Fish Passage Barriers

Free passage describes the absence of barriers to the free instream movement of adult and juvenile salmonids. Free movement in streams allows salmonids to find food, escape from high water temperatures, escape from predation, and migrate to and from their stream of origin as juveniles and adults. Temporary or permanent dams, poorly constructed road crossings, landslides, debris jams, or other natural and/or man-caused channel disturbances can disrupt.

There are a total of 30 know barriers blocking approximately 28 miles of stream in the Outlet Creek Basin. Seven are complete, 23 are partial, and 12 barriers of unknown status. There are a total of 11 partial barriers blocking about 9 miles of stream plus 5 of unknown status in the Northern Subbasin. There are a total of 5 barriers blocking 3 miles of stream, 2 are complete, 3 are partial, plus 5 of unknown status in the Middle Subbasin. There are a total of 14 barriers blocking 16 miles of stream, 5 complete and 9 partial barriers, plus 2 of unknown status in the Southern Subbasin. (Figure X. Known fish passage barriers in the Outlet Creek Basin.

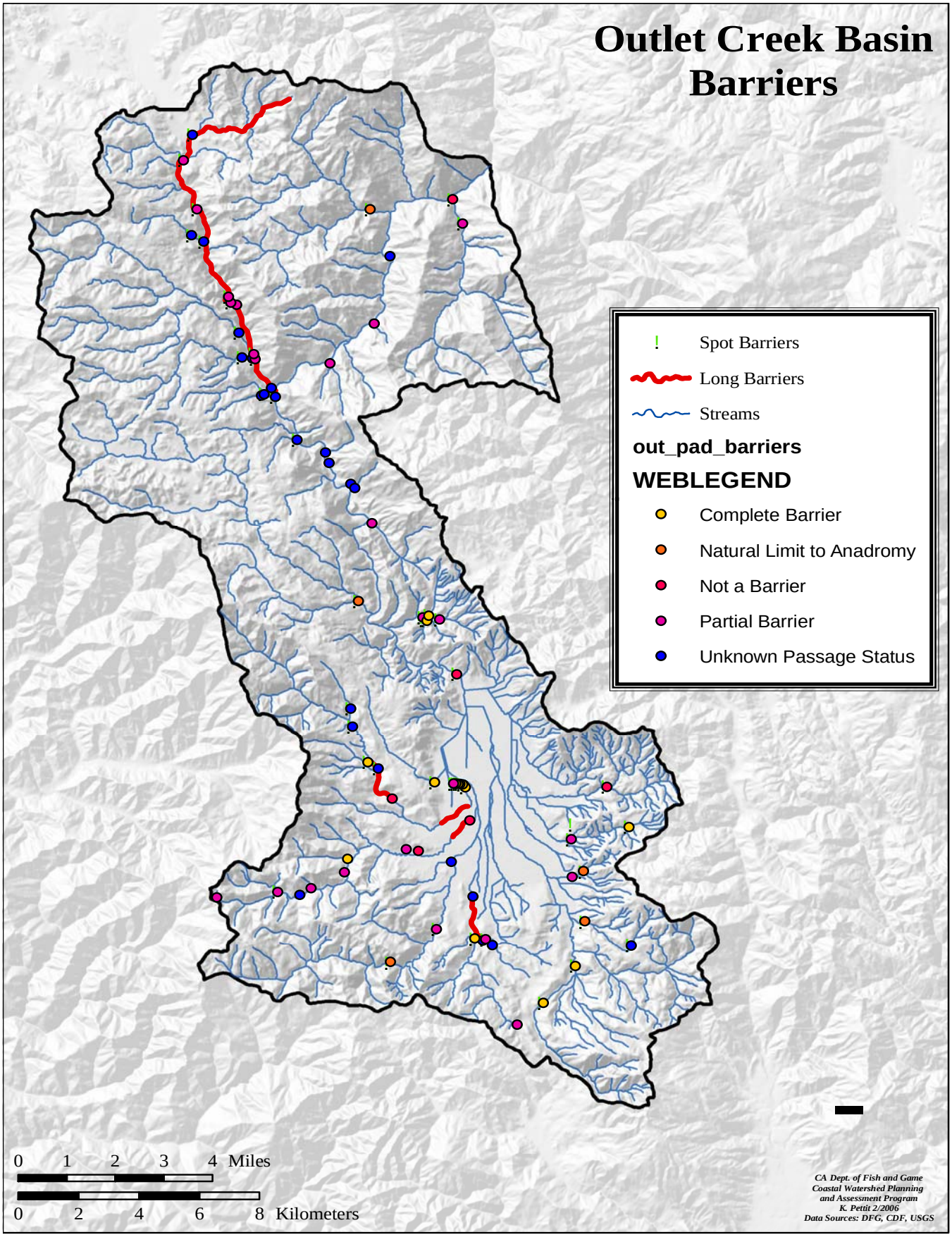

Figure X. Known fish passage barriers in the Outlet Creek Basin. ***OLD MAP REPLACE***

Analysis of Tributary Recommendation

In order to compare the frequency with which recommendations were made within the Outlet Creek Basin, the top ranking recommendations for each tributary were compiled. Each tributary was originally assigned anywhere from zero to ten recommendations, which were ranked in order of importance.

