide, allowing for extensive summer cover from overhanging shrubby vegetation, particularly reed canary grass and vine maple in the reach below the road crossing. Above the road crossing, increased meander has developed undercut banks that provide excellent summer cover.

The pool surface area (sq ft) of the first ten pools of this creek were measured during the field inventory as part of a comparison with other tributaries of the Mosby Cr subbasin to assess their capacity to support summer rearing salmonids. Sisson Cr had an average of 197 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.5 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover). The highest average complexity score for all of the tributaries was 2.6.

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Channel incision and lack of floodplain interaction on the manipulated reach of lower Sisson Cr leaves the channel with no current or potential for developing winter habitat. From the railroad grade to the road crossing, the lack of floodplain connection precludes the provision of winter habitat. Above the road crossing, with the increased sinuosity and deeply undercut banks, winter cover is more abundant but limited by a narrow floodplain (this section represents a natural channel form for Sisson Cr).

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Sisson Creek is a low gradient stream up to the road crossing with an 8’ bankfull channel width. Across the pasture, the stream channel has been moved to facilitate historical agriculture (currently pasture) The channel was straightened and moved to the edge of the pasture. It is incised 4 ft with no floodplain connection. Above the railroad grade to the road crossing, there is increased meander in the native channel with low terraces on the meander bends and undercut banks. However there is also no floodplain.

Above the road crossing, the stream character and channel form changes dramatically. There are highly functional deep undercuts and high sinuosity with a controlling terrace of 4 ft. The floodplain is wider in this reach (15’) and there appears to be more flow. This may be an indication that the lower incised reach is carrying a large percentage of its flow subsurface in the hyporheic zone. A deposition plain of gravels exists above the road crossing that has been created by the grade control established by the undersized road culvert (Photo 48).

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Below the road crossing, the stream channel has no potential for increased complexity due to deep channel incision (excavated / not natural). Above the road crossing, the channel character changes, displaying increased potential for channel complexity. Even though pools are dominated by lateral scours, the sinuosity is moderate here.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Below road crossing: Deep artificial channel incision (4 ft); no floodplain.
2) Above road crossing: 4 ft terraces; narrow floodplain; narrow channel width (8 ft).

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

These limitations cannot be addressed effectively through meaningful restoration. No prescriptions are recommended.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

The RBA snorkel inventory implemented in the summer of 2013 by BioSurveys LLC observed no O.mykiss and very low densities of cutthroat and 0+ trout. An expanded estimate of only (10) cutthroat and (25) 0+ age trout were observed in the 0.5-mile reach that was surveyed. RBA surveyors noted that flows were low, relative to other Mosby Cr tributaries (Appendix 3).

Perkins Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The riparian corridor along Perkins Creek has excellent canopy cover. The riparian overstory in the lower 1.0-mile includes older age class vegetation, with high diversity (western red cedar, maple, cottonwood, Doug fir) with mature vine maple and dogwood overhanging the stream channel (Photo 51). About a mile upstream of the mouth, transitioning from residential/farm to forest land use, the riparian vegetation is a younger age class, but intact and exhibiting diversity.

About 1500 ft above the mouth (WP 876), three 2 ft stems of Japanese knotweed were pulled during the 2013 field inventory. A large (8ft X 20 ft) patch of knotweed is present on the left bank at approximately river mile 0.5 (WP 878).

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Riparian wood is currently being recruited and contributing at a modest rate to keep the channel accumulating bedload. There is a level of impacts caused by the human environment (removing trees) that has reduced the rate of riparian wood recruitment, but not eliminated it. This is unlike what has happened in the torrented headwater tributaries of the Mosby Cr subbasin. There are examples of recent recruitment (Photo 52) of large (4 ft dbh) cedar to the channel that clearly are responsible for providing the majority of the observed channel complexity.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

No thermal problems related to riparian condition were noted in the 2013 field survey. The off-channel pond on the left bank of Perkins Cr appears to have no stream linkage.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

Mosby Cr Rd crossing (WP 1002): 55'X6' corrugated metal pipe (CMP) has good passage for adults and juveniles. The bottom of the pipe is rotted out badly on the lower end. This is not a resource access issue, however it is a County maintenance issue. The bankfull width of the channel is 12', so the pipe is also quite undersized, as evidenced by the large scour pool below the pipe.

River Mile 0.5: This driveway crossing (WP 879) includes two 4'X28' CMP pipes (separated by 4 ft between) with rotted bottoms and a 15" perch (Photo 53). This crossing denies all access for upstream migrations at summer flows. The perches at least terminate all adult lamprey and cutthroat during some flow regimes. Replacing this crossing is a high priority restoration action within the Perkins Cr subbasin but ranks low for basin scale actions because it's outside the identified Core area.

Just 45' upstream of the aforementioned crossing is a second driveway crossing of a 5' X 20' pipe with an old 4' pipe buried to the right (Photo 54). This pipe is passable but very undersized. Consider a combined single crossing, ramped up to a bridge.

River Mile 1.0: (est. WP 881.1) A member of the landowner's family conveyed that they have 3 undersized culverts on their driveway crossing with an approximate 1' perch at summer flows. Annual winter cleaning is required. They denied access to review the site but the anecdotal information suggests at least a barrier to upstream migration exists here also.

Driveway at 35041 Perkins Cr Rd (next property upstream): (WP 882) has a triple culvert crossing 4', 5' and 5' with perches of 3', 2' and 2' (Photo 55). The 4' pipe has a 2' debris dam at the inlet (Photo 56). These are definitive barriers for adult connectivity. The pipes are rotten through the bottom, leaking flow and undermining the fill. Replacing these culverts, and others located further upstream, drops to low priority until the passage problems on the downstream property are addressed.

Driveway at 35100 Perkins Cr Rd: (WP 883) Above the trib split, there is a 5' squash pipe with a 30" overflow that is on bedrock but is not perched and is fully passable (Photo 57).

Driveway at 35108: (WP 884) This crossing has a 6’ round pipe with a 1’ perch (Photo 58), creating a barrier to juveniles only.

Driveway at 35188: This 4’ pipe on the tributary crossing has no perch and is fully passable.

Forest Road Crossing: (WP 885) This is a 5’ squash pipe with a 4’ perch in an 11’ channel (Photo 59) and creates a complete barrier to migration of all salmonids.

Forest Road Crossing: (WP 886) This a 5’ round pipe with a 5’ perch in a 9’ bankfull channel width (Photo 60) and creates a complete barrier to migration of all salmonids.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

Data collected by CFWWC indicates that stream temperatures at the mouth of Perkins Cr did not exceed the DEQ threshold for salmonid rearing at any time during the summers of 2012 or 2013. Maximum temperatures did not exceed 63 deg F in 2012 and did not exceed 60 deg F in 2013 (Figure 23). This cool temperature profile would be expected to attract salmonids to Perkins Cr for summer rearing. However, that behavior was not observed, suggesting no salmonid juveniles exist in the adjacent mainstem to seek thermal refugia.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

Substrates exhibit significant embeddedness from coarse sands. The D100 of the stream is approximately 250mm. Perkins Cr has relatively good potential for bedload transport and recruiting spawning gravels. Gravels accumulate easily above full spanning jams (Photo 50). Thirty-nine square feet (4 GC) of spawning gravels suitable for anadromous O.mykiss were observed in the field inventory in the lower 0.5 miles of Perkins Cr (Figure 8). Beginning about 700 ft above the mouth, the stream is loaded with cutthroat spawning gravel in every tailout. Perkins Cr has a relatively high potential for recruiting, storing and sorting spawning gravels appropriate for native and fluvial cutthroat.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Older age trees overhanging the banks have created excellent undercuts on meander bends to provide valuable summer cover for juvenile salmonids.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.2 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover).

The pool surface area (sq ft) of the first ten pools of this creek were measured during the field inventory as part of a comparison with other tributaries of the Mosby Cr subbasin to assess their capacity to support summer rearing salmonids. Perkins Cr had an average of 362 sq ft of pool surface area per 100 ft of stream within its ten-pool reach compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr. This ranks Perkins Cr among the tributaries offering the greatest capacity for summer rearing. However, while late spring flows were medium (ranked 3 on a scale of 1-5) when compared to other Mosby tributaries, summer flows were observed to isolate pools, reducing their capacity for summer rearing.

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Winter cover is often expressed in terms of wood density and the presence of complex channel forms. In addition, the relationship between the active channel and its floodplain terraces are also critical for the provision of winter cover. Moderate levels of winter habitat are available in Perkins Creek within the lower mile of stream, supported by excellent sinuosity and low interactive terraces within a narrow floodplain. The presence of large wood in the channel supports this channel complexity and offers additional winter cover.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Perkins Cr is a low (est. 2%) gradient stream with a 12 ft active channel width and a 4-5 ft confining secondary terrace. It has good sinuosity within the confinement of the upper terraces but exhibits a narrow floodplain. Terraces on meander scallops are low (1-2 ft). A bedrock intrusion, located 150-200 ft above the Mosby Cr Rd crossing establishes a permanent grade control for the channel upstream (Photo 49) and supports the maintenance of a functional channel structure. Approximately one mile above the mouth, the channel characteristics change to express no floodplain and very tight hillslope confinement.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Perkins Cr exhibits extensive bedload transport; sediments seem to be naturally recruiting from the stream adjacent terraces because of the good sinuosity and the hydraulic capacity to recruit wood from the riparian (Photo 61). Its sinuosity however is constrained by a narrow floodplain within a secondary terrace structure, limiting its potential for increasing its background level of channel complexity.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Narrow floodplain, terrace constrained.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

No restoration prescriptions for increasing channel complexity are recommended in Perkins Creek.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

The RBA snorkel inventory implemented in the summer of 2013 by BioSurveys LLC observed no O.mykiss in Perkins Cr (Appendix 3). Low densities of 1+ age class cutthroat were observed (an expanded estimated count of 100 fish). An abundance of trout in the 0+ age class were observed (expanded estimate of 665 fish), one of the top two strongholds for the 0+ age class in the Mosby Cr suite of tributaries (comparable to Brownie Cr). However, densities of 0+ trout per sq m of pool surface area were still low when compared to functional stream reaches in other Willamette River subbasins. During the summer RBA snorkel inventory, flows were low enough to isolate pools. Cool stream temperatures, excellent cover from predation and consolidated rearing densities from intermittent flows are likely key factors creating and supporting this abundance.

Smith Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The lowest reach of Smith Cr includes a stand of older age conifer in a private woodland planting (Photo 64). Much of the balance of upstream riparian overstory vegetation is dominated by alder (30 yr). An exception to this condition is within the extensive beaver flat reach, vegetation is primarily tall shrubs (willow, etc) with few larger trees (Photo 66). Reed canary grass has invaded much of the historical extent of beaver dam impoundments (Photo 68). Outside of this flat, the riparian buffer is quite narrow and has been compromised by blow down associated with the surrounding clearcuts (Photo 69).

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Beyond the very lowest reach of Smith Cr, large wood recruitment is limited due to a lack of conifer within the alder dominated riparian. What conifer is available is unlikely to recruit prior to a 50-100 year timeframe. At the head of the beaver flat (just below the major tributary split), wind-throw from the narrow riparian buffer (8 -10 Inch dbh) is recruiting and robbing the stream of its future conifer potential.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

Within the legacy beaver flat, reed canary grass has interrupted the natural succession of willow and alder reestablishing within the riparian, leaving the stream exposed to solar radiation. In much of the balance of the riparian upstream of the beaver flat, the buffer width is narrow, exposing the stream channel to warming influences particularly from the south side. Adjacent clearcuts can influence and overwhelm ambient air temperatures within the riparian and limit the effectiveness of the riparian buffer.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

Approximately 250 ft upstream from the mouth of Smith Cr (WP 850), a remnant water intake structure has created a 24" perch (Photo 63). The concrete dam is currently degraded and dysfunctional but is creating a definitive barrier to summer juvenile migration. Adult salmonids (all species) can likely manage migration over the dam during winter flow regimes.

Currently summer migration for juveniles is terminated about 0.4 miles above the mouth at an ephemeral full-spanning log jam with bedload accumulation creating an impassable vertical lift.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

Data collected by CFWWC indicates that stream temperatures at the mouth of Smith Cr exceeded the DEQ threshold for salmonid rearing (64 deg F) on a total of only 6 days in the summer of 2012. In a warmer summer, 2013, the stream temperatures exceeded the DEQ threshold for 35 days (Figure 25).

Even though Smith exhibited a mid-summer temperature limitation, it appears that some upstream migration may have been occurring from the mainstem of Mosby Cr as detected in both the density and number of cutthroat utilizing the lower pool habitats during the RBA snorkel inventory. This was a weak signal and replicate inventories would be desirable to definitively establish the existence of an upstream temperature dependent migration pattern.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

During the May 2013 field inventory, 16.7 sq meters of spawning gravel, suitable for anadromous O.mykiss were observed on Smith Cr distributed throughout the lower 0.8 miles of stream (Figure 8). Large amounts of high quality, well-sorted gravels appropriate for cutthroat were also observed to have dropped out in the low gradient reach at the head of the legacy beaver flat (Photo 70). Potential for spawning gravel recruitment on Smith Cr is some of the highest of the Mosby Cr tributaries, along with Cedar, Big Dry and Brownie creeks. Four lamprey redds were observed downstream of the beaver pond reach (44% of all lamprey redd observations in tributaries).

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Smith Creek is richly endowed with deep undercut banks below old maples. There is a clear legacy of at least four significant beaver dams on Smith Cr that in the recent past provided an expansive amount of ponded area, supporting summer and winter rearing habitat for salmonids. With the loss of these beaver dams, the available pool surface area has been greatly reduced. None of the legacy beaver dams were intact or functional. Beaver were present however in the reach.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.3 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover). The highest score for average complexity for all of the tributaries was 2.6.

The pool surface area (sq ft) of the first ten pools of this creek were measured during the field inventory as part of a comparison with other tributaries of the Mosby Cr subbasin to assess their capacity to support summer rearing salmonids. Smith Cr had an average of 476 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and second only to the highest average of 490 sq ft on Brownie Cr. This attribute comparison suggests that Smith Cr is one of the key tributaries for salmonid production because of it physical rearing potential.

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The high quality floodplain connectivity and sinuosity observed in Smith Cr provide valuable winter refugia for salmonids. The large woody debris that is present in the channel provides additional complexity and winter cover. This instream wood resource however, is rapidly degrading and not being replenished from the early seral riparian. The loss of winter stable beaver dams has resulted in a radical reduction in rearing potential that Smith Cr has the potential to provide. This type of channel morphology is rare in the Mosby basin and actions to restore and enhance beaver within Smith Cr would be part of any significant recovery plan.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Smith Creek is one of the lower gradient streams in the Mosby subbasin (rank 4 on a scale of 1-5) with active channel width of approximately 20 ft and a broad floodplain that is interactive in normal high flows where terraces are low (1-2'). It displays some of the largest tributary flows in the system, along with Rock, East Fork and Middle Fork.

The existing remnants of the concrete dam located 250 ft above the mouth are providing grade control to create a significant zone of floodplain connectivity for over 450 ft upstream (Photo 65). Removal of this dam to provide passage for summer juveniles would have a negative impact on floodplain connectivity here (should verify existence of upstream temperature dependent migration).

Approximately 1500 ft upstream of the mouth, a large legacy beaver flat exists (one of few observed in the system) with an obvious history of long time beaver occupation, but displaying no recent dam building activity (Photo 67). Anecdotal information from a local landowner suggests that the primary dam complex was lost about ten years ago. Within this reach, the controlling terrace is approximately 4 ft (vertical) with recent evidence that a new 2' incision has occurred that has accelerated channel degradation. There are signs of beaver activity; two beaver feeding stations were observed throughout the extensive length of the historical beaver flat. In May 2013, they did not appear to be building dams. However, by July of the same year, there were 3 active beaver dams.

Low terraces extend upstream to the trib split where the floodplain is still 100' wide. Terraces are low (in the 1' range) where there is large wood persisting in the channel. Above the trib split Smith Cr reverts to a hillslope confine tributary with significantly less rearing potential.

There are high levels of sediment retention in Smith Creek, not observed in many other tributaries. The sediment retention is an indicator of good nutrient loading in a very sterile pinnate system flushed annually by high winter flows.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Potential to develop channel complexity within Smith Cr is some of the highest among all the tributaries to Mosby Cr. The low gradient, broad floodplain, low terraces, bedload resources and hydraulic capacity combine to create excellent conditions for producing channel complexity. There are indicators of overtopping flows on the primary floodplain terrace and sites of 1 ft high depositions of bedload that demonstrate the potential for winter flows to boost the abundance of channel braiding. These are highly functional attributes to maintain and support.

The legacy beaver flat reach has begun to experience channel incision, but still remains highly complex with many braids and potential winter backwaters. However, this high quality habitat is clearly beginning to unravel. The current state of the channel in this reach displays the picture of its past and present as well as the future condition that is moving towards incision and simplification. The only means to truncate this trajectory is to inject wood to slow the degradation process or to get beaver to recolonize the site.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Insufficient large wood replenishment in the stream channel resulting in a trajectory toward channel incision and simplification. Existing wood is of an old age that is rapidly degrading, resulting in the release of accumulated bedload.
2) Lack of a long-term supply of large woody debris.
3) Lack of winter-stable beaver impoundments.
4) Potential for loss of grade control with removal of the concrete dam near the mouth.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Construct full spanning log structures within the lower 0.8 miles. Adding large wood is difficult within the legacy beaver flat because of the lack of standing trees to key logs into. See prescription 3).
2) Interplant conifer opportunistically to provide a long-term source of woody debris.
3) Install vertical wooden posts in the channel at the location of the 6 legacy dams to encourage and facilitate winter stable dam construction.
4) If concrete dam is removed to facilitate summer juvenile passage, install structure placements downstream to control the grade and prevent a significant head-cut resulting in channel incision for hundreds of feet upstream. The high terrace on the right bank below a house and low terrace on left provides good site for large wood placement for grade control below the dam (Photo 62).

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

O.mykiss were observed in low numbers in the lower 0.3 miles of Smith Cr (expanded estimate of 15) during the RBA snorkel inventory conducted by BioSurveys LLC in July 2013. Cutthroat in the 1+ age class were present at an expanded estimated of 120 fish in the lower 1.1 miles (Appendix 3). An expanded estimate of 585 trout in the 0+ age class were observed distributed across the 1.5-mile survey reach. This is one of the highest 0+ abundance's in the Mosby Cr tributaries. Higher abundance of both cutthroat and 0+ trout in the lowest reach indicate that Smith Cr may be providing cool water refuge for an upstream temperature dependent migration of mainstem fish. During the field survey in May, abundant fry were observed at the head of the legacy beaver flat.

Anchor Site 1

Location and length

Describe the location and length of this Anchor Site. Identify location by river mile, tributary junctions, and other map features.

The 0.8 mile reach of Smith Creek, from the mouth upstream to where the streams splits 60/40 (Figure 7), defines the boundaries of an anchor site that has the attributes to provide for all the essential habitat features necessary to support Cutthroat Trout through all four seasons of their freshwater life history: summer, winter, spring and incubation. This is the only identified anchor site that exists outside the Core area. This suggests that there are issues associated with habitat linkages for the larger meta-population of salmonids in the Mosby Cr basin. This singular issue (habitat fragmentation) plays heavily into restoration actions in Smith Cr being ranked lower than actions within the Core area.

Channel structure

Describe channel form in terms of meander, braiding, side channel, alcove, backwater and other complex channel structures.

This anchor site exhibits an active channel width of approximately 20 ft. Floodplain interaction is evident with meander and braiding across the primary terrace in multiple locations. Current sinuosity is high, but is on a trajectory toward simplification with the observed degradation of legacy wood and beaver dams. The legacy beaver flat reach has begun to experience channel incision, but still remains highly complex with many braids and potential winter backwaters. However, this high quality habitat is clearly beginning to unravel.

Floodplain structure and interactivity

Describe the floodplain terrace structure in relation to channel level and complexity. Explain how these allow or restrict high flood access to the floodplain.

Floodplain terraces are in the 3-4 ft range within the legacy beaver flat reach where channel incision has been initiated by beaver dam failure and insufficient woody debris. There are indicators of overtopping flows on the primary 3' terraces. The balance of the anchor reach has low terraces in the 1-2 ft range. Where wood is present, the floodplain terrace is in the 1' range and achieving a full 100' wide meander belt. An exception to these conditions is about 300 linear ft that is scoured to bedrock within a confined channel.

Rearing contribution

Describe how the Anchor Site contributes to spawning, incubation, summer rearing, and winter rearing.

This anchor site constitutes the entire reach of Smith Cr that contributes to spawning, incubation and summer and winter rearing. Spawning gravels sufficient for 17 anadromous O.mykiss redds were observed in this reach during the May 2013 field survey (approximately 11 spawning pairs) (Figure 8). Four lamprey redds were observed. The available pool surface area for summer rearing was not nearly seeded to capacity even before beaver impoundments are added to the available habitat.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) Lack of current recruitment of large wood to the stream channel to support the streams potential to create winter habitat across the broad floodplain.
2) Summer stream temperatures in warm years can exceed temperatures that are conducive to salmonid rearing (64 deg F).
3) Lack of beaver damming activity to support winter-stable impoundments that would maximize the summer and rearing habitat and potentially mitigate for elevated summer temperatures (development of a thermocline).
4) Potential for loss of existing grade control resulting in channel incision.
5) Lack of a spawner population to seed available winter or summer habitat. Pool surface area for summer rearing is not currently seeded to capacity. To illustrate this condition by example - in the lower 700 ft of Smith Cr, the pool surface area (302 sq m) should be sufficient to support 226 O.mykiss and cutthroat combined when seeded to the habitats capacity (based on densities observed in other Willamette River tributaries). A combined expanded estimate of 55 O.mykiss and cutthroat were observed in the 2013 RBA snorkel inventory.

Addressing the limitations

List and rank the restoration work at the site that would most effectively improve rearing conditions within the Anchor Site and stabilize the core population at a higher base level.

1) Construct full spanning log structures within the anchor reach.

2) Protection of upslope large wood resources – Develop a conservation easement strategy that establishes a 200 ft wide riparian buffer for the identified anchor reach.
3) Interplant conifer opportunistically in the deciduous dominated portion of the riparian to provide a long-term source of persistent woody debris.
4) Install vertical posts in the channel at the location of the 6 legacy beaver dams to encourage and facilitate dam building.
5) If concrete dam is removed, install structure placements downstream to control the grade and prevent the development of a head-cut that would result in channel incision for hundreds of feet upstream. The high terrace on the right bank below a house and low terrace on left provides good site for large wood placement for grade control below the dam (Photo 62).

Kennedy Creek

Access beyond the culvert near the mouth (Photo 71) of Kennedy Creek was restricted by landowners, resulting in an incomplete survey.

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

Not assessed.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Not assessed.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

Temperatures were not monitored. However, a large man-made pond is evident from aerial imagery that could negatively influence stream temperatures if it surface spills into Kennedy Cr. The dynamics of this situation were not revealed within the scope of the LFA inventory. In summary, the flows reaching the confluence of mainstem Mosby Cr during mid-May were so low that even if the stream were contributing elevated summer flows, their impact on mainstem thermal loading would be classified as insignificant.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

Approximately 230 ft above the mouth (WP 849), a concrete sectional culvert restricts passage to adults and juveniles (Photo 72). The three 3' sectional culverts in a 10' channel have 4-10" perches. However, this tributary's flow is not sufficient enough (even in May) to rank this as a priority passage issue to be addressed.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

There was minimal flow evident at the mouth in May 2013, indicating that the temperature logger deployed in 2012 by CFWWC may have been out of water for a period of time, registering air temperatures. Therefore, temperature data has been excluded from this assessment.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

Not assessed.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.0 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover).

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Not assessed.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Not assessed.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Not assessed.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Low flows – low hydraulic potential.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

This limitation cannot be addressed effectively through restoration. No prescriptions recommended.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

The BioSurveys LLC RBA snorkel surveyors noted during their survey in July 2013 that the channel of Kennedy Creek had no positive surface flow and only stagnant isolated pools existed.

Fall Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The riparian canopy on Fall Cr is intact, dominated by deciduous trees with a limited conifer component.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

There is a limited supply of conifer within the close riparian that is available for near-term recruitment to the stream channel. Steep canyon walls support wood recruitment from far beyond the potential 100 ft riparian buffer.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

No thermal problems were currently observed in association with riparian conditions on Fall Cr. No adjacent upslope harvest has resulted in an broad and effective air shed currently surrounding lower Fall Cr.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

No migration barriers were observed on Fall Cr until the 11 ft bedrock falls (Photo 74) located approximately 200 ft above the mouth that terminates all anadromous access.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

No stream temperature data is available for Fall Cr.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

No spawning gravel suitable for anadromous O.mykiss was observed in Fall Cr during the 2013 field inventory. Small cobble is being kicked out to the side within the 15' active channel as a result of confined winter hydraulics. Potential for spawning gravel recruitment is very low in this stream.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Summer pool habitat is limited primarily to plunge pools with little cover. The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.0 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover).

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Fall Creek lacks an interactive floodplain to provide winter refuge from the high velocities of winter flows that would be generated in this steep gradient stream.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Fall Cr is a high gradient stream – the gradient at the mouth is approximately 10% (Photo 73). Active channel width is approximately 15 ft. The channel is hillslope constrained with no floodplain terrace. Pool structure is limited primarily to plunge pools.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Due to the steep gradient and lack of floodplain terrace, Fall Cr has no potential for the development of complex channel features.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Steep gradient.
2) No floodplain.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

These limitations cannot be addressed effectively through restoration.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

The RBA snorkel survey in July 2012 noted low flows on Fall Cr. An expanded estimate of 5 cutthroat, 20 juveniles in the 0+ age class and 0 O.mykiss were documented rearing in Fall Cr below the barrier falls (Appendix 3).

Short Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

Red alder dominates the riparian canopy in the lower 300 ft of Short Cr. Above the lower culvert crossing, the riparian transitions to a mix of deciduous and conifer. Willow is present within the legacy beaver flat on lower Short Cr as a source of forage for beaver, however the channel currently displays an open canopy where it passes through the previously impounded flat (Photo 76).

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Conifer is present above the lower road crossing. However, the active channel lacks the hydraulic capacity to recruit or transport large wood. Beaver activity has the best potential for recruiting wood to the channel within the legacy beaver flat.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

No thermal problems are currently observed to be originating from riparian conditions on Short Cr with the exception of the open beaver flat. Short Cr has a very narrow channel (4 ft) that allows even streamside brush to provide full cover from solar exposure. This stream has very low summer flows that would have little influence on downstream temperatures.

A channel spanning beaver dam at least 6ft vertical was removed in spring of 2013 just above the road crossing. This dam provided large capacity storage (30,000 sq ft) well into the summer of cool tributary flows for mainstem temperature mitigation. The height of the dam was likely significant enough to facilitate the development of a thermocline that would have functioned to release cool flows through the porous bottom of the dam. This is the type of habitat restoration that would have had the potential to address the primary seasonal habitat limitation for salmonids had it not been manually removed.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

A 4 ft vertical migration barrier has formed at the mouth of Short Cr associated with the riprap placed at the bridge crossing (Photo 75). This could be altered with a series of 3 step pools from the mainstem upstream to the bridge footing.
The culvert located approximately 300 ft above the mouth (WP 715) is a 4' squash pipe in a 4' active channel that is half full of mobile substrate but is fully passable.

Approximately 550 ft above the mouth (WP 716), a sill log with a 2 ft perch has formed an ephemeral barrier to upstream summer juvenile migrants (Photo 77). From here upstream, there is no summer rearing because sill logs in the steeper gradients create summer low flow barriers. This marks the upstream end of functional habitat, being too steep for linkage with the mainstem.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

No stream temperature data is available for Short Cr. This stream has very low summer flows that, without storage, would have little influence on downstream temperatures.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

Spawning potential is limited in Short Creek. No cutthroat gravels were seen up to the culvert, even though the substrates are of appropriate sizes they were not sorting into usable depositions.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The primary contribution of complex summer cover on Short Creek had been provided by the large beaver impoundment that existed in years prior to the 2013 field inventory. With the removal of this beaver dam, summer cover has been reduced to small simple pools.

From approximately 550 ft above the mouth, there is no summer rearing because sill logs in the steeper gradients create summer low flow barriers (Photo 77). This marks the upstream end of functional habitat, being too steep for linkage with the mainstem.

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The primary contribution of winter cover on Short Cr was historically provided by the large beaver impoundment that existed prior to the 2013 field inventory.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Just upstream of the bridge crossing on Short Creek, a beaver dam as high as 5-6 ft existed as recently as spring 2013. The impoundment from this dam created a pond across the broad floodplain terrace of approximately 300’ X 100’. The dam was mechanically removed. Currently, flow emanates from several spring sources within the old beaver flat.

Approximately 300 ft above the mouth, just upstream of the culvert, there is a major gradient shift to 6-7%. This reach has no floodplain terrace structure. It appears that the current channel was relocated to facilitate the development of road bed. The relocation of the channel created the existing marshy flat.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Potential for channel complexity is high within the broad floodplain terrace that is the site of the historic beaver impoundment in the lower reach of Short Cr. Impoundment of the stream would have additional value in contributing to sustained flows into the summer. However, upstream of the culvert at 300 ft, the potential for channel meander is low due to steep gradient and lack of floodplain.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Downstream of the culvert, lack of beaver dam building activity is the current limitation.
2) Upstream of the culvert, the development of channel complexity is limited by steep gradients and the lack of a functional floodplain.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Encourage beaver dam building. A dam height regulator (pond leveler) in the next impoundment may be helpful in managing perceived risks to road infrastructure.
2) Upstream of the culvert, the limitations cannot be addressed with restoration.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

Short Cr was not inventoried in the 2013 RBA snorkel survey due to insignificant summer flows.

Blue Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

Blue Creek is supported by a full vegetative canopy from a 50 ft buffer of deciduous riparian vegetation, including shrubs that provide overhanging cover to the channel. Below the falls, a stand of large (50 yr) conifer is present outside this buffer. Above the bedrock falls, large western red cedar and Douglas fir are present within the 50' buffer on BLM ownership.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Conifer is not available within the inner riparian for recruitment. Large conifer located outside the 50' riparian buffer are available for recruitment in the long term from wind-throw, however these trees are unlikely to reach this stage as they are not within the reserved buffer regulated by Oregon Forest Practices.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

No thermal problems are currently observed to be originating from the existing riparian conditions on Blue Cr.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

No man-made migration barriers are present on Blue Creek.

Summer migration potential for all juvenile salmonids ends approximately 425 ft upstream of the mouth (WP 713) where the active channel changes to narrow hillslope confinement. Full spanning logs have created vertical perches that are only passable during winter flow regimes (Photo 79).

A 5 ft bedrock falls located 750 ft upstream of the mouth (WP 714) terminates all anadromous access (Photo 80).

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

No stream temperature data is available for Blue Cr.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

Cobble and small boulders up to 12” diameter dominate the substrate on Blue Cr. No spawning gravels suitable for anadromous O.mykiss were observed in Blue Cr. The active channel width of Blue Cr is too small for anadromous O.mykiss to spawn. Spawning potential for cutthroat is limited because of substrate size and lack of accumulations of well-sorted fine gravels. However, at the base of the bedrock falls, at least four potential redd sites for Cutthroat Trout were observed.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The simplified channel of Blue Cr provides little summer pool habitat. Overhanging vegetation however does provide some protective summer cover. The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.0 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover).

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The lower 400 ft of Blue Cr has limited winter cover across an interactive floodplain. Beyond this short reach, there is no slack water winter habitat due to the steep gradient and lack of an interactive floodplain.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Blue Cr enters on a steep gradient (6%), depositing alluvium in a fan at the mouth (Photo 78), supplying a high quality gravel resource to the mainstem. This deep deposition of gravels at the mouth of Blue Cr has the potential to create a summer disconnect from the mainstem in low flows. Blue Cr has a bankfull channel width of 12 ft. A broad (60’) interactive floodplain terrace extends from the mouth upstream approximately 425 ft. Alternating terraces are 2-4’ in height within this reach. Upstream of this extent, the channel becomes hillslope confined with no significant floodplain terrace.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Potential exists in the lower 425 ft to increase sinuosity across the interactive floodplain terrace. Little or no potential for channel complexity exists beyond approximately 425 ft.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Lack of wood in stream channel in lower reach up to 425 ft.
2) Hillslope confinement beyond 425 ft upstream of mouth.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) In-stream wood treatment associated with every harvest rotation because the small stream classification would result in all future potential conifer outside the 50’ buffer being removed.
2) This limitation cannot be effectively addressed with restoration actions.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

An expanded estimate of 5 cutthroat and 45 trout in the 0+ age class were observed in Blue Cr during the 2013 summer RBA snorkel survey. No O.mykiss were observed. The survey extended upstream 730’ to a bedrock falls (Appendix 3).

Simpson Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The lower 1000' reach of Simpson Cr has good riparian cover with a mix of deciduous & conifer trees in the 20-30 yr age class. Above this reach the riparian is dominated primarily by alder in the 20 yr age class. Approximately 0.25 miles upstream of the mouth, the riparian buffer is thin on the south side due to the impacts of wind-throw on the edge of a clearcut (Photo 82).

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Potential exists for future source of large woody debris on Simpson Cr, but it's likely 50-75 years out. Most of the conifer exists outside of the recruitment corridor. In the lower reach, the stream has no potential to create the sinuosity and scour required to recruit conifer from the riparian. Increased meander in the middle reach could function to recruit alder. The upper reach has steeper slopes that would allow more upslope recruitment.

Approximately 2,000 ft above the mouth, wind-throw from a clearcut (Photo 82) has delivered some young alder and conifer to a couple hundred feet of channel – but the wood is 6-12" diameter and short-lived. Small diameter fir is also currently being delivered from a debris slide approximately 0.4 miles upstream of the mouth (WP 725).

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

The riparian buffer generally does a good job of shielding Simpson Cr from solar warming. However at approximately 0.25 miles, the thin riparian resulting from wind-throw at the edge of the clearcut has exposed the stream on the south side to solar exposure that may influence the temperature profile of the stream.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

A bedrock intrusion approximately one half mile above the mouth of Simpson Cr (WP 728), coupled with an increase to 10% gradient forms a barrier to summer juvenile migration (Photo 85).

A 6.5 ft bedrock falls located 0.6 miles upstream of the mouth (WP 730) terminates all anadromous migration (Photo 87).

A 5' culvert (in good condition) located another .7 miles above the bedrock falls (WP 732) poses a barrier to resident cutthroat passage (Photo 88). The pipe is under a deep fill with a 1' outlet perch. Water is flowing under the pipe, but the pipe bottom is solid. This is not a high priority pipe for replacement because passage would only benefit resident cutthroat (not multi-species) that would not need to migrate upstream for cold-water access at this location because cold water is available downstream. A rock weir placed downstream of the culvert could address the perch. A significant sediment source enters the creek on the downstream (left) side of this crossing. A low spot on the inside corner directs sediment flow directly to the creek. Filter bags had been installed at the road edge in an attempt to address the problem, but were not working. Consider building up the inside corner with rock to provide additional sediment filter.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

Simpson Creek is the most downstream tributary of the Mosby Cr subbasin with significant summer flows that maintains consistent cool temperatures throughout the summer. Data collected by CFWD at the mouth of Simpson Cr in the summers of 2012 and 2013 displayed a temperature profile for Simpson Cr where, in both years, the 7-day average maximum temperature never exceeded the 64 deg F threshold established by DEQ for salmonid rearing. Maximum temperatures only exceeded 64 deg F for 8 hours (over 2 days) in 2012 and 25 total hours (over 7 days) in 2013 (Figure 25). Simpson Cr could provide valuable cool temperature refugia from warm mainstem conditions – temperature profiles in 2013 showed Simpson Cr tracking as much as 11 deg F cooler than mainstem temperatures measured just downstream of the confluence with Simpson Cr.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

The substrates of Simpson Cr range from fine gravels up to small (12-16”) boulders. No spawning gravels suitable for anadromous O.mykiss were observed in the 2013 field inventory. Appropriate size gravels are available in good quantity but are unconsolidated and unsorted and generally being transported out of the system. Fine gravels, suitable for Cutthroat Trout are sorting, but are not abundant.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

There is very low summer cover available on lower Simpson Cr, due to a simplified channel and limited undercutting. The pool surface area (sq ft) of the first ten pools of this creek were measured during the field inventory as part of a comparison with other tributaries of the Mosby Cr subbasin to assess their capacity to support summer rearing salmonids. Simpson Cr had an average of only 93 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr. This metric is reflective of the summer pool rearing capacity of the lower 1500 ft of Simpson Cr and is not consistent with the more functional channel form displayed in the middle to upper reaches where the abundance of summer cover increased but still exhibits low function related to a simple channel and exposed bedrock.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.0 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover).