The top improvement recommendations in each tributary in each subbasin were summed (Table X. Occurrence of improvement Recommendations Summary of the Outlet Creek Basin). Overall, the basin had the highest occurrence of Pool and Shelter recommendations. Spawning Gravel, Bank, Canopy and Fish Passage recommendations were the next highest recommendations. The highest occurrences in the Northern Subbasin were Pool, Shelter and Spawning Gravel. The Southern Subbasin also had the highest recommendations for Pool and Shelter, while the Middle Subbasin had high Bank and Shelter recommendations (Table X. Occurrence of improvement recommendations for the Outlet Creek Basin).

Table X. Occurrence of improvement recommendations for the Outlet Creek Basin.

Stream	Number of Sites	Survey Length (ft.)	Bank	Roads	Canopy	Temp	Pool	Shelter	Spawning Gravel	LDA	Wildlife Livestock	Fish Passage
Northern	19	20,950	7	10	12	8	31	26	31	0	1	2
Middle	7	7,498	7	3	0	0	4	6	4	0	0	5
Southern	24	19,520	8	4	10	6	19	22	7	0	8	13
Basin	50	47,968	22	17	22	14	54	54	42	0	9	20

Table X. How improvement recommendations were collapsed into recommendation categories

Stream Recommendation Category	Subbasin Recommendation Category
Bank/Roads	Erosion/Sediment
Canopy/Temp	Riparian/Water Temp
Pool/Shelter	Instream Habitat
Spawning Gravel/LDA	Gravel/Substrate
Livestock/Barrier	Other

Table X. Distribution of basin-wide recommendations for the Outlet Creek Basin.

Subbasin	Erosion/Sediment	Riparian/Temperature	Instream Habitat	Gravel/Substrate	Other
Northern	17	20	57	31	3
Middle	10	0	10	4	5
Southern	12	16	41	7	21
Basin	39	36	108	42	29

However, comparing recommendation categories between streams could be confounded by the differences in the survey distance measured. Of the sixteen streams evaluated, 47,968 stream feet were surveyed in the Outlet Creek Basin. Therefore, the percentage of stream feet assigned to the various recommendation categories was calculated for each stream.

Instream Habitat was the most important recommendation category followed by Gravel/Substrate, Erosion/Sediment and Riparian/Water Temperature in the basin (Table X. Distribution of basin-wide recommendations for the Outlet Creek Basin). Therefore, the number one priority rankings remained the same for the basin and its subbasins whether assessed by the number of tributaries or the percentage of stream feet. Additionally, the overall rankings of Recommendation Categories in the basin as a whole remained the same in both analyses.

The high number of Instream Habitat and Gravel/Substrate Recommendations across the Outlet Creek Basin indicates that high priority should be given to restoration projects emphasizing pools and shelter, and reflects the lack of suitable spawning substrate and the opportunity to implement both retention and addition of gravel where appropriate. The Riparian/Temperature Recommendation indicate that summer and fall flows

must be protected from legal and illegal water extraction, enforce bypass flows from the six dams in the Southern Subbasin, and replanting and protecting the riparian habitat.

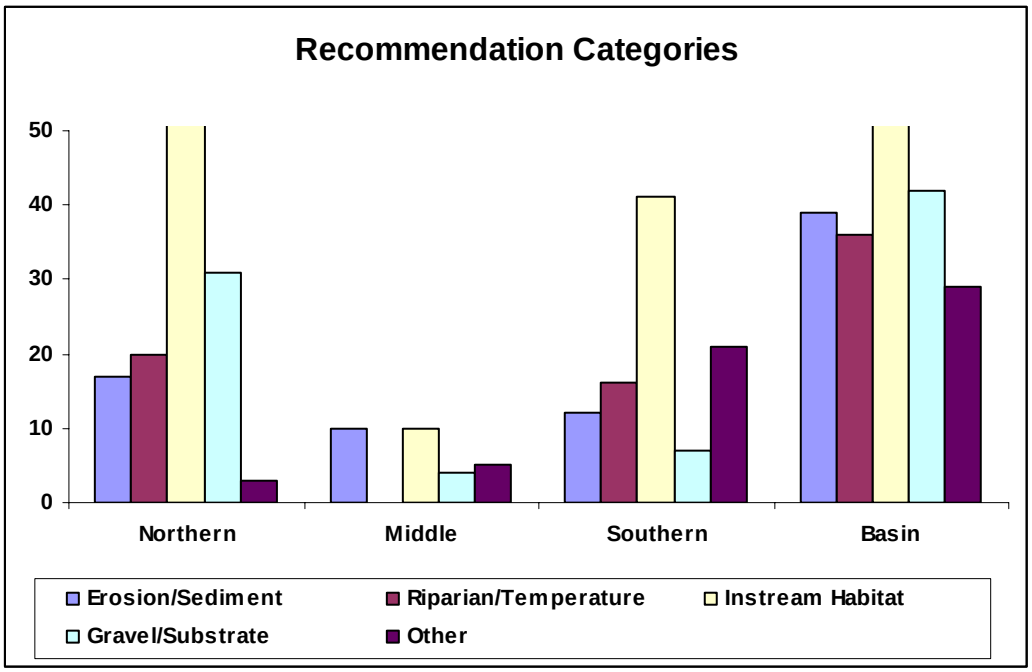

Figure X. Frequency of recommendation categories in the streams surveyed in the Outlet Creek Basin.

Limiting Factors

A main objective of this assessment was to identify factors that limit production of anadromous salmonid populations in the Outlet Creek Basin and its subbasins. This process is known as a limiting factors analysis (LFA). One component is the analyses of the freshwater habitat in order to identify whether any factors are at a level that limits production of juvenile anadromous salmonids in the Southern Subbasin. This limiting factors analysis (LFA) provides a means to evaluate the status of key environmental parameters that affect anadromous salmonid life history. These analyses are based on comparing measures of habitat data such as water temperature and pool complexity to a range of reference conditions determined from empirical studies and/or peer reviewed literature. If a component's condition does not fit within the range of reference values, it may be viewed as a limiting factor. This information will be useful to identify underlying causes of stream habitat deficiencies and help reveal if there is a linkage to watershed processes and land use activities.

Salmonids are limited by flow and water quality, erosion and fine sediment, riparian and instream habitat deficiencies. The Northern and Southern subbasins appear to have more limiting factors than the Middle Subbasin. Most limiting factors center around flow and water quality and instream conditions. Table X. and Figure X. detail the basin's limiting factors and their associated locations.

Table X: Limiting Factors Analysis of the Outlet Creek Basin and Subbasins.

Limiting Factor	*Basin*	*Northern*	*Middle*	*Southern*

Flow and Water Quality	Low and/or absent flow in August and September	**X**	**X**	**X**	**X**
	Low and/or absent flow during November	**X**	**X**	**X**	**X**
	High summer water temperatures	**X**	**X**	**X**	**X**
	Subsurface flows obstructing fish migration	**X**	**X**	**X**	**X**
Erosion and Fine Sediment	Bank and debris slide erosion	**X**	**X**	**X**	**X**
	Fine sediment from roads, culverts, and land use activities.	**X**	**X**	**X**	**X**
	Bank erosion from livestock		**X**		**X**
Riparian and Instream Habitat	Low canopy density	**X**	**X**	**X**	**X**
	Inadequate structure, like large woody debris.	**X**	**X**	**X**	**X**
	Inadequate pool depth and frequency	**X**	**X**	**X**	**X**
	Barriers to migration	**X**	**X**	**X**	**X**
	Channelized and leveed stream banks	**X**	**X**	**X**	**X**
	Disconnected floodplains and inadequate sinuosity				**X**