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Winter cover is severely lacking in Simpson Creek. The lower reach displays a simple incised channel with no floodplain connectivity. The middle reach has more potential but is currently lacking wood to promote floodplain interaction. The upper reach is too steep to offer any winter habitat.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The lower 1500 ft of Simpson Creek has a bankfull channel width of 13 ft with no floodplain. The channel in this reach is highly simplified and deeply incised to 4 ft (Photo 89). A series of bedrock intrusions creates permanent grade control; however the channel is repeatedly scoured to bedrock. A bedrock falls (Photo 81) located 1000 ft above the mouth (WP 721) consolidates flow to allow access, but may concentrate fish below the falls.

Approximately 1500 ft above the mouth (WP 722), the channel broadens to 18 ft and displays a 1-2 ft floodplain terrace and a floodplain width of 60 ft that extends for approximately 1200 ft upstream. Overall function is low; much of the channel is scoured to bedrock (Photo 83). Multiple bedrock intrusions and falls (WP 723, 724) complicate juvenile migration but do not appear to fully block movement (Photo 84).

In the upper reach, from 0.5 miles above the mouth, and extending to the 6.5 ft bedrock falls, the gradient increases to about 15% with no terrace structure (Photo 86). The bedrock falls ends migration for all sizes and all species (Photo 87).

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The lower 1500 ft reach has low potential for developing channel complexity – the channel is simplified and incised throughout the reach. Within the middle reach (RM 0.25-0.5) potential for developing channel complexity is much higher with low terraces and a broader floodplain. Sinuosity is low and the channel has simplified with no significant wood in the channel. In the upper end of this 1200 ft reach, an historic side channel that functioned to dissipate hydraulic potential during winter flows was formed above a blockage created by an old landslide (WP 726-727). The upper reach has no potential for channel complexity due to high gradient and no floodplain.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Lower reach (mouth to 0.25 miles): Channel incision, lack of floodplain terrace, no sinuosity.
2) Middle reach (0.25-0.5 miles): Lack of woody debris, low sinuosity and channel incision isolates historic side channel.
3) Upper reach (above 0.5 miles): High gradient and no floodplain.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Lower reach: Install edge-oriented wood to promote bank scour to recruit riparian alder.
2) Middle reach: Install full-spanning logs to create deflection and boost sinuosity to recruit wood from the riparian and support sorting of spawning gravels; reconnect historic side channel with strategic placement of full-spanning wood downstream. This whole section is road adjacent for easy equipment access.
3) Upper reach: Limitation cannot be addressed through restoration actions.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

O.mykiss were observed in low numbers (expanded estimate of 30) in the lower 2,000 ft of Simpson Cr during the RBA snorkel survey conducted by Bio Surveys LLC in July 2013. Low densities of 1+ age class cutthroat were observed unevenly distributed with a total expanded estimate of 100 cutthroat across the 1.0-mile survey reach. Most of these were again observed in the lower 2000 ft reach. An expanded estimate of 370 trout in the 0+ age class were observed well distributed in low densities across the 1-mile survey reach. Only one of the 21 sample pools had no 0+ trout (Appendix 3).

Despite the cool water contribution to the mainstem of Mosby Cr, there was no evidence of an upstream temperature dependent migration of juveniles. Mosby exhibited a maximum 7-day average temperature of 74.4 deg F suggesting that the potential for upstream movement into Simpson existed. This is a similar situation to other cool water tributaries documented in the lowest 6th field of Mosby Cr. There are no fish available in the mainstem of Mosby to migrate when condition deteriorate.

This significantly informs the prioritization of restoration prescriptions. Addressing passage issues for juvenile access in the lower Mosby Cr 6th field will have no short term benefit until conditions in the Core area are addressed that will allow expansion of a remnant population of salmonids.

Lewis Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The riparian vegetation along the lower 0.25-mile reach of Lewis Cr is alder dominated with a component of western red cedar in the 10-20 year age class. Above 0.25 miles, the riparian vegetation is a mix of alder and Doug fir of the 20-30 year age class. The riparian buffer on the south side is narrow and impacted by an opening for the lower 0.5 miles created by a stream adjacent harvest unit.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Good potential to recruit conifer from the riparian exists beyond the 50-75 year timeframe.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

The solar exposure caused by the narrow buffer and open harvest unit on the south side generating warm ambient air temperatures that contribute to thermal loading in Lewis Cr.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

Approximately 1,400 feet above the mouth of Lewis Cr (WP 750), a bedrock falls with substantial steps of 6 ft over 30 horizontal feet, ends summer migration (Photo 93). This falls would not likely stop an adult spawning migration however.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

Data collected by CFWWC in the summers of 2012 and 2013 display a temperature issue for the aquatic habitat on Lewis Cr. The data for 2012 indicated 13 days where temperatures exceeded the 64 deg F DEQ threshold for salmonid rearing. In 2013 (a warmer summer) maximum temperatures exceeded the threshold for a total of 49 days. Upstream and downstream tributaries, Simpson and Rock creeks, remained below the 64 deg F threshold throughout 2013 while temperatures on Lewis Cr consistently tracked as much as 3-4 degrees F warmer than these tributaries (Figure 25). At the same time, Lewis Cr tracked 3-4 degrees cooler than mainstem Mosby Cr temperatures measured at a point approximately 2,000 ft upstream of the confluence with Lewis Cr.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

No spawning gravels suitable for anadromous O.mykiss were observed in Lewis Cr during the 2013 field inventory. Potential for spawning gravel recruitment is relatively high however. Significant bedload resources are stored in a deep gravel lens (Photo 92).

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Pool surface area for summer rearing habitat is limited on Lewis Cr. The pool surface area (sq ft) of the first ten pools of this creek were measured during the field inventory as part of a comparison with other tributaries of the Mosby Cr subbasin to assess their capacity to support summer rearing salmonids. Lewis Cr had an average of only 126 sq ft of pool surface area per 100 ft of stream within its first ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 1.9 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover). In general an average score of 1.9 would be considered low.

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Winter cover on Lewis Cr is currently low, limited by a lack of wood functioning to scour and connect the available low floodplain terraces.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The mouth of Lewis Cr enters mainstem Mosby across a large gravel deposition that creates a 3 ft lift in the tributary channel (Photo 90). The channel width is generally about 15 ft and the width of the floodplain terrace on the lower reach varies from 60 to 90 ft with a 1-3 ft terrace height. Above 300 ft from the mouth, the channel widens to 25 ft for approximately 100 lineal ft. In this reach, the floodplain terrace drops to 1-2 ft in height (Photo 91). These low terraces maintain throughout the 0.25-mile reach that extends to a bedrock falls that marks the upper extent of access for juveniles for summer migration (Photo 93).

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Lewis Creek displays substantial potential for the provision of rearing habitat for multiple species of salmonids in the lower 0.25 miles, up to the bedrock falls. The zone from 300 to 900 ft above the mouth exhibits the best potential for encouraging off-channel habitat development with its wide interactive meander channel and low floodplain terraces. About 900 ft upstream of the mouth (WP 749), a significant bedrock intrusion marks the upper extent of this more interactive zone.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Lack of wood complexity.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) The addition of full-spanning wood is prescribed for trapping and sorting spawning gravels and encouraging increased sinuosity to establish off-channel floodplain linkages during winter flows.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

No O.mykiss were observed in Lewis Cr during the RBA snorkel inventory conducted by Bio Surveys LLC in July 2013. Low densities of 1+ age class cutthroat were observed in only 4 of the 18 sample pools in the 5600 ft survey reach (expanded estimate of 35 total fish). Trout in the 0+ age class were observed in low densities throughout the survey reach (expanded estimate of 310). Only one of the 18 sample pools had no 0+ trout (Appendix 3). No upstream temperature dependent migration of salmonid juveniles from mainstem Mosby Cr was observed.

Rock Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

Rock Cr has a good riparian cover, composed primarily of alder. The conifer component is minimal in the lowest 0.25-mile reach. Above this extent, mature cottonwood are present for a short distance before returning to an alder dominated condition with few conifer.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

The legacy of landslides and major debris torrents as a source of bedload recruitment to Rock Cr is evident from the depositions of alluvium across the available floodplain, the dikes that have formed along the channel, and the abundance of stumps and logging debris stored on the stream edge. However, a history of conifer removal from the riparian leaves very little potential for future sources of large wood delivery to the channel.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

No thermal problems related to riparian condition were noted in the 2013 field survey.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

A sill log located about 1000 ft above the mouth forms a 2 ft perch that is an ephemeral barrier to juvenile salmonids attempting an upstream summer migration (Photo 95).

A 7 ft bedrock falls (Photo 99) terminates anadromous migration 0.6 miles from the mouth (WP 744).

In addition, it was noted that the entrance of Rock Cr to the mainstem of Mosby is a steep cascade. This may also frustrate significant use of Rock Cr as summer thermal refugia.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

No temperature issues were identified for Rock Cr. Data collected by CFWWC in 2012 and 2013 indicated that stream temperatures at the mouth of Rock Cr consistently maintain a cool temperature profile through the summer months, below the DEQ established threshold (64 deg F) for salmonid rearing (Figure 24).

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

Rock Cr is endowed with abundant gravels, substrates ranging in size up to 18" small boulders. However, gravels are present only as a percentage of mobile substrates that are not at all sorted. Where wood is present, gravels accumulate, but limited spawning gravels are sorting – only 1 sq meter of gravels suitable for anadromous O.mykiss were observed in the 2013 field survey (Figure 8). Rock Cr is currently limited by a lack of well-sorted spawning gravels but has a reasonable potential for recruiting this habitat component.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Pool surface area for summer rearing habitat is relatively well distributed on Rock Cr, however pools lack complexity and cover. The pool surface area (sq ft) of the first ten pools were measured during the field inventory to facilitate a comparison with the other tributaries of Mosby Cr subbasin for capacity to support summer rearing of salmonids. Rock Cr had an average of only 210 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 1.9 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover). In general an average score of 1.9 would be considered low.

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Overall, winter cover is limiting the salmonid habitat on Rock Cr. Winter cover is available primarily within a 400 ft reach of Rock Cr where a broad low flat is currently interactive with the active channel during high winter flows. Much of the remainder of the Rock Cr channel is simplified with low sinuosity such that little winter slack water habitat is available.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Rock Cr has a bankfull channel width of 20 ft and a 15 ft wetted channel. It has some of the highest summer flows of all the Mosby tributaries (along with Smith, E Fk and W Fk Mosby creeks). The lower 1250 ft reach of Rock Cr displays a simple channel (Photo 94) with little to no floodplain. Wood observed in the channel displays an ancient forest legacy – short pieces of large diameter logs, some with fire scars, that have accumulated massive quantities of unsorted gravels upstream (Photo 96). Where no wood is present, the channel is scoured to bedrock. At the top of this reach, an exposed bedrock intrusion exhibits a 6 ft gain in elevation over 50 ft of length (Photo 97).

Just upstream of this bedrock intrusion, the channel character changes dramatically to a 200 ft interactive floodplain (Photo 98) with an extremely low (1 ft) terrace. This broad flat extends for about 400 ft, displaying pooled water that is currently being fed by hyporheic connections. Low floodplain terraces continue for another 800-1000 ft upstream alternating right to left with the influence of significant debris jams.

Above this interactive reach, the stream returns to a simplified channel that extends upstream to a 7 ft bedrock falls that ends anadromous migration, 0.6 miles from the mouth (Photo 99).

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Currently sinuosity on much of Rock Cr is minimal resulting in a simple channel with low complexity. If large wood were present in the channel to initiate scour and interaction with the broad low terraces, it would have all the elements to support its high potential for developing complex channel forms.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Lack of wood complexity and scour elements.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Install full-spanning large wood to initiate scour and trap and sort the abundant gravels that are migrating through Rock Cr.
2) Develop alcove at the broad low flat near first right trib. This site is being fed from hyporheic flow that will guarantee a functional alcove with year around positive outlet flow.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

One O.mykiss was observed in Rock Cr during the RBA snorkel inventory conducted by Bio Surveys LLC in July 2013. Very low densities of 1+ age class cutthroat were observed distributed throughout the 4,500 ft survey reach (expanded estimate of 90 fish). Trout in the 0+ age class were observed sporadically throughout the survey reach at very low densities (expanded estimate of 125). To put this in perspective, full seeding of 0+ trout would be expected to show a density of 3 fish per sq m of pool surface area. The first 10 pools of Rock Cr (242 sq m) have a full-seeding capacity of 726 trout in the 0+ age class (Appendix 3).

No upstream temperature dependent migration of salmonid juveniles from mainstem Mosby Cr was observed.

Palmer Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

Palmer Cr has full canopy cover throughout the surveyed reach, though narrow where adjacent to recently harvested timber units. The vegetation is composed primarily of a mix of alder, maple, ash, and vine maple. Douglas fir is present in the riparian in higher elevation locations alongside old western red cedar stumps. The riparian timber type has been transformed from western red cedar on wet terraces among braided side channels. With the removal of the cedar, the eventual loss of large wood in the channel, and the resultant drop in water table in the floodplain, the terraces became drier and Douglas fir became established in the higher elevation locations.

About 2,000 ft above the mouth, the riparian transitions to strong alder dominance regenerated on a debris torrent run out (Photo 105). This condition continues to the top of the torrent track (about 1500 ft), where the riparian transitions to 30 year alder (Photo 108) with a mix of young hemlock and western red cedar coming in that is being actively browsed by elk.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Limited conifer is present in the riparian, but unavailable for recruitment within a 50-75 year timeframe. Protection of young hemlock and cedar in the upper reach from elk browse would assist in securing this long-term source of large wood.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

Where a narrow riparian buffer is directly adjacent to recently harvested timber units, the ambient air temperature contributes to warming influences on the stream.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

Approximately 2,000 ft above the mouth (WP 757), a debris torrent flow created a two-stage jam with a 5' vertical jump (Photo 106) followed by another 6' vertical sill log barrier 60' upstream of the first. This is an ephemeral barrier and in time will become more passable for migratory adults over time. It is currently a barrier for migration of both juveniles and adults.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

No temperature issues were identified for Palmer Cr. Data collected by CFWWC in 2013 indicated that stream temperatures at the mouth of Palmer Cr maintain a cool temperature profile through the summer months, remaining significantly below the DEQ established threshold (64 deg F) for salmonid rearing (Figure 22).

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

During the 2013 field inventory, 36 sq ft of spawning gravel for anadromous O.mykiss was observed in the lower 700 ft reach of Palmer Cr (Figure 8). Palmer Cr has a noticeable lack of fine gravels appropriate for cutthroat spawning.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Palmer Cr displays beautiful undercut banks as a result of higher sinuosity than normally observed in the pinnate tributaries of Mosby Cr. The pool surface area (sq ft) of the first ten pools were measured during the field inventory to support a comparison with the other tributaries of Mosby Cr subbasin for capacity to support summer rearing of salmonids. The lower 650 ft of Palmer Cr had an average of 296 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.1 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover).

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

With the broad floodplain, low terraces and high sinuosity that are all well displayed on Palmer Cr, winter habitat is abundant, particularly in lower 2,000 ft of stream. This is related to the fact that the first 2,000 ft traverses the broad historical floodplain of mainstem Mosby Cr. There is extensive potential in this lower end for the development of off channel backwater habitats and alternative linkages to mainstem Mosby Cr involving the development of side channels in Mosby Cr. The morphology of Palmer Cr as it traverses the Mosby Cr floodplain is also ideal for impoundment initiated by beaver dams. This is currently an unrealized resource that would dramatically expand both summer and winter rearing habitat.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Palmer Creek is unique among the Mosby tributaries as it traverses the broad interactive terrace and an active side channel of mainstem Mosby Creek (Photo 102), in contrast to the steep entry that many of the other tributaries exhibit. This creates a low gradient transition that allows abundant spawning gravels to drop out. Bankfull and wetted width of Palmer Cr is 12-14’. Floodplain terraces are very broad, up to 500 ft in width in places (Photo 103), with no hillslope confinement. Terraces heights are very low (1-3’) and exhibit a history of braiding and vast wetland habitats that are simplifying and being reduced in abundance by the lack of wood in the channel to prevent incision. Beaver and their impoundments would be expected in this environment, but are noticeably missing (no food source).

Approximately 2,500 ft upstream of the mouth, the channel character changes to exhibit the legacy of a massive debris torrent event that has left deep alluvium as well as woody debris on floodplain terraces (Photo 107) for the next 850 ft. At the lower end of this reach, deposition from a debris torrent has blocked the top of an historic side channel.

The stream gradient increases over the next 3,000 ft with boulder and cobble rapids until reaching a pair of back-to-back bedrock falls (7 ft and 8 ft) that transition into a tight hillslope confined canyon.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Palmer Cr currently exhibits some of the highest channel complexity as well as some of the highest potential for expanding complexity among all the Mosby Cr tributaries. Of particular value is the potential to increase the hyporheic connection between the mainstem Mosby Cr side channel in Mosby Anchor #5 and lower Palmer Cr. This could provide extensive thermal refugia to address the primary seasonal habitat limitation. The low floodplain terraces and legacy of side channels provide the canvas for injecting the missing ingredients (large wood) that will regain a fully functioning and fully linked mainstem and tributary.

Approximately 2,000 ft above the mouth (WP 757), a debris torrent flow created a two-stage jam with a 5' vertical jump (Photo 106) that is currently isolating an historic side channel. This debris flow occurred approximately around 1983, based on the estimated age of the alder on the disturbed alluvium of the torrent track. A design to relink historical habitat here would be necessary.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Lack of scour elements (wood) required to dig into deep alluvium to expose hyporheic refugia in both the Mosby Cr and lower Palmer Cr side channels.
2) Lack of wood complexity to encourage meander and to trap and sort spawning gravels.
3) Lack of beaver dams to store flows on broad interactive floodplain terraces to expand summer pool surface area and store ground water to mitigate for summer low flows.
4) Lack of hyporheic connection to floodplain terraces within debris torrent depositions.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Develop a log jam on the point bar at the top of the mainstem side channel that Palmer Cr enters (Photo 101).
2) Treatment reach 1 (mouth to WP 755): Install full-spanning large wood to encourage scour, deflection and gravel sorting and support winter stability of beaver dams.
3) Treatment reach 2 (WP 755-757): Install full-spanning large wood to trap and sort spawning gravels. Develop alcove at the bottom end of historic side channel

(Photo 104) located near the first significant left trib split (WP 756), approximately 2,200 ft upstream of the mouth.

4) Treatment reach 3 (WP 757-758): Install full-spanning large wood to raise the channel to connect to broad debris terrace of alluvium to maximize hyporheic flows.
5) Consider treating mainstem Mosby Anchor 5 simultaneously so that design concepts can include the inter relation of lower Palmer and mainstem Mosby as it relates to the reconnection of multiple side channels.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

No O.mykiss were observed in Palmer Cr during the RBA snorkel inventory conducted by Bio Surveys LLC in July 2013 (Appendix 3). Very low densities of 1+ age class cutthroat were observed distributed throughout the 5,600 ft survey reach (expanded estimate of 70 fish). Trout in the 0+ age class were observed distributed throughout the survey reach but at low densities (expanded estimate of 310). To put this in perspective, full seeding of 0+ trout would be expected to show a density of 3 fish per sq m. The lowest 10 pools on Palmer Cr had a surface area of 174 sq m. This could support as many as 522 trout in the 0+ age class in this 632 ft reach alone. No upstream temperature dependent migration of salmonid juveniles from mainstem Mosby Cr was observed.

Anchor Site 1

Location and length

Describe the location and length of this Anchor Site. Identify location by river mile, tributary junctions, and other map features.

The approximately 700 ft reach of Palmer Creek from the mouth upstream defines the boundaries of an anchor site that has the attributes to provide for all the essential habitat features necessary to support the complete freshwater life history of Cutthroat Trout (Figure 7). This anchor reach traverses the broad interactive floodplain terrace and an active side channel of mainstem Mosby Creek (Photo 102). It also overlaps mainstem Mosby Cr anchor 5 and the two should be treated and managed as a single anchor during the development of a restoration plan.

Channel structure

Describe channel form in terms of meander, braiding, side channel, alcove, backwater and other complex channel structures.

This anchor site exhibits an active channel width of 12-14 ft with a legacy of extensive braiding and side channels, many of which are currently disconnected at most flow levels.

Floodplain structure and interactivity

Describe the floodplain terrace structure in relation to channel level and complexity. Explain how these allow or restrict high flood access to the floodplain.

This anchor site has an extremely broad (500') floodplain that exists within the broad floodplain of mainstem Mosby Cr. Terraces heights are very low (1-3') and exhibit a history of braiding and vast wetland habitats that are simplifying and being reduced in abundance by the lack of wood in the channel to prevent incision.

Rearing contribution

Describe how the Anchor Site contributes to spawning, incubation, summer rearing, and winter rearing.

All of the small amount of spawning gravels suitable for anadromous O.mykiss that were observed on Palmer Cr during the May 2013 field survey were located within this anchor site (36 sq ft in lower 700 ft), enough to support 4 O.mykiss redds (2-3 spawning pair). The 2013 RBA snorkel inventory did not detect an unusual concentration of salmonid juveniles within the anchor site. No O.mykiss were observed and densities of both 0+ trout and cutthroat were very low. Pool surface area for summer rearing is not nearly seeded to capacity.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) Lack of suitable spawning gravels. Lack of large wood complexity to trap and sort spawning gravels and to encourage floodplain interaction and prevent incision over time.
2) Lack of a secure source of long-term large wood for recruitment to the channel – Oregon Forest Practices Act only protects the inner 70 ft of riparian buffer on medium fish-bearing streams, with alternatives available for reduced buffer width.

Addressing the limitations

List and rank the restoration work at the site that would most effectively improve rearing conditions within the Anchor Site and stabilize the core population at a higher base level.

1) Construct full spanning log structures within the anchor reach to trap and sort spawning gravels and encourage floodplain connectivity.

2) Protection of riparian and upslope large wood resources – explore interest in conservation easements to expand the functional width of the riparian.
3) Consider treating mainstem Mosby Anchor 5 simultaneously so that design concepts can include the inter relation of Palmer Anchor #1 and mainstem Mosby as it relates to the reconnection of multiple side channels.

Cow Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

Within 50 ft of the mouth of Cow Cr, the riparian is endowed with plentiful willow that is supporting at least one beaver colony in Mosby Cr side channels (Photo 109). From the mouth to the bridge, blackberry has infested the riparian from an abandoned settlement or homestead site (Photo 110). Above the bridge, the riparian has good canopy cover with high vegetative diversity that includes western red cedar, Douglas fir, maple and alder with some older age class conifer. An exception is where the riparian is thin for a short distance adjacent to a recently harvested timber unit. A complex wetland also exists near an abandoned quarry. The wetland is well protected with a wide riparian belt. About 0.5 miles upstream of the mouth, the riparian vegetation transitions to be dominated by an alder canopy.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Conifer is present as a near-term contributor to the channel in about a .25-mile reach above the bridge. However Cow Cr lacks the hydraulic potential to deliver this wood downstream to the mainstem of Mosby Cr.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

The blackberry in the lower reach of Cow Creek excludes native vegetation and trees from establishing. However, due to the narrow channel and overhanging nature of the blackberry, thermal impacts to the stream corridor from direct solar exposure are negligible. No other major thermal problems are currently observed to be originating from riparian conditions on Cow Creek.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

An abandoned road crossing, located 0.5 miles above the mouth (WP 765) presents a barrier to upstream summer migration (Photo 111).

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

No stream temperature data is available for Cow Cr. This stream has low summer flows that would have little influence on downstream temperatures. The mitigating influence of the upstream wetland on downstream temperature profiles is likely significant for maintaining high water quality within Cow Cr however.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

There are no spawning gravels for large anadromous salmonids on Cow Cr, and there is also no potential for spawning because of the small size of the habitat (active channel less than 8 ft).

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Summer rearing pool surface area is very limited on Cow Cr. However, cover is good. The pool surface area (sq ft) of the first ten pools were measured during the field inventory to support a comparison with the other tributaries of Mosby Cr subbasin for capacity to support summer rearing of salmonids. Cow Cr had an average of 75 sq ft of pool surface area per 100 ft of stream within its ten-pool reach. This was the lowest average for all the tributaries compared using this metric. The beaver impoundment at the mouth offers excellent summer cover and exists on the Mosby Cr floodplain.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.6 on a scale of 1-5. This scale is based on the total percent of pool

surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover).

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

In the upper end of the survey reach, wood densities are high, providing excellent winter cover.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Cow Cr has an 8 ft bankfull width, with a primary terrace height of 3-4 ft. The channel in the lowest 1,000 ft reach is incised. Cow Cr flows are very low during pinch period summer flows.

In the quarry area, there is excellent water storage and groundwater cooling occurring on two 150' wide terraces where quarry rock has essentially created hydraulic controls that have functioned to store broadly dissipated stream flows. The large bedload of alluvium is protecting flows in the hyporheic lens. This type of ground water storage is extremely valuable for temperature maintenance and directly addresses the primary seasonal habitat limitation in the Mosby Cr basin. A couple small wetlands surround these flats and they have been well protected by a wide riparian belt. It appears that a blocked culvert was recently pulled at the quarry crossing that could result in loss of the artificial grade control that has been supporting the upstream flat.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

There is limited hydraulic potential for developing sinuosity and trapping transient gravels.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Limited hydraulic potential.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) This limitation cannot be effectively addressed with restoration actions.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

During the 2013 RBA snorkel inventory conducted by Bio-Surveys LLC, there were no O.mykiss, an expanded estimate of 15 cutthroat and 15 trout in the 0+ age class observed in the sample pools on Cow Cr (Appendix 3). Flows were very low and pools were isolated from each other by mid-July.

No upstream temperature dependent migration of salmonid juveniles from mainstem Mosby Cr was observed.

Clearing Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

Clearing Cr has good riparian cover. Overstory vegetation in the lower 1,000 ft is composed of maple, alder & cottonwood. Above this reach, the terraces created by a debris flow event are dominated by 30-40 yr old alder interspersed with young understory hemlock.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

No conifer is available for recruitment in the lowest reach of Clearing Cr. Minimal potential exists in the debris torrent reach that starts 1,000 ft above the mouth, but this is very young hemlock that will not be available for over more 100 years.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

No thermal problems are currently observed to be originating from riparian conditions on Clearing Creek.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

About 1,000 ft above the mouth (WP 780), a log jam with a 4 ft vertical sill log is an ephemeral barrier to summer migration (Photo 112).

About 0.75 miles up Clearing Cr, an undersized (6 ft pipe in 12 ft channel) perched (6") culvert (Photo 114) was installed across a historic debris torrent jam. Replacement of this pipe would be complicated by the elevation of the jam and would have little value to the aquatic resource profile – no net gain and very high risk.

A short distance below this culvert (WP 783), two back-to-back barriers (4 ft followed by 6 ft vertical) resulted from a debris torrent (Photo 115) that formed an ephemeral barrier that currently ends all anadromous migration. The 4 ft barrier is large material, very stable and on the channel bottom. The jam is old and breaking down, but any attempt to replace the upstream culvert now could very likely end up with a major culvert perch from the resultant loss of this grade control.

About one mile up Clearing Cr (WP 1001), a 9 ft bedrock falls is the permanent terminus for all anadromous migration.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

No stream temperature data is available for Clearing Cr.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

The substrate of Clearing Cr is gravel dominated (85% gravel/15% cobble) with the D100 approximately 6" cobble. While gravels are abundant, they are not well sorted for spawning. Gravels are cast to the side at the mouth where high flows that reach the mainstem Mosby floodplain create slow water that allows gravels to drop out. During the 2013 field inventory, 9 sq ft of spawning gravels suitable for anadromous O.mykiss was observed approximately 600 ft above the mouth (Figure 8).

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Summer cover on Clearing Cr is very limited, resulting from low wood densities and a lack of sinuosity. The pool surface area (sq ft) of the first ten pools was measured during the field inventory to support a comparison with the other tributaries of Mosby Cr subbasin for capacity to support summer rearing of salmonids. The lower 600 ft of Clearing Cr had an average of 185 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr.

The 2013 RBA snorkel survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.1 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, large substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover).

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The substrates in the mainstem of Clearing Cr are too small to provide significant hiding cover (interstitial voids in unimbedded substrates) for winter rearing O.mykiss. While the incised channel limits floodplain connection, side channels and debris torrent associated wood in the channel provide some opportunity for the development of off channel habitat (winter cover).

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The Clearing Cr channel averages a width of 15 ft. Overall, the channel has taken on a simplified character with little sinuosity. In its lower 1,000 ft, Clearing Cr exhibits a history of debris flows with an alluvial fan expanding onto the 150' wide floodplain. Terrace heights are about 3' with only one dominant terrace and with limited variability in height. About 600 ft above the mouth (WP779) a historic side channel was blocked on the upstream end by deposition and diking associated with the debris flow.

About 1,000 ft above the mouth, above a large debris torrent jam, (WP 780) terraces are lower (1-2 ft) but as the foundational wood in the debris jam decays, head cutting through these low upstream terraces will begin. Here, the floodplain narrows to 60 ft (hillslope to hillslope). The low terraces extend for another 700 ft where another debris jam used to block the channel. Currently there is a 6' channel incision through the debris torrent deposition and the resultant head cutting upstream has left a simplified channel form behind (Photo 113). Above mile 0.75, the channel becomes hillslope confined and gradients increase.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The reach from the mouth to 1,000 ft upstream has good potential to increase sinuosity and reconnect the broad historic floodplain. The potential is less over the next 3,000 ft – low terraces exist, but the floodplain is narrow. Above the culvert (0.75 mile), the potential for developing channel complexity is nonexistent due to hillslope confinement.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Lower reach (mouth to 1,000 ft) – lack of wood and simplified channel
2) Middle reach – narrow floodplain
3) Above culvert (0.75 mile and upstream) – hillslope confinement

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Lower reach – Install full-spanning wood to sort gravels and increase the frequency of floodplain connectivity.
2) Middle reach – restoring channel and floodplain connectivity here would work but have less benefit due to the narrow floodplain.
3) Above culvert – this limitation cannot be effectively addressed with restoration.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

No O.mykiss were observed in Clearing Cr during the O.mykiss inventory conducted by Bio-Surveys LLC in July 2013 (Appendix 3). Very low densities of 1+ age class cutthroat were observed sparsely distributed throughout the 1.0-mile survey reach (expanded estimate of 30 fish). Trout in the 0+ age class were observed distributed throughout the survey reach at low densities and an expanded estimate of 155 fish. To put this in perspective, full seeding of 0+ trout would be expected to show a density of 3 fish per sq m. The lowest 10 pools on Clearing Cr had a surface area of 104 sq m. This could support as many as 312 trout in the 0+ age class in this 600 ft reach alone.

No upstream temperature dependent migration of juveniles from mainstem Mosby Cr was observed.

Cedar Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

Along the lower 0.5 miles of Cedar Cr, within BLM ownership, alder dominates the riparian vegetation with scattered large (5 ft diameter) Douglas fir in the 100-year age class. Where the ownership shifts to private, the riparian becomes alder dominated with no conifer in the riparian for about the next 0.3 miles. Above this reach, the riparian transitions to include an increased component of young conifer (30yr) within the riparian followed by the upper reach where diversity increases to include cottonwood, western red cedar and Douglas fir (40 yr class) as a stronger component of the riparian vegetation.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Cedar Cr has good potential for recruiting large persistent conifer in the near term within the lower 0.5 miles. Conifer for large wood contribution is not available in the middle reach, and is 50 years or more away for the upper reach.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

No thermal problems are currently observed to be originating from riparian conditions in Cedar Creek.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

The steep bedrock entry at the mouth of Cedar Cr is a barrier to upstream juvenile migrants (Photo 116). This is not an access issue for winter spawning migrations of salmonids, including cutthroat.

About 1,000 ft above the mouth (WP 770), a sill log on bedrock impounding gravel and debris has formed an ephemeral summer juvenile barrier (Photo 119). This log jam is likely to blow out in the near future.

On the first left trib, a 30" rotted out corrugated metal pipe in a 4 ft channel is perched 18" (Photo 123) (WP 774). It is not a significant tributary for fish habitat and a 4' vertical bedrock barrier is located just above the culvert. However, the culvert is a serious road maintenance issue that risks the failure of a 10' road fill.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

No temperature data is available for Cedar Cr.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

During the 2013 field inventory, 111 sq ft of spawning gravel appropriate for anadromous O.mykiss was observed in Cedar Cr (Figure 8). Cedar Cr has some of the best spawning gravel potential of all the Mosby Cr tributaries (Photo 120) – plentiful mobile gravels that include a high percentage of perfect sizes for cutthroat to anadromous O.mykiss. High quality spawning gravels are abundant but are unsorted and unusable unless they are associated with large woody debris (Photo 118).

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Upstream of the bedrock dominated lower 500 ft reach of Cedar Cr, summer cover is excellent because of good quantities of large wood in the channel. The pool surface area (sq ft) of the first ten pools was measured during the field inventory to support comparison with the other tributaries of Mosby Cr subbasin for capacity to support summer rearing of salmonids. The lower 525 ft of Cedar Cr had an average of 228 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.1 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover).

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Upstream of the bedrock dominated lower 500 ft reach of Cedar Cr; winter cover is excellent due to the high density of large wood in the active channel.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Cedar Cr enters the mainstem across a bedrock slide 4 ft in height (Photo 116). The channel is bedrock dominated for about the lower 300 ft, extending to the bridge with bedrock step pools (Photo 117). Bankfull width is 15 ft. Within the bedrock reach, Cedar Cr exhibits a low inner terrace of 1-2' and 6' wetted summer channel.

The gradient of the stream is moderate (2-3%) through the lower 0.5 miles. Terraces alternate side-to-side in small floodplain scallops that are 75-100' long with a terrace height of 1-2 ft. The channel is harshly scoured to bedrock over the majority of the lower where wood is absent. Full spanning wood jams are currently storing massive amounts of bedload, but are displaying potential to blow out in the near future as wood resources are not replaced (Photo 119).

At about 0.5 miles, channel diking is evident from a debris flow that originated in a right tributary canyon. The primary terrace condition improves over the next 0.5 mile with a 150' total floodplain width. The active channel widens to 20 ft, a lower (2 ft) terrace 60 ft in width is backed by a secondary 2 ft higher terrace that is 80 ft in width (Photo 122).

About a mile above the mouth, the channel increases in gradient and becomes more hillslope/terrace constrained.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The mile of stream channel above the bridge crossing displays a low gradient profile that is highly desirable for providing more significant and frequent floodplain linkages to low terraces during winter flows. Channel braiding across alluvial depositions are present. Channel complexity increases with increased wood. This is displayed in side channels piloted across the terrace (Photo 121) as a result of increased wood complexity.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Limited floodplain interaction during mean winter flow profiles.
2) Breakdown of in-channel wood may be leading to loss of accumulated bedload and reducing frequency of floodplain connectivity.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Increase instream wood complexity to trap and sort gravels and expand floodplain interaction – this will serve production, diversity and hyporheic storage and cooling.
2) Increase instream wood to support and trap bedload and prevent channel incision to bedrock as existing jams deteriorate.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

No O.mykiss were observed in Cedar Cr during the RBA snorkel inventory conducted by Bio-Surveys LLC in July 2013 (Appendix 3). Very low densities of 1+ age class and older cutthroat were observed sparsely distributed throughout the 2-mile survey reach (expanded estimate of only 60 fish). Trout in the 0+ age class were observed distributed throughout the 2-mile survey reach at low densities and an expanded estimate of 345 fish. To put this in perspective, full seeding of 0+ trout would be expected to display a density of 3 fish per sq m. The lowest 10 pools on Cedar Cr had a surface area of 111 sq m. At fully seeded densities this could support as many as 333 trout in the 0+ age class in this 525 ft reach alone.

No upstream temperature dependent migrations from mainstem Mosby Cr were observed. This was related to the bedrock step at the confluence.

Stell Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

Mainstem Stell Cr has good riparian cover with vegetation dominated by alder with low density Douglas fir (20-25 yr) in the lowest reach. About 500 ft above the mouth, there is a scattering of older age class alder as well as a few large western red cedar and Douglas fir. Where the riparian is adjacent to recently harvested timber units, near and above the N Fk/S Fk split, the buffer is thin and the active channel solar exposed. South Fork Stell has good riparian cover accept adjacent to the roadway. Alder with a few 25-40 year old Douglas fir dominates the NF Stell riparian corridor.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

In the lowest 500 ft reach, conifer is present, but young, with the potential for delivery beginning in the 50-year timeframe. The middle reach, up to the NF/SF split, has more mature conifer in the riparian and the potential for recruitment is high in the 25-40 year time frame.
Mainstem Stell and SF Stell, above the culvert, are actively recruiting wood from the adjacent upslope harvest unit (blown down riparian buffer).