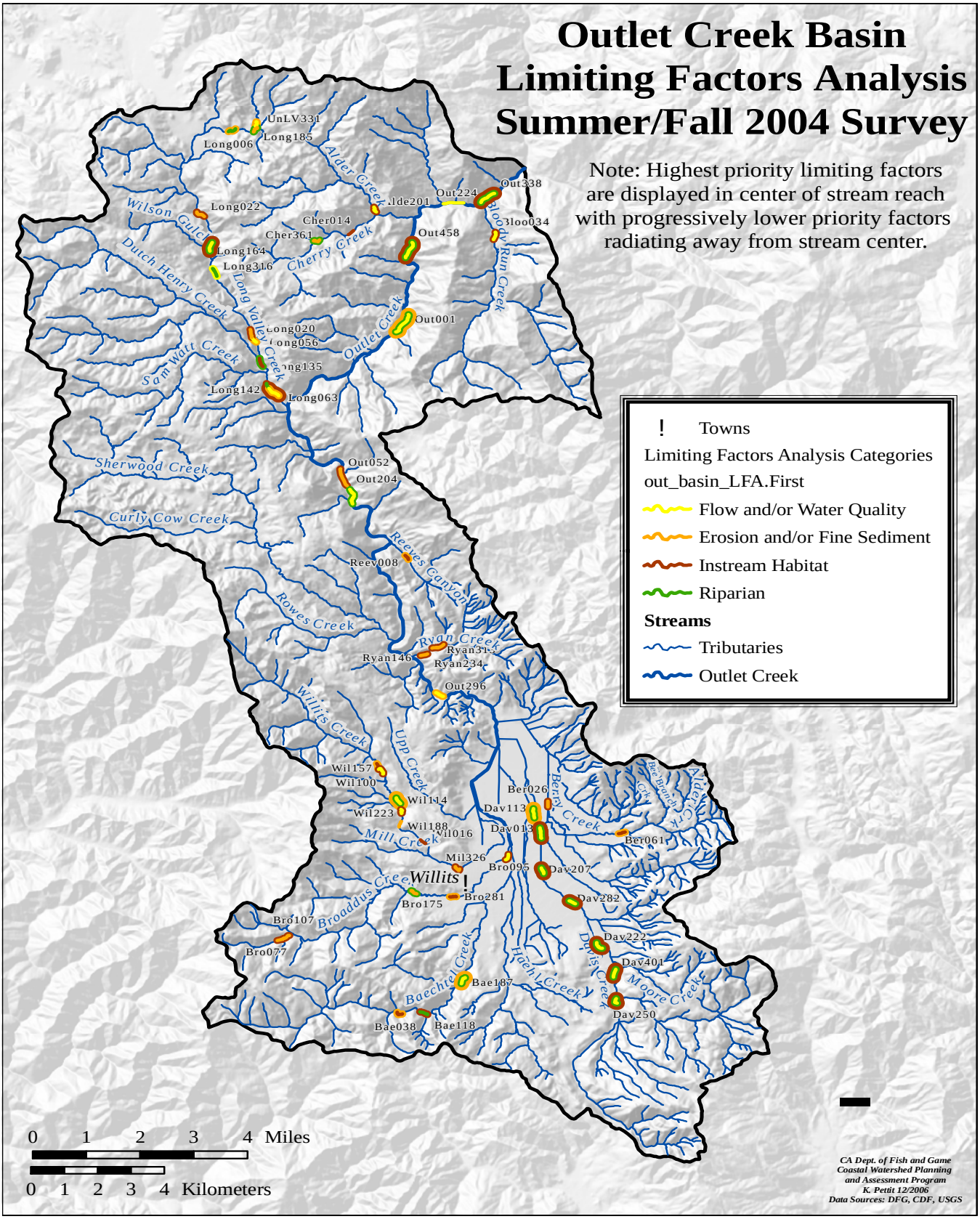

Figure X. Limiting Factors in the Outlet Creek Basin

Refugia Areas

Refugia habitat was identified and characterized in the Basin using current (2004) and habitat typing (1995) data and then comparing our findings with local fishery and watershed experts, and EMDS results. The criteria

included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, forestry and other land use, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity.

Salmonid refugia habitat conditions in the Basin were generally rated as Low to Medium Quality refugia. The Northern Subbasin provided mostly Low Quality habitat. The Southern Subbasin provided Low to Medium Quality habitat quality. Sites surveyed in the Middle Subbasin provide some high quality refugia. All three subbasins provide critical contributing area (Table X). The locations of the refugia are shown in Figure X.

Table x. Subbasin salmonid refugia area ratings in the Outlet Creek Basin.

	Refugia Categories:					Other Categories:	
	High Quality	**Medium-High Quality**	**Medium Quality**	**Low- Medium Quality**	**Low Quality**	**Critical Contributing Area**	**Data Limited**
Northern				X		X	X
Middle		X				X	X
Southern			X			X	X
Basin			X			X	X

Table X . Streams and the associated number of survey sites designated salmonid refugia in the Outlet Creek basin.

Subbasin	High Quality	Medium-High Quality	Medium Quality	Low- Medium Quality	Low Quality
Northern		Long Valley Ck (1) Cherry Creek (1)	Long Valley Ck (1) Outlet Creek (1)	Outlet Creek(1) Cherry Creek (1) Long Valley Ck (2)	Outlet Creek (3) Long Valley Ck (7) Bloody Run (1) Cherry Creek (1)
Middle	Ryan Creek (3)		Outlet Creek (3)	Reeves Cyn Creek (1)	
Southern			Willits Creek (2) Broaddus Creek (2) Baechtel Creek (2) Mill Creek (1) Davis Creek (2)	Willits Creek (1) Davis Creek (2)	Willits Creek (3) Broaddus Creek (2) Davis Creek (3) Berry Creek (2) Baechtel Creek (1)
Basin	3	2	14	8	23