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

Thin riparian buffers adjacent to recently harvested timber units on upper Stell and SF Stell allow solar exposure that contributes to thermal loading high in the basin (Photo 127).

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

A 4 ft X 40 ft culvert in an 8 ft channel on mainstem Stell Cr above the confluence of NF Stell (WP 798) has a 5 ft perch (Photo 128) and blocks access for migrating Cutthroat Trout to abundant high quality spawning gravels upstream (Photo 129). Upper Stell Cr is too small for anadromous O.mykiss to spawn and too far upstream for temperature dependant migrants from the mainstem of Mosby Cr, so replacement of this culvert would benefit resident cutthroat only. This crossing services an unrocked/unimproved road that accesses a recently harvested unit only. The most effective and cost effective solution is to remove and not replace the existing perched pipe. Replacement of this pipe would not be cost effective given the limited multi species value.

A 3 ft vertical plunge over boulders exists about 300 ft above the bridge on NF Stell Cr (WP 797) that poses a summer migration barrier for all juvenile salmonids.

A definitive barrier to upstream movement occurs 350 ft further upstream (WP 795) of the boulder falls on NF Stell where a series of two back-to-back bedrock steps (4' and 3') terminates anadromous migration (Photo 130). High quality resident cutthroat habitat extends well above this barrier.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

No temperature data is available for Stell Cr. There was however some indication that Stell Cr was being utilized as thermal refugia from the mainstem of Mosby Cr during summer flow regimes.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

Unsorted gravels are abundant and cobbles dominate Stell Cr with 10% small (12") boulders, 60% cobble, and 30% gravel. Substrates are a mix of basalt and sandstone. During the 2013 field inventory, 61 sq ft of spawning gravels appropriately sized for anadromous O.mykiss were observed in the zone between 500 and 3,000 ft above the mouth (treatment reach) (Figure 8). Another 9 sq ft of spawning gravels were observed on the NF Stell Cr, just above the confluence. Mainstem Stell Cr, above NF Stell, has excellent cutthroat spawning gravels, fine and well sorted (Photo 129).

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

In the lower 500 ft reach of Stell Cr, the channel is highly simplified with low summer cover. Above this reach and extending 2,500 ft upstream (treatment reach), increased sinuosity has created undercut banks for summer cover. In addition, overhanging vine maple protects the banks and provides additional cover. The pool surface area (sq ft) of the first ten pools was measured during the field inventory to support comparison to the other tributaries of Mosby Cr subbasin for capacity to support summer rearing of salmonids. The lower 1,200 ft of Stell Cr had an average of 226 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr. However, much of this 10-pool reach was within the incised, simple channel of the lower end and was not reflective of the overall channel characteristics of Stell Cr that existed upstream in the proposed treatment reach.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.4 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

No winter cover exists in the lowest 500 ft of Stell Cr that functions only as a transport reach. In the middle reach of Stell Cr (500 to 3,000 ft above the mouth), current sinuosity engages the floodplain terraces to provide good winter cover.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

At the mouth of Stell Cr, mainstem Mosby Creek's bankfull width has reduced to 55 ft. Stell Cr enters Mosby Cr across a bedrock slide with a 3-4 ft elevation gain over 35 ft (Photo 124). This is followed upstream by a bedrock pinch and series of bedrock steps (Photo 125). The lower 500 ft reach, to just above the mainline bridge, is entrenched with steep opposing hillslopes and no floodplain. This reach is scoured to bedrock and serves only as a transport reach. It is however providing a permanent grade control for the more functional reach above it.

Beginning just above the mainline bridge, gradient is low with a 1-4 ft highly variable and complex terrace structure. A narrow inner terrace (18”) alternates from side to side (developed by channel meander) and creates undercut banks (Photo 126). The channel has a 20 ft bankfull width. The 100-150 ft wide floodplain alternating from side to side suggests that moderate sinuosity exists. The older age cedar and alder on the stream banks are indicative of a very stable stream channel. There is no wood in the channel resulting in a channel that is simple and rapid/riffle dominated. There is no legacy of debris torrents here as observed in many other upper Mosby Cr tributaries.

The upper reach of Stell Cr is a simplified transport reach to the NF Stell Cr confluence where there is a split in flow of 60% NF / 40% mainstem Stell Cr.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Within the treatment reach (500 to 3,000 ft above the mouth), the sinuosity is high as expressed by many deep lateral scours with well-established undercuts. The potential to increase the current complexity across the floodplain terraces is high. No potential exists to develop complex channel forms in the lower and upper reaches of Stell Cr.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Reach 1 (lower 500 ft): Simplified, incised transport reach with no floodplain.
2) Reach 2 (500 to 3,000 ft): Low wood densities in channel – what exists is rapidly deteriorating. Wood that is present is sorting gravels but in places that aren’t usable for spawning (outside main flows) need more wood interacting with the channel and with other wood.
3) Reach 3 (above 3,000 ft): Hillslope confined transport reach.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Reach 1 (lower 500 ft): Limitations cannot be addressed with restoration actions.
2) Reach 2 (500 to 3000 ft): Place full-spanning large wood to sort gravels and increase floodplain interaction.
3) Reach 3 (above 3000 ft): Limitations cannot be addressed with restoration actions.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

During the RBA snorkel inventory conducted by BioSurveys LLC in July 2013, O.mykiss were observed in Stell Cr in low numbers (expanded estimate of 25), concentrated in the lower 1,100 ft above the mouth (Appendix 3). This may be an indication that O.mykiss parr were present as a result of an upstream temperature migration from the mainstem of Mosby Cr, which was temperature limited during the time of the inventory. This distribution profile was not observed for cutthroat or the 0+ age class however. It is also interesting to note that Stell Cr is the lowest tributary in the identified Core area where thermal refugia may be utilized by upstream migrants fleeing temperature limitation in mainstem Mosby Cr, even though other cold-water sources were identified contributing to the mainstem lower in the system.

Considering the current level high level of function observed in the treatment reach of Stell Cr, surprisingly low densities of 1+ age class and older cutthroat were observed sparsely distributed throughout the 0.8 mile survey reach (expanded estimate of 40 fish). Low densities of trout in the 0+ age class were observed concentrated in the same reach (expanded estimate of 255 fish).

Bark Shanty Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The riparian corridor of Bark Shanty Cr has good canopy cover, though the buffer (50-70 ft) is bordered on both sides by recently harvested timber units throughout the lower 0.5 miles. Riparian overstory is made up of alder and a good stocking of 20 yr old Douglas fir, and interspersed mature cottonwood, and western red cedar.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

There is potential to recruit large wood from the riparian of Bark Shanty Cr, but the current size of conifers puts that recruitment period out 50-75 years.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

The ambient air temperatures generated in the broad harvested areas that border the narrow riparian buffer on both sides of the creek have an unquantified effect on the capacity of the riparian canopy to maintain cool stream temperatures.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

No migration barriers were identified on Bark Shanty Cr in the 2013 field inventory.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

No temperature data was collected by CFWWC on Bark Shanty Cr.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

Similar to Stell Cr, substrates on Bark Shanty are composed of a mix of basalt and sandstone, displayed in bedrock formations and mobile substrates. Gravel size ranges up to small boulders (D100 = 20”), distributed as cobble 60%, small boulders 15%, and gravel 25% (Photo 132). In the 2013 field inventory, 18 sq ft of spawning gravel suitable for anadromous O.mykiss was observed on Bark Shanty (2 redd locations) (Figure 8).

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Bark Shanty Cr does not provide significant summer habitat for salmonids. The pool surface area (sq ft) of the first ten pools was measured during the field inventory to support a comparison to the other tributaries of Mosby Cr subbasin for capacity to support summer rearing of salmonids. The lower 1,100 ft of Bark Shanty Cr had an average of only 92 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.2 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover).

The primary role of Bark Shanty in system function is to supply cold flow directly and hyporheicly to attract upstream temp dependent migrants to the Mosby Cr side channel at the mouth of Bark Shanty. The location of Bark Shanty Cr is important because upstream temperature dependent migrants in mainstem Mosby Cr will be pushed by this confluence as temperatures rise in the mainstem.

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Bark Shanty Cr does not provide significant winter habitat for salmonids.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The lower 300 ft of Bark Shanty Cr is directly linked to a mainstem Mosby Cr side channel (Photo 131). At the top of this reach, summer flows go partly subsurface as they feed the mainstem side channel. Above this reach, Bark Shanty is relatively high gradient with a very narrow floodplain (generally 40 ft). Bankfull width is 16 ft and the floodplain terraces have a height of 3-4 ft (Photo 132). At the upper forks, the flow splits 70% to the right, 30% to the left trib. The Bark Shanty channel functions as a transport system only.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Potential to develop additional channel complexity on Bark Shanty Cr is low.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Terrace confined transport reach, no historical floodplain, and no historical meander.
2) Upper reach is hillslope confined.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

These limitations cannot be effectively addressed with restoration actions.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

During the RBA snorkel inventory conducted by Bio-Surveys LLC in July 2013, no O.mykiss were observed on Bark Shanty Cr. Cutthroat in the 1+ age class were observed in only one sample pool in the entire 0.7-mile survey reach on Bark Shanty (Appendix 3). Trout in the 0+ age class were observed concentrated in the lower reach that is connected to the Mosby Cr side channel, and then dispersed across the survey reach in lower densities for an expanded estimate of 265 fish. Unfortunately, salmonid numbers were so low in Bark Shanty Cr that it was not possible to evaluate their distribution pattern to determine if a temperature dependent migration was occurring from salmonids escaping temperature limitations in the mainstem of Mosby Cr.

Big Dry Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

Big Dry Cr has an intact riparian canopy of alder interspersed with 20-30 year old Douglas fir, young western red cedar and mature cottonwood. The riparian buffer is 50' on the right with an adjacent recently harvested timber unit that extends for 0.7 miles (Photo 135). The left side is currently marked for a 50' riparian buffer, even though ODF classifies the lower 1,700 ft of Big Dry Cr as a large-size stream (requiring a 100ft riparian setback) and the upper reach as a medium-size stream.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Big Dry Cr has good long-term recruitment potential due to the sinuous nature of the channel. The strong meander pattern in the 0.75 to 1.0 mile reach is currently recruiting riparian trees and has the potential for additional near-term recruitment as riparian trees mature. Long-term future recruitment from wind-throw or decay occurring outside the narrow riparian buffer will be non-existent under the current timber management practices of 30-40 year rotations.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

The ambient air temperatures generated in the broad recently harvested units that border the narrow riparian buffer of the creek have an unquantified effect on the capacity of the riparian canopy to maintain cool stream temperatures. No temperature data was collected by the CFWWC.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

In July 2013, during the RBA inventory, the mouth of Big Dry Cr exhibited no flow with isolated pools and sections of dry channel upstream. This condition would suggest that Big Dry is not a target for thermal refuge due to the early loss of linkage to the mainstem of Mosby Cr.

At the second significant trib split (WP 815), the trib crossing has a 3 ft culvert in a 4 ft channel with a 3 ft perch. However, the gradient of this trib is approximately 8%, rendering this not a priority for connectivity and therefore not a priority for replacement.

Summer juvenile migration and adult anadromous migrations currently terminate at approximately river mile 2.0 (WP 814) where at a 5’ diameter sill log creates a perch of 6 ft. This is an ephemeral barrier.

Just above river mile 2.0 (WP 813), an undersized (3 ft) culvert in an 8 ft channel is not perched (Photo 138) and is not an issue for connectivity. However, this situation has a high risk for road failure due to a collapsed inlet end (Photo 139). The road prism at risk is approximately 3,000 cu ft of material (15’X7’X30’).

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

No temperature data was available for Big Dry Cr.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

During the 2013 field inventory, 221 sq ft of spawning gravel, suitable for anadromous O.mykiss was observed on Big Dry Cr, most of which were in the lower 0.5 miles (Figure 8). A single lamprey redd was observed in the lower end. Big Dry Cr appears to contribute massive amounts of mobile gravel to mainstem Mosby Cr during winter flow regimes.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Overhanging vine maple, good sinuosity and undercuts (Photo 134) provide for good summer cover on Big Dry Cr. However, summer pinch period flows were notably low, as observed in the July 2013 inventory. This resulted in subsurface flows and isolated pool habitats delinked from the mainstem of Mosby Cr. The pool surface area (sq ft) of the first ten pools was measured during the field inventory to support a comparison to the other tributaries of Mosby Cr subbasin for capacity to support summer rearing of salmonids. The lower 1,000 ft of Big Dry Cr had an average of 290 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr. However, the lowest reach of Big Dry Cr does not reflect the summer habitat existing in the high functioning middle reach.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.4 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover).

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

In the reach between approximately river miles 0.25 and 1.0, winter cover provided by low interactive terraces is plentiful.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

A massive alluvial fan at the confluence of Big Dry and Mosby creeks (Photo 133) suggests that Big Dry is a regular contributor of large gravel volumes to the mainstem, more so than any other tributary.

Big Dry Cr has a 20’ bankfull width. Much of the lower 0.25 miles displays a simple channel, fairly confined within a 10 ft high controlling terrace. The 50’ floodplain is almost fully above the influence of peak winter flows because of deep channel incision in the reach.

At approximately 0.25 miles, a 4 ft lift in the channel occurs, with a mid-channel island (Photo 136). The 15 ft channel is terrace confined with a 4 ft terrace that extends upstream for approximately 0.4 miles.

At this point, about 0.7 miles above the mouth (WP 808), the channel transitions to a highly interactive zone with an approximate 2% gradient and a very low (18”) terrace. This highly functional reach continues upstream to about river mile 1.0.

A 50:50 trib split occurs just above the upper bridge where the gradient increases to 3-4%. The abundant gravel resources observed in the lower end of Big Dry are coming from both primary headwater tributaries.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The lower 0.25 miles is a simple, constrained channel, with highly mobile gravels and with no potential for encouraging floodplain connection.

From river mile 0.25 to 1.0, the channel is currently highly functional with an active meander across low floodplain terraces. This reach has split channels, backwaters and lots of fine, cutthroat size spawning gravels sorting out. Low velocity winter habitat can be found here commonly. The full terrace is engaged with a highly complex channel meander. Generous amounts of riparian wood have recently recruited to the channel in the upper 0.25-mile, perhaps during the winter flows of 2011-12. This reach is a valuable reference site for observing desired natural channel function (Photo 137).

The upper reach is steeper gradient and compared to downstream, lacks the same level of potential to develop complex channel forms.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Lower 0.25 miles: 10' controlling terrace, deep channel incision and low floodplain connectivity.
2) Middle reach – miles 0.25-1.0: Insufficient densities of large woody debris.
3) Upper reach – above mile 1.0: Steeper gradient (3-4%), terrace confined.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Lower 0.25 miles: These limitations cannot be effectively addressed with restoration.
2) Middle reach – miles 0.25-1.0: Add large wood to the channel. In the lower end of this reach, include deflector logs. In the upper end of this reach, support the existing meander potential that is currently recruiting riparian trees. With the strong potential for meander recruiting 40-50 yr conifer in the near riparian, treatment here would provide benefit in the short term that would more likely be backed up by natural recruitment and may not require a second treatment.

3) Upper reach – above mile 1.0: These limitations cannot be effectively addressed with restoration.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

During the RBA snorkel inventory conducted by BioSurveys LLC in July 2013, O.mykiss were observed in Big Dry Cr in low numbers (expanded estimate of 25), sporadically distributed across the lower 1.0 mile (Appendix 3). Moderate densities (avg. 0.11 fish / sqm) densities of 1+ and older age class cutthroat were observed evenly distributed throughout the 1.5-mile survey reach (expanded estimate of 115 fish). Trout in the 0+ age class were observed distributed throughout the survey reach and at low densities (expanded estimate of 505 fish). Surveyors noted that flows were low, resulting in subsurface flows and isolated pools. The pool inventory in Big Dry is a fair representation of the actual rearing population because of the reduced capacity of fast water habitats to retain fish when nearly or completely subbed out.

Dahl Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

Dahl Cr has good canopy cover throughout its riparian corridor. On the lower end the overstory is alder dominated with interspersed western red cedar and Douglas fir in the 25 yr age class. Upstream of river mile 0.5, above the first channel split, alder is in the 20-25 yr age class. Mature cottonwood and young western red cedar are present and there is a 15 yr old Douglas fir plantation on the south side.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Conifer is present throughout the riparian corridor to provide a future supply of large woody debris (50-75 year timeframe); however hydraulic potential to deliver this wood downstream is limited.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

No thermal problems related to riparian condition were identified in the 2013 field inventory. This system functions primarily as a critical cold water contributor to the mainstem temperature of Mosby Cr. The protection of riparian function has particularly high value for addressing the primary basin wide limitation of elevated summer water temperatures in the mainstem.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

A debris torrent associated log jam approximately 1.2 miles upstream of the mouth (WP 824) creates an ephemeral passage barrier that currently terminates all summer migration as well as all winter anadromous passage.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

No temperature data was available for Dahl Cr but surveyor field notes describe it as a cool water contributor.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

During the 2013 field inventory, 18 sq ft of spawning gravels suitable for anadromous O.mykiss was observed in the lower reach of Dahl Cr (Figure 8). Spawning gravels suitable for cutthroat were unusually abundant in the lower end (Photo 141). Above the trib split (river mile 0.5), the stream becomes boulder dominated (60% small boulder, 30% cobble, 10% gravels) with boulders up to 3 ft in diameter and spawning potential decreases as the gradient shifts above 4% (Photo 144). Substrates appear stable with moss and no indication of frequent mobility. Potential for spawning gravel recruitment and improved gravel sorting is relatively low.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Some summer cover for juvenile salmonids is provided by boulder substrate on Dahl Cr. This is a cover class particularly suited for O.mykiss that is capable of providing both summer and winter refuge. The pool surface area (sq ft) of the first ten pools was measured during the field inventory to support a comparison with the other tributaries of Mosby Cr subbasin for capacity to support summer rearing of salmonids. The lower 960 ft of Dahl Cr had an average of 115 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.2 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover).

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Winter cover is poor within this transport reach.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Dahl Cr has a 13 ft bankfull channel width. At the mouth, the channel is simplified (Photo 140). Above this lowest reach and throughout most of the next 0.3 miles, the gradient increases, the channel is terrace confined, with a 3-4 ft incision (Photo 142) and there is no floodplain of any consequence. Multiple long bedrock and stepped boulder riffles are present. Before the channel splits at about mile 0.5, some small alternating terraces (2' vertical) develop. Above the channel split, the terraces become broader and remain low (1-2 ft) (Photo 143) across the deposition fan of a legacy debris torrent. Above mile 1.0, the channel is hillslope confined (Photo 144) to the headwaters. Overall, the stream functions as a transport corridor for upslope resources. The most recent torrent event, judging by even age alder on disturbed alluvium, was approximately 1990. There are still some legacy cedar logs being transported through the system, all with bucked ends (remnants of 1960's harvest where cedar was felled and left on the ground).

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The potential for the development of channel complexity on Dahl Cr is low. This system functions to transport upslope resources to the mainstem of Mosby Cr. This includes wood, mobile bedload and cold water for mainstem temperature maintenance.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) High gradient – transport reach.
2) Channel incision.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

These limitations cannot be effectively addressed with restoration actions.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

During the RBA snorkel inventory conducted by Bio-Surveys LLC in July 2013, no O.mykiss were observed in Dahl Cr. Cutthroat in the 1+ and older age class were observed in low densities (expanded estimate of 90 fish) distributed sporadically throughout the 1.25 mile survey reach on Dahl Cr (Appendix 3). Trout in the 0+ age class were observed distributed across the 1.25 mile survey reach at low densities (expanded estimate of 310 fish). To put this in perspective, full seeding of 0+ trout would be expected to show a density of 3 fish per sq m. The lowest 10 pools on Clearing Cr had a surface area of 102 sq m. This could support as many as 306 trout in the 0+ age class in the lower 950 ft reach alone. Surveyors reported medium flows at the mouth of Dahl Cr during the July snorkel inventory.

Norwegian Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The riparian corridor on Norwegian Creek has good canopy cover provided by 25-30 year old Douglas fir and alder. The plantation has been harvested on the north side for the lower 0.25 miles and is marked for harvest on the south side.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Conifer is present in the riparian. However Norwegian Creek lacks the meander to recruit its own riparian wood resources and the hydraulic potential to transport large wood to the mainstem. Recruitment would depend solely on debris flow or streamside blow down related to exposing the riparian buffer to post-harvest wind throw.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

No thermal problems were observed on Norwegian Cr that were associated with riparian condition. However, the scheduled removal of the timber on the south side of Norwegian Cr can be expected to affect ambient air temperatures which may result in impacts to summer stream temps in Norwegian Cr.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

Approximately 0.6 miles above the mouth (WP 1000), a 6 ft steel culvert is perched 3 ft, creating an impassable barrier to adult and juvenile migration. During the 2013 snorkel inventory conducted by Bio Surveys LLC, a high concentration of Cutthroat Trout were stacked up in the pool below this culvert indicating that upstream movement was occurring.

Temperature Issues

Describe where and how elevated summer temperatures restrict use of stream channels for rearing or for movement to more favorable locations. Identify locations by river mile, tributary junctions, and other map features.

No temperature data was available for Norwegian Cr.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

No spawning gravels suitable for anadromous O.mykiss were observed in Norwegian Cr during the 2013 field inventory. There is also no potential for recruiting suitable gravels for large anadromous spawners.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Overhanging brush and boulders provide excellent protection for summer rearing Cutthroat Trout on Norwegian Cr. The pool surface area (sq ft) of the first ten pools was measured during the field inventory to allow us to compare to other tributaries of Mosby Cr subbasin for capacity to support summer rearing of salmonids. The lower 470 ft of Norwegian Cr had an average of 81 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.1 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover).

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Norwegian Cr does not provide any significant winter rearing potential.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Norwegian Cr enters Mosby Creek over a boulder deposition (Photo 145). The channel has a 10 ft bankfull width and is hillslope constrained with relatively high gradient (Photo 146). There is a 3-4 foot incision with no inner terrace.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

There is little to no potential to develop complex channel characteristics on Norwegian Cr.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Narrow hillslope constrained channel.
2) Steep gradient.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

These limitations cannot be effectively addressed with restoration actions.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

During the RBA snorkel inventory conducted by Bio-Surveys LLC in July 2013, no O.mykiss were observed in Norwegian Cr. Cutthroat in the 1+ and older age class were distributed primarily between mile 0.5 and 0.75 (to the culvert barrier), in some of the highest densities observed in all of the Mosby Cr tributaries (expanded estimate of 130 fish) (Appendix 3). All of the high pool densities were observed in pools directly below the perched culvert and an indication that cutthroat were attempting to get higher in the system to escape increasing summer water temperatures. Trout in the 0+ age class were also observed in some of the highest pool densities of any Mosby Cr tributary, particularly in the lowest 1000 ft above the mouth (expanded estimate of 215 fish), both of these indicators suggest that Norwegian Cr was functioning to provide thermal refugia to fish moving out of the mainstem of Mosby Cr. Surveyors reported low flows at the mouth of Norwegian Cr during July.

Norwegian enters the mainstem of Mosby Cr just 0.68 miles below the confluence of Shea Cr which is the approximate end of where the 7 day average of daily maximum temperatures stops exceeding 64 deg F in the mainstem of Mosby Cr. This relationship suggests that adjacent tributaries could be targets for thermal refugia especially if there were juvenile migration barriers in the mainstem, which there were just below the confluence of Brownie Cr (Figure 12).

Gray Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The riparian corridor along lower Gray Cr is in excellent condition with intact canopy cover. Overstory vegetation is composed of relatively old alder (40 yr) with an understory of young western red cedar, 20-30 year old Douglas fir and larger conifer exist in the outer riparian. Vine maple overhangs the stream channel.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

The sinuous nature of Gray Cr is actively recruiting wood from the inner riparian. A stand of 25-year-old conifer is just beyond 50 ft from channel, as a future recruitment resource in the 50-year timeframe.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

No thermal problems were observed on Gray Cr associated with riparian condition.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

Located 250 ft above the mouth of Gray Cr (WP 828), a set of two 4' round CMP culverts in a 12 ft channel are likely juvenile barriers at low summer flows (Photo 148). The right culvert has an 8" perch and a rotten bottom that is losing flow. The left culvert has a 7" perch and a 14" bedload blockage at the inlet.

About 1200 ft upstream of the mouth of Gray Cr (WP 832), a sill log creates a 2 ft perch with bedload behind the log and flow dropping between the log and a rock (Photo 150) forming an ephemeral barrier that blocks summer migration.

Temperature Issues

No temperature data was collected by CFWWC on Gray Cr.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

No spawning gravels suitable for anadromous O.mykiss were observed on Gray Cr in the 2013 field inventory. There are however an unquantified amount of fine cutthroat gravels present.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Overhanging vegetation provides good summer cover on Gray Cr. The narrow active channel (<12 ft) allows wood to be retained for pool complexity and pool development. The pool surface area (sq ft) of the first ten pools was measured during the field inventory to support a comparison to the other tributaries of Mosby Cr subbasin for capacity to support summer rearing of salmonids. The lower 500 ft of Gray Cr had an average of 131 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.2 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover).

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The narrow active channel allows wood to be retained for pool development in the short reach above the road crossing that has an interactive floodplain terrace.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Gray Cr enters Mosby across a bedrock slide (Photo 147). Overall, Gray Cr exhibits about a 3% gradient. Bankfull width is 12 ft. In the reach from the mouth 250 ft upstream to the culverts, there are no inner terraces. The channel is deeply incised with a 5' controlling terrace. The channel in this lowest reach is scoured to bedrock. There were indications that at least one of the two culverts had plugged in 2011-12. Cleaning this obstruction may have initiated the scour event witnessed below the culvert that scoured the channel to bedrock.

Above the road crossing, the stream exhibits a significant change in structure with a floodplain that expands to 100 ft and low interactive terraces (1-2 ft) in places where wood has accumulated (Photo 149). The floodplain appears to be the remnants of a debris flow event that terminated a couple hundred feet above the culverts where a significant stand of alder, Douglas fir and cedar stopped the run out. These trees are still standing, but are mostly dead and have been continually recruiting to the active channel. The narrow active channel <12' allows the wood to be retained for pool complexity and pool development.

Beyond about mile 0.25, the stream becomes completely hillslope confined with no floodplain potential. Anadromous access to upstream habitats is maintained by low gradients for an undetermined distance.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The potential for developing complex channel forms exists on Gray Cr only within the 1,000 ft reach above the road crossing where the floodplain terrace is broad and low.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Narrow active channel.
2) Short reach of interactive floodplain terraces.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

The limited extent of potential complex habitat for multiple salmonid species does not warrant restoration actions on Gray Cr to support increased channel complexity.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

During the RBA snorkel inventory conducted by Bio-Surveys LLC in July 2013, no O.mykiss were observed on Gray Cr (Appendix 3). Cutthroat in the 1+ and older age class were distributed evenly throughout the 0.8 mile reach and in somewhat higher densities than observed in many other Mosby Cr tributaries (expanded estimate of 80 fish). Trout in the 0+ age class were observed in low densities (expanded estimate of 175 fish). To put this in perspective, full seeding of 0+ trout would be expected to show a density of 3 fish per sq m. Surveyors reported low flow at the mouth of Gray Cr.

No indications of an upstream temperature dependent migration from the mainstem of Mosby Cr were observed. However, the blockage located 250 ft above the mouth would have crippled the detection of this behavior because only every 5^{th} pool was sampled. The location of Gray Cr in the zone where temperature limitations in the mainstem of Mosby Cr as well as juvenile barriers in the mainstem of Mosby would suggest that any adjacent cold water contributor could be a target for juveniles seeking thermal refuge.

Shea Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The riparian corridor on Shea Cr has good canopy cover. Alder with scattered 20-30 yr Douglas fir and younger hemlock and western red cedar dominate the overstory vegetation.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

There is good stocking of scattered conifer in the riparian for a long-term (50-year timeframe) source of large wood. There is currently alder poised to recruit from the inner riparian belt (Photo 155).

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

No thermal problems were observed on Shea Cr associated with riparian condition.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

Near the mouth of Shea Cr (WP 836), a 5 ft culvert is rotted out and is scheduled for replacement with a bridge – the site has been surveyed and beams are on site 5-6-13. This is currently not a passage issue.

Approximately 500 ft above the mouth (WP 837), a log jam/sill log has created an 18" barrier to upstream juvenile migration (Photo 152) complicated by overhanging debris and followed by a similar 24" barrier just upstream. These are ephemeral barriers to summer migrants.

Temperature Issues

No temperature data was available for Shea Cr.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

No spawning gravels suitable for anadromous O.mykiss were observed in Shea Cr during the 2013 field inventory and the potential for recruiting supplemental spawning gravels is low.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Within the deposition plain resulting from a debris torrent event, woody debris is providing excellent cover. The pool surface area (sq ft) of the first ten pools was measured during the field inventory to support a comparison to the other tributaries of Mosby Cr subbasin for capacity to support summer rearing of salmonids. The lower 490 ft of Shea Cr had an average of 173 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.1 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Winter habitat provided by floodplain interaction across the torrent deposition plain is degrading as debris flow woody debris deteriorates and the channel begins to incise and simplify.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Shea Cr enters mainstem Mosby Cr over a bedrock step (Photo 151). The bankfull channel width is 12 ft and the gradient is relatively steep. Like many other Mosby Cr tributaries, there is a legacy of multiple debris torrent events on Shea Cr. The terminus of the most recent event was about 500 ft above the mouth. Above this point there is stacked wood in the form of logging debris and large conifer stumps in the channel and on the banks (Photo 153). There are observable impacts from the 1964 event and then one that is approximately 20 years later. Young alder is present on the terrace with older era debris in the channel – the age differential indicating there must have been a later second event. Young conifer (10-15 yr) has recruited on top of old debris of 50 yrs.

There are places below mile 0.25 on the debris torrent track where the floodplain extends to 75 ft wide, but the channel has consistently entrenched over time to be confined in a 12 ft wide channel between 5 ft vertical alluvial terraces. This condition is getting worse as the decomposition of woody debris continues.

At about mile 0.25, the floodplain narrows to exhibit no real habitat potential.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The steep gradient of Shea Cr limits its potential to retain bedload and provide floodplain interaction. A major breakdown of legacy jams appears to have occurred very recently (2011-12). The wood that has been holding the plunge pool structure (Photo 154) is rotting and breaking down, releasing large quantities of stored bedload and reducing the capacity of the stream to interact with its floodplain. The channel is currently on a trajectory toward increased incision and the loss of bedload recruited during the 1964 flood event.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Channel entrenchment.
2) Steep gradient.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

These limitations are difficult to address with restoration actions.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

During the RBA snorkel inventory conducted by Bio-Surveys LLC in July 2013, no O.mykiss were observed in Shea Cr (Appendix 3). Cutthroat in the 1+ and older age class were distributed sparsely throughout the 1.0 mile reach, in medium densities (expanded estimate of 60 fish). Trout in the 0+ age class were observed in low densities (expanded estimate of 310 fish) relative to a full-seeding potential of 3 fish per sq m. Surveyors reported 300 ft of dry channel between the mouth and the culvert on July 17. This would suggest that Shea Cr is an unlikely target for upstream temperature dependent migrations of juvenile salmonids from the mainstem of Mosby Cr. This was verified in the distribution pattern observed for both cutthroat and the 0+ age class.

Brownie Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The riparian corridor of Brownie Cr has good riparian canopy throughout. The overstory vegetation is composed of 30-40 year old Douglas fir and alder, with maple on the upper terrace. Alder dominates the inner riparian, Doug fir dominates the outer riparian (Photo 160). Above mile 0.5, young western red cedar and hemlock are becoming established within the understory of the alder dominated floodplain.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Plentiful old wood is mobilizing in the channel, but little older age wood exists on floodplain terraces to replace it, with the exception of some standing burned wood observed at approximately mile 0.3 indicating a legacy of fire in this drainage. The live conifer existing in the riparian will provide future (50+ years) large wood recruitment.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

No thermal problems were observed on Brownie Cr associated with riparian condition.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

A steep bedrock slide (4 ft vertical over 10 ft) at the mouth of Brownie Cr complicates but does not block summer access for juvenile salmonids (Photo 156).

About 2,500 ft above the mouth (WP 913), a 5 ft vertical log jam creates an ephemeral barrier that stops all resident and anadromous migration (Photo 162). The jam exists in a natural pinch point created by hillslope confinement (opposing bedrock toe slopes). The road here has also exacerbated the confinement.

At the NF/SF confluence (WP 918), a new bridge is staged roadside to replace a 5' culvert with a 4' perch.

Temperature Issues

No temperature data was available for Brownie Cr.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

Abundant gravels in deep depositions are stored behind legacy large wood in the Brownie Cr channel (Photo 157). Gravels even spill from small ephemeral tributaries (Photo 159). During the 2013 field inventory, 171 sq ft of spawning gravel, suitable for anadromous O.mykiss was observed in Brownie Cr - 45 sq ft of this was observed in the lower 0.25 mile and 126 sq ft was observed between 0.25 mile and 0.5 mile (Figure 8). While gravels are abundant, they are not well sorted. Potential for gravel recruitment on Brownie Cr is some of the highest of all the Mosby Cr tributaries. This includes its potential to deliver to the mainstem of Mosby Cr.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Summer cover associated with the large wood component on Brownie Cr is moderately abundant. Abundance of summer pool surface area is higher on Brownie Cr than any other Mosby Cr tributary. During the July 2013 RBA snorkel inventory, it was observed that many pools on Brownie Cr become isolated during pinch period summer low flows, but remain deep and cool and are linked hyporheicly through deep depositions of bedload (Photo 157). The pool surface area (sq ft) of the first ten pools was measured during the field inventory to support a comparison with the other tributaries of Mosby Cr subbasin for capacity to support summer rearing of salmonids. The lower 850 ft of Brownie Cr had an average of 490 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, the highest average of all the Mosby Cr tributaries.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.6 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover

(2 is 1-25%, 3 is 26-50% of pool surface area associated with cover). This was the highest average pool complexity of all the surveyed tributaries.

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Floodplain interaction is moderate in the lower 0.5 miles of Brownie Cr, resulting in limited winter cover. Above this reach and continuing for 0.6 miles, floodplain interaction is maximized on the low terraces and winter habitat is abundant in the form of off-channel surface area (backwaters, side channels and alcoves).

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Brownie Cr enters mainstem Mosby Cr across a steep bedrock slide (Photo 156) that may complicate juvenile access in low flows, but is not a complete barrier to summer access. Above this entry, the gradient flattens and the channel has a bankfull width of 18 ft with multiple channel braids. In the lower half mile, floodplain interaction on the 60 ft floodplain is moderate. There is a two-terrace structure – the first terrace is 2 ft and the second is 4 ft (Photo 756). The inner terrace in inundated on a bi-annual cycle. There are currently good key wood densities that are holding the channel together, but it is starting the process of incision as legacy wood decays; winter flows are not reaching the higher second terrace. The big wood is very old and has been recently mobilized in the channel. It is visibly degrading and starting to pulse downstream (Photo 161).

At about mile 0.5, a series of three sill logs creating step pools (Photo 163) are providing grade control to the upstream reach where the floodplain width increases to 90'. The terrace structure is highly interactive, wall-to-wall across the floodplain. Terraces are as low as 6" to 1' in the upper end of this reach that extends for at least 0.5 miles upstream.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The lower 0.5 miles of Brownie Cr has moderate sinuosity and has formed multiple channel braids across the terrace (Photo 158). With increased floodplain interaction, this reach has great potential for increased sinuosity and channel complexity. Wood densities to support the channel form are currently high but are rapidly degrading. Loss of this wood will result in channel incision and the loss of the observed channel complexity.

From mile 0.5 to 1.0, the channel is currently fully functioning to its highest potential, with high sinuosity, abundant channel braiding, multiple side channels and backwaters throughout the reach (Photo 164). Large wood is currently sufficient and actively recruiting to maintain this optimum functionality. This is an awesome reference site for observing natural stream function that should be the target of activities elsewhere in the Mosby Cr basin.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Lower 0.5 miles: Legacy wood is deteriorating and mobilizing, leading to channel incision, no replacement wood recruiting to the active channel.
2) Mile 0.5-1.0: Status of future large wood contribution supply is unsecure – potential for harvest outside the regulated buffer width of 70 ft.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Lower 0.5 miles (Upstream of log jam at 600 ft above the mouth, and extending 0.25 miles - WP 908-911): add full-spanning large wood to support channel complexity in this reach as well as to provide long-term support for the upstream anchor site (this could probably wait 5 years and still be sufficient to avert the loss of existing wood in the channel).
2) Mile 0.5-1.0: (WP 914-917) Protection of upslope large wood resources – consider land exchange between Weyerhaeuser and BLM to establish and maintain wide riparian buffer on Brownie Cr.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

During the RBA snorkel inventory conducted by Bio-Surveys LLC in July 2013, no O.mykiss were observed in Brownie Cr (Appendix 3). Low densities of 1+ and older age class cutthroat were observed concentrated in the best of habitats but in low densities between mile 0.5 and 1.0 (expanded estimate of 115 fish). Trout in the 0+ age class were observed concentrated in this same reach but also at a low density (expanded estimate of 670 fish). To put this in perspective, full seeding of 0+ trout would be expected to show a density of 3 fish per sq m. The lowest 10 pools on Brownie Cr had a surface area of 379 sq m. This could support as many as 1137 trout in the 0+ age class in this 850 ft reach alone.

Surveyors noted that the lowest 300 ft of channel above the mouth was dry and upstream of this, the flows were low and pools were frequently isolated. The pools remained deep and large and cool despite the intermittent dry channel condition.

Anchor Site 1

Location and length

Describe the location and length of this Anchor Site. Identify location by river mile, tributary junctions, and other map features.

Anchor 1 begins approximately 0.5 miles above the mouth and extends for 0.5 miles upstream (WP 914-917), just about 300 ft short of the trib split of NF Brownie (85% flow contribution) and SF Brownie (15% flow contribution) (Figure 7).

Channel structure

Describe channel form in terms of meander, braiding, side channel, alcove, backwater and other complex channel structures.

This anchor site exhibits a high state of function and a complex channel structure with extensive braiding, mid-channel islands, backwaters and side channels. This is a reference site for channel complexity in Mosby Cr subbasin.

Floodplain structure and interactivity

Describe the floodplain terrace structure in relation to channel level and complexity. Explain how these allow or restrict high flood access to the floodplain.

Floodplain terraces are 6” to 2’ with braided channels within this anchor site. There is currently excellent winter floodplain interaction, displayed by sands deposited on the terrace. Near the top end, channel incision increases to 3’ but potential is still off the charts for floodplain connectivity during winter flow regimes.

Almost all of the wood holding this together is legacy cedar. Legacy logs in the anchor site have not mobilized like the proposed treatment reach below the pinch. There is very little of any other wood source, only alder is available for near channel recruitment (Photo 164).

The anchor site is supported at this juncture by the three-sill-log step and the log jam in the narrow pinch located just downstream. However, with deterioration of the downstream large woody debris will eventually result in the same type of unraveling observed in many other Mosby Cr tributaries. This is a remnant of the kind of function that has existed for the last 50 years that is being lost and not replaced because of the global lack of a riparian LWD resource.

Rearing contribution

Describe how the Anchor Site contributes to spawning, incubation, summer rearing, and winter rearing.

During the July 2013 RBA snorkel inventory, conducted by Bio-Surveys LLC, no O.mykiss and very low densities of cutthroat were observed utilizing the abundant summer habitat within this anchor site. Extensive amounts of winter rearing habitat is available within the anchor that also is unutilized (low stocking rate). Summer habitat is concentrated in deep cool pools, fed by hyporheic flows coursing through deep accumulations of bedload. Spawning gravels for anadromous O.mykiss were abundant (121 sq ft) within the anchor site, some of the highest observed in all of the Mosby Cr tributaries (similar to Smith and Big Dry), sufficient to support approximately 9 spawning pairs of anadromous O.mykiss at an assumed 1.5 redds / female.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) Potential future loss of current critical grade control existing in roadside pinch point.
2) Lack of a secure source of long-term large wood for recruitment to the channel, Oregon Forest Practices Act only protects the inner 70 ft riparian buffer on medium fish-bearing streams, with alternatives available for reduced buffer width.
3) Lack of adult spawners to seed available spawning gravels, winter or summer habitat. Current pool surface area for summer and winter rearing not nearly seeded to capacity in the highest quality habitat observed in the entire Mosby Cr basin.

Addressing the limitations

List and rank the restoration work at the site that would most effectively improve rearing conditions within the Anchor Site and stabilize the core population at a higher base level.

1) Treat the downstream 0.25-mile reach with full-spanning large wood.
2) Protection of upslope large wood resources – explore conservation easements or land swaps in the subbasin (extensive BLM ownership here). Goal would be to secure a broad functional riparian to secure future upslope wood resources and protect and create a functional riparian air shed for protecting stream temperatures (Figure 30).
3) Restoration actions within the Anchor Site cannot directly address the limitation of a lack of spawners to utilize the available habitat.

Lilly Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The riparian corridor along Lilly Cr has a good canopy cover for the most part. The riparian vegetation is alder dominated with scattered mature cottonwood. The riparian buffer is very narrow in places where adjacent to the road and a recently harvested timber unit (Photo 166).

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Very little conifer is available for recruitment to the active channel in the next 50-100 years. Riparian buffers are narrow, alder dominated, and upslope conifer has been removed or exists in active plantations managed on a short-rotation. About 1,500 ft above the mouth, a recent slide (circa 2009, based on the age of young alder on the torrent track) has contributed alder to the channel (Photo 168). Gravels deposited on the alder dominated floodplain have inundated and killed the standing alder (Photo 169), which will be recruited to the stream channel shortly (next 5 years). Alder is an ephemeral component of streams wood budget and not capable of providing the persistent backbone required to build a functional channel / floodplain interface.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

The only obvious thermal relationship between the riparian corridor and the stream channel is that the riparian buffer is too narrow to create an effective air shed to protect surface flows from the impact of elevated summer air temperatures. This is a consistent problem throughout the basin tributaries that are required to deliver cool water to the mainstem as their number one most important function.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

Approximately 800 ft above the mouth of Lilly Cr (WP 843), a 6 ft vertical debris jam forms an ephemeral barrier that ends summer upstream migration of juvenile salmonids. However, it appears passable for anadromous adults in winter flows (Photo 127).

At approximately mile 1.2, a 3 ft bedrock falls along with a large boulder and log jam forms an ephemeral barrier at least to summer migration, and possibly all anadromous migration.

Temperature Issues

No temperature data was available for Lilly Cr.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

During the field inventory of 2013, 34 sq ft of spawning gravel suitable for anadromous O.mykiss was observed on the lower 1500 ft of Lilly Cr (Figure 8). Substrate is generally cobble/small boulder (D100 = 18") with a distribution of substrates of approximately 60% cobble, 30% small boulder, 10% gravel. Very little spawning gravel is sorting and the potential for the future recruitment of spawning gravel is classified as moderate.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Some summer cover for juvenile salmonids is provided by the boulder substrate. The pool surface area (sq ft) of the first ten pools was measured during the field inventory to support a comparison to the other tributaries of Mosby Cr subbasin for capacity to support summer rearing of salmonids. The lower 750 ft of Lilly Cr had an average of 233 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.1 on a scale of 1-5. This scale is based on the total percent of pool

surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover).

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Off-channel winter habitat is present in the upper end, but is limited by the lack of floodplain connectivity. Woody debris volumes are not well distributed with most significant key pieces concentrated in a few large jams.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Lilly Cr enters mainstem Mosby at a gravel point bar on the mainstem (Photo 165) with a bankfull channel width of 17 ft. The interactive floodplain of Mosby Cr extends up Lilly Cr for approximately 125' (excellent access for summer juvenile migrations). Beyond the Mosby Cr floodplain (above the bridge), the lower end of Lilly Cr has a simplified hillslope-confined channel (Photo 166).

Approximately 1,500 ft above the mouth (WP 844), Lilly Cr exhibits its first substantial floodplain terrace that is 75 ft wide. This condition extends for about 1,800 lineal ft before the floodplain narrows to 50 ft with a 2 ft terrace and then returns to hillslope confinement.

There is the same debris torrent legacy in Lilly Cr observed in many other Mosby Cr tributaries that extends back approximately 30 years. The floodplain terraces here were formed by these events, displaying low 2 ft well-functioning terraces, but not providing much off-channel winter habitat (low wood densities for altering gradient profiles of channel braids).

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Floodplain terraces oscillate from side-to-side with some degree of sinuosity and limited floodplain interaction exists within the 1,800 ft treatment reach (mile 0.3 to 0.6). The potential for increasing floodplain interaction and channel complexity is high where floodplain terraces are broad and low (Photo 170). Elsewhere, above and below this reach, potential is substantially lower due to hillslope confinement and the lack of a functional floodplain.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Upper and lower reaches: Hillslope confinement.
2) Middle reach: Lack of stable in-stream wood component to hedge against the unraveling that will occur as the older torrent delivered wood resources decay and transport out of the system. No future source for replacement exists.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Upper and lower reaches: Hillslope confinement.
3) Middle reach: (begins 1,500 ft above the mouth and extends for 1,800 ft - WP 844-846) Add full-spanning large wood to the channel to support the existing wood component that is deteriorating. This reach is road adjacent, providing good access for large wood placement.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

During the RBA snorkel inventory conducted by Bio-Surveys LLC in July 2013, no O.mykiss were observed in Lilly Cr. Low densities of 1+ and older age class cutthroat were observed fairly well distributed across the 1.5 mile survey reach (expanded estimate of 265 fish) (Appendix 3). Trout in the 0+ age class were similarly distributed also at a low density (expanded estimate of 295 fish). Surveyors noted that in July 2013, flows at the mouth of Lilly Cr were medium-high (relative to other Mosby Cr tributaries).

There was no evidence in the distribution profile of either cutthroat or the 0+ age class of a temperature dependent migration from the mainstem of Mosby Cr. The location of Lilly Cr 0.68 river miles above the approximate end of the mainstem temperature limitations in Mosby Cr at the confluence of Shea Cr suggests that tributary habitats are no longer required for thermal refugia.

Miles Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The riparian corridor along Miles Cr has good riparian canopy. Riparian overstory vegetation is alder dominated close to the stream channel with a good stocking of 20-30 year old fir planted in an outer band (Photo 173).

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

There is a good stocking of Douglas fir on Miles Cr that has the potential to recruit as harvest related wind-throw from the outer riparian edge in the next 50+ years.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

No thermal problems were observed on Miles Cr associated with the current riparian condition.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

Approximately 1,000 ft above the mouth of Miles Cr (WP 925), summer juvenile migration is currently terminated by an ephemeral debris jam (Photo 172) forming a 4' sill log perch. Winter passage for adults is accommodated with a good jump pool below the sill log.

About 0.5 miles above the mouth, a 4 ft bedrock falls is a permanent barrier to juvenile migration.

Temperature Issues

No temperature data was available for Miles Cr.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

Substrates range from coarse sand to 20" small boulders. But because of steeper gradient (4%), fewer small spawning gravels are sorting out. During the 2013 field inventory, spawning gravel suitable for anadromous O.mykiss was observed in the lower reach of Miles Cr -- 18 sq ft at the bridge crossing just above the confluence and another 18 sq ft in the next 750 ft upstream of the bridge (Figure 8).

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The pool surface area (sq ft) of the first ten pools was measured during the field inventory to support a comparison with the other tributaries of the Mosby Cr subbasin for capacity to support summer rearing of salmonids. The lower 760 ft of Miles Cr had an average of 162 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 1.8 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover). In general an average score of 1.9 would be considered low.

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Miles Cr drops steeply over a cobble cascade into the mainstem of Mosby Cr. Upstream, the average gradient is about 4% and the bankfull channel width is approximately 16'.

On the lower reach, floodplain interaction is low within a narrowly confined floodplain (30-40 ft) and sinuosity is low (Photo 171) resulting in a simplified channel. Approximately 1,000 ft upstream of the mouth, the channel becomes hillslope confined, limiting the floodplain to just a narrow inner terrace. The stream-adjacent road at 1,000 ft further confines the active channel and may be at risk for undermining (WP 924).

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Potential for development of channel complexity on Miles Cr is low, due to low sinuosity and high gradients confined within a narrow floodplain morphology.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) High gradient.
2) Narrow floodplain morphology

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

These limitations cannot be effectively addressed through restoration actions. No prescriptions recommended.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

During the RBA snorkel inventory conducted by Bio-Surveys LLC in July 2013, no O.mykiss were observed in Miles Cr. Very low densities of 1+ and older age class cutthroat were observed poorly distributed across the 0.6 mile survey reach (expanded estimate of 30 fish) (Appendix 3). Trout in the 0+ age class were similarly distributed also at very low densities (expanded estimate of 45 fish). Surveyors noted that in July 2013, flows at the mouth of Miles Cr were medium (relative to other Mosby Cr tributaries).

The absence of good cutthroat densities in Lilly Cr in a section of the Mosby Cr basin that is not suffering from thermal limitations may suggest that if summer habitat conditions are adequate in the mainstem, then mainstem Mosby Cr may be preferential habitat. This is really only a significant thought trajectory when attempting to prioritize restoration prescriptions in the Core Area.

West Fork Mosby Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The riparian corridor along WF Mosby Cr has good canopy cover. The overstory vegetation within the riparian is all alder with no conifer. An exception to this condition is in the vicinity of mile 0.7, where Douglas fir appear to have been planted in the riparian about 25 years ago.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

WF Mosby Cr has the hydraulic capacity and the sinuosity to recruit large wood from within its meander belt and is presently recruiting alder. However, the more long-lasting species (conifer) are not available except where sinuosity can be boosted to the plantation edge. Two recent slope failures at approximately 2,000 ft and 3,500 ft above the mouth (Photo 177, 180) are contributing alder to the active stream channel.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

No thermal problems associated with riparian condition were observed on WF Mosby Cr.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

At approximately 0.5 (WP 1087) miles above the mouth, a natural sill log barrier ends summer migration (Photo 179). However, WF Mosby, being high in the drainage is not likely a key destination for upstream temperature dependent migrations. There is abundant cold-water refugia available downstream in the mainstem.

Temperature Issues

No temperature data was available for WF Mosby Cr.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

Within the lower 1,500 ft of WF Mosby Cr, substrates are highly variable with size ranging from pea size to 3' boulders. However there has been no sorting of spawning gravels and none were observed in this reach in the 2013 field inventory. The potential for recruitment of spawning gravels however is high. Within the next 2,000 ft of WF Mosby Cr, sorting of mobile gravels is occurring. During the field inventory, sufficient spawning gravels to support 11 spawning pairs of anadromous O.mykiss were observed within this reach (Figure 8). Above this location, the substrate is boulder dominated with no potential to recruit spawning gravels.

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Pool surface area on WF Mosby is relatively low. However, the woody debris component, where present, provides very high pool complexity and summer cover. The pool surface area (sq ft) of the first ten pools was measured during the field inventory to support a comparison with the other tributaries of Mosby Cr subbasin for capacity to support summer rearing of salmonids. The lower 1,200 ft of WF Mosby Cr had an average of 175 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.2 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover).

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Winter cover on WF Mosby is abundant within the extent of the shared floodplain with mainstem Mosby Cr as well as on the low, interactive terraces observed between 1,500-2,500 ft above the mouth.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

W Fk Mosby Cr exhibited some of the highest tributary flows of all the Mosby Cr tributaries in July 2013. The bankfull channel width is 20 ft. The lowest reach of WF Mosby Cr displays a 200 ft wide floodplain, as the channel traverses the shared floodplain of mainstem Mosby Creek (Photo 174), with excellent low (2 ft) terraces and excellent connectivity. This condition is maintained for approximately 600 ft upstream of the mouth.

Above this reach, the gradient increases immediately to 2% or more, and for about the next 900 ft, bedrock exposure is apparent (Photo 175). The stream is severely terrace confined with opposing 3-6 ft terraces. The channel is entrenched to bedrock in many places. Stream clearing occurred here in the past, with evidence of old bucked cedar logs in the channel (Photo 176).

At about 1,500 ft above the mouth, a legacy of riparian cedar remains active in the channel and is holding the stream together, unlike what is observed downstream. Full spanning log jams support a broad, interactive 100 ft wide floodplain with low 1-2 ft terraces (Photo 178). This has also resulted in the presence of the first suitable spawning gravels observed in W Fk Mosby for large anadromous salmonids. WF Mosby has some of the most plentiful spawning gravels of all the Mosby Cr tributaries (comparable to Smith and Brownie creeks). This sinuous, interactive condition continues for about 2,000 ft upstream.

Above this interactive reach, about 3,500 ft from the mouth, the channel transitions to a steeper gradient and a more incised channel that is hillslope and terrace confined with a 30’ floodplain width.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Within the lowest 600 ft reach of WF Mosby, as it traverses the mainstem Mosby floodplain, potential for increasing sinuosity and the development of channel braids and off-channel features is high. The middle reach (600-1500 ft) is incised and confined with low sinuosity and low potential to develop additional channel complexity. The 1,500-3,500 ft reach is currently highly interactive with great potential for increasing winter habitat features. Above this reach, there is no potential for increased channel complexity due to steep gradient and a narrow confined floodplain.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Reach 1 (mouth to 600 ft): Lack of in-stream wood to encourage sorting of spawning gravels and pool scour.
2) Reach 2 (600 to 1500 ft): Incised channel, steep gradient.
3) Reach 3 (1500-3500 ft): Insufficient wood recruitment to support existing complexity or to support potential for channel complexity.
4) Reach 4 (above 3500 ft): Narrow floodplain.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Reach 1 (mouth to 600 ft): Install full-spanning log structures.
2) Reach 2 (600 to 1500 ft): This limitation cannot be effectively addressed with restoration – no prescription recommended.
3) Reach 3 (1500-3500 ft): Install full-spanning log structures.
4) Reach 4 (above 3500 ft): This limitation cannot be effectively addressed with restoration – no prescription recommended.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

During the RBA snorkel inventory conducted by Bio-Surveys LLC in July 2013, no O.mykiss were observed in WF Mosby Cr. Low densities of 1+ and older age class cutthroat were observed distributed across the 1.0 mile survey reach (expanded estimate of 85 fish) (Appendix 3). Trout in the 0+ age class were similarly distributed at very low densities (expanded estimate of 150 fish).
Surveyors noted that in July 2013, flows at the mouth of WF Mosby Cr were high (relative to all the other Mosby Cr tributaries).

Anchor Site 1

Location and length

Describe the location and length of this Anchor Site. Identify location by river mile, tributary junctions, and other map features.

Anchor Site 1 begins at the mouth of WF Mosby and extends approximately 600 ft upstream to an old log stringer bridge crossing (WP 1076-1080) (Figure 7).

Channel structure

Describe channel form in terms of meander, braiding, side channel, alcove, backwater and other complex channel structures.

As WF Mosby Cr traverses the mainstem Mosby floodplain, side channel and backwater habitat is abundant.

Floodplain structure and interactivity

Describe the floodplain terrace structure in relation to channel level and complexity. Explain how these allow or restrict high flood access to the floodplain.

This Anchor Site traverses the mainstem Mosby Creek floodplain (Photo 174), with low (1-2 ft) terraces and excellent connectivity with winter channels across the 200' total floodplain width.

Rearing contribution

Describe how the Anchor Site contributes to spawning, incubation, summer rearing, and winter rearing.

No spawning gravel was observed within this reach during the 2013 field inventory. Winter rearing habitat is expansive across the 200 ft interactive floodplain associated with the confluence of Mosby Cr. Summer habitat is limited with pool surface area in the lower 1200 ft being present at an average rate of only 175 sq ft per 100 lineal ft of stream. By comparison, Brownie Cr lowest ten pools had an average rate of 490 sq ft per 100 ft of stream. The July 2013 RBA snorkel inventory observed no O.mykiss within this reach.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) Insufficient wood densities to support trapping and sorting spawning gravel and pool scour- no spawning gravels currently being trapped or sorted.
2) Lack of a secure source of long-term large wood for recruitment to the channel – Oregon Forest Practices Act only protects the inner 70 riparian buffer on medium fish-bearing streams, with alternatives available for reduced buffer width.

Addressing the limitations

List and rank the restoration work at the site that would most effectively improve rearing conditions within the Anchor Site and stabilize the core population at a higher base level.

1) Install full-spanning large wood where wood density is low.
2) Protection of upslope large wood resources – explore conservation easements to protect and expand the Riparian Management Area (RMA).

Anchor Site 2

Location and length

Describe the location and length of this Anchor Site. Identify location by river mile, tributary junctions, and other map features.

Anchor Site 2 begins approximately 1,500 ft above the mouth, above a full spanning log jam, and extends upstream for approximately 2,000 ft (WP 1084-1088) (Figure 7).

Channel structure

Describe channel form in terms of meander, braiding, side channel, alcove, backwater and other complex channel structures.

Within this Anchor Site, there are several awesome channel braids with excellent wood densities. Sinuosity is high and channel meander engages the full floodplain (Photo 178).

Floodplain structure and interactivity

Describe the floodplain terrace structure in relation to channel level and complexity. Explain how these allow or restrict high flood access to the floodplain.

The floodplain is 100' in width. Low 1-2 ft terraces are highly interactive in winter flows. Gradient shifts to 2% in this reach.

Rearing contribution

Describe how the Anchor Site contributes to spawning, incubation, summer rearing, and winter rearing.

Sorting of spawning gravels is occurring within this Anchor Site. During the 2013 field inventory, sufficient spawning gravels to support 11 spawning pair of anadromous O.mykiss were observed. While winter habitat is extensive, summer habitat is limited by pool surface area. The July 2013 RBA snorkel inventory observed no O.mykiss and only an expanded estimate of 45 cutthroat within this reach.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

1) Potential for loss of existing floodplain function from deterioration of existing woody debris.

2) Lack of a secure source of long-term large wood for recruitment to the channel – Oregon Forest Practices Act only protects the inner 70’ riparian buffer on medium fish-bearing streams, with alternatives available for reduced buffer width.

Addressing the limitations

List and rank the restoration work at the site that would most effectively improve rearing conditions within the Anchor Site and stabilize the core population at a higher base level.

1) Install full-spanning large wood to extend the retention of existing wood density.
2) Protection of upslope large wood resources – explore conservation easements or opportunities to reconnect the riparian with upslope ownership by trading for some public resources elsewhere in the basin.

Anchor Site rankings

Function

Rank the identified anchor sites in terms of current function (1= best).

1) Anchor 2
2) Anchor 1

Restoration potential

Rank the identified anchor sites in terms of restoration potential.

1) Anchor 1
2) Anchor 2

East Fork Mosby Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The condition of the riparian corridor on EF Mosby Cr is varied and dependent on ownership. Along the lowest .25 miles above the mouth, the riparian is alder dominated with a one-sided 100' harvest buffer (Photo 182) of 30 yr old conifer. Upstream of this, as the creek passes through BLM land, the riparian character changes dramatically to old growth (Photo 185). A radical drop in air temperatures was observed at this transition in upslope management at noon in May. Ambient air temperature has a powerful influence on stream temperature.

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?

Within the BLM ownership, riparian wood recruitment potential is stunning with old growth Douglas fir dying and falling into the stream and old growth recruiting from both the riparian and from far beyond the riparian. This is a applicable reference site for observing a high functioning upslope / aquatic relationship. Recruitment potential is so high that there is no need to treat. The trajectory here is rapidly accelerating toward peak complexity as the old growth canopy begins to unravel with age and contribute to the aquatic corridor.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

No thermal problems associated with riparian condition were observed on EF Mosby Cr.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

Approximately 2.5 miles above the mouth, a 3 ft bedrock falls creates a permanent barrier to summer migration.

Temperature Issues

No temperature data was collected by CFWWC on EF Mosby Cr.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

Substrates are cobble/small boulder with small boulders up to 6" in diameter. The boulders play a role in trapping wood and creating adjacent deep pool scour.
During the 2013 field survey, no spawning gravels appropriate for anadromous O.mykiss were observed in the lower .25-mile of the E Fk within industrial forest lands. Above this point, within the more complex channel that passes through BLM land, there was a total of 105 sq feet of spawning gravel observed (Figure 8). Two lamprey redds were observed on EF Mosby in the May 2013 field inventory (Figure 11).

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Pool surface area on EF Mosby is relatively low. However, the woody debris component, where present, provides very high pool complexity and summer cover. The pool surface area (sq ft) of the first ten pools was measured during the field inventory to allow us to compare to other tributaries of Mosby Cr subbasin for capacity to support summer rearing of salmonids. The lower 1,150 ft of EF Mosby Cr had an average of 261 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr.

The 2013 RBA survey conducted by Bio-Surveys identified an average summer pool complexity score of 2.0 on a scale of 1-5. This scale is based on the total percent of pool surface area that is associated with some form of structural complexity, such as over-hanging vegetation, larges substrate, wood or undercut bank, capable of providing cover (2 is 1-25%, 3 is 26-50% of pool surface area associated with cover

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Large boulders play a role in trapping wood and encouraging adjacent deep pool scour to create excellent winter habitat for both cutthroat and O.mykiss.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

At their confluence, EF Mosby Cr contributed 40% and the MF Mosby Cr contributed 60% of the flow to Mosby Cr (Photo 181). The active channel width of mainstem Mosby below the EF/MF split is 50 ft. East Fk Mosby channel width is 20' and the estimated gradient is 4-5%.

The lower 0.25-mile of EF Mosby (within industrial forest land ownership) has a floodplain width of 60' with a dominant terrace height of 3'. Sinuosity is very low within this reach (Photo 183). Large boulders play a role in trapping wood and creating adjacent deep pool scour. This is high quality winter habitat for O.mykiss.

Above 0.25 miles, within BLM ownership, the channel complexity shifts to display fully interactive low 2ft terraces. Within this reach, large wood jams are trapping mobile bedload that were not observed in the 0.25 miles. There is evidence of stream-cleaning on the BLM ownership that bucked giant old growth conifer out of the active channel (Photo 184). The stream clearing that occurred here has set the entire length of Mosby Cr back decades in relation to bedload storage and the development of complex channel forms. In addition, the impacts of headwater debris flows observed in the mainstem of Mosby Cr below the confluence of the EF would not have occurred. This is an easily accessible roadside reference site for conducting tours to observe properly functioning stream conditions.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Channel complexity potential is very high on EF Mosby Cr, above RM 0.25 where the low floodplain terraces are actively engaged at normal winter flow levels and high wood densities exist both short and long term for the provision of complex cover.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Reach 1 (mouth to 0.25 miles): Terrace height (3 ft); lack of in-stream wood.
2) Reach 2 (above 0.25 miles): No current limitations.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Reach 1 (mouth to 0.25 miles): Yes, supplement with LWD in full and edge oriented applications.
2) Reach 2 (above 0.25 miles): No prescriptions recommended.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

During the RBA snorkel inventory conducted by Bio-Surveys LLC in July 2013, no O.mykiss were observed in EF Mosby Cr. Low densities of 1+ and older age class cutthroat were observed distributed across the 1.0 mile survey reach (expanded estimate of 85 fish) and at an overall average density of .07 fish per sqm (full seeding is estimated at .75 fish/sqm). Trout in the 0+ age class were similarly distributed at a low overall average density of .14 fish per sqm. To put this in perspective, full seeding of 0+ trout would be expected to show a density of 3 fish per sq m.

Surveyors noted that in July 2013, flows at the mouth of EF Mosby Cr were high (relative to other Mosby Cr tributaries). Because the EF is one of the 3 primary headwater tributaries (EF, WF, MF Mosby) its most highly prized contribution to the Mosby Cr mainstem is its high quality and quantity summer flows. Even though most restoration prescriptions will focus on the recovery of crippled processes in other portions of the basin, paramount concern should perpetually be placed on the protection and conservation of the headwater flows emanating from the EF Mosby Cr.

Middle Fork Mosby Creek

Riparian corridor overview

The purpose of this section is to characterize the content and status of the riparian vegetation as these affect its ability to deliver large wood to the channel and to protect it from solar heating. In this section, focus on conditions and not their effects on salmonid distribution.

Dimensions and location

Describe the lineal dimensions and location of deciduous, coniferous, and open canopy.

The riparian corridor of MF Mosby Cr has good canopy cover. Alder dominates the vegetation on the lower 0.75 miles. Upstream of this extent, on BLM ownership, the overstory is composed of a mix of alder and mature Douglas fir (Photo 188).

Large wood recruitment potential

What is the recruitment potential and time frame for delivery to the channel?
Within the lower 0.75 of MF Mosby, recruitment potential is limited to short-lived wood from the alder canopy. On BLM land upstream of this point, there is a strong long-term supply of old growth conifer that will be available for recruitment for many years.

Thermal problems

Describe the relationship between riparian condition and thermal problems in the aquatic system. Include locations and causes.

No thermal problems associated with riparian condition were observed on MF Mosby Cr.

Aquatic habitats overview

The purpose of this section is to make a broad and integrative description of the factors currently restricting salmonid use of the stream's channel system. In this section, focus on conditions and not their effects on fish distribution.

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

Summer juvenile migrations on the MF Mosby Cr end at an ephemeral sill log barrier (Photo 187) approximately .75 miles above the mouth (WP 250) and about 600 feet above the confluence with Broken Leg Cr.

About 0.9 miles above the mouth of MF Mosby (WP 251), a full span log jam (Photo 190) creates an ephemeral but stable barrier that terminates all anadromous migration.

Spawning gravel distribution

Describe the quantity, quality and location of spawning gravels. Identify locations by river mile, tributary junctions, and other map features.

Spawning gravel is virtually non-existent for large anadromous salmonids in MF Mosby Cr. During the 2013 field inventory, only 9 sq ft of spawning gravels for anadromous O.mykiss were observed (1 spawning pair) (Figure 8).

Summer cover

Describe the character and distribution of summer cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

Pool surface area on MF Mosby is low. However, the woody debris component, where present, provides very high pool complexity and summer cover. The pool surface area (sq ft) of the first ten pools was measured during the field inventory to allow us to compare to other tributaries of Mosby Cr subbasin for capacity to support summer rearing of salmonids. The lower 1,250 ft of MF Mosby Cr had an average of 197 sq ft of pool surface area per 100 ft of stream within its ten-pool reach, compared to the lowest average of 75 sq ft on Cow Cr and the highest average of 490 sq ft on Brownie Cr.

Winter cover

Describe the character and distribution of winter cover. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The large substrate size (cobble/small boulder to 4’) provides high quality winter habitat for O.mykiss.

Channel form and floodplain interaction

Describe channel form and degree of floodplain interaction. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

At its confluence, MF Mosby Cr contributes 60% of the flow to the mainstem (Photo 181). The bankfull channel width on MF Mosby is 22 ft and the gradient is about 4%. Near the confluence of the EF and the MF, the floodplain width is 125’ with two terraces, a 3 ft inner terrace and a 5 ft outer terrace. The lower reach of MF Mosby has a very simple channel structure with low sinuosity and low wood density. Just 0.25 miles above the mouth, there is almost a complete loss of floodplain. There are very small and minor short side channel that would be washed high velocity habitat during winter flows. The MF is steeper than the East Fork. Because of this fact, it develops greater hydraulic potential at peak winter flows.

Approximately 0.75 miles above the mouth (within the BLM reach), there is a radical shift in stream character with increased complexity and improved riparian recruitment potential.

There is evidence of stream-cleaning, even down onto private industrial forestland (Photo 186). Both of the headwater forks (EF and MF) exhibit the same legacy of large wood removal. The removal of old growth logs from the stream corridor flushed mountains of bedload, accelerated incision and robbed the upper mainstem of Mosby Cr from the debris torrent protection provided by the stable old growth jams existing prior to stream-cleaning.

Channel complexity potential

Assess the potential for the development of meander, braiding, side channel, alcove, backwater and other complex channel forms. (This evaluation generally lacks quantitative measurement, and relies primarily on professional judgment.)

The potential for the development of additional channel complexity within the MF Mosby is limited by landscape scale morphology. The stream gradient averages 4% within the first mile and the active channel is hillslope confined from both sides. This eliminates the potential for the development of even small interactive terraces that may not be revealed in HIP (High Intrinsic Potential) modeling layers. There is however, very high potential for the development of high quality dam pool habitats from jams formed by the recruitment of massive old growth conifer from the intact riparian corridor. These jams and their associated deposition plains are capable of providing low gradient, low velocity winter habitats within the high gradient active channel that are unique forms of habitat complexity not observed anywhere else in the Mosby Cr system except EF Mosby Cr.

Channel complexity limitations

List and rank the factors currently limiting the development of channel complexity.

1) Reach 1 (mouth to 0.25 miles): Low wood densities, simplified channel.
2) Reach 2 (0.25 to 0.75 miles): Lack of floodplain.
3) Reach 3 (0.75 to 0.9 miles): Steep gradient.

Addressing the limitations

Are these limitations addressable through restoration work? Explain for each limitation listed above.

1) Reach 1 (mouth to 0.75 miles): Edge oriented LWD placement
2) Reach 2 (0.25 to 0.75 miles): Edge oriented LWD placement
3) Reach 3 (0.75 to 0.9 miles): This limitation cannot be adequately addressed by restoration actions.

Summer juvenile distribution

Describe the summer distribution of juvenile salmonids and relate it to the riparian and channel conditions presented in the previous two sections. Include a description of the resources used.

During the RBA snorkel inventory conducted by Bio-Surveys LLC in July 2013, 7 O.mykiss juveniles were observed (expanded estimate of 35 fish) in MF Mosby Cr rearing shortly above the confluence with the EF Mosby Cr. Low densities of 1+ and older age class cutthroat were observed distributed across the 1.0 mile survey reach (expanded estimate of 220) and at an overall average density of .11 fish per sq m (full seeding is estimated at .75 fish/sqm) (Appendix 3). Trout in the 0+ age class were similarly distributed at a very low average density of .04 fish per sq m.

Surveyors noted that in July 2013, flows at the mouth of MF Mosby Cr were high (relative to other Mosby Cr tributaries). Because the MF is one of the 3 primary headwater tributaries (EF, WF, MF Mosby) its most highly prized contribution to the Mosby Cr mainstem is its high quality and quantity summer flows. Even though most restoration prescriptions will focus on the recovery of crippled processes in other portions of the basin, paramount concern should be perpetually placed on the protection and conservation of the headwater flows emanating from the MF Mosby Cr.

Secondary Branch 1

Broken Leg Creek

Location and length

Describe the location and length of this Secondary Branch Site. Identify location by river mile, tributary junctions, and other map features

The confluence of Broken Leg Cr and MF Mosby Cr is located approximately 0.6 miles upstream of the mouth of MF Mosby (Photo 192).

Migration barriers

Describe the location and character of barriers to migration by adult and juvenile salmonids. Identify locations by river mile, tributary junctions, and other map features.

The terminus of a debris flow event on Broken Leg Cr exists about 125 ft above the confluence with MF Mosby (WP 252). This is the end of summer migration at a 3 ft ephemeral sill log (Photo 193).

Approximately 1,000’ above the confluence of Broken Leg and MF Mosby (WP 244), on Broken Leg Cr, a 3.5 ft bedrock falls (Photo 191) terminates all anadromous migration.

Rearing contribution

Describe how the Secondary Branch site contributes to spawning, incubation, summer rearing, and winter rearing.

During the RBA snorkel inventory conducted by Bio-Surveys LLC in July 2013, 1 O.mykiss were observed (expanded estimate of 5 fish) in Broken Leg Cr. Low densities of 1+ and older age class cutthroat were observed distributed sparsely across the 0.35 mile survey reach (expanded estimate of 50) and at an overall average density of .09 fish per sqm (full seeding is estimated at .75 fish/sqm). Trout in the 0+ age class were similarly distributed at a very low average density of .10 fish per sq m.

Rearing limitations

Which functions limit the site's production potential, and what causes these limitations?

No spawning gravels suitable for anadromous O.mykiss are currently available on Broken Leg Cr, winter and summer habitat are limited by steep gradient and lack of floodplain terraces.

Restoration analysis

Defining the connectivity of habitats

This document has made distinctions between habitat segments that assist in breaking down the analysis into manageable stream reaches. These reaches include the mainstem as well as the 30 primary tributaries of Mosby Cr, each playing a distinct yet interactive role in salmonid production in the overall Mosby Cr subbasin.

Mosby Cr, as a network of interconnected streams, exhibits tremendous historic potential for the provision of all seasonal habitats requirements for the freshwater life history of salmonids. Even though the abundance of fully functional habitats has been severely reduced contemporarily by the repeated cycle of upslope and riparian resource extraction (most acutely observed in the mainstem), many tributary corridors still display fully functional conditions with greatly underutilized aquatic rearing areas. The consistent display of very low salmonid densities (all species) in every tributary is clearly revealed in the distribution and abundance graphics presented in the Pivot Table Workbook (Excel) provided with this document as well as in Appendix 3.

This analysis has identified a clear disconnect between functional spawning and rearing habitats within the basin. The extensive pool habitats of the lower 18 miles of mainstem Mosby Cr (81% of the mainstem) are rendered dysfunctional for summer salmonid rearing by temperature impairments (Appendix 4). Spring fry generated in these lower 18 miles must find summer rearing habitat within the tributaries or upper mainstem reaches where flows are cooler.