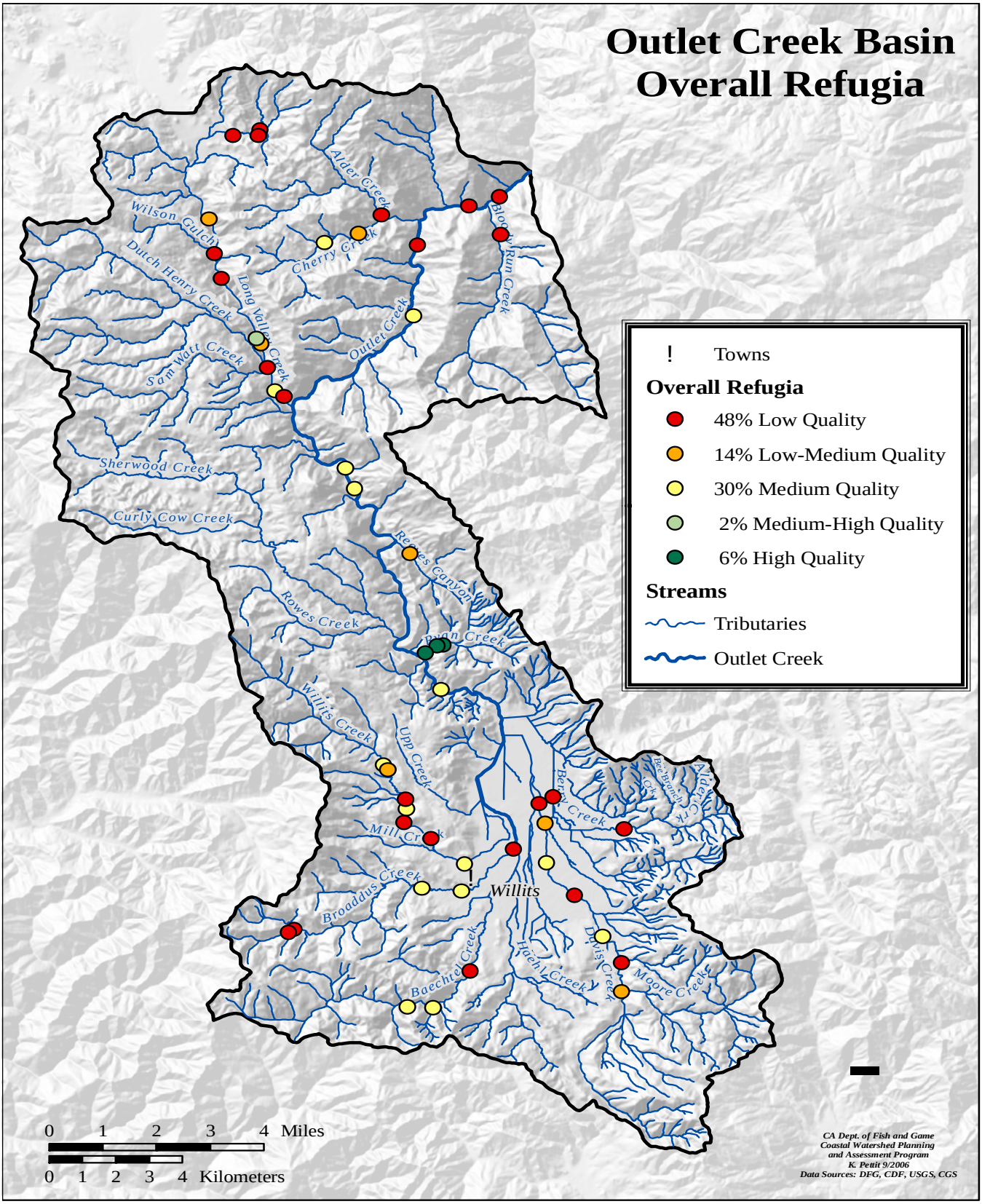

Figure X. Refugia areas in the Outlet Creek Basin.

Responses to Assessment Questions

What are the history and trends of the sizes, distribution, and relative health and diversity of salmonid populations in the Outlet Creek Basin?

Findings and Conclusions:

- The numerous villages around the Eel River System and the five tribes of Pomo living in Little Lake Valley support the notion that the salmon and steelhead trout populations were healthy and productive prior to European colonization in the 1840s;
- The fall run of salmon on the Eel River began to be commercially fished in 1853 and became the second most important salmon producer in California. By the close of the decade there were seven packing plants which supplied cured fish to the miners and townspeople of northwestern California as well as for export. By the 1880s, the fish canning industry became unprofitable due to the lack of salmon on both the Eel and the Sacramento rivers;
- With the Outlet Creek Basin being a headwater stream of the Eel River System, we are lead to assume that it also had healthy and productive salmonid populations and experienced a similar decline from the 1840s-1926;
- Due to the Basin's inland location and gradient, we also assume that steelhead trout were the most numerous salmonid historically present, followed by Chinook salmon. Coho salmon were probably always the least abundant;
- The Outlet Creek strain of steelhead trout were known for their large size and "good fight". Steelhead juveniles from Outlet Creek were out planted in the Big and Russian river basins, and tributaries in Marin County in an effort to increase the size of the individuals in those populations;
- Based on population estimates for the Eel River, Outlet Creek's Chinook spawning run was probably around 1,380, the coho around 600, and the steelhead was about 2,300 between 1938-1962;
- From 1971-2000, 6 tributaries had records of coho salmon, 12 streams had records of Chinook salmon, and 14 had records steelhead trout;
- Steelhead trout were documented in more reaches surveyed by CDFG since 1990 than coho salmon.

What are the current salmonid habitat conditions in the Outlet Creek Basin? How do these conditions compare to desired conditions?

Findings and Conclusions:

Flow/Water Quality

- Spawning salmonids need a minimum stream flow of 25 cfs. to migrate upstream to their natal spawning grounds. USGS stream gauge data showed that November (1990-93) flows were less than 25 cfs. Winter flows have been insufficient to allow adult salmonids to migrate upstream;
- Precipitation during the 1950's was roughly 60 inches per year, or 512,000 AFY over the entire Outlet Creek basin. Precipitation during the 1990's was 65 inches per year, an increase over the period of the 1950's. Yet, discharge was only 181,000 AFY during 1990-1993. While precipitation increased, discharge decreased in Outlet Creek in the early 1990's. The decrease in discharge coincides with the construction of Centennial Dam in 1989;
- In the 1980s-90s, absent or low flow conditions were recorded by the USGS stream gage located in August and September. In 2004, flows were absent or low on many tributaries and in Outlet Creek as measured by a flow meter. Low flow conditions have been exacerbated by a lack of bypass flows from impoundments and legal and illegal water extraction. Summer and early fall flows have not been sufficient to allow juvenile salmonids to migrate around or exit the basin;
- From 1958-1988, the average summer water temperature in the lower section of Outlet Creek were considered lethal (71.1F);
- In 2004, the Maximum Weekly Average Temperature ranged from 56.7-78.1 F. Water temperatures across the basin showed that temperatures were generally suitable in the smaller tributaries and unsuitable in the mainstem;

- Turbidity and conductivity samples were taken at each of the 50 GRTS site in 2004. In the basin overall, turbidity and conductivity ranged from 0.45-80.0 and 249-2,080, respectively.