Spawning gravels are broadly distributed throughout the 22.2 miles of mainstem Mosby Cr, with a concentration in the middle 6th field (between Palmer Cr and Stell Cr) (Figure 8). Since swim-up fry upon emergence are swept downstream to populate habitats below the actual physical location of spawning gravel, the spawning gravels existing outside the Core area (below Rock Cr) are delivering fry to an extremely temperature limited segment of mainstem Mosby Cr. The survival rates of these fry would likely be extremely low whether they could escape this limitation or not because of the increased distance they would have to travel to find either tributary refuge or refuge higher in mainstem Mosby Cr later in the spring. Increased travel distance to thermal refugia increases exposure to predation.

One way to look at fragmented connectivity is that it provides a platform for the development of unique survival strategies. After a thorough review of all tributary and mainstem aquatic habitats outside the Core area, it is apparent that no strong deme of the Mosby Cr cutthroat population exists outside the Core area. For the nomadic life history strategy to succeed, migrants need to locate functional cold-water refugia in order to persist through summer pinch period flow regimes that present stream temperatures above survival thresholds. Because the lower mainstem of Mosby Cr does not provide this kind of refugia, nomadic migrants would have to migrate far upstream to approximately RM 18, or into cool water tributaries. There were no upstream temperature dependent migrations of juvenile salmonids observed in tributaries below the Core area. This habitat disconnect is further complicated by several juvenile barriers on the mainstem that exist at RM 2.7, RM 3.7 and RM 8, effectively terminating upstream temperature dependent upstream juvenile migrations (especially the 0+ age class).

The RBA snorkel survey identified that the majority (71%) of the cutthroat rearing existed in tributary habitats (O.mykiss abundance was so low that limited conclusions could be based on their relative abundance). The combined pool surface area of all 30 tributaries inventoried was just 15% of the total pool surface area available for rearing. Only a 4.2-mile segment of mainstem Mosby Cr (not including its headwater tributaries, MF and EF) exhibits adequate functionality for the provision of summer habitat. To support an expansion of the population within the upper watershed, specific attention will need to be focused on restoring ecosystem processes in the Core area. Efforts outside the Core will have limited potential for achieving any uplift in salmonid abundance because of the severity of the disconnect between functional incubation and summer rearing habitats. A suite of tributaries in the Core area would have historically provided cool water refugia from the mainstem. Currently, deep channel incision in the mainstem and the lack of retained bedload for storing runoff in these tributaries has resulted in a loss of tributary access due to exposed bedrock steps and low summer flows emanating from the tributaries.

Without the collection of significant additional data (scale or otolith analysis) we are currently unable to evaluate the existence or the comparative success of any unique life history strategy. If we adopt the most conservative view of the current range of life histories that might be functioning, we would assume from the current abundance and distribution that most 0+ age nomadic salmonids that drop out of the Core area below the confluence of Rock Cr perish (not observed retreating into tributaries outside the Core). This view reduces the importance of restoring lower tributaries that exhibit recovery potential and significant pinch period flows (Smith Cr and Perkins Cr). This assessment is presented to justify the prioritization of restoration actions within the Core even though substantial potential exists in some of the contributing tributaries outside the Core area.

The provision of winter refuge on floodplain habitats in close proximity to functional summer habitats is extremely important for supporting the resident life history strategy that resides year around in the headwater reaches. Being pulsed out of the headwaters during winter flow regimes has no survival advantage if there is no hope for returning to headwater thermal refuge the following summer. Fry generated in the lower mainstem 6^{th} field, currently have extremely limited access to winter floodplain habitats within Mosby Cr and rapidly become vulnerable to the effects of low habitat complexity.

Seasonal Habitat Limitations

We believe the fundamental purpose of the entire limiting factor analysis is to step back and take a basin-scale view of the biological, morphological and physical interactions that combine to influence survival and consequently salmonid production. In this larger view, we see four very significant issues at play in the Mosby Cr basin:

1) Severely elevated summer temperatures acutely affect summer rearing of salmonids in the lower and middle 6th fields of mainstem Mosby Cr, at least below Dahl Cr.
2) Many of the cool water tributaries of Mosby Cr have insignificant summer flows and/or juvenile barriers at their confluence with mainstem Mosby Cr (providing barriers to accessing thermal refugia during summer low flows).
3) The absence of large conifer in the riparian management area has resulted in a collapse of a fundamental system process that would have historically maintained a complex channel form.
4) A blatant lack of channel roughness (boulders, wood) exists for storing a high volume of mobile bedload for protecting limited summer flows in deep alluvium from the impact of sun and the ambient temperatures.

Defining the production bottleneck

Does the seasonal bottleneck identified remain the primary limiting habitat when each of the other issues identified in the assessment process are factored in? Explain.

When the 2012 and 2013 stream temperature profiles and the abundance and distribution of juvenile salmonids are superimposed, it is clear that the majority (81%) of the mainstem of Mosby Cr is completely dysfunctional for the provision of summer rearing habitat for salmonids. There are vast areas of pool surface area that are not supporting salmonids because they heat up to levels near or above thresholds for survival. In addition, high volumes of spawning gravel are completely underutilized (no adult escapement of spring Chinook, no significant escapement of summer or winter O.mykiss).

In the absence of an augmentation program for adult spring Chinook that could effectively utilize the high volumes of large anadromous spawning gravels, where emergent fry would immediately migrate out of the observed summer dysfunction (severe temperature limitations), boosting survival rates at each life history stage for resident and fluvial cutthroat (emergent fry, summer parr and winter parr) becomes the primary objective for guiding a salmonid recovery plan in the basin.

The ultimate goal of this document is to prepare a long term restoration plan that specifies how to overcome current seasonal habitat limitations so as to develop a self-sustaining (viable) population of naturally reproducing salmonids (likely cutthroat in Mosby Cr). We emphasize that this can only be accomplished by restoring key ecosystem processes that have been lost (the current channel form has been classified as simplified and degraded).

We have stated that addressing the primary seasonal habitat limitation (in this case, the abundance of functional summer rearing habitat) will not in itself boost survival of all life history stages. We believe the recovery of system function within the identified anchor habitats of the Core area will have the capacity to restore these processes on a large enough scale to positively impact survival and even expand the range of the existing remnant population of cutthroat.

Ownership issues

To what degree would land use and ownership allow restoration work?

In the Mosby Cr basin, about 63% of the land base is owned and managed by large private industrial timber companies (Figure 2), with about 59% of the entire land base managed by a single industrial timber company (Weyerhaeuser). This ownership is concentrated in the middle and upper basin. Publicly owned land (primarily BLM) in the basin totals about 16,500 acres (28% of the total land base and 30% of the large timber acreage). These timberland owners are critical partners in improving the long-term health and productivity of the Mosby Cr subbasins streams and riparian canopies. The largest industrial landowner in the watershed has taken action to resolve fish passage barriers and has collaborated extensively on instream restoration actions that have been innovative and effective (boulder weirs). There is currently no economic incentive for industrial timber managers to reestablish conifer within the riparian or to retain a wider buffer that includes conifer to support long-term sources of large woody debris. This suggests that other incentives may be required to boost cooperation.

The balance of acreage within the basin (about 5300 acres) is distributed between tracts of less than 5 (187 parcels), 6-40 (116 parcels) and 41-300 (32 parcels) acres. The lower 8 miles of mainstem Mosby Cr and the tributaries within this reach are mostly small privately owned tracts. Land use along the stream is not in conflict with restoration, however, most of the area that is in small privately owned parcels is outside of the prescribed restoration reaches. 100% of the designated Core Area is within industrial timber or public ownership.

Channel complexity summary

What is the potential to increase channel complexity in the long term through natural recruitment processes, with and without restoration?

The long term potential for increasing channel complexity has clearly been compromised by complete removal of the old conifer resources in the riparian corridor that lasted into the 1970's. The ramifications of that 150 year long process is that most aquatic corridors have been simplified and have lost their ability to store cool flows in the deep alluvium that would have been supported by large wood complexity in the channel. Consequently, large portions of mainstem Mosby Cr and many of its primary tributaries continue on a trajectory toward degradation as the little remaining legacy wood is flushed out with successive flood events. A short-term solution is needed to replace depleted large woody debris volumes within the aquatic corridor until riparian recovery and protection actions can sustain the delivery of large wood through natural recruitment.

The high priority prescriptions designed to address the primary seasonal habitat limitation (functional summer habitat) will also benefit the abundance of both spawning gravel and low velocity winter refugia. The accumulation of migratory bedload from wood or boulder weir placement lifts the stream adjacent water table, aides in the recovery of functional off channel beaver dam complexes, stores and sorts more gravels and builds a deep bedload that protects hyporheic flows from the effects of the ambient air.

Potential restoration prescriptions and sites

Site-specific prescriptions have been assigned a map number that refers to a geographical location in Figures 26-27 in Appendix 5. Each prescription is then described and prioritized in tabular format, found in Figure 28 in Appendix 5.

Prescription implementation

All of the prescriptions listed in Figures 31-32 are included in the following condensed discussion of general issues, goals, methods, complications and results.

Issues, Goals & Methods

1) Issue: Inventories of juvenile salmonids indicate that existing summer, winter and spawning habitats are currently severely underutilized and that in 2013 there were not enough anadromous O.mykiss or spring Chinook returning to spawn to seed even the current low levels of functional habitat.

   Goal: Maximize the complexity and quality of existing summer and winter rearing habitats to boost the fry-to-parr survival rates of the progeny produced from currently returning adults within reaches that display the highest current function for all seasons (Anchor Sites).

   Method: Increase or support existing channel complexity and cover in identified anchor sites to protect the survival and retention of emergent fry being produced. Secondly, protect and increase water quality for the provision of additional rearing capacity in the identified anchor sites.

2) Issue: Mainstem Mosby Cr from its mouth to RM 18 exhibits impaired summer stream temperatures that significantly reduce the abundance of functional summer habitat for salmonids. Due to incomplete temperature data, all the contributors to this cumulative problem are not fully understood. However, it

appears that extensive bedrock exposure in the broad mainstem channel unequivocally contributes to these cumulative warming impacts. Temperature impairments accumulate and become most severe in downstream mainstem reaches.

Goal: Address the summer temperature limitations in mainstem Mosby Cr by establishing and/or protecting wide riparian buffers and protecting side channels from the influence of summer surface flows to develop a temperature differential in the stored hyporheic lens.

Method: Actions include employing large wood complexes or boulder weirs to accumulate bedload. Delink existing side channels from summer flows with point bar log jam developments. Create a complex of scour logs in side channel habitats designed to develop deep pool scour for revealing the hyporehic lens during pinch period summer flows (creating accessible thermal refugia), expand and protect riparian buffer widths.

3) Issue: Depleted in-channel woody debris volumes throughout the stream network has created channel simplification resulting in the loss of diverse aquatic habitats, stored bedload and hyporehic flows isolated from the influence of solar and air exposure. The combination of these losses has reduced the ability of the floodplain to store and retain ground water well into the summer months. This loss of function has elevated summer stream temperatures beyond the threshold for salmonids in the majority of their historical range in the basin.

   Goal: Provide a short-term solution for boosting large wood volumes within the aquatic corridor until riparian recovery and protection actions can sustain the delivery of large wood through natural recruitment.

   Method: Place large wood structures and boulder weirs as short-term solutions to the lack of channel roughness. Select sites with the morphological characteristics for maximizing floodplain interaction (identified as Anchor Sites or treatment reaches).

4) Issue: While beaver are not present throughout much of the Mosby Cr basin, the legacy of their presence suggests a historical abundance higher than currently observed. The legacy beaver flats that historically provided the morphological potential for the development of a winter stable colony are currently not impounded. The direct benefits to the documented seasonal habitat limitation (abundance of functional summer habitat) are significantly addressed by beaver dams as they store winter rains and recharge ground water lenses.

   Goal: Support beaver dam building activity that contributes to increased floodplain storage and additional summer and winter habitat.

Method: Increase woody debris volumes to provide the foundational channel complexity that will support beaver dam construction and provide winter stability. Where it is difficult to secure wood in the channel, consider installing posts across the channel to provide an initiation site. Provide protection for culverts, roads, trees and other infrastructure on neighboring properties to reduce the potential for conflict. Develop a riparian planting strategy in select locations that encourages the recolonization of beaver by providing a self-sustaining food resource.

5) Issue: Ineffective trapping and sorting of mobile spawning gravels was identified as a concern for large anadromous production in many tributary reaches where gravel resources are extensive.

   Goal: Improve the storage of well-sorted spawning gravels by promoting the trapping and sorting of gravels with priority for reaches that display the highest current function for all seasons (Anchor Sites and treatment reaches).

   Method: Boost instream wood densities, influencing stream gradients and floodplain interaction to increase the capacity for trapping and sorting spawning gravels.

6) Issue: Barriers to fish passage can limit adult access to spawning habitat and/or access to summer thermal refugia.

   Goal: Provide unencumbered access to functional spawning and summer rearing habitats existing in high priority tributaries.

   Method: Remove and/or replace culverts and dam structures, prioritizing those that address the primary seasonal habitat limitation (lack of functional summer habitat). Aggrade the active channel on mainstem Mosby Cr in specific locations that would assist in mitigating for the entrenchment observed at the confluence of many tributary corridors that complicates access to thermal refugia at summer low flows.

7) Issue: Most of the conifer was harvested from the riparian corridor decades ago and natural regeneration is dominated by faster growing alder, which is a short-lived component of in-stream woody debris. This has resulted in a resource void that can be addressed in the short-term with installed log structures (see Issue 3), but calls for a parallel solution that replaces this resource in riparian for the long-term.

Goal: Develop a long-term riparian recovery plan that replenishes the large conifer component in the riparian management area for future recruitment to the active channel.

Method: There are multiple options for addressing this issue in the Mosby Cr system. Determining the most appropriate method(s) will require considering the current potential of the system, the local conditions of the site and the interest and willingness on the part of the landowner. Priority for treatment should focus on the identified Anchor Sites and treatment reaches that have the greatest long term potential for providing aquatic function.

1) Where alder canopy dominates the riparian and conifer are not present or minimal, consider conversion of alder to conifer on a scale and site that does not interrupt the shade canopy by girdling or dropping alder toward the stream and inter-planting with shade tolerant conifer (i.e. western red cedar).
2) Explore opportunities to establish wider riparian buffers through cooperative agreements or conservation easements with current landowners.
3) Explore opportunities to exchange public land outside the large wood recruitment corridor for private lands within the recruitment corridor whereby a greater width of riparian buffer could be perpetually maintained (Figure 30).
4) Incorporate a routine practice of adding large wood to the stream on the same schedule as harvest rotations (30-50 years) so that wood supplementation occurs on a regular basis until natural recruitment can be restored.

Potential complications

Conservation easements

Conservation easements are a tool that requires considerable planning and a commitment to a long-range recovery vision. The resources to support the acquisition of conservation easements are becoming increasingly difficult to access as social acceptance increases. Priorities for acquisition should be well grounded in their benefit to stream function (i.e. south facing slopes on perennial streams) and critical salmon rearing and spawning areas.

Culvert replacements and dam structure removal

Several culverts and dam structures were identified in the assessment that currently block fish passage (Figure 29). Some block adult migration, some are barriers to juveniles, some only benefit a single species - Cutthroat Trout. Establishing reasonable priorities for the best investment strategy must take into account the quality and function of habitats that are located behind barriers and the seasonal timing of accessibility. In prioritizing restoration actions for the Mosby Cr system, strong consideration has been given to actions that directly address the primary limitation of the lack of functional summer habitat and access to thermal refugia. In this regard, just the lower 0.5 miles of a cold water tributary has been observed to be the primary target for upstream migrants seeking cold-water refugia. This may result in culvert crossings higher in a tributary system ranking significantly lower in the prioritization tables.

Restoring beaver populations as an integral part of a restoration strategy

Beaver dam building activity currently occurs to a very limited degree on Mosby Cr tributaries. Increasing the abundance and stability of impoundments as a restoration trajectory could lead to future conflict. Beaver are well known for developing conflicts with property and infrastructure. In order to successfully increase and maintain the presence of beaver ponds, it will be necessary to raise public awareness of the key role of beaver in ecosystem process and salmonid production. It may also be necessary to provide protection for culverts, trees and other infrastructure on host or neighboring properties to reduce the potential for conflict.

Large wood and boulder placement

Locations of in-stream restoration actions, such as large wood and boulder placement, must be carefully sited. With the exception of lower Smith Cr, all the large wood and boulder placements recommended within this document are not in close proximity to residential sites and the risk for conflict would be primarily adjacent road infrastructure. A thorough assessment of risks and open communications with the landowners will be important in planning restoration on all sites, and particularly on lower Smith Cr.

Mainstem side-channel improvement

The actions prescribed for improving side channel function are not controversial or problematic. The fact that the hydraulic potential of side channel habitats is significantly less than observed in the mainstem of Mosby Cr suggests that it’s a good way to start to achieve success.

Conifer interplantings

Establishing conifer within an alder dominated riparian can be challenging as the deciduous canopy is well established and competes most effectively for sunlight. Species selected must be shade tolerant. Western red cedar is recommended as it is naturally occurring in the riparian, is relatively shade tolerant, and is the best long term source of woody debris (based on longevity). Site selection to assure appropriate soil and moisture conditions and alder thinning (felling or girdling) will be required. Follow up maintenance and protection from animal browse will be necessary for successful establishment.

Expected results

Conservation Easements

This is a long-term investment that can be expected to produce results in the form of sustainable processes within the watershed that reduce stream temperatures and directly address the seasonal habitat limitation for salmonids. Protecting riparian corridors from harvest produces shade, creates a functional air shed, adds forest nutrients and secures a long-term future source of wood recruitment to the active stream channel. While landslides occur naturally and are a valuable source of bedload for streams, protecting unstable slopes from timber removal and road construction reduces the frequency of catastrophic debris torrent events precipitated by management activity.

Culvert replacements and dam structure removal

Where the assessment has demonstrated the presence of inaccessible cold water refugia, the value of removing the identified barriers is elevated because of the actions ability to provide supplemental cold water habitats for upstream temperature dependent migrations of juvenile salmonids seeking refuge from the temperature limited portions of the mainstem of Mosby Cr. These actions would then provide immediate benefit to salmonid survival and develop additional life history diversity for the greater Mosby Cr meta-population.

Restoring beaver populations as an integral part of a restoration strategy

Understanding how beaver can contribute to the recovery of ecosystem function and even mitigate for upslope cumulative impacts is a big step in preparing an effective restoration plan. The abundance of summer habitat is magnified by the presence of a beaver dam. Beaver dams can function as a cornerstone of salmonid productivity in fresh water; they increase the seasonal survival rates of juvenile salmonids by storing nutrients that initiate a trophic cascade that boosts growth and survival, they provide deep water for the development of a summer thermocline, they provide low velocity winter habitat, they maximize the period of floodplain inundation and recharge ground water tables.

Beaver impoundments have the ability to stratify and provide cool water to downstream habitats by releasing from the bottom of the pond and not spilling from the heated surface strata. Monitoring data from other Coast Range locations has documented the capacity of beaver ponds to mitigate for upstream temperature impacts when flows permeate from the bottom of stratified ponds.

Large capacity beaver ponds also saturate floodplain water tables by storing winter rains far beyond the visible extent of the ponded storage. The broader the floodplain, the greater the capacity for late season ground water storage (dependent on soil type and underlying geology). In a temperature limited basin such as Mosby Cr, increasing water storage to extend the delivery of cool ground water assets to the stream network further into the summer, directly mitigates for the dominant basin scale seasonal habitat limitation identified for salmonids in this analysis (functional summer habitat).

The potential for recovering beaver within the Mosby Cr basin in general is not large because of the limited morphology that would support broad ponded areas. However, where the potential exists, the services that beaver ponds would have significant quantifiable benefit.

Large Wood Placement

Large wood placements provide a short-term solution to the lack of channel roughness and the low in-stream wood densities that have resulted in the simplification of stream channels. This simplification is expressed in deep channel entrenchment, the lack of channel braiding, losses in the stored bedload that include spawning gravels, declines in water quality (temperature), decreases in the floodplain storage of ground water, loss of late summer hyporheic flow, and reductions in pool surface area and pool complexity. Wood in the channel creates the foundation for a cascading chain of events that restores system function.

Conifer interplantings

Due to its rapid rate of decay, alder is not a key source of large woody debris and its primary role is in supplementing more long-lived key wood components in the stream channel of the coniferous origin. Conifer interplanting within the alder dominated riparian results in the long-term availability of a persistent wood resource. It will reestablish the natural process of large wood recruitment over time that sustains the processes that depend on wood for capturing gravels, storing hyporheic flows and facilitating high frequency floodplain interaction during winter flow regimes.

Appendix 1

Mosby Creek Limiting Factors Analysis Study Area 2013

Figure 1

BioSurveys LLC
Map prepared by Karen Fleck Harding

Appendix 1

Mosby Creek Subbasin
Land Ownership
May 2014

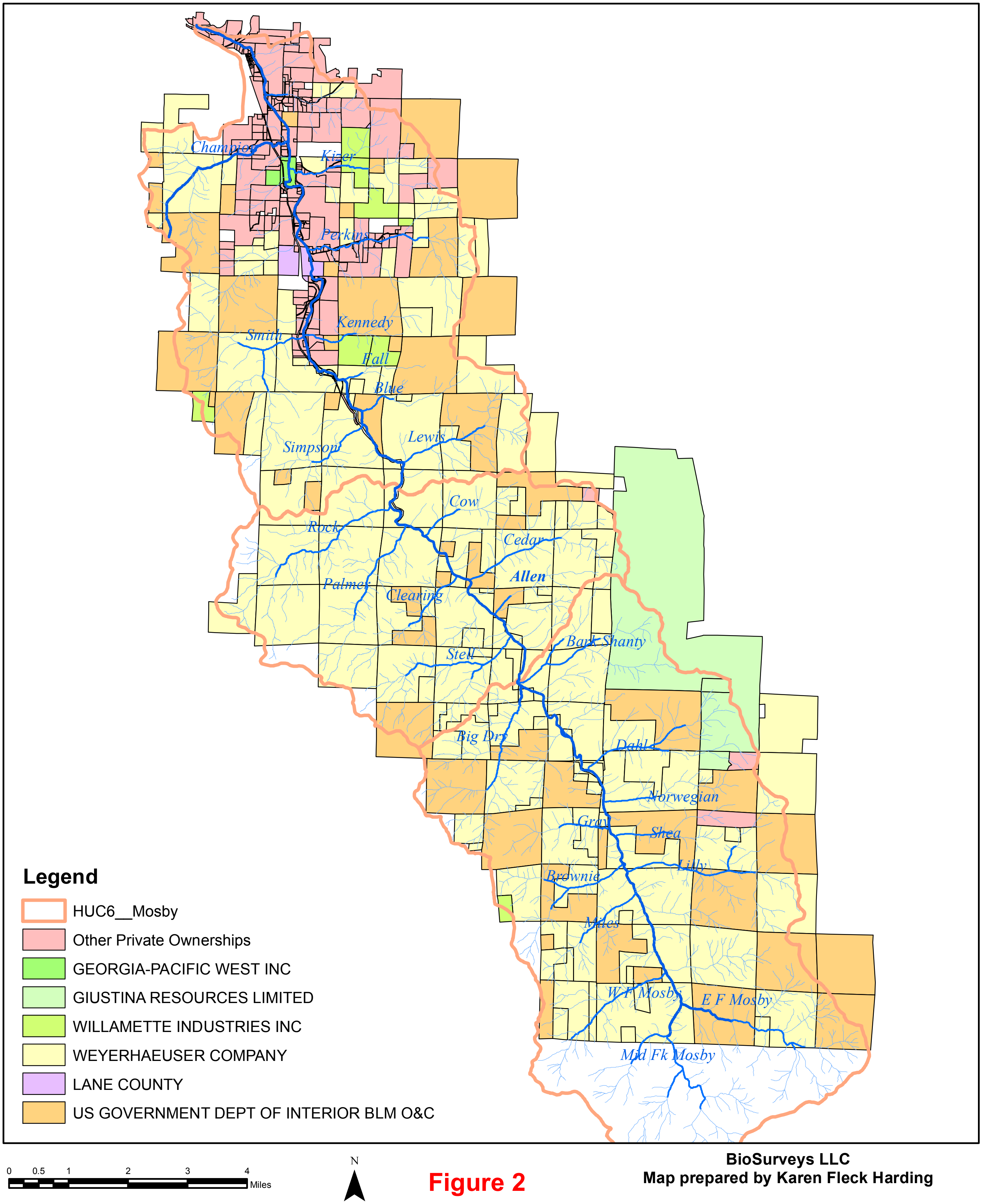


Figure 2

BioSurveys LLC
Map prepared by Karen Fleck Harding

Appendix 1

Source: A geological framework for interpreting the low-flow regimes of Cascade streams, Willamette River Basin, Oregon Christina Tague Gordon E. G,ant

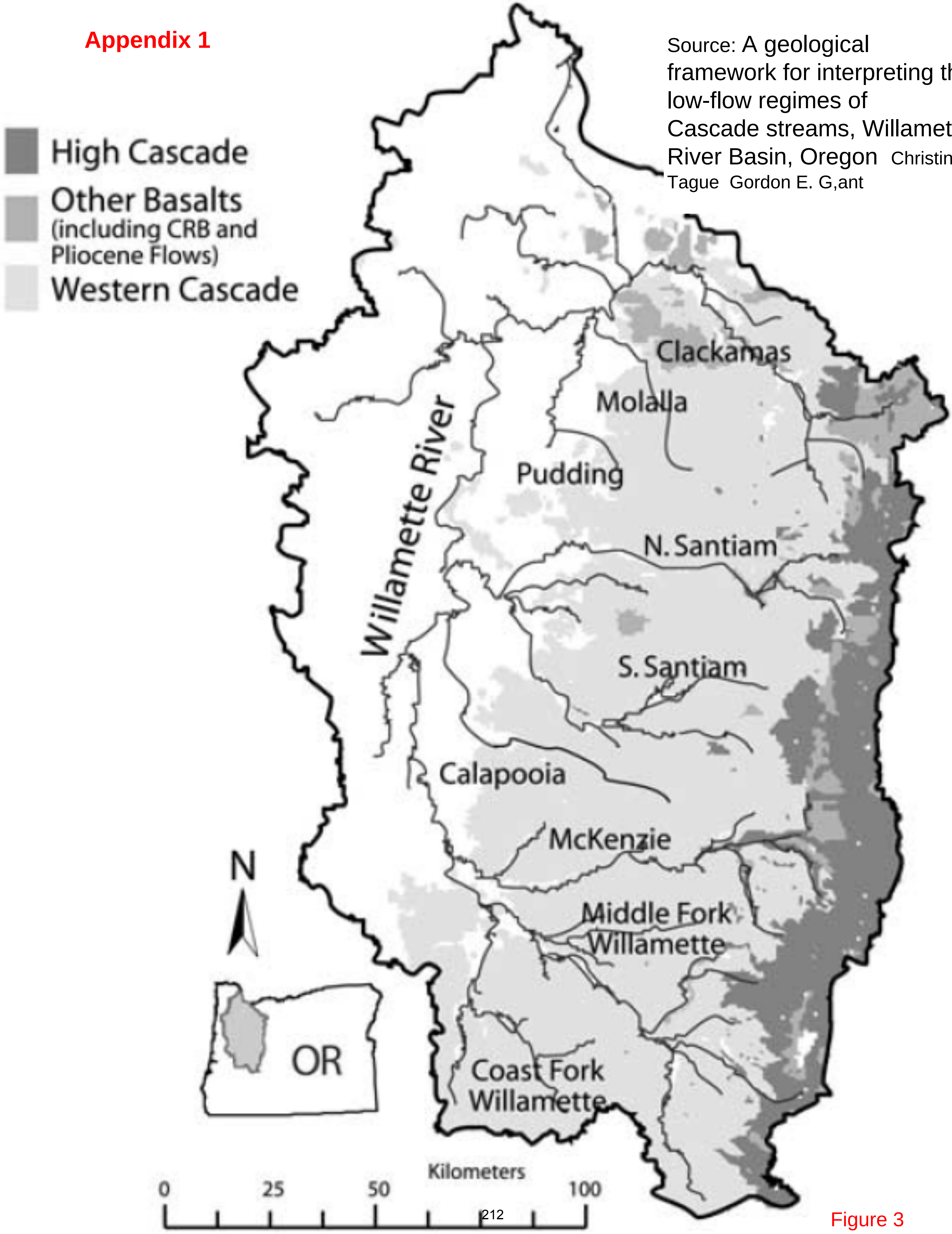
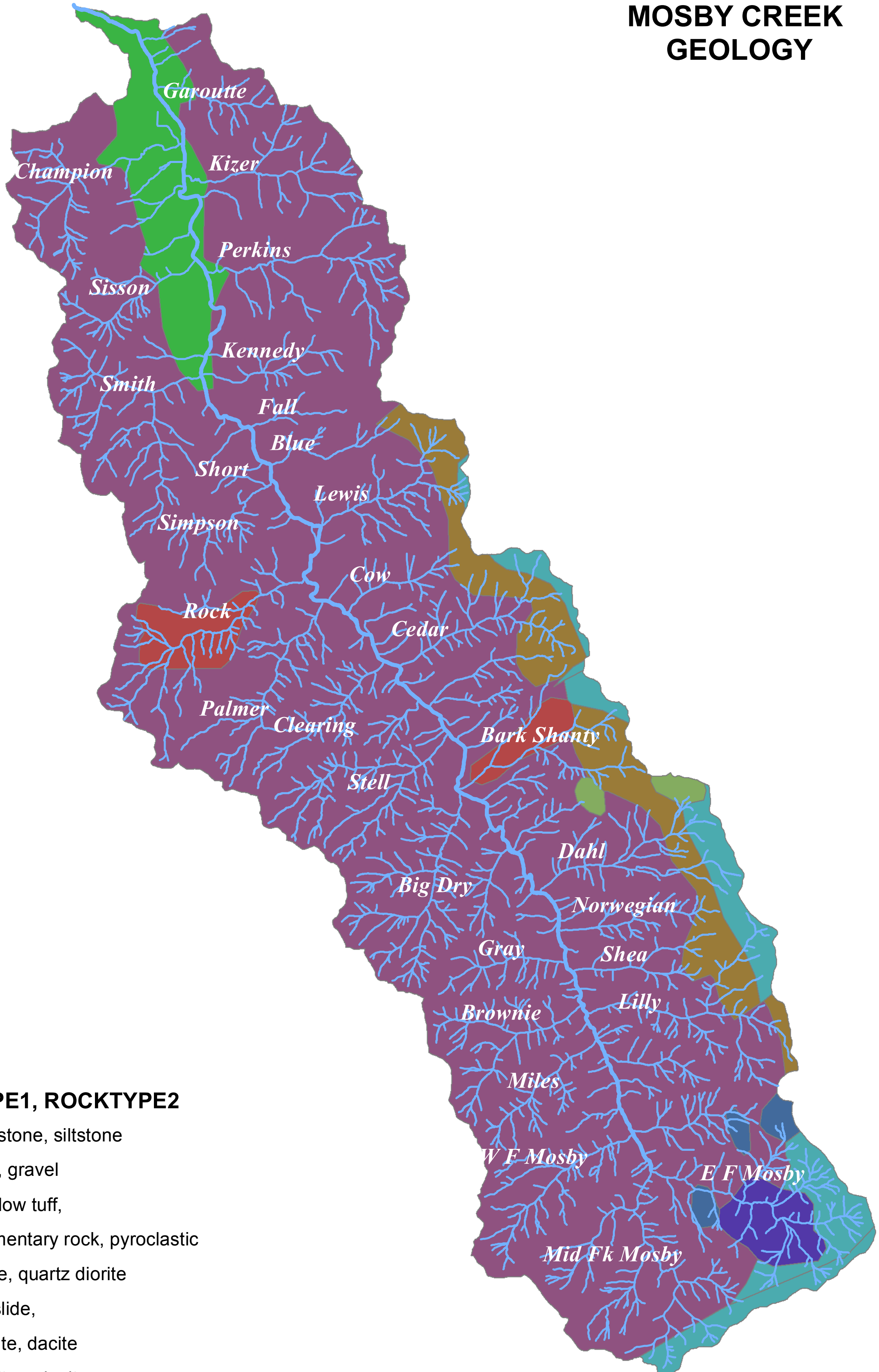


Figure 3

Appendix 1

MOSBY CREEK GEOLOGY



Legend

ROCKTYPE1, ROCKTYPE2

- sandstone, siltstone
- sand, gravel
- ash-flow tuff,
- sedimentary rock, pyroclastic
- diorite, quartz diorite
- landslide,
- rhyolite, dacite
- basalt, andesite

Source: US Geological Survey

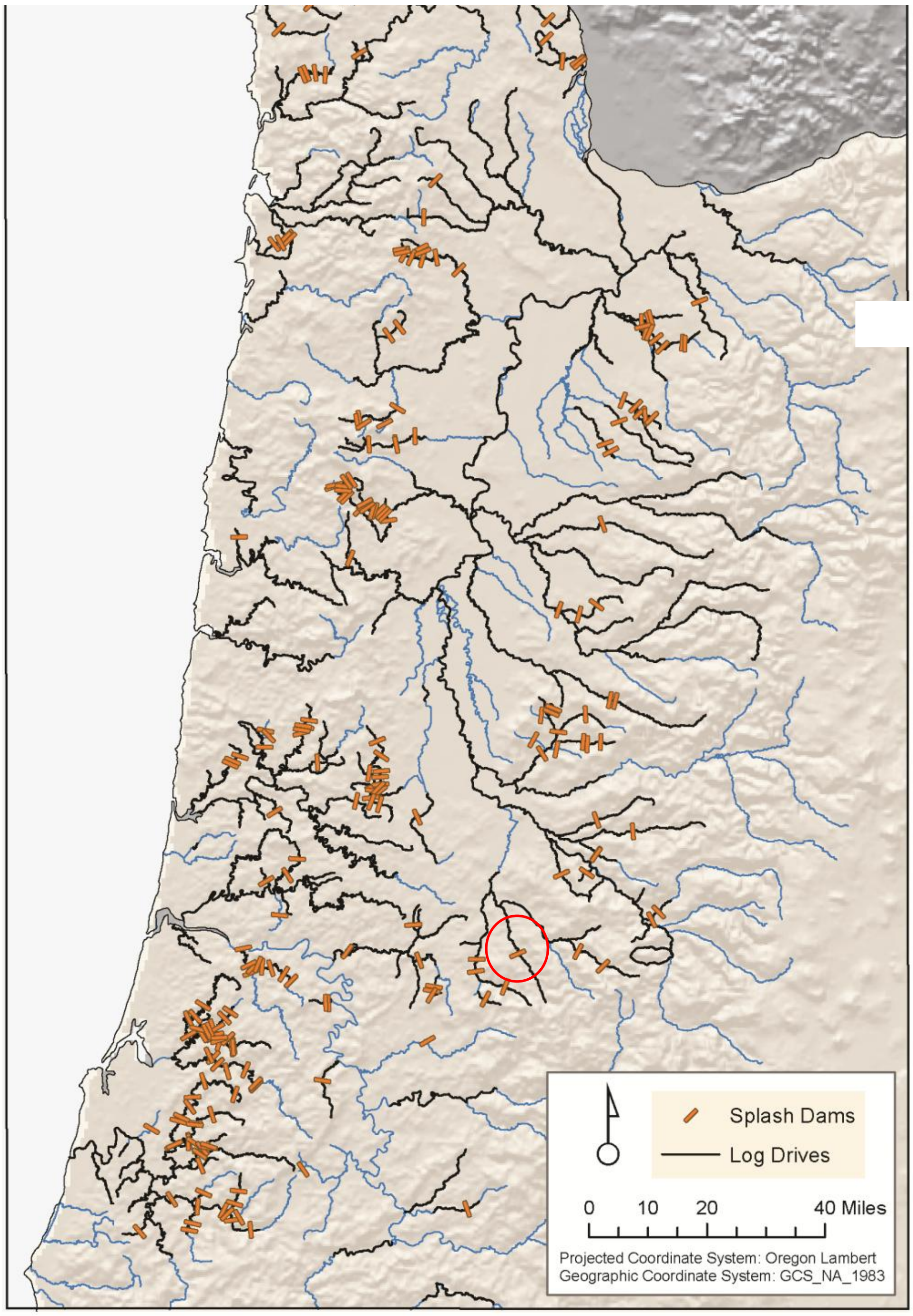
Figure 4

0 0.75 1.5 3 4.5 6 Miles

N

BioSurveys LLC
Map prepared by Karen Fleck Harding

Excerpt from: ***"Is the Past Present? Historical Splash-dam Mapping and Stream Disturbance Detection in the Oregon Coastal Province"*** by Rebecca R. Miller.
A thesis submitted to Oregon State University in partial fulfillment of the requirements for the degree of Master of Science. Presented September 23, 2010.