Fish Passage

- Six impounds restrict flow and slow and/or retard the adult spawning migration both in Outlet Creek and the main stem Eel. The impounds have decreased available juvenile rearing habitat in some areas;
- In 1995 and 2004, CDFG survey crews encountered many large water drafting operations which were draining pools, which created areas of dry channel (barriers) to migration indicate fish passage problems in some tributaries during the summer and fall.

Erosion/Sediment

- Bank erosion, debris slides, Class 4 roads (unimproved and unpaved), and road-related gullies were the most common fine sediment sources;
- Non-land use associated activities such as debris slides and bank erosion contribute the greatest amount fine sediment;
- Geologic findings indicate that most of the fine sediment originates in the Southern Subbasin, specifically from Little Lake Valley;
- Fine sediment from stream banks in the Middle and Southern may be limiting the health and production of salmonids in the Outlet Creek Basin. This finding is supported by the TMDL (U.S. EPA 2005);
- Embeddedness values indicate that fine sediment has increased and spawning conditions have deteriorated between 1995 and 2004.

Riparian Condition

- Surveys taken in 1995 showed the Northern and Middle subbasins had canopy densities of 65% and 71%, respectively. The Southern Subbasin had a canopy density of 81%. Most of the streams in the Outlet Creek Basin were covered by deciduous canopy. Coniferous species provided less than 10% to the canopy. Almost one-third of the total canopy over the stream surveyed was open (absent);

- The sites surveyed in 2004 show the Northern and Southern subbasins have canopy densities of 61% and 71%, respectively. The Middle Subbasin had a canopy density of 91%. Most of the sites surveyed were covered by deciduous canopy, although the Northern Subbasin appeared to be dominated by coniferous species, this data is skewed due to sample site locations. Coniferous species provided about 20% to the canopy density in the Southern and Middle subbasins. Less than one-third of the total canopy over the stream surveyed was open (absent);
- EMDS compared the canopy density between 1995 and 2004. The results appeared to be similar between the two sampling methods and years. The Northern Subbasin showed an increase in canopy density in the lower reaches of Long Valley Creek.

Instream Habitat

- In general, a high incidence of shallow pools, and a lack of cover and large woody debris indicate simplification of instream salmonid habitat in surveyed tributary reaches and the estuary.

Gravel/Substrate

- Cobble embeddedness values in many CDFG surveyed reaches were unsuitable for salmonid spawning success. In 1995, only 16 % of the streams surveyed had cobble embeddedness less than 26%. The Middle Subbasin provided the most suitable spawning substrate;
- In 2004, only 2% of the GRTS stream sites surveyed had cobble embeddedness less than 26%;
- Permeability sampling in four locations throughout the basin indicated low to moderate amounts of fine material. This could indicate suitable to somewhat unsuitable conditions for salmonid in these sample sites.

Refugia Areas

- Most juvenile salmonid habitat conditions in the Outlet Creek Basin are of low or low-medium quality. One Middle Subbasin tributary was rated as high potential refugia.

What are the impacts of hydrologic, geologic, vegetative, fluvial, and other natural processes on watershed and stream conditions?

Findings and Conclusions:

Hydrology

- The stream network flows primarily in a northern direction. Six streams flow into Little Lake Valley which from Outlet Creek. Seven additional streams flow into Outlet Creek before reaching the confluence with the main stem Eel River;
- Artificial channels were created and natural channels straightened to facilitate the draining of Little Lake into Outlet Creek. This practice widened the channels, increased water transport rates, decreased pool depth, and increased runoff related stream bank erosion;
- Average rainfall is 56 inches per year with a range from 35-90 inches.

Geology

- The basin is underlain by the Pliocene-Cretaceaous Coastal Belt (73%), Tertiary-Jurassic Central Belt (17%), Pliocene-Pleistocene Valley Fill (3%) and Quaternary alluvium (8%).

Vegetation

- Redwood and fir forests have historically dominated the basin. Additional vegetation includes tan oak, madrone, alder, bishop pine, ponderosa pine, willow, grass, oak, bay laurel, manzanita, and blue blossom. Pre-European forests consisted of mostly large old-growth redwood, ponderosa, and Douglas fir trees;
- Fire was also used extensively in all portions of the Basin by early homesteaders and ranchers prior to logging activities to create and maintain grazing lands for livestock. Smith (pers. comm. 2004) recalls that between 1912 and 1915, his grandfather was paid 2 cents for every fir tree he girdled by fire near what is known today as the Shamrock Ranch.
- Fires have occurred in all three subbasins and 38,387 acres were burned. The Strong Mountain fire was the largest recent fire which burned 20,619 acres on the west side of the Outlet Creek Basin.

How has land use affected these natural processes?