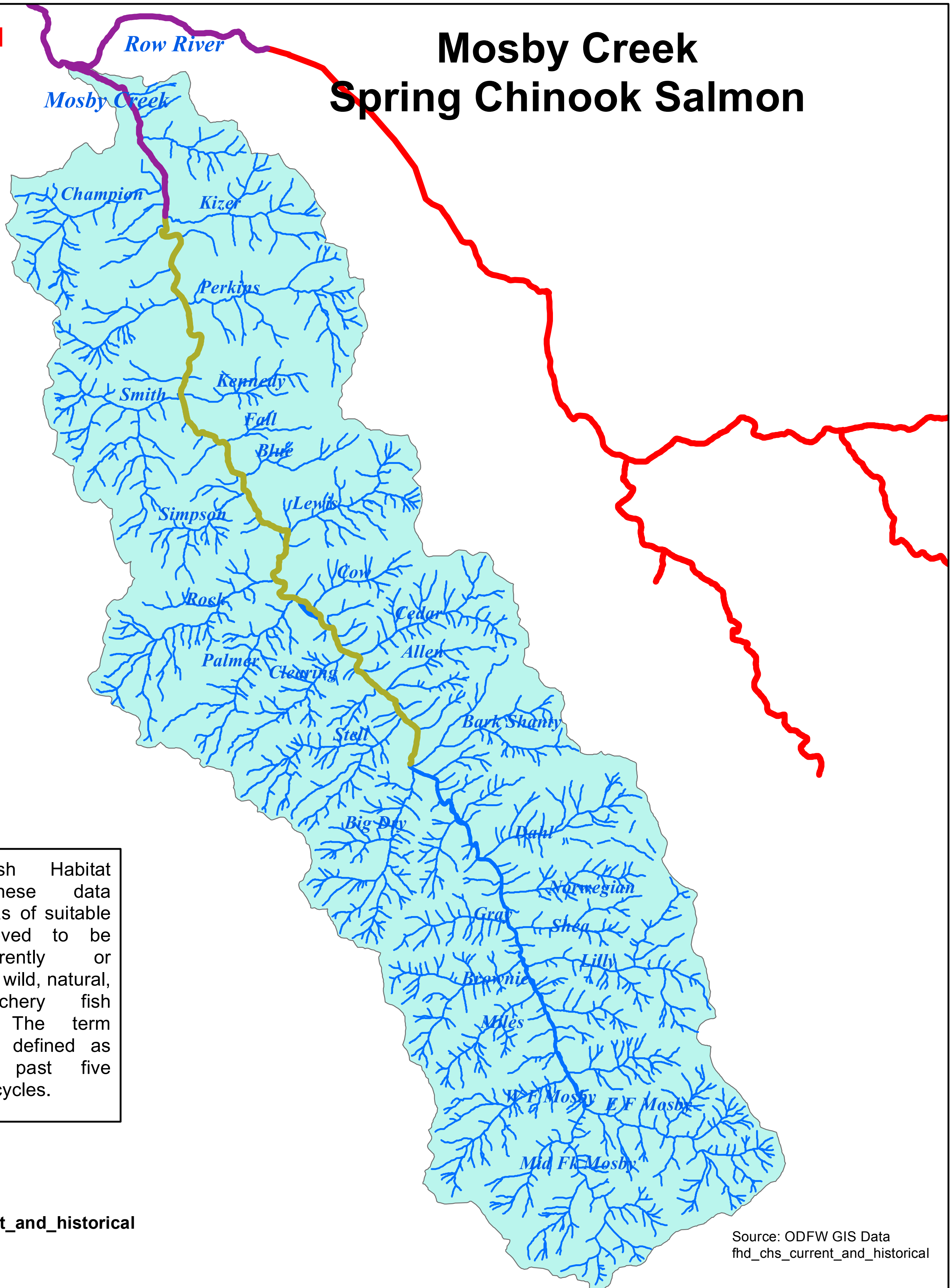
Notation added. Mosby Cr splash dam site.

Figure 2.6. Splash dams and log drives located within western Oregon identified through archive searches and local meetings.

Figure 5

Appendix 1

Mosby Creek Spring Chinook Salmon



Oregon Fish Habitat Distribution.These data describe areas of suitable habitat believed to be used currently or historically by wild, natural, and/or hatchery fish populations. The term "currently" is defined as within the past five reproductive cycles.

Legend

fhd_chs_current_and_historical

fhdUseTy

- Historical
- Rearing- Juveniles migrate up from mainstem Willamette R
- Spawning

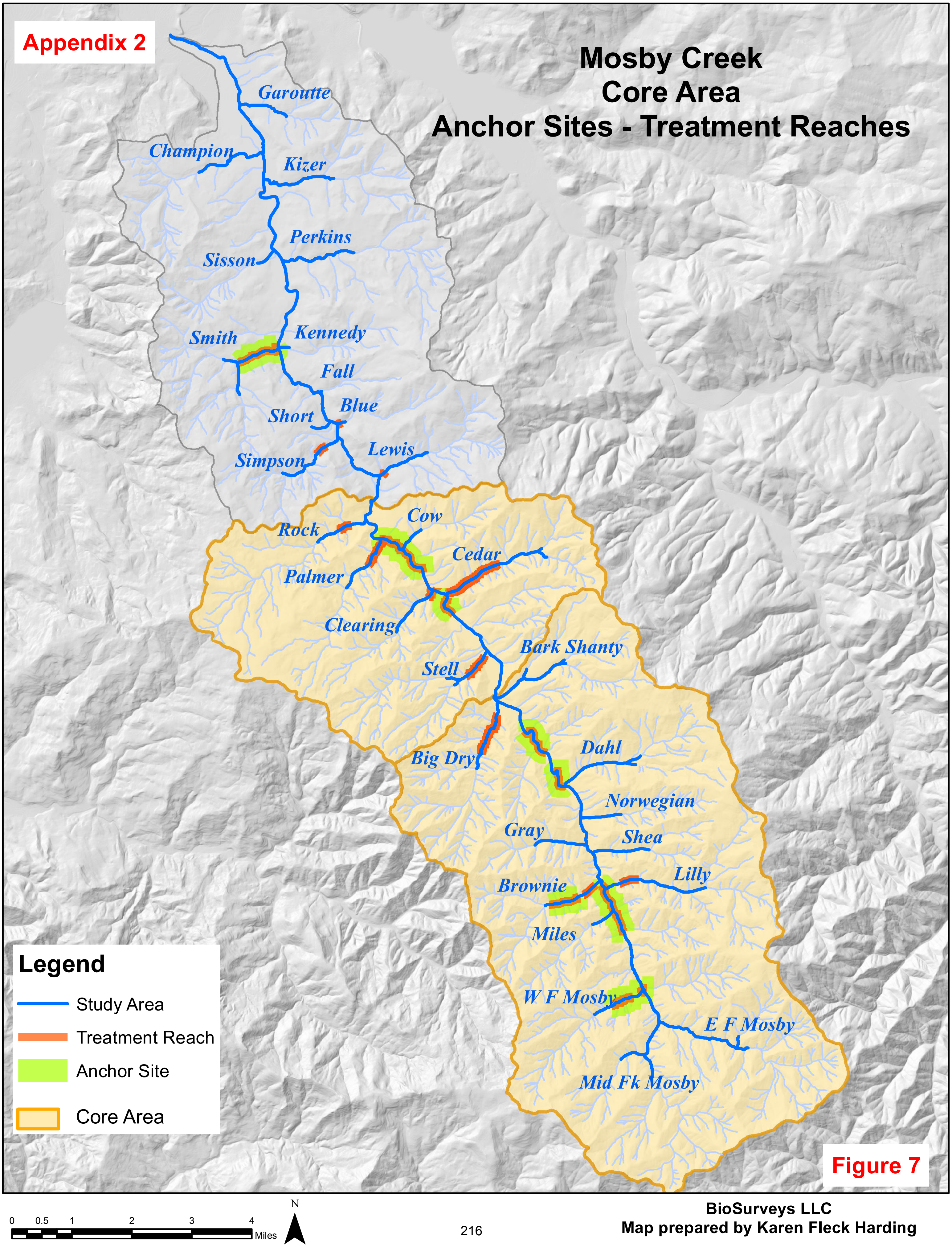
Source: ODFW GIS Data
fhd_chs_current_and_historical

Figure 6

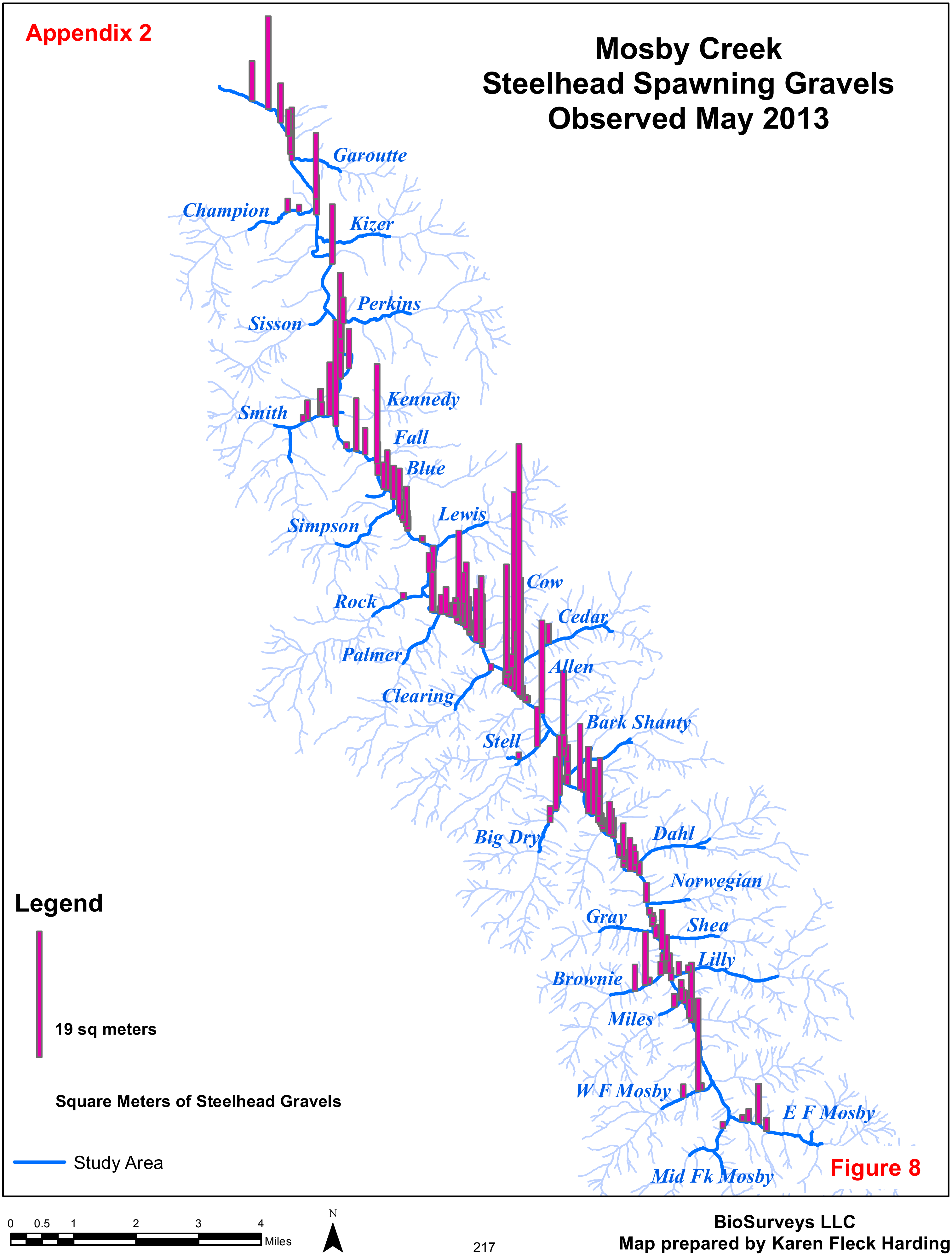
0 0.75 1.5 3 4.5 6 Miles

N

BioSurveys LLC
Map prepared by Karen Fleck Harding



BioSurveys LLC
Map prepared by Karen Fleck Harding



BioSurveys LLC
Map prepared by Karen Fleck Harding

Appendix 2

Steelhead Spawning Gravels Summary

Gravel Count *	Mainstem	Tribs	Total
Rock Cr and upstream (Core Area)	382	105	487
Downstream of Rock Cr	202	25	227
Total	**584**	**130**	**714**

Steelhead Spawning Gravel by Stream

	Gravel Count *
Bark Shanty	2
Brownie	18
Cedar	11
Champion	3
Clearing	1
Dahl	2
Dry	21
East Fk Mosby	13
Lilly	3
Mid Fk Mosby	1
Miles	4
Mosby mainstem	584
No Fk Stell	1
Palmer	4
Perkins	4
Rock	1
Smith	18
Stell	6
W Fk Mosby	17
Total	**714**

* **Gravel Count:** A gravel count (GC) = a minimum of 1sqm of the appropriate sized gravel for steelhead or coho located where large anadromous salmonids would choose to spawn.

Figure 9

Appendix 2

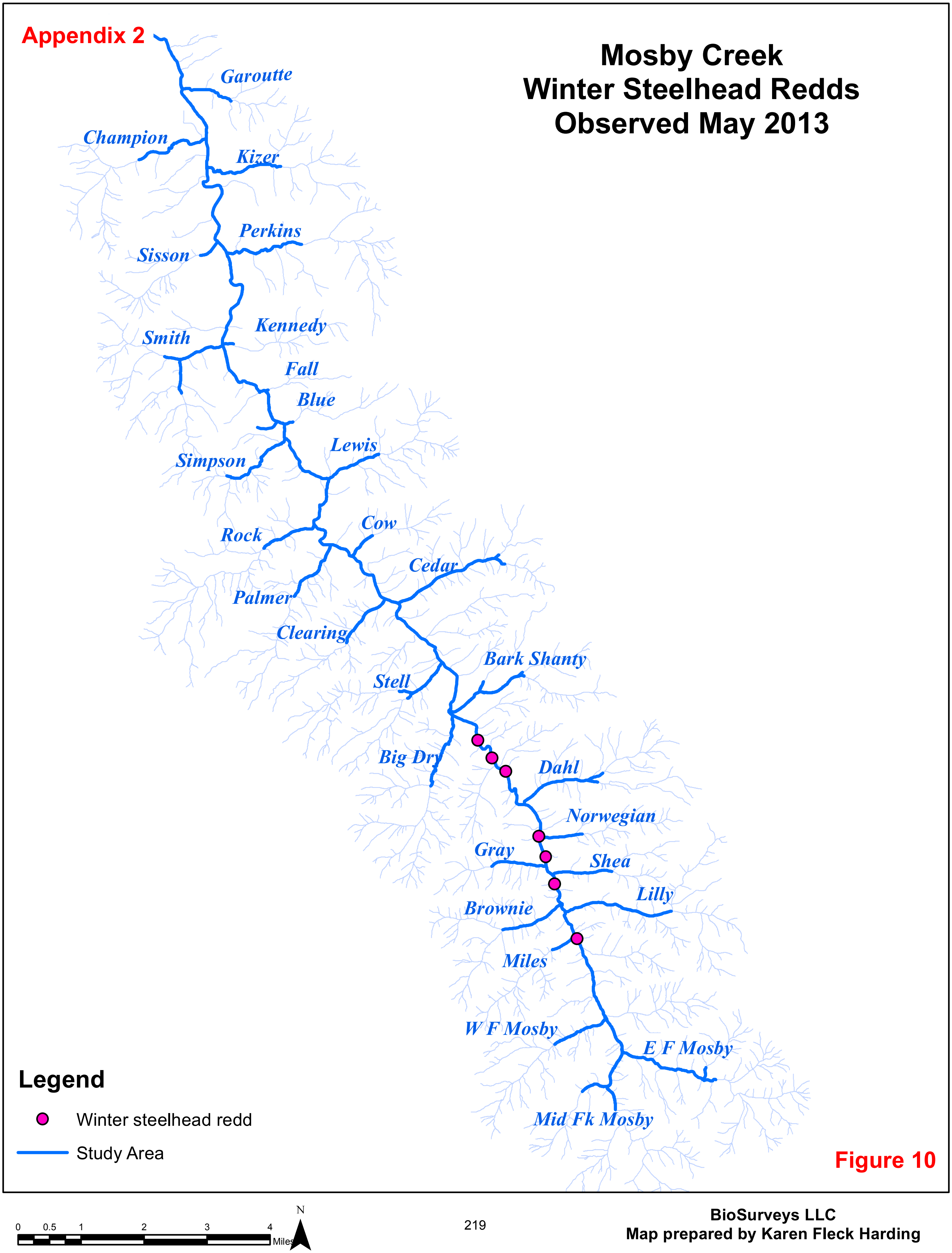


Figure 10

BioSurveys LLC
Map prepared by Karen Fleck Harding

Appendix 2

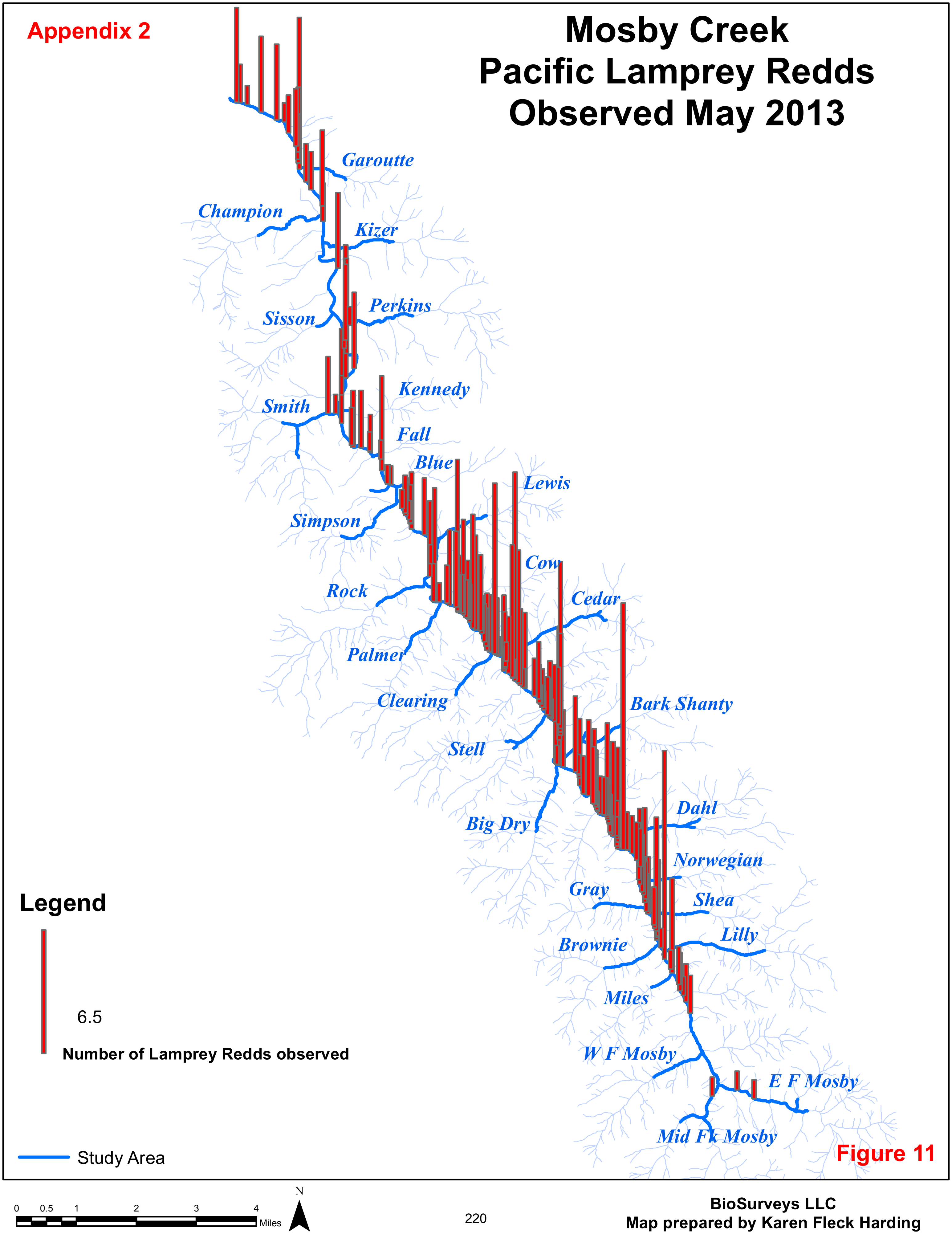
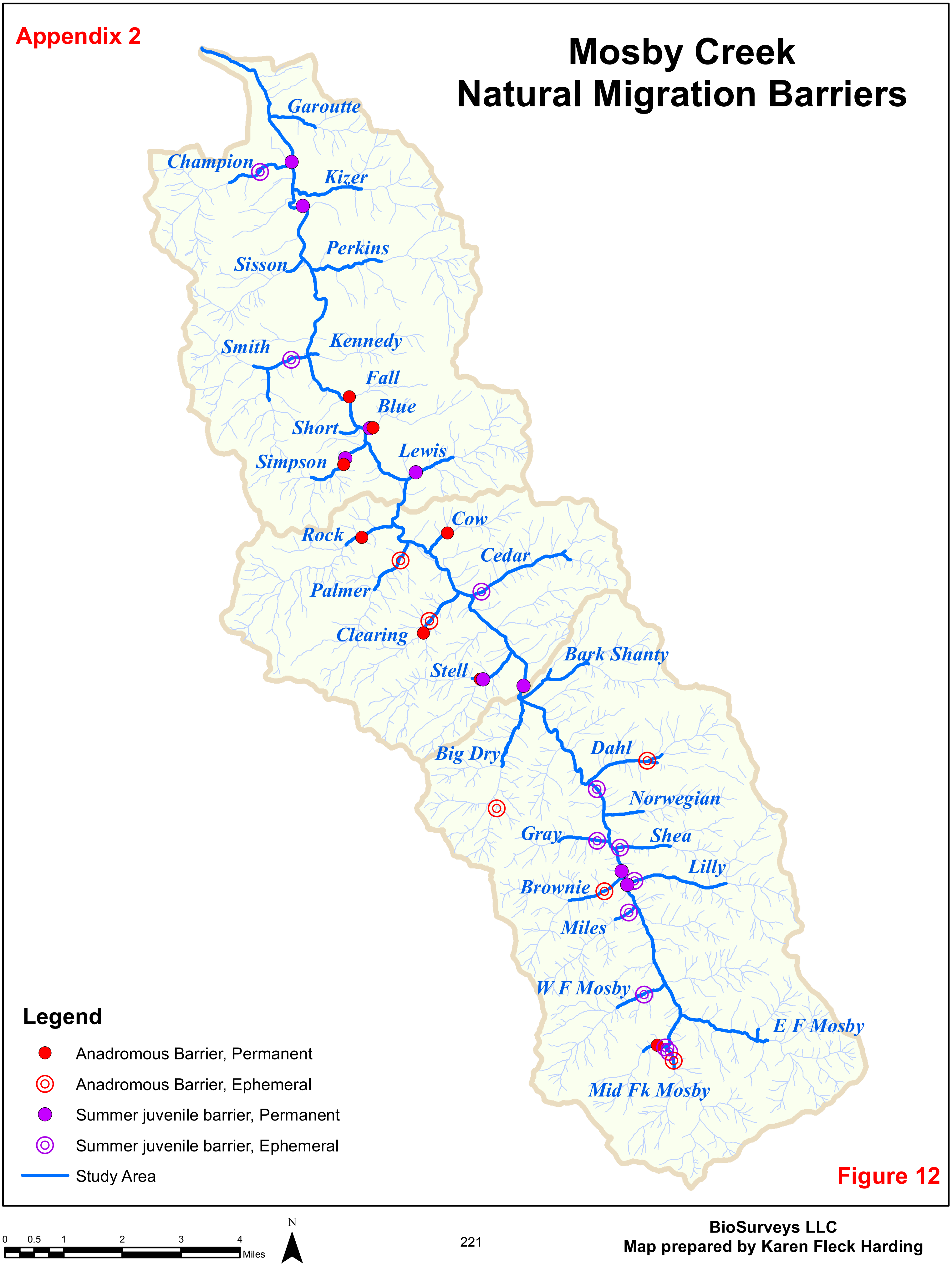
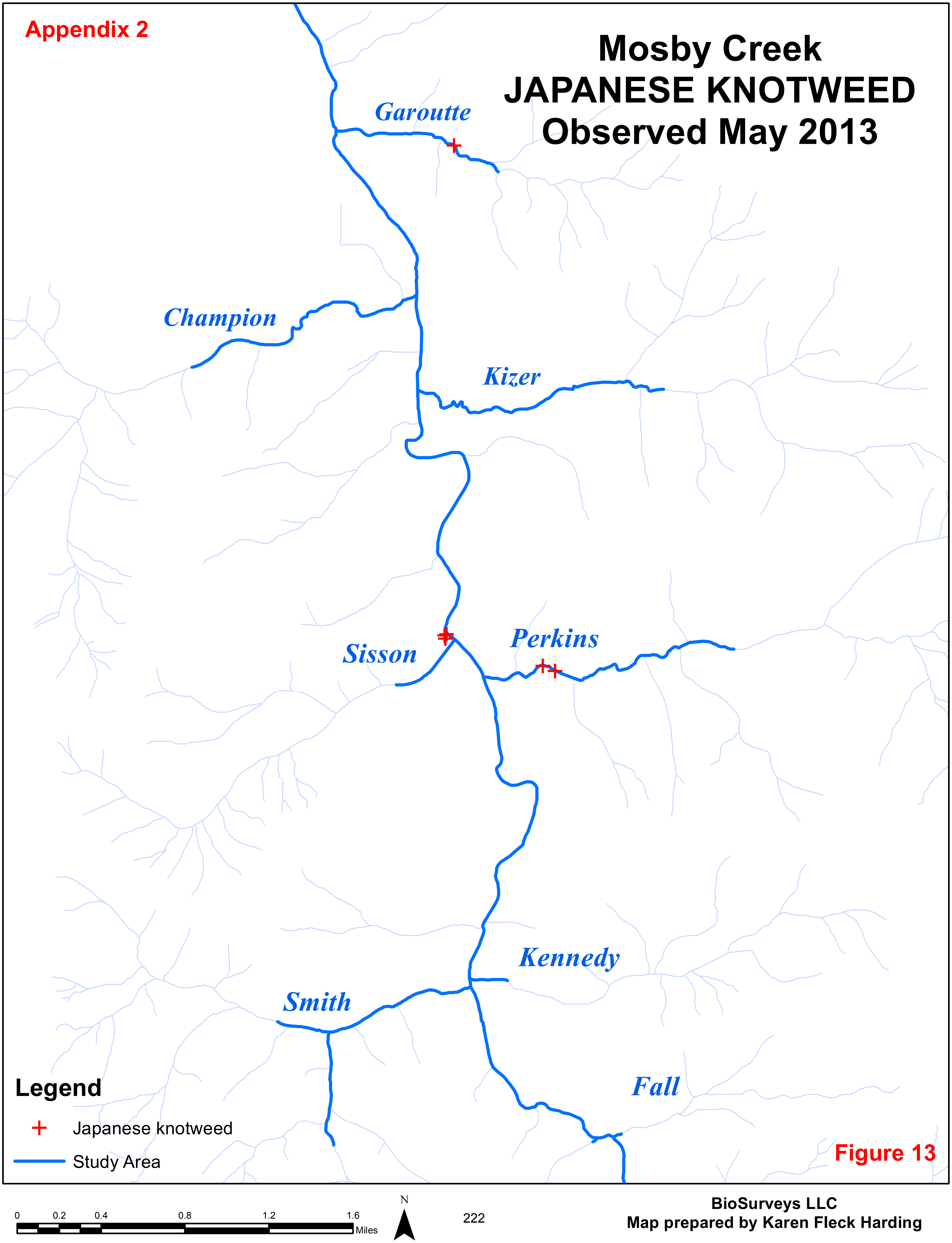


Figure 11

BioSurveys LLC
Map prepared by Karen Fleck Harding


Appendix 2
Mosby Creek
Natural Migration Barriers
Garoutte
Champion
Kizer
Perkins
Sisson
Smith
Kennedy
Fall
Blue
Short
Simpson
Lewis
Cow
Rock
Cedar
Palmer
Clearing
Bark Shanty
Stell
Big Dry
Dahl
Norwegian
Gray
Shea
Lilly
Brownie
Miles
W F Mosby
E F Mosby
Mid Fk Mosby
Legend
Anadromous Barrier, Permanent
Anadromous Barrier, Ephemeral
Summer juvenile barrier, Permanent
Summer juvenile barrier, Ephemeral
Study Area
Figure 12
0 0.5 1 2 3 4 Miles
N
BioSurveys LLC
Map prepared by Karen Fleck Harding



BioSurveys LLC
Map prepared by Karen Fleck Harding

Appendix 3

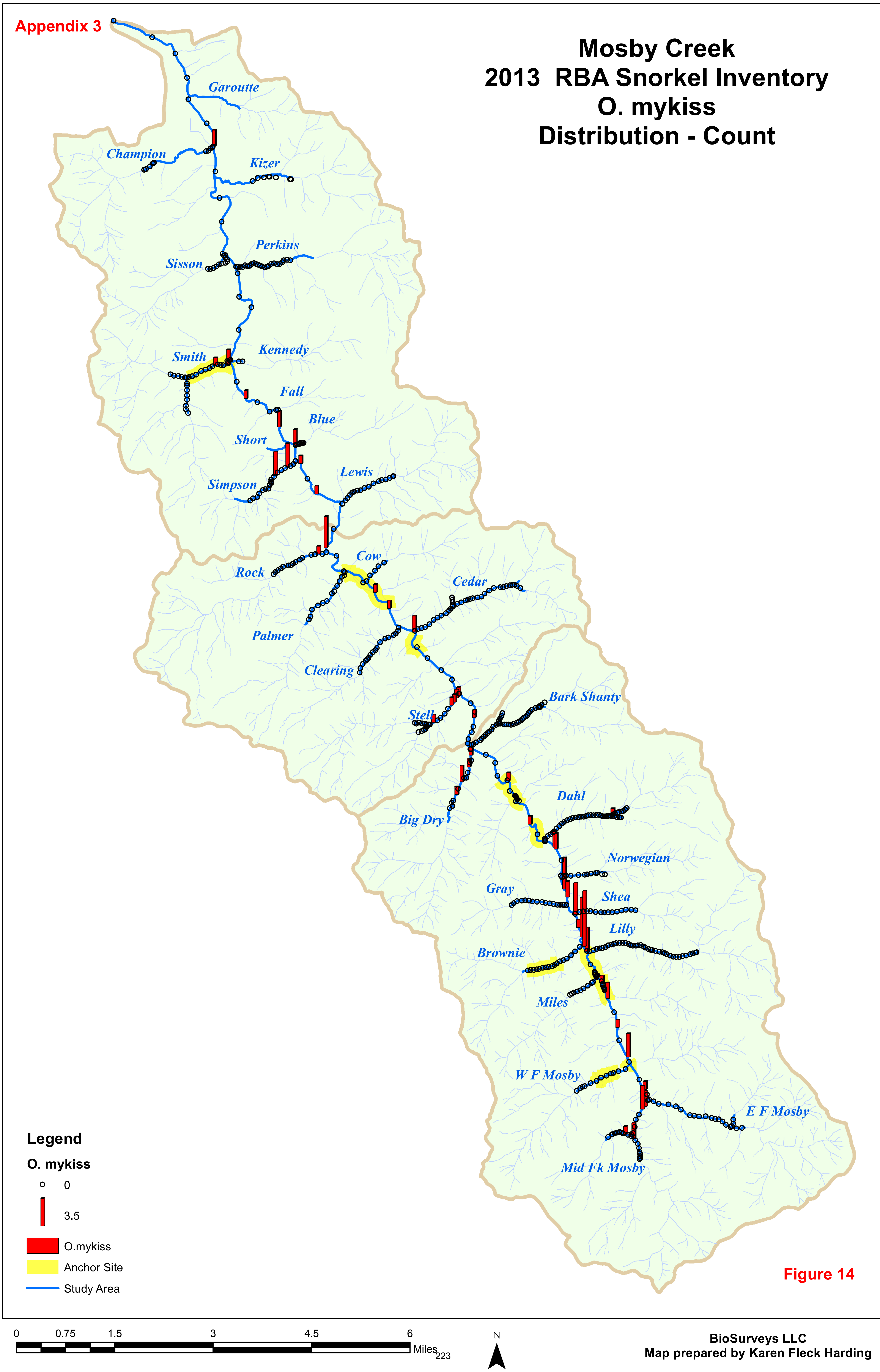


Figure 14

BioSurveys LLC
Map prepared by Karen Fleck Harding

Appendix 3

Mosby Creek 2013 RBA Snorkel Inventory 1+ and Older Cutthroat Trout Distribution - Count

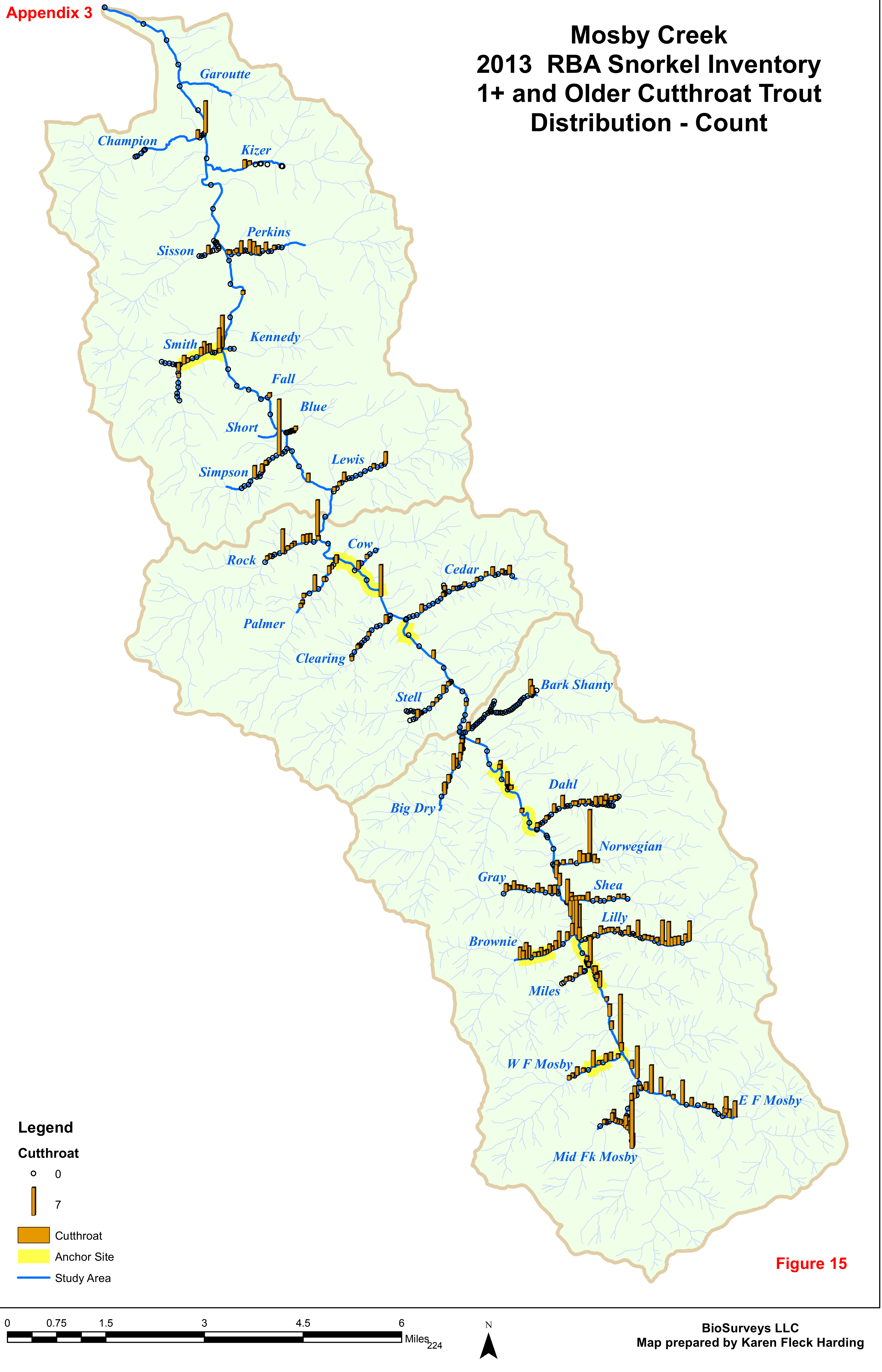


Figure 15

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Map prepared by Karen Fleck Harding

Appendix 3

Mosby Creek 2013 RBA Snorkel Inventory 0+ Juvenile Trout Distribution - Count

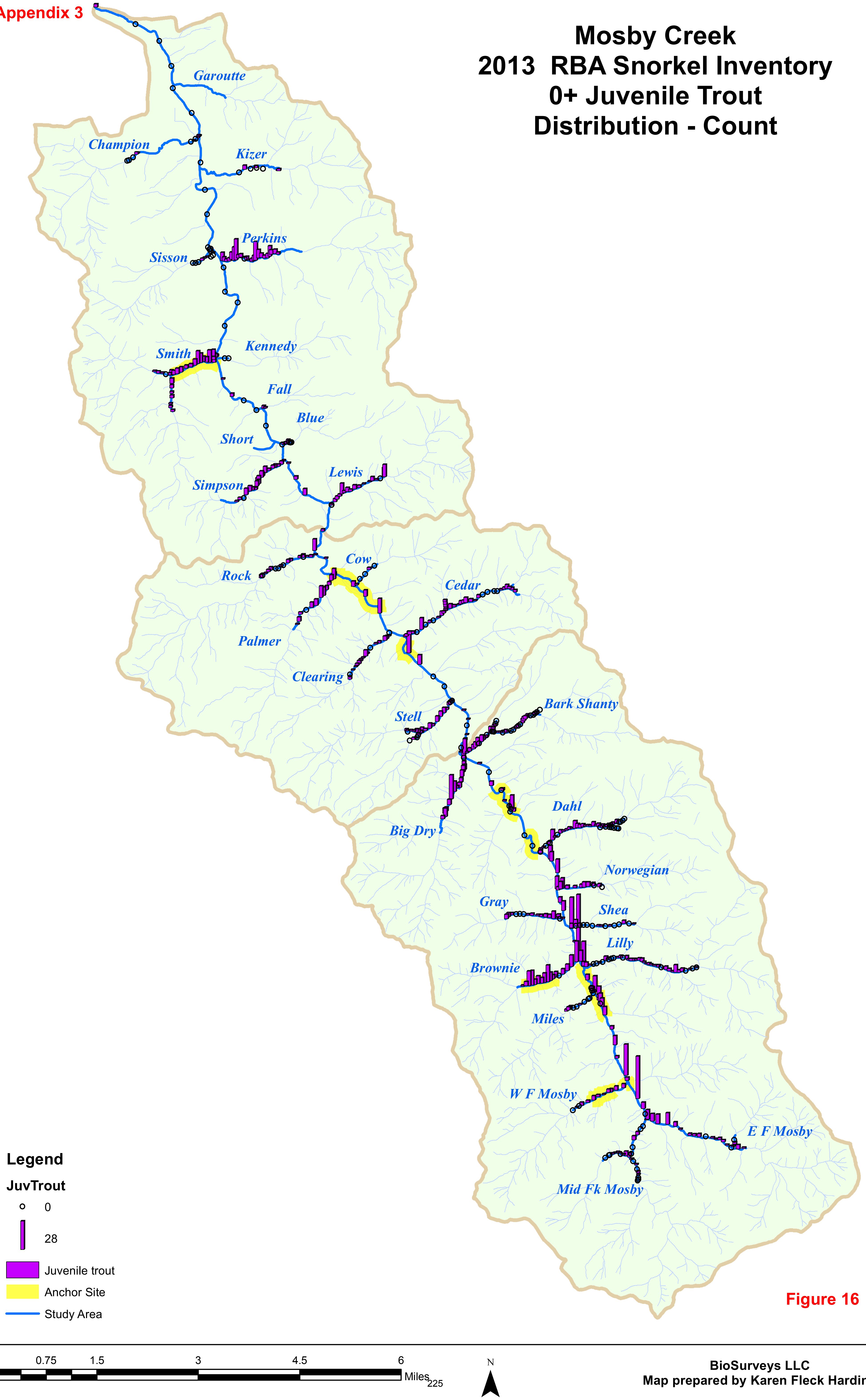

Figure 16

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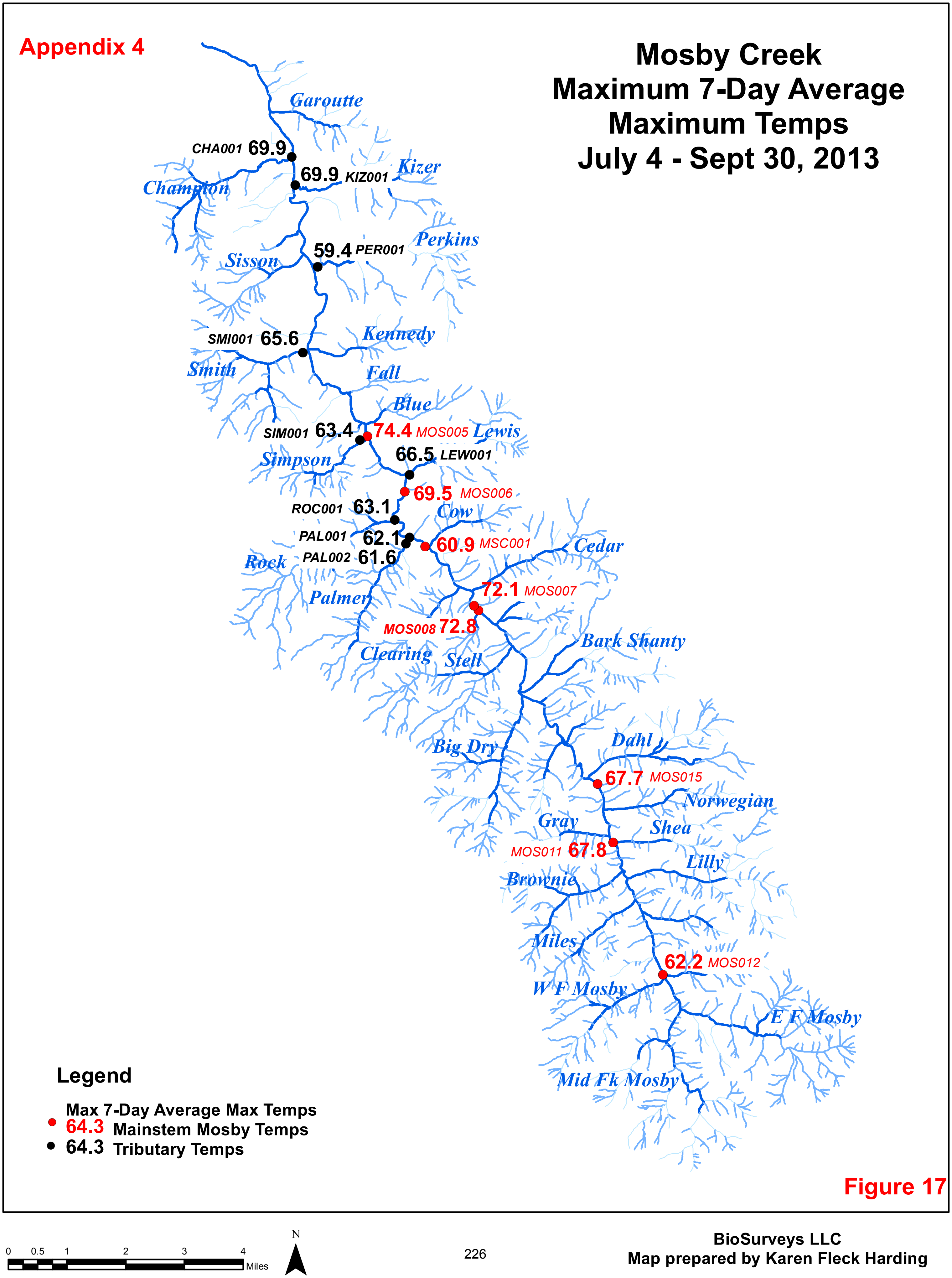
Map prepared by Karen Fleck Harding



BioSurveys LLC
Map prepared by Karen Fleck Harding

Appendix 4

Mosby Creek Maximum 7-Day Average Maximum Temps July 4 - Sept 30, 2012

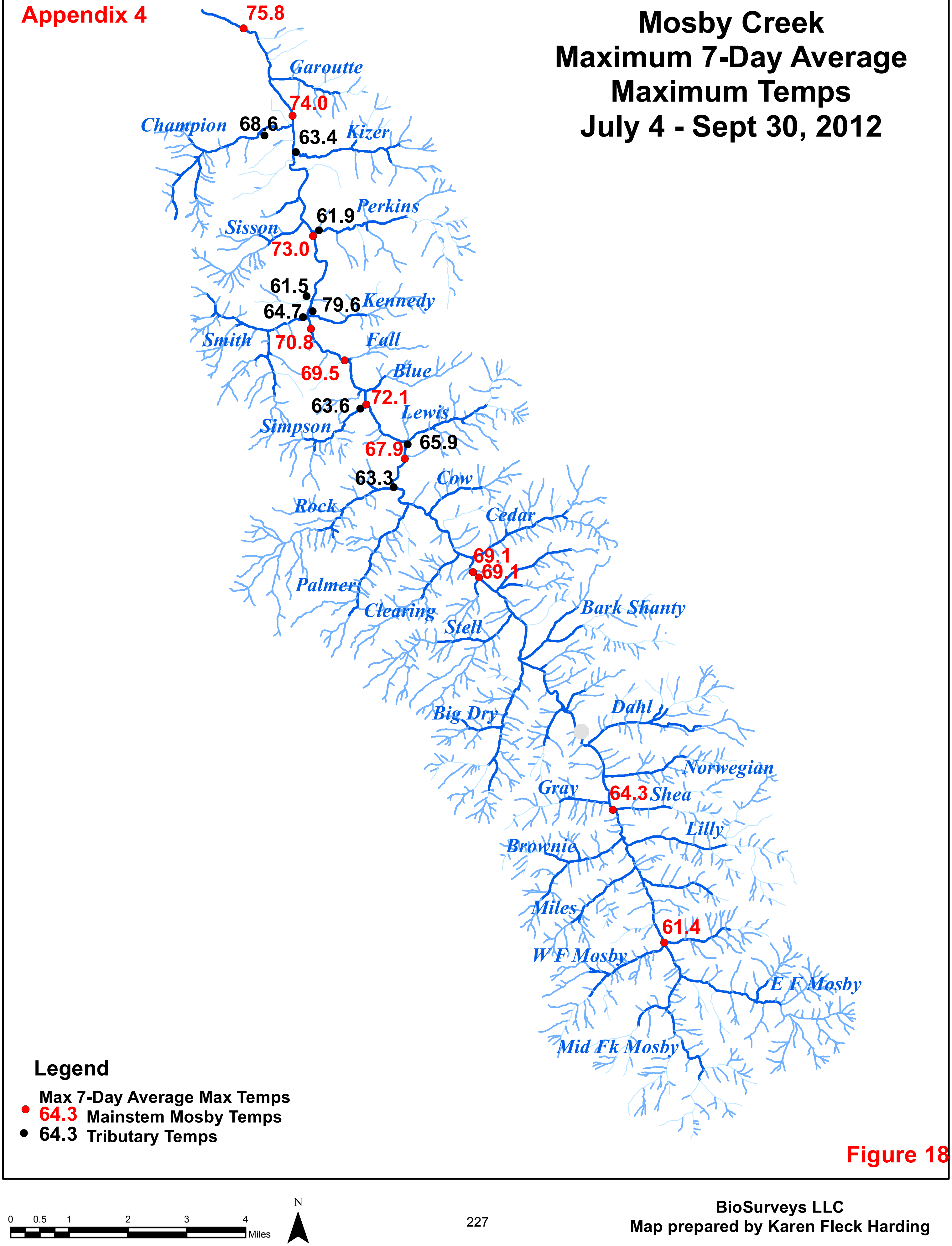


Figure 18

BioSurveys LLC
Map prepared by Karen Fleck Harding

Appendix 4

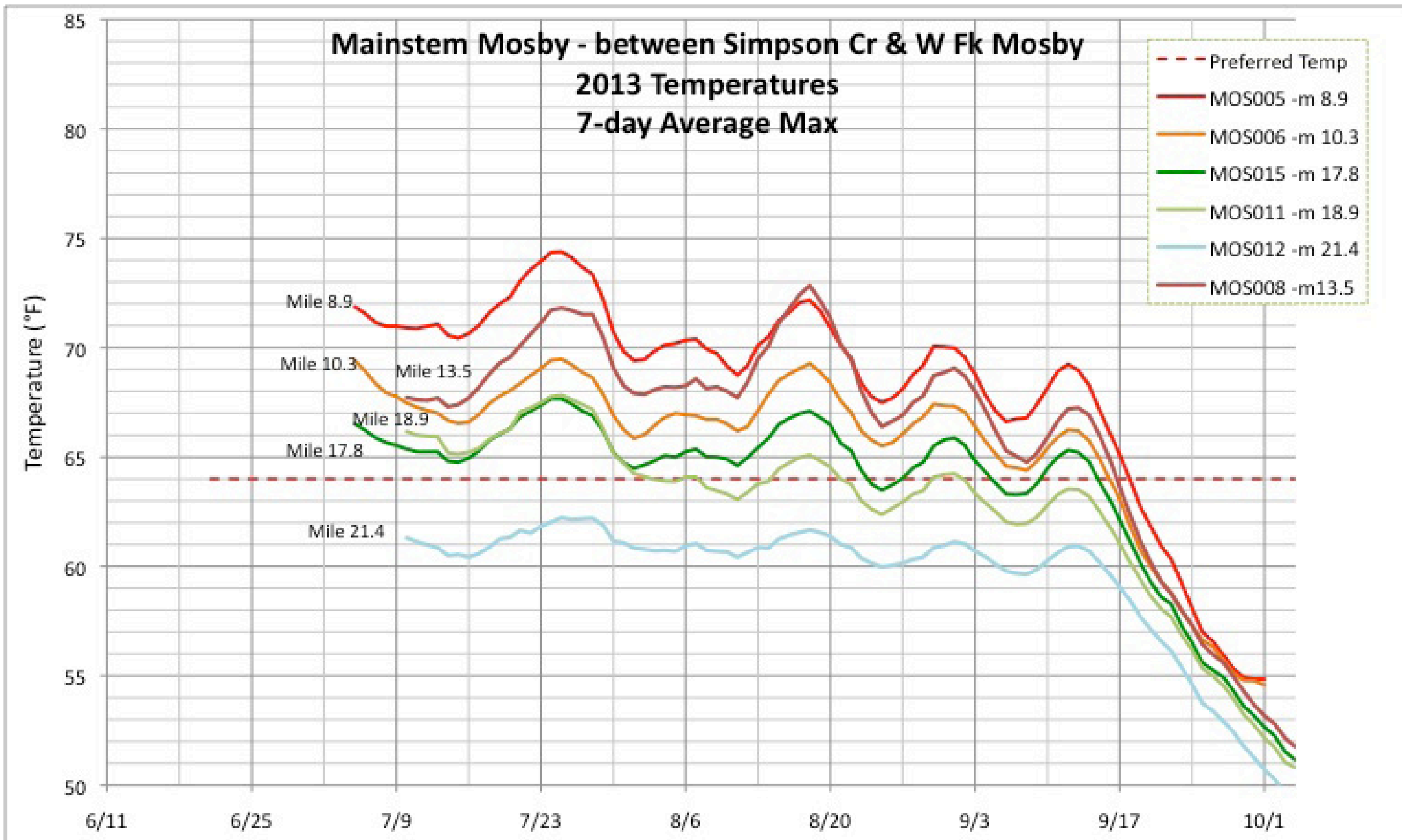


Figure 19

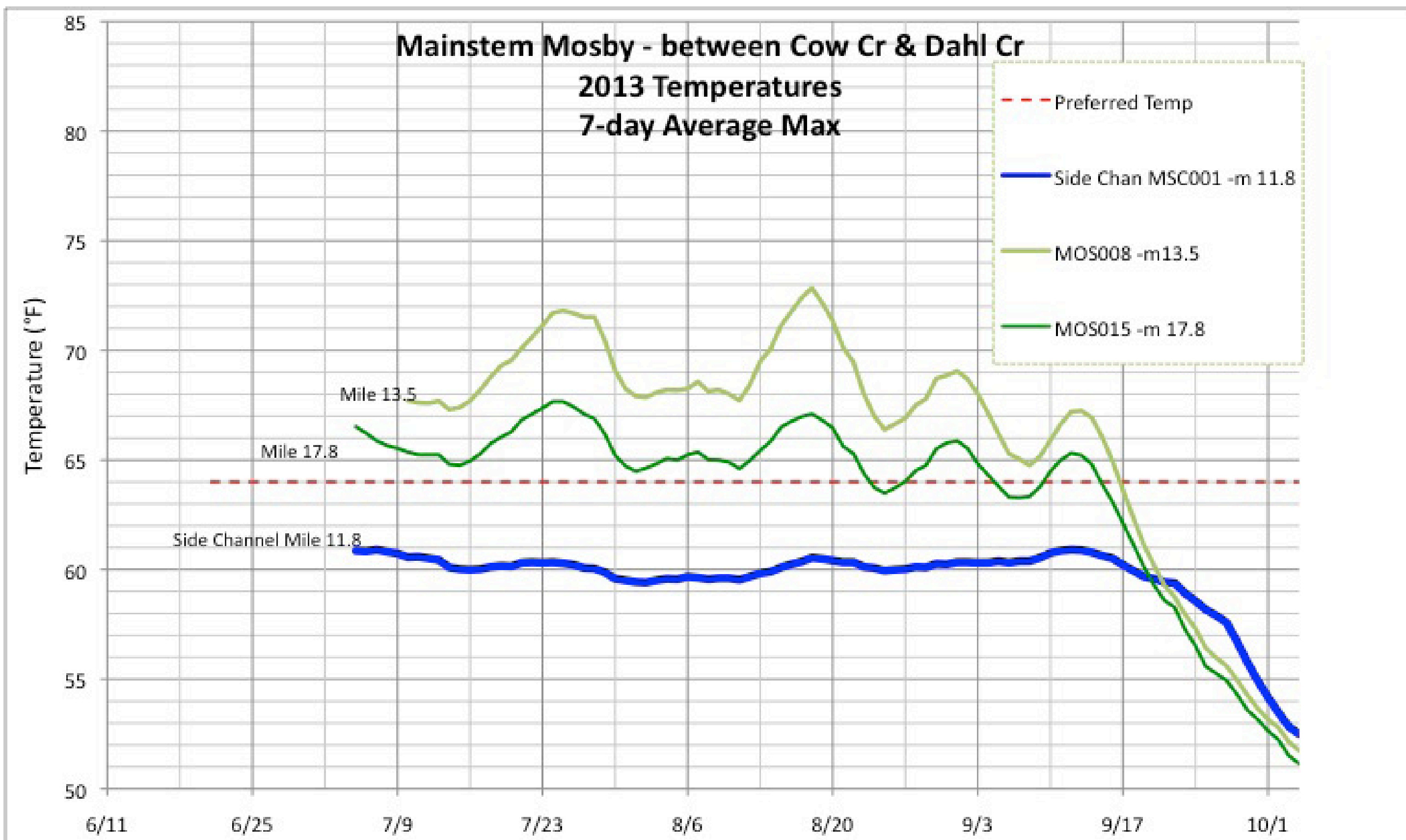


Figure 20

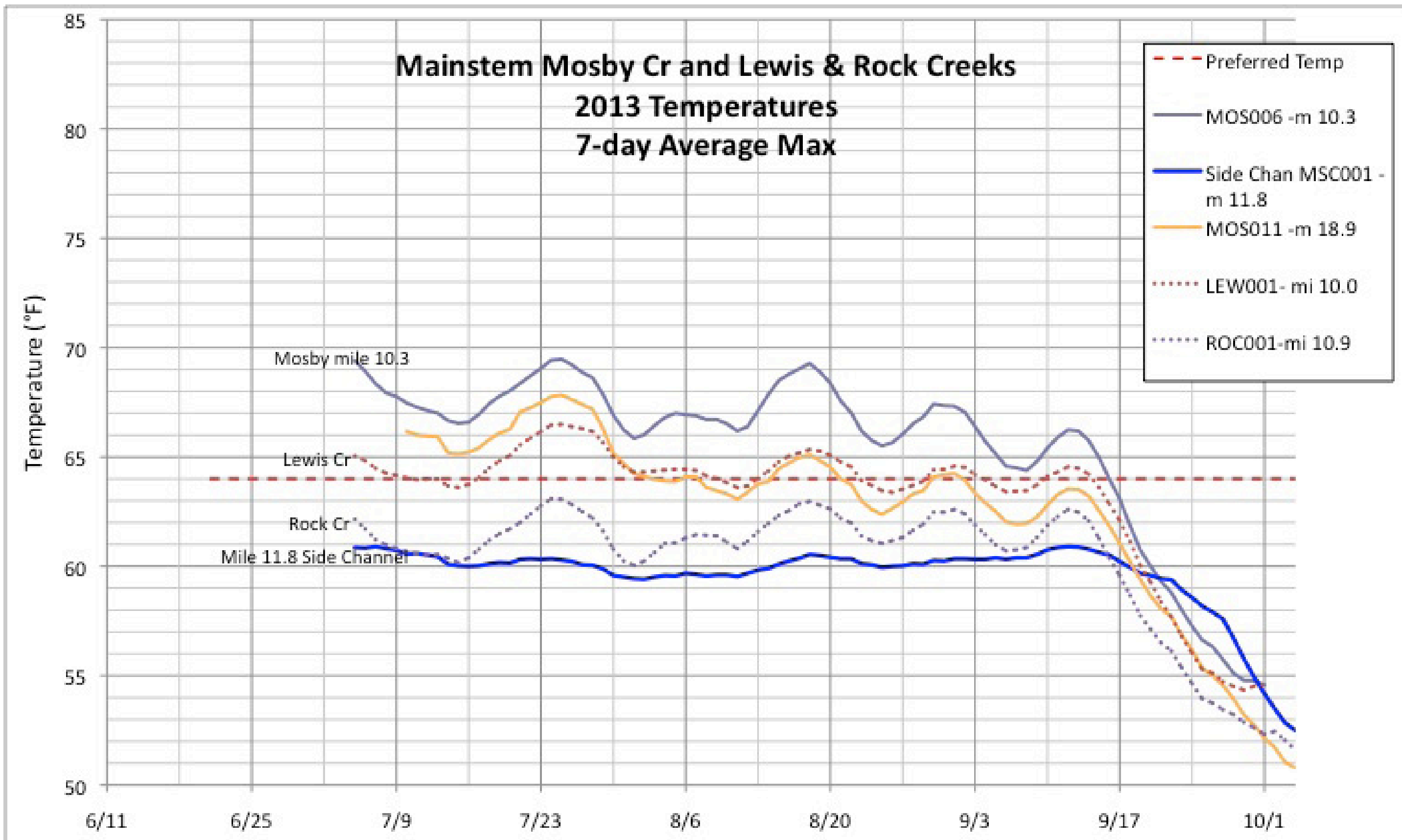


Figure 21

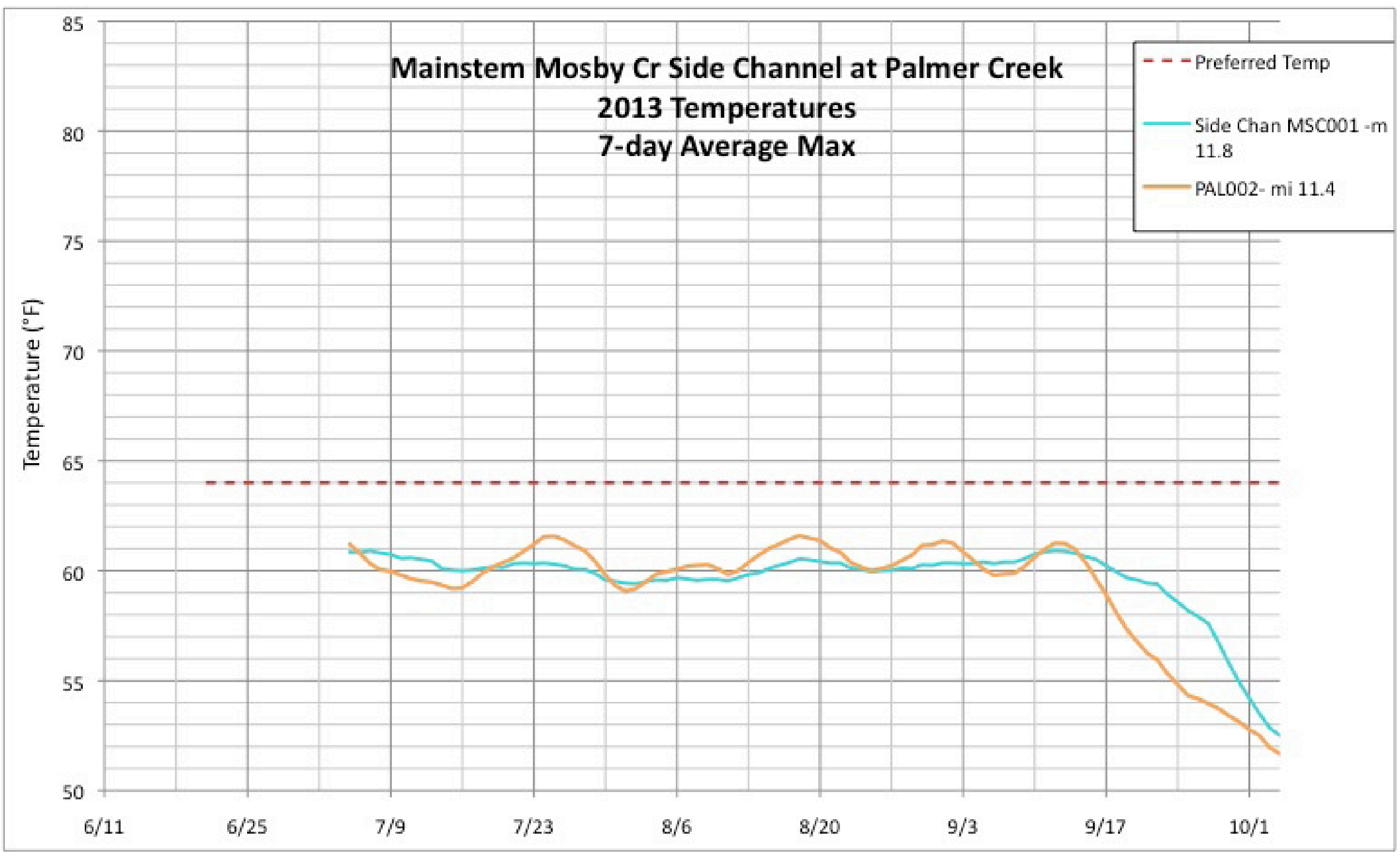


Figure 22

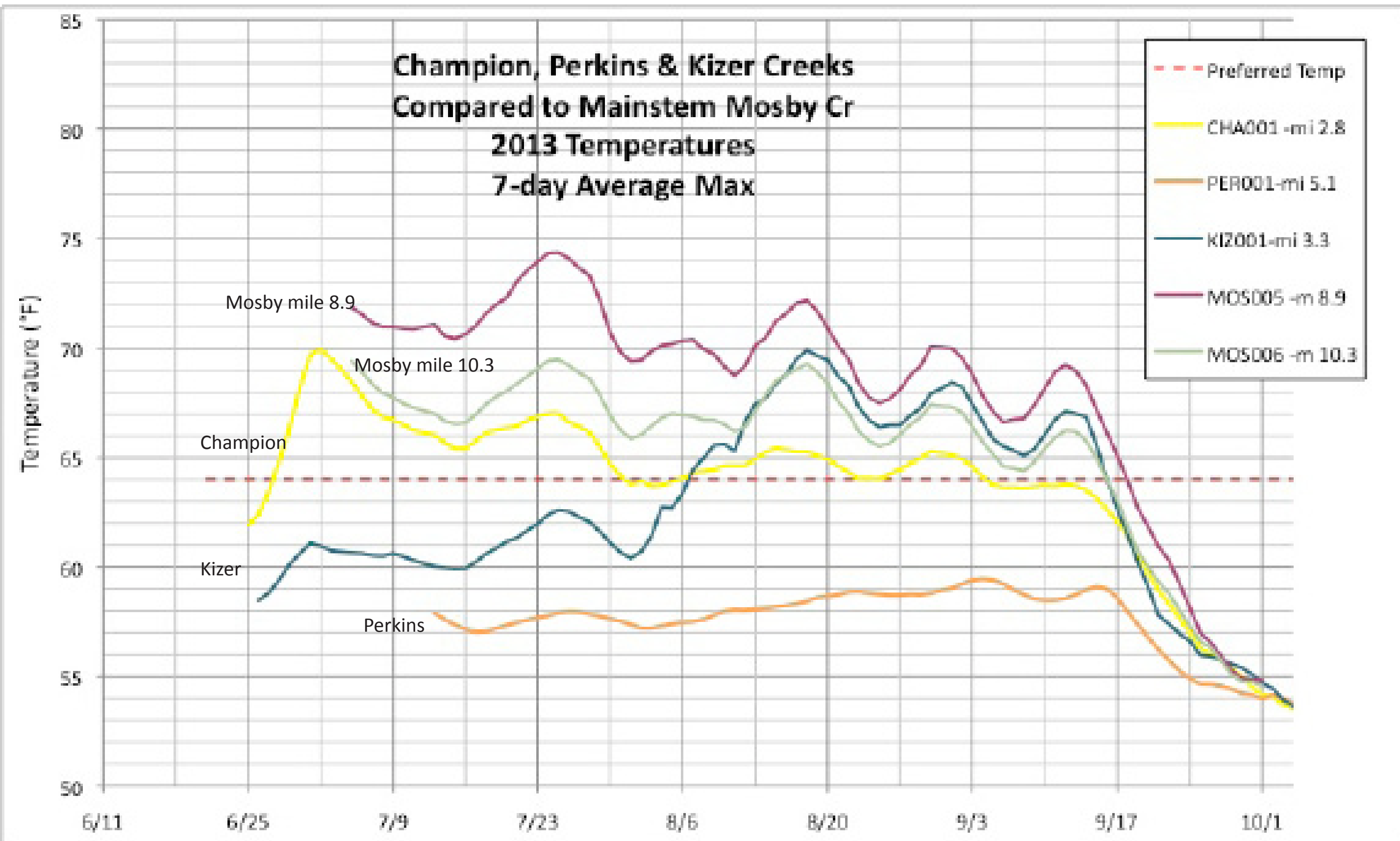


Figure 23

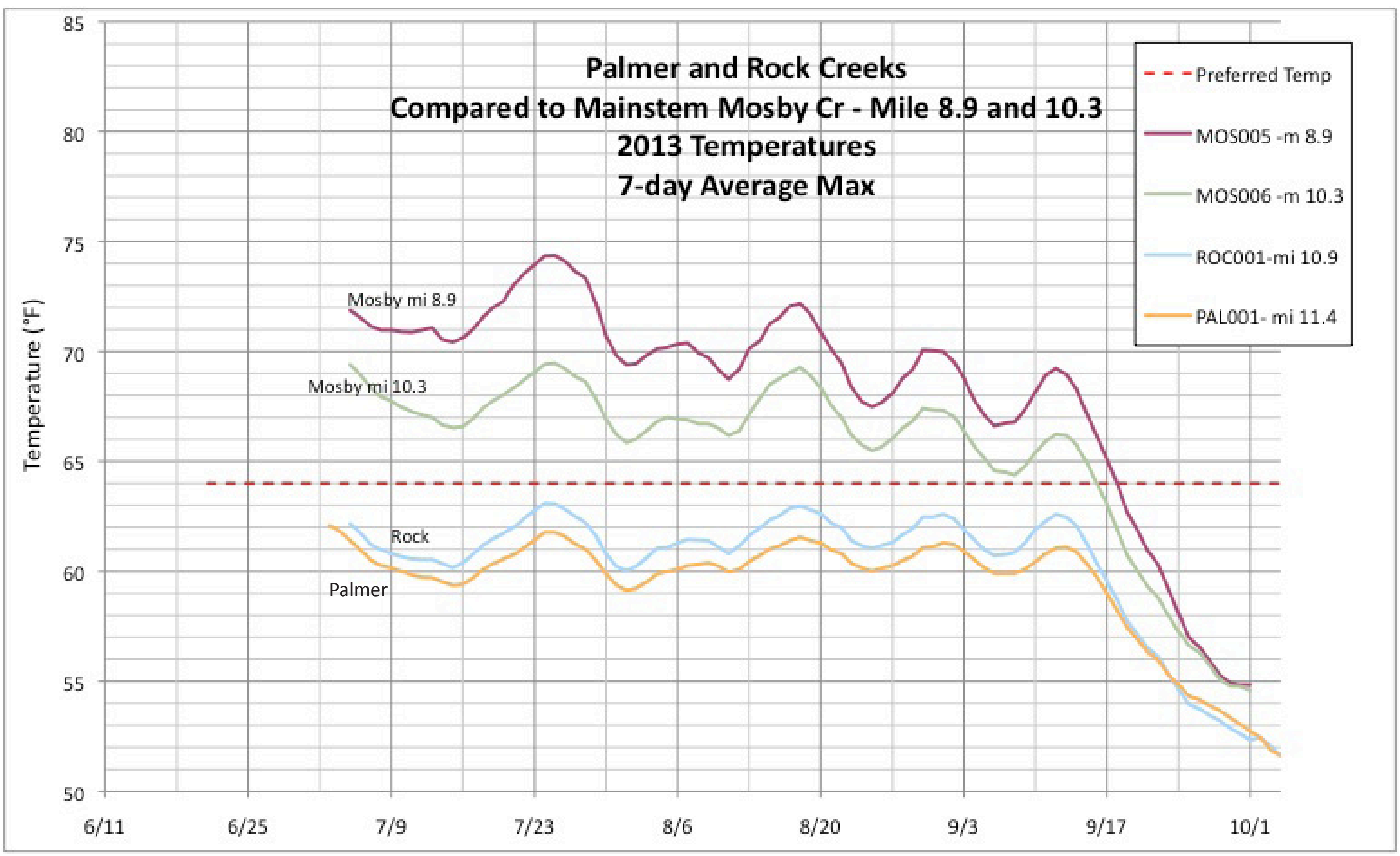


Figure 24

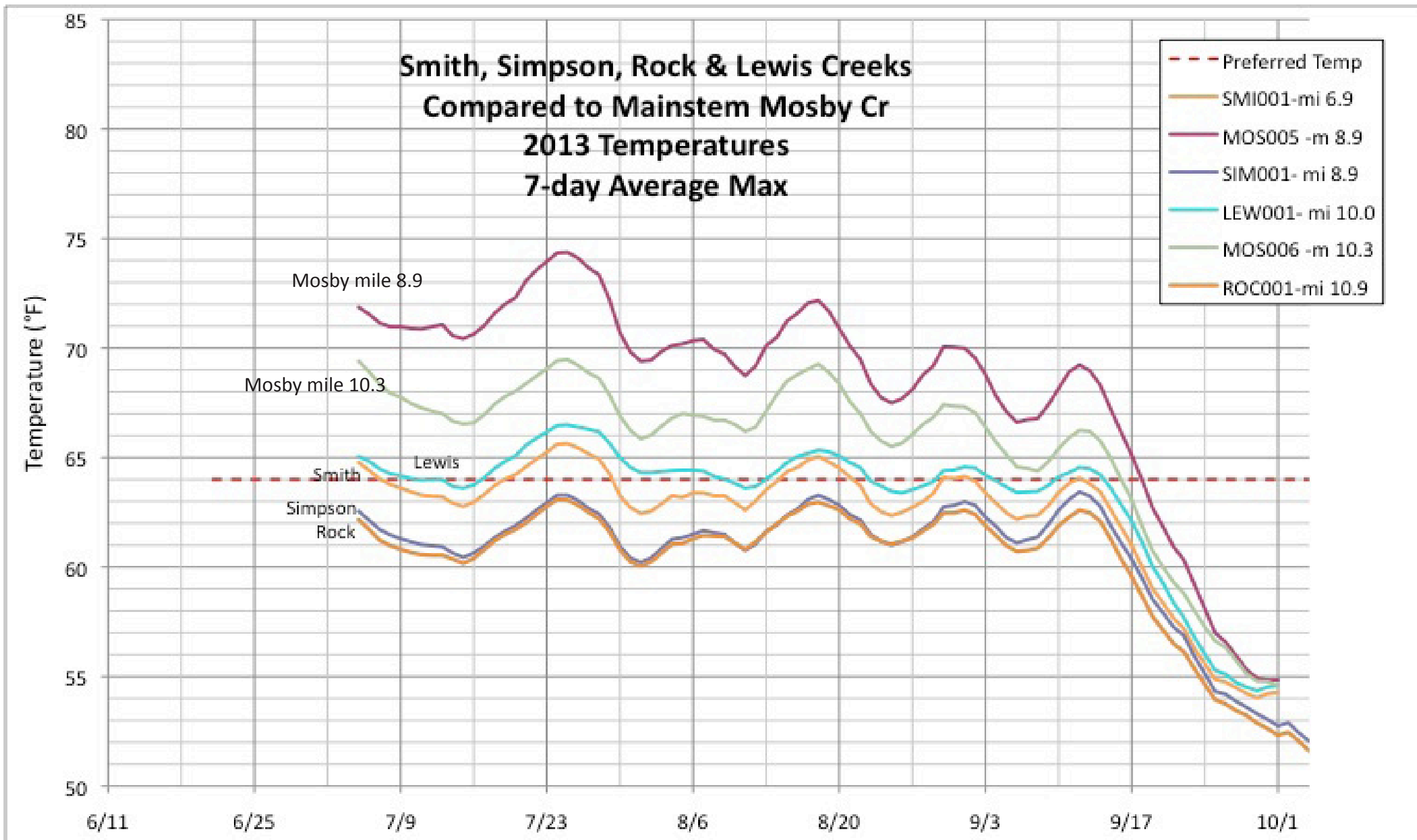
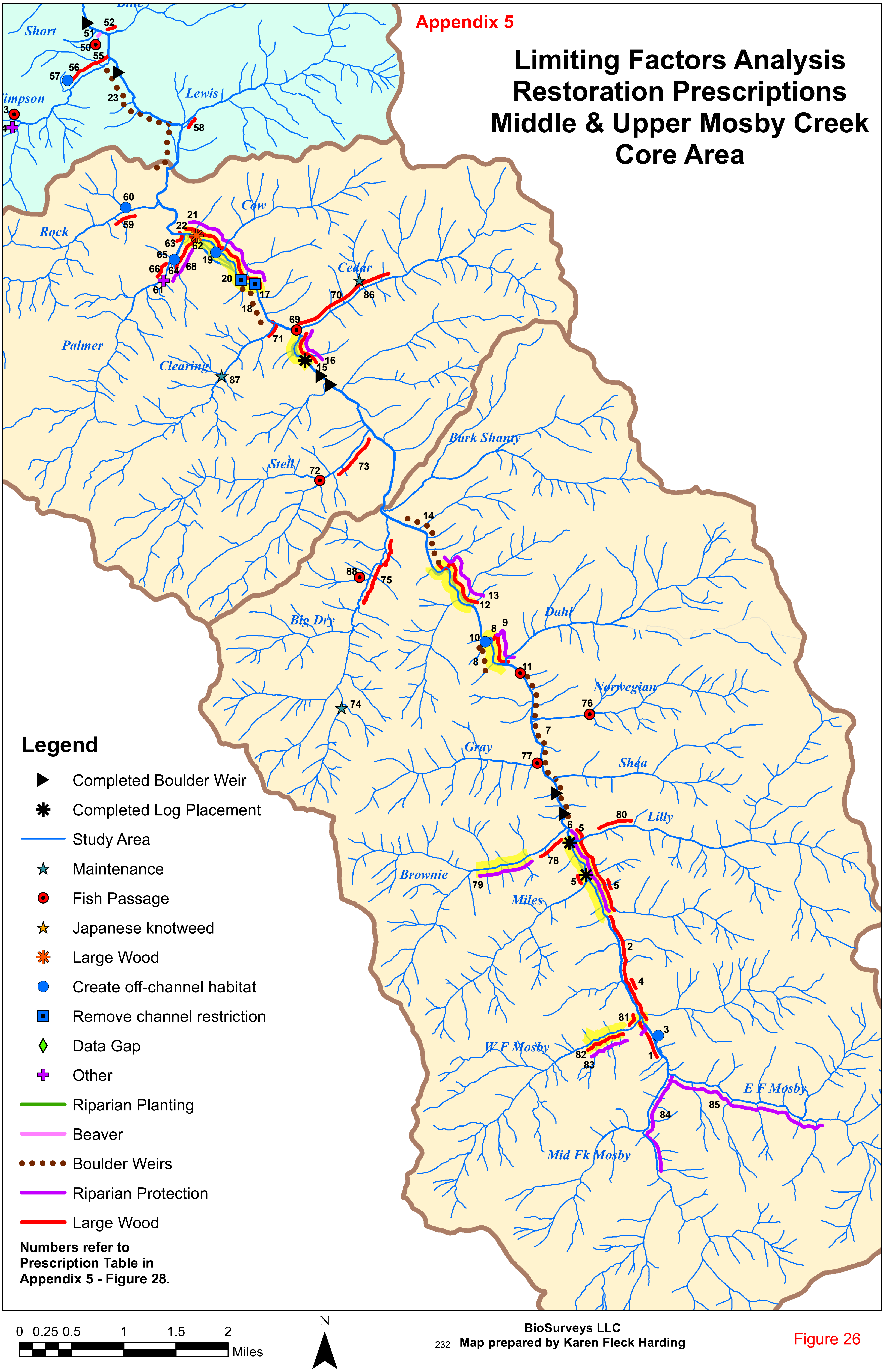