Findings and Conclusions:

- The land uses include grazing, timber production, and large rural residential properties which can change the composition of the vegetation and reduce surface water flow and aquifer dynamics;
- Natural low flow conditions are severely reduced by legal and illegal dewatering;
- Roads and railroad lines have disconnected the stream bank and flood plains from the instream habitat.

Based upon these conditions trends, and relationships, are there elements that could be considered to be limiting factors for salmon and steelhead production?

Findings and Conclusions: Findings and Conclusions:

Based on the information available for this assessment, it appears that salmonid populations are currently being limited by:

- Low and/or absent flows in August and September;
- Low and/or absent flows in November;
- High summer water temperatures;
- Subsurface flows obstructing fish migration;

- Fine sediment from bank erosion, debris slide erosion, roads, culverts, livestock, feral pigs and other land use activities;
- Bank erosion for wildlife;
- Low canopy density increasing water temperatures;
- Inadequate instream shelter, pool depth and frequency;
- Natural and man-made barriers;
- Channelized and leveed stream banks.

What watershed and habitat improvement activities would most likely lead toward more desirable conditions in a timely, cost effective manner?

Flow and Water Quality Improvement Activities

- Enforce regulations to eliminate water extraction in July, August, and September, especially in Outlet and Long Valley Creeks;
- Start a neighborhood watchdog group to report water extraction during the late summer and early fall months.

Fish Passage

- Enforce and continue to enforce bypass flows on Morris dam and out of Lake Emily;
- There are a total of 30 know barriers blocking approximately 28 miles of stream in the Outlet Creek Basin. Seven are complete, 23 are partial, and 12 barriers of unknown status;
- Replace and/or eliminate culverts which inhibit migration.

Erosion and Sediment Delivery Reduction Activities

- Unpaved, unimproved rural roads should be upgraded to reduce erosion which contributes fine sediment to the streams.

Riparian and Instream Habitat Improvement Activities

- Restoration efforts focused on improving canopy be located in streams with unsuitable EMDS ratings such as Outlet, Long Valley, and Bloody Run creeks;
- Major restoration efforts should be focused on improving pool depths and shelter, and located in steams with unsuitable EMDS ratings such as Outlet, Long Valley, and Cherry creeks;
- Implementation of restoration projects focused on increasing canopy, and pool depth and shelter, will improve the overall reach conditions.

Education, Research, and Monitoring Activities

- Continue to support efforts to establish and maintain an active watershed group focused on the outlet Creek Basin;
- CDFG should continue and expand existing monitoring of anadromous salmonid populations to include some winter and spring fish sampling;
- Support stream gage installations and maintenance to establish a long term record of the Outlet Creek hydrologic conditions;
- Continue water temperature monitoring at current locations and expand these efforts where appropriate.

Table X. Prioritized Improvement Activities

Location	Improvement Activity	DFG Fisheries Project Types	Coho Recovery Plan Task Number	Steelhead Recovery Plan Task Number	CWPAP Priority
Basin	Eliminate illegal water drafting by closing vehicle access to the creek through riparian restoration.	HR	RW-II-A-02		1
Basin	Monitor and assess the salmonid populations. Conduct inventories salmonid populations by snorkel surveys or by operating fish counting weirs.	HR-MD	RW-XXIX-F-01	NC-02 and 03; NC-24	2
Basin	Disseminate bilingual educational materials, outreach and training for issues such as poaching, pollution, riparian destruction, illegal stream crossing and illegal water withdrawl.	WC	RW-XXXIII-A-	NC-08	1

			23		
Basin	Monitor water quality. Improve water quality by reducing or minimizing point and non-point source nutrient input.	MD	RW-V-B-01	NC-08	1
Basin	Add large woody debris and/or other instream structures	HI	RW-XXII-A-04	NC-08	1
Basin	Re-vegetate stream bank to develop and/or expand canopy.	HI	RW-XXII-A-04		2
Basin	Remove non-native invasive plant species on stream banks and replant with native species to increase both stream bank stability and canopy cover .	HR	RW-XXII-A-04		2
Basin	Remove Fish Passage barriers	FP	RW-XXII-A-04	NC-02 and 03; NC-24	1
Basin	Identify sediment input from roads and culverts. Reduce or eliminate sediment input.	HU HS	RW-VI-D-01		2
Northern Southern	Install wildlife friendly and livestock exclusion fencing in damaged riparian, unstable stream banks or other sensitive areas.	HI	RW-XXII-A-02		2
Southern	Restore natural drainage patterns and minimize hydrologic connectivity of roads, where feasible.	HS	RW-VI-B-01 RW-XIII-C-01 and 02	NC-08	1
Southern	Maintain and continue to maintain compliance with the City of Willits water permit from the Department of Fish & Game;	MD	RW-XXXIII-A-01 ER-OC-02		1
Southern	Replenish gravel below Centennial Dam on Davis Creek. Continue to replenish gravel below the Lake Emily dam.	HI	RW-XXIX-F-01	NC-08	1
Southern	Develop water conservation measures in and around the City of Willits such as water conservation reminders to monthly bills, changing rate structure so that water becomes more expensive with increased usage, develop an incentive program to convert existing faucets, shower heads, and toilets to low flow versions.	WC	RW-XXXIII-A-01 ER-OC-02b		1