Smith, Simpson, Rock & Lewis Creeks
Compared to Mainstem Mosby Cr
2013 Temperatures
7-day Average Max
Preferred Temp
SMI001-mi 6.9
MOS005 -m 8.9
SIM001- mi 8.9
LEW001- mi 10.0
MOS006 -m 10.3
ROC001-mi 10.9
Mosby mile 8.9
Mosby mile 10.3
Lewis
Smith
Simpson
Rock
Temperature (°F)
85
80
75
70
65
60
55
50
6/11
6/25
7/9
7/23
8/6
8/20
9/3
9/17
10/1

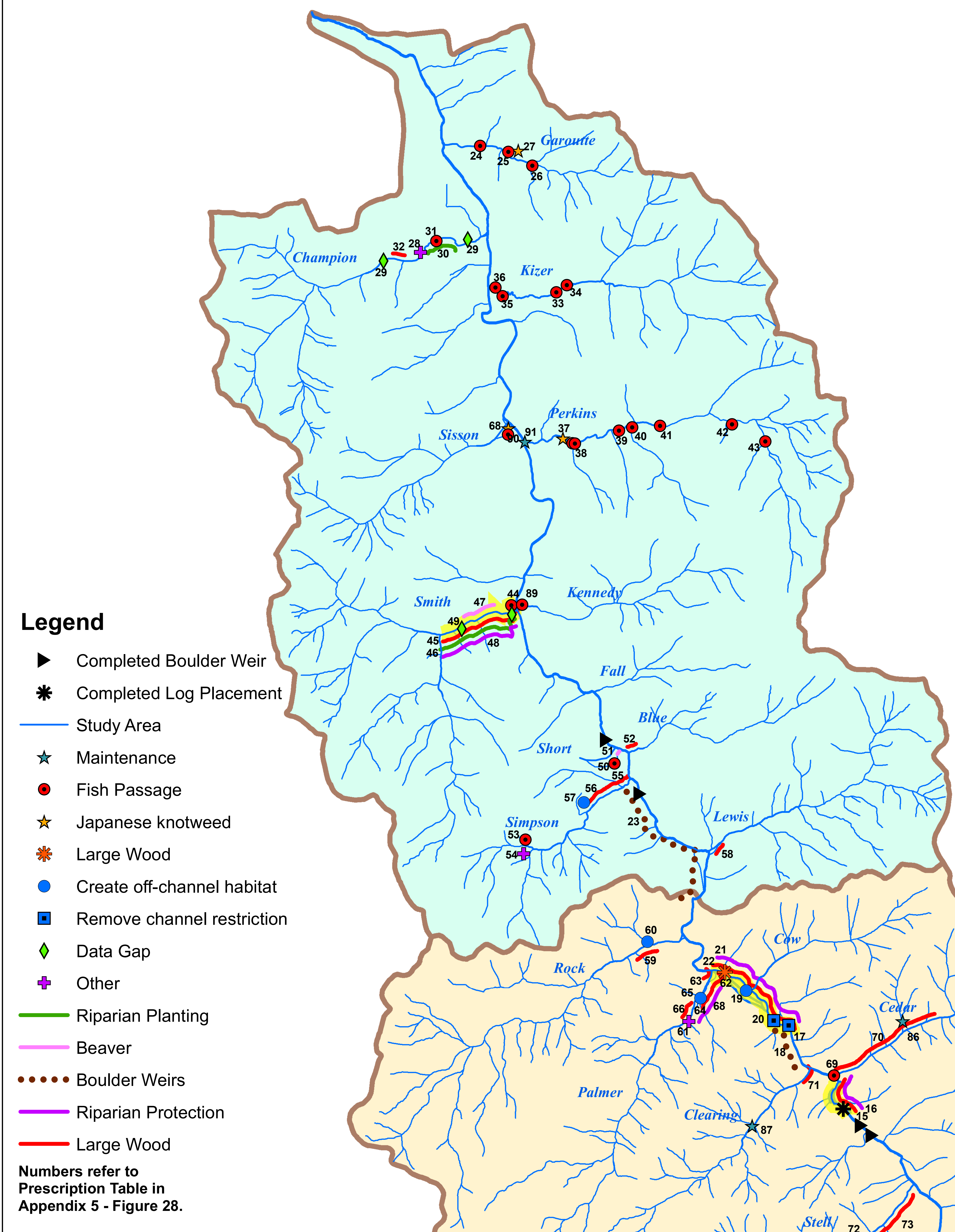
Figure 25



BioSurveys LLC
Map prepared by Karen Fleck Harding

Figure 26

Limiting Factors Analysis
Restoration Prescriptions
Lower Mosby Creek



0 0.25 0.5 1 1.5 2 Miles

N

BioSurveys LLC
Map prepared by Karen Fleck Harding

Figure 26

Mosby Cr Limiting Factors Analysis (2013)

Final Restoration Prescriptions

Prepared by Bio-Surveys,LLC

Prioritized in groups from 1-6 (High Priority = 1)

This table can be sorted by attribute in spreadsheet format provided as supplemental file.

Appendix 15. Mosby Cr Tributaries, prioritized list of prescriptions.

Map #	Wpt	Priority Level	Stream	Anchor Site	Category	Action	Comment
1	561-565	2	Mosby		LWD Full & Edge	The addition of LWD complexes throughout reach. Structure type and location would be highly site specific.	To increase pool complexity, pool frequency, recruitment of transient material and improve floodplain interaction.
2	565-575	2	Mosby		LWD Edge	The addition of LWD complexes throughout reach. These structures would likely benefit from boulder incorporation.	To increase pool complexity, recruitment of transient material and improve floodplain interaction.
3	SC 2	3	Mosby		Off-channel habitat	Re-link side channel 2 whose inlet was isolated during a debris torrent event. Treatment includes protecting inlet with LWD to delink during summer flow regimes for the provision of thermal refugia provided by hyporehic flow only.	This would improve the existing function in this high gradient reach and boost juvenile survival rates both summer and winter.
4	SC 3	2	Mosby		LWD	The addition of LWD complexes in side channel 3. Treatment includes protecting inlet with LWD to delink during summer flow regimes for the provision of thermal refugia provided by hyporehic flow only.	To increase pool complexity and depth within the side channel habitat.
5	SC 4&5	1	Mosby	1	LWD Edge	The addition of LWD complexes in anchor 1 including side channels 4 & 5. Treatment includes protecting inlet with LWD to delink during summer flow regimes for the provision of thermal refugia provided by hyporheic flow only.	To increase pool complexity, the recruitment of transient wood and gravel resources and improve floodplain interaction.

6		1	Mosby	1	Protect	Develop and purchase a riparian conservation easement to increase riparian buffer width throughout the anchor (200ft each side)	This would assist in mitigating for downstream temperature limitations and ensure future wood recruitment to the channel in this critical location.
7	591-608	1	Mosby		Boulder Weir	Continue boulder weir treatment through reaches of exposed bedrock.	To develop an uninterrupted hyporheic lens for protecting limited summer flows in deep alluvium. Directly addresses primary limiting factor.
8		1	Mosby	2	LWD Edge and Boulder.	Place side oriented LWD and/or boulder complexes.	To narrow channel and increase horizontal erosion and floodplain interaction within the anchor.
9		1	Mosby	2	Protect	Develop and purchase a riparian conservation easement to increase riparian setback throughout the anchor (200ft each side)	This would assist in mitigating for downstream temperature limitations and ensure future wood recruitment to the channel in this critical location.
10	617	3	Mosby	2	Off-channel habitat	Explore the development of off channel habitat at pond location. The potential for aggravating temperature impacts should be closely considered.	This location could provide extensive off channel rearing during both summer and winter, improving retention and survival rates in the anchor.
11	608	1	Mosby		Fish Passage	Remove or retrofit with supplemental boulder weir just downstream. Restoration sill log is creating juvenile low flow barrier.	Improves access to thermal refugia for juvenile salmonids migrating upstream in identified critical zone of movement.
12		2	Mosby	3	LWD Edge	Place side oriented LWD complexes within anchor and associated side channels. Treatment includes protecting inlet with LWD to delink during summer flow regimes for the provision of thermal refugia provided by hyporehic flow only.	To increase pool complexity, the recruitment of transient wood and gravel resources and improve floodplain interaction.
13		1	Mosby	3	Protect	Develop and purchase a riparian conservation easement to increase riparian setback throughout the anchor (300ft each side)	This would assist in mitigating for downstream temperature limitations and ensure future wood recruitment to the channel in this critical location. Current 100ft buffer width has been completely recruited in multiple locations.
14	638-645	3	Mosby		Boulder Weir	Continue boulder weir treatment through reaches of exposed bedrock.	To develop an uninterrupted hyporheic lens for protecting limited summer flows in deep alluvium. Directly addresses primary limiting factor but is ranked lower because of its spatial location.

15		2	Mosby	4	LWD Edge	Place side oriented LWD complexes within anchor and associated side channels that are not yet treated. Previously treated reach within anchor is good example. Treatment includes protecting inlet with LWD to delink during summer flow regimes for the provision of thermal refugia provided by hyporehic flow only.	To increase pool complexity, the recruitment of transient wood and gravel resources and improve floodplain interaction.
16		1	Mosby	4	Protect	Develop and purchase a riparian conservation easement to increase riparian setback throughout the anchor (200ft each side)	This would assist in mitigating for downstream temperature limitations and ensure future wood recruitment to the channel in this critical location.
17	688	2	Mosby	5	Remove channel restriction	Remove rip-rap bank stabilization to encourage stream meander toward adjacent east side terrace.	This would improve the natural function of the anchor extending down stream and encourage lateral movement.
18	683-689	3	Mosby		Boulder Weir	Continue boulder weir treatment through reaches of exposed bedrock.	To develop an uninterrupted hyporehic lens for protecting limited summer flows in deep alluvium. Directly addresses primary limiting factor but is ranked lower because of its spatial location.
19	699	3	Mosby	5	Off-channel habitat	Develop design solution for linking hyporehicly fed terrace pond for juvenile access during summer flow regimes.	This would improve the existing function of the anchor and boost juvenile survival rates well down into the zone of mainstem temperature limitations. Provides critical thermal refugia.
20	690	3	Mosby	5	Remove channel restriction	Remnants of an old rail or road bed dike confine natural meander patterns. Breach and remove in select locations (outside meander bends).	This would encourage further horizontal channel movement and improve anchor function.
21		1	Mosby	5	Protect	Develop and purchase a riparian conservation easement to increase riparian setback throughout the anchor (500ft each side)	This would assist in mitigating for downstream temperature limitations and ensure future wood recruitment to the channel in this critical location.
22		2	Mosby	5	LWD Edge	Place side oriented LWD complexes within anchor and associated side channels that are not yet treated. Previously treated reach within anchor is good example. Treatment includes protecting inlet with LWD to delink during summer flow regimes for the provision of thermal refugia provided by hyporehic flow only.	To increase pool complexity, the recruitment of transient wood and gravel resources and improve floodplain interaction.

23	709-719	2	Mosby	5	Boulder Weir	Continue boulder weir treatment through reaches of exposed bedrock.	To develop an uninterrupted hyporheic lens for protecting limited summer flows in deep alluvium. Directly addresses primary limiting factor but is ranked lower because of its spatial location.
24	903	6	Garoutte		Fish Passage	Replace undersized perched culvert	At approximately river mile 0.3, a driveway crossing on Garoutte Cr has an undersized corrugated metal pipe with a 6” perch (photo 749)
25	905	6	Garoutte		Fish Passage	Replace undersized culvert	Approximately 0.5 miles upstream of the mouth (0.85 miles up Garoutte Rd), a 30” concrete pipe is undersized for the 5’ channel width (wpt 905).
26	906	6	Garoutte		Fish Passage	Replace undersized perched culvert	The crossing at stream mile 0.85 (wpt 906) is a 5’ pipe with a 20” perch (photo 751) that would terminate summer migration of juvenile salmonids.
27	904	3	Garoutte		Invasives	Treat Japanese knotweed	Approximately 0.85 miles up Garoutte Rd, in the vicinity of the stream crossing (wpt 904 & 905), two large patches of Japanese knotweed were observed (100’X10’ and 20’X20’ in size) (photo 750). It is likely that additional patches of knotweed are present in the stream channel downstream from this location.
28	896	6	Champion		Livestock	Fence livestock crossing to restrict access to riparian.	Water source for livestock requires access.
29	890, 897	6	Champion		Data Gap	Conduct additional temperature monitoring to determine sources of warming - above below beaver and pasture reaches.	
30	891-894	5	Champion		Planting	Riparian planting for shade and conifer for future LWD in lower reach.	
31	893	4	Champion		Fish Passage	Modify dam structure with graded riffle/rock weir below concrete apron and removal of dam boards at least Nov1- Jun 1 to allow for spawning access.	A slotted dam board structure below a bridge on a farm access crossing (wpt 893) presents a permanent barrier to all anadromous and resident salmonids as well as lamprey. 12” perch below the concrete apron and a 36” perch at the dam boards
32	897-898	5	Champion		LWD	Place large wood structures within forested wetland.	

33		6	Kizer		Fish Passage	Replace undersized perched culverts.	34612 Kizer Cr Rd: Two 30" culverts that are perched 24" creating a barrier to juvenile passage
34		6	Kizer		Fish Passage	Replace undersized perched culverts.	34770 Kizer Cr Rd has two culverts 30" and 24" with fully rotted bottoms that have eroded into perches of 4-6".
35	901	6	Kizer		Fish Passage	Replace undersized perched culverts.	Mosby Cr Rd crossing (photo 739-40) is a 36" concrete pipe with a 15" perch dropping onto
36	902	6	Kizer		Fish Passage	Replace undersized perched culverts.	Two 36" pipes. One not perched and receives half the flow. Second set higher and perched 12". Both with rotted bottoms, such that stream flows under pipe. As flows decrease, most of flow will go under pipe.
37	878	3	Perkins		Invasives	Treat Japanese knotweed	8' X 20' patch is present on the left bank - more may be present upstream or downstream.
38	879	5	Perkins		Fish Passage	Replace undersized/perched culverts at two crossings or install shared bridge.	34854 Perkins Cr Rd: (2) 4'X28' CMP pipes with rotted bottoms and a 15" perch denies all upstream migration at summer flows. Just upstream at , a second crossing is a 5' X 20' pipe that is passable but very undersized.
39	881	5	Perkins		Fish Passage	Replace undersized perched culverts.	Landowner reported 3 undersized culverts on driveway crossing with an approximate 1' perch likely blocks passage at summer flows.
40	882	5	Perkins		Fish Passage	Replace undersized perched culverts.	35041 Perkins Cr Rd: Triple culvert crossing 4', 5' and 5' with perches of 3', 2' and 2' and rotten bottoms leak flow.
41	884	5	Perkins		Fish Passage	Replace undersized perched culverts.	35108 Perkins Cr Rd: crossing has a 6' round pipe with a 1' perch creating a barrier to juveniles only.
42	885	5	Perkins		Fish Passage	Replace undersized perched culverts.	Forest Road Crossing: a 5' squash pipe with a 4' perch in an 11' channel creates a complete barrier to migration.
43	886	5	Perkins		Fish Passage	Replace undersized perched culverts.	Forest Road Crossing: 5' round pipe with a 5' perch in a 9' bankfull channel creates a complete
44	850	3	Smith	1	Fish Passage	Remove remnant dam structure - retain grade control with downstream log structure placements.	The dam is currently degraded and dysfunctional but is creating a definitive barrier to summer juvenile migration.
45		4	Smith	1	LWD	Construct full-spanning log structures within the anchor reach.	
46		4	Smith		Planting	Interplant conifer opportunistically to provide a long-term supply of woody debris.	

47	853-859	4	Smith	1	Beaver	Install vertical posts in the channel at the sites of the 6 legacy dams to encourage and facilitate dam building.	
48		4	Smith	1	Protect	Protection of upslope large wood resources	Explore conservation easements to protect a broader riparian corridor and/or consider land exchange with public lands elsewhere in the subbasin.
49	860, 851	6	Smith		Data Gap	Conduct additional temperature monitoring to determine sources of warming - above below beaver reach.	
50		6	Short		Fish Passage	Install series of 3 step-pools between mainstem Mosby and the bridge crossing.	4' vertical migration barrier associated with riprap at the bridge crossing.
51		6	Short		Beaver	Encourage beaver dam building in lower reach legacy beaver flat - install height regulator	
52		6	Blue		LWD	Place full-spanning large wood structures in the lower 425 ft reach.	To increase channel complexity and trap and sort spawning gravels.
53	732	6	Simpson		Fish Passage	Place a rock weir/graded riffle downstream of culvert.	Culvert located upstream of bedrock falls benefits resident cutthroat only.
54	732	6	Simpson		Sediment	Build up inside corner with rock to provide sediment filter.	A low spot on the inside corner directs sediment flow directly to the creek.
55	718-722	5	Simpson		LWD	Place edge oriented large wood structures in the lower 1100 ft reach.	To promote bank scour to recruit alder.
56	722-728	5	Simpson		LWD	Place full-spanning large wood structures in the middle 1100 ft reach.	To create deflection and boost sinuosity to recruit wood from the riparian and support sorting of spawning gravels.
57	727-728	5	Simpson		Off-channel habitat	Place large wood structures strategically to affect the reconnection of historic side channel.	To provide hydraulic relief from winter flows.
58	746-749	5	Lewis		LWD	Place full-spanning large wood structures in the middle 400-600 ft reach.	To trap and sort spawning gravels and encourage off-channel linkages during winter flows on the low terrace.
59	739-743	3	Rock		LWD	Place full-spanning large wood structures in the middle 1400 ft reach.	To initiate scour and trap and sort the abundant gravels that are migrating through Rock Cr.
60	740	4	Rock		Off-channel habitat	Develop alcove at the broad low flat near first right trib.	This site is being fed from hyporheic flow that will guarantee a functional alcove with positive outlet flow.
61	758	5	Palmer		Browse protection	Protect young riparian hemlock & cedar from elk browse.	Reach located about .66 miles upstream from the mouth.
62	751	2	Palmer		LWD	Construct log jam at the top of the mainstem Mosby side channel that Palmer Cr enters.	To encourage scour elements to support summer hyporheic flow.
63	753-755	2	Palmer	1	LWD	Place full-spanning large wood structures in the lower 650 ft reach.	To encourage scour, deflection and gravel sorting.

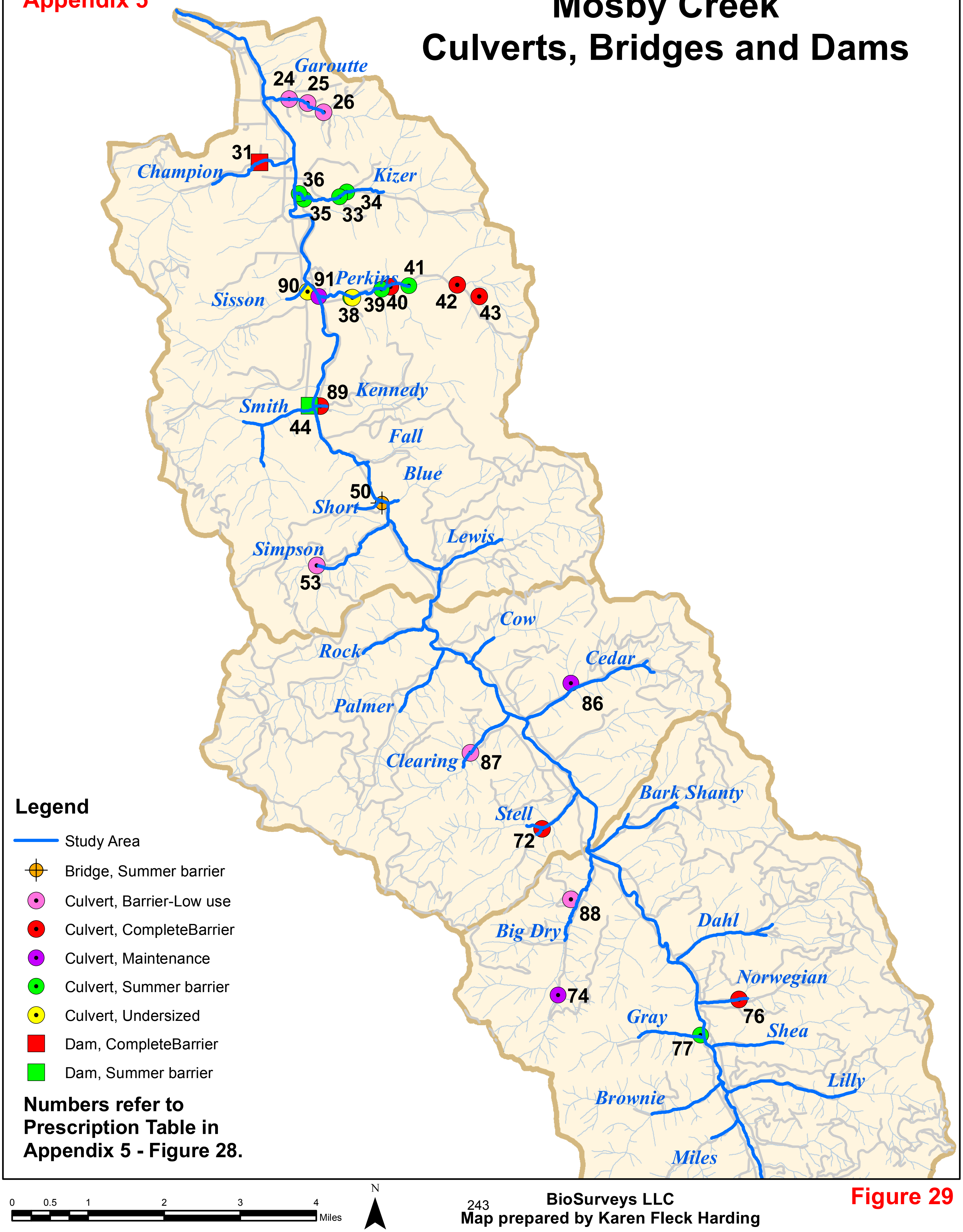
64	755-757	2	Palmer		LWD	Place full-spanning large wood structures in the middle 2000 ft reach.	To trap and sort spawning gravels.
65	756	3	Palmer		Off-channel habitat	Develop alcove at the bottom end of historic side channel.	
66	758	3	Palmer		LWD	Place full-spanning large wood structures in the upper 850 ft reach.	To raise the channel to connect to broad debris terrace of alluvium to maximize hyporheic flows.
67		2	Palmer	1	Protect	Protection of upslope large wood resources	Consider land exchange between Weyco and BLM to establish and maintain wide riparian buffer.
68	864-866	3	Sisson		Invasives	Treat Japanese knotweed	Japanese knotweed is present in at least 5 small patches along the lower end of Sisson Cr.
69	766	3	Cedar		Fish Passage	Create backwater influence on mainstem with edge oriented wood or boulder weirs.	To address juvenile barrier.
70	767-777	3	Cedar		LWD	Place full-spanning large wood structures in the .9 mile treatment reach above the bridge crossing.	To trap and sort gravels, expand floodplain interaction and to support and trap bedload and prevent channel scouring to bedrock as existing jams deteriorate.
71	778-780	3	Clearing		LWD	Place full-spanning large wood structures in the lower 950 ft reach.	To sort gravels and increase floodplain interaction.
72	798	4	Stell		Fish Passage	Remove culvert and pull back fill.	4’X40’ culvert in an 8 ft channel on mainstem Stell Cr above No Fk Stell has a 5 ft perch and blocks access for migrating cutthroat trout to excellent and abundant spawning gravels above. Replacement would benefit cutthroat only.
73	787-791	3	Stell		LWD	Place full-spanning large wood structures in the middle 2500 ft reach.	To trap and sort gravels and to increase floodplain interaction.
74	813	2	Big Dry		Maintenance	Replace undersized culvert.	3' pipe in 8' channel with risk of road failure.
75	806-810	2	Big Dry		LWD	Place full-spanning large wood structures in the middle 0.75 mile reach.	In the lower end of this reach, include deflector logs. In the upper end of this reach, support the existing meander potential that is currently recruiting riparian trees.
76	1000	2	Norwegian		Fish Passage	Replace undersized, perched culvert.	A 6 ft steel culvert is perched 3 ft.
77	828	3	Gray		Fish Passage	Replace undersized, perched and rotted culverts.	Two 4’ round CMP culverts in 12 ft channel (1) 8” perch and a rotten bottom (1) 7” perch and a 14” bedload blockage at the inlet.
78	908-911	1	Brownie		LWD	Place full-spanning large wood structures in the lower 0.5 mile reach.	To support channel complexity in this reach as well as to provide long-term support for the upstream anchor site. This could be delayed for 5 years.

79		1	Brownie	1	Protect	Protection of upslope large wood resources	Consider land exchange between Weyco and BLM to establish and maintain wide riparian buffer.
80	844-846	3	Lilly		LWD	Place full-spanning large wood structures in the middle 1800 ft reach.	To support the existing wood component that is deteriorating.
81	1076-1080	1	WF Mosby	1	LWD	Place full-spanning large wood structures in the lower 600 ft reach.	To encourage sorting of spawning gravels and pool scour.
82	1084-1088	1	WF Mosby	2	LWD	Place full-spanning large wood structures in the middle 2000 ft reach.	To support existing complexity or to support potential for channel complexity.
83		1	WF Mosby		Protect	Protection of upslope large wood resources	Consider land exchange between Weyco and BLM to establish and maintain wide riparian buffer.
84		1	MF Mosby		Protect	Protection of upslope large wood resources	Consider land exchange between Weyco and BLM to establish and maintain wide riparian buffer.
85		1	EF Mosby		Protect	Protection of upslope large wood resources	Consider land exchange between Weyco and BLM to establish and maintain wide riparian buffer.
86	774	4	Cedar		Maintenance	Replace rotted out culvert to prevent road failure.	On the first left trib, a 30” rotted out corrugated metal pipe in a 4 ft channel is perched 18”. It is not a significant tributary for fish habitat and a 4’ vertical bedrock barrier is located just above the culvert. However, the culvert is a serious road maintenance issue that risks the failure of a 10’ road fill.
87	783	6	Clearing		Maintenance	Replace undersized culvert.	An undersized (6 ft pipe in 12 ft channel) perched (6”) culvert was installed across a historic debris torrent jam. Replacement of this pipe would be complicated by the elevation of the jam and would have little value to the aquatic resource profile – no net gain and very high risk.
88	815	6	Big Dry		Fish Passage	Replace perched culvert.	This trib crossing has a 3 ft culvert in a 4 ft channel with a 3 ft perch. The gradient of the trib is approx 8%, rendering this a low priority for connectivity and therefore not a priority for replacement.
89	849	6	Kennedy		Fish Passage	Replace perched culvert.	Three 3’ sectional culverts in a 10’ channel have 4"-10” perches. Tributary flow is not sufficient enough (even in May) to rank this as a priority passage issue to be addressed.

90		6	Sisson		Maintenance	Replace undersized culvert.	Crossing has twin 3’ concrete pipes with one pipe half full of bedload -not a passage issue, but is a maintenance issue. It is likely to plug and overtop the road in a high flow event.
91	1002	5	Perkins		Maintenance	Replace deteriorated undersized culvert.	Mosby Cr Rd crossing: 55’X6’ corrugated metal pipe (CMP) has good passage for adults and juveniles. The bottom of the pipe is rotted out badly on the lower end and the pipe is undersized. This is not a resource access issue, however it is a County maintenance issue.

Appendix 5

Mosby Creek Culverts, Bridges and Dams



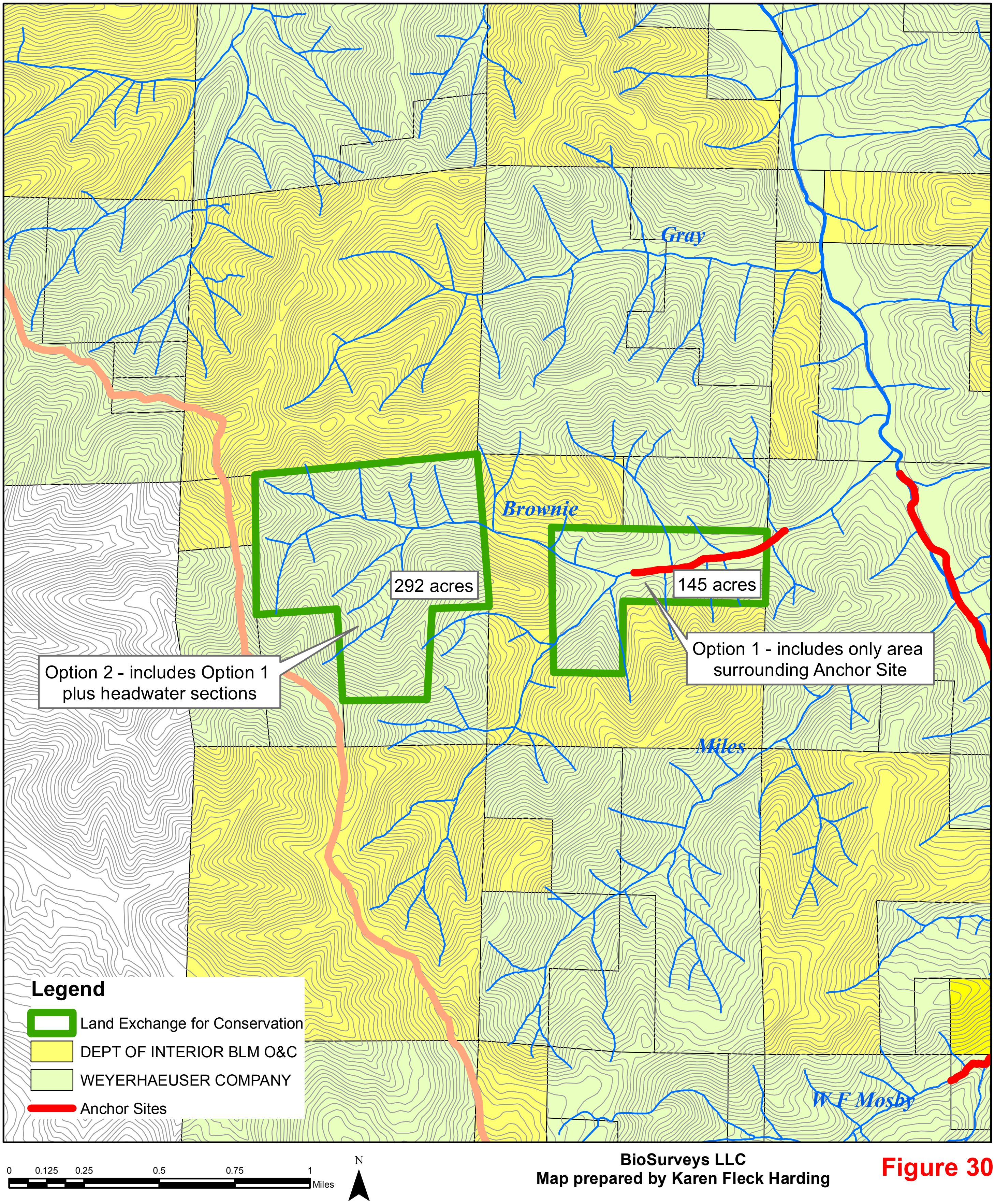
Numbers refer to Prescription Table in Appendix 5 - Figure 28.

Figure 29

BioSurveys LLC
Map prepared by Karen Fleck Harding

Appendix 5

Conservation Land Exchange Example
To Establish Publicly-Owned Riparian Reserve Area
Brownie Creek



BioSurveys LLC
Map prepared by Karen Fleck Harding

Figure 30