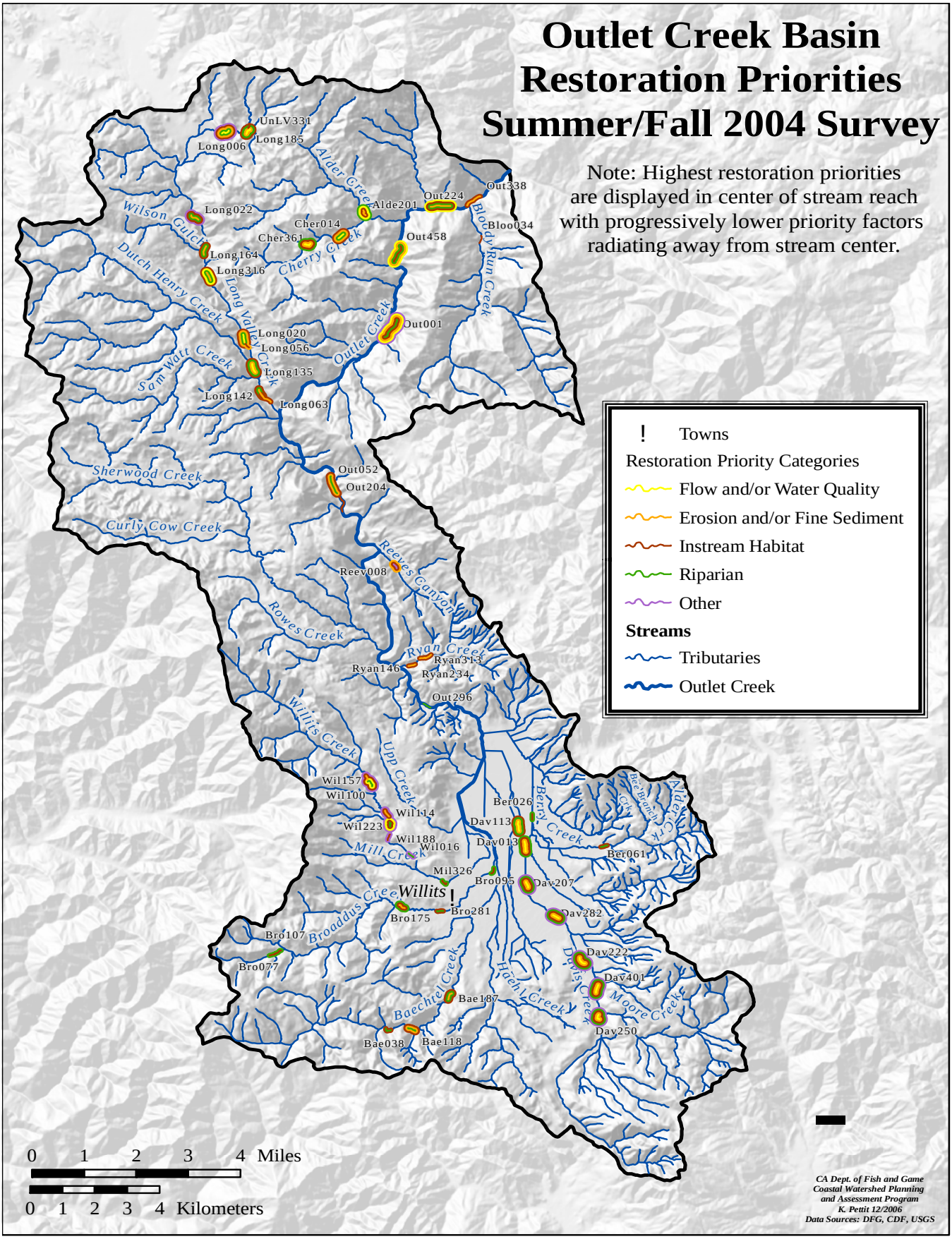

Figure X. Primary Restoration Category by Priority

Outlet Creek Basin Conclusions

The Outlet Creek Basin, in the Eel River System, has been greatly affected by land use changes over nearly the last two centuries. Salmonid populations have been challenged by channelization, levees, dams, intense fisheries and timber harvest practices, road construction, grazing and agriculture, and legal and illegal dewatering. Ninety-nine percent of this basin is privately owned. Salmonid populations are currently being limited by reduced habitat complexity, high water temperatures, low summer stream flows, embedded spawning gravels, and artificial passage barriers. Historical accounts indicate that stream conditions were favorable for salmonid populations in the past. There are many opportunities for improvements in stream conditions in the basin as well as a great need to restore areas of stream refugia. Surveys by landowners, water temperature monitoring, riparian canopy restoration, and improvements to channel complexity such as additional LWD are examples of such opportunities. The stability and erosiveness of terrain should be considered before project implementation and appropriate BMPs should be followed to minimize erosion and sediment delivery to streams. Conditions beneficial to salmonids may be further enhanced in this basin through encouraging all motivated basin landowners to us good land stewardship practices and enlisting the aid and support of agency funding opportunities