Section F

Fish Habitat Assessment

Introduction

The anadromous fish species inhabiting the Noyo River WAU are coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*O. mykiss*). Other non-salmonid species include the three spine stickleback (*Gasterosteus aculeatus*), Pacific lamprey (*Lampetra tridentata*), and sculpin (*Cottus* spp.). A level II fish habitat assessment was conducted in the Noyo River WAU to identify the current habitat conditions and areas of special concern regarding the three life history stages of salmonids: spawning, summer rearing, and over-wintering.

Field studies conducted to evaluate the quality and quantity of fish habitat in the Noyo River WAU include fish habitat assessment, fish distribution, stream gravel permeability measurements, and bulk streambed gravel samples. The evaluation of fish habitat conditions is based on target conditions presented in The Watershed Analysis Manual (Version 3.0, Washington Forest Practice Board), The Louisiana-Pacific Watershed Analysis Manual, and on inherent geomorphic characteristics of the stream. The target conditions for pools, wood, and fine sediment defined in these manuals are based on research of unmanaged drainages, technical studies, and professional judgment by fisheries biologists.

Fish distribution surveys were conducted in the WAU from 1994-1996. Surveys were conducted during the late summer and early fall months to assess present juvenile salmonid distribution and species composition. Surveys were conducted over a three year period because coho salmon adhere to a strict three year life history cycle and one goal was to capture all possible coho population year classes. Sites were selected in 1994 to cover the widest geographic area and the number of sites surveyed increased annually until the completion of the surveys in 1996.

Permeability and gravel composition samples were taken in fish-bearing reaches of the Noyo River WAU to measure the quality of spawning or potential spawning gravel. Permeability and gravel particle size distribution are stream substrate parameters which affect survival of incubating salmonid embryos. Salmonid eggs buried under as much as a foot of gravel depend on sufficient intergravel water flow for their survival and development. Fine sediment within spawning gravel can impede intergravel water flow, reducing the delivery of dissolved oxygen to the eggs, there by increasing mortality in the egg to emergence stage. Forest management practices may increase the delivery of fine sediment to the stream channel, potentially impacting spawning gravel. The assessment of substrate permeability and composition is useful in monitoring the effects of increased sediment delivery on salmonid spawning and incubation conditions.

Steelhead Trout

Steelhead (*Oncorhynchus mykiss*) migrate upstream to spawn during the winter. Steelhead begin entering spawning streams in October and November and continue through February and March. The mainstem and major tributaries of the Noyo, North Fork Noyo, and Middle Fork North Fork provide the primary portion of steelhead spawning and rearing habitat. Smaller tributaries, characterized by steep gradient and high confinement, limit the availability of habitat for anadromous fish. Map F-2 shows the areas of life history use for steelhead. Map F-1 identifies adult migration barriers.

After completing their upstream migration, adult females construct redds for spawning by excavating gravel 4” to 12” deep and fifteen inches in diameter (Needham and Taft 1934; Shapovalov and Taft 1954). Redds are oval shaped depressions excavated by the tail of a female. Suitable gravel for steelhead spawning range in size from 0.25” to 5” in diameter (Barnhart 1991). Eggs are deposited in excavated depressions. Gravel which has been cleaned and sorted through the excavation process is used to cover the eggs in pockets. Male steelhead fertilize the eggs during the redd construction process and aggressively defend the area against other males. Redd construction takes place in pool tail-outs or riffle heads where water is the most oxygenated. Length of incubation for eggs is temperature dependent and ranges between twenty and 100 days (Roelofs 1985; Barnhart 1991). Adult steelhead are capable of returning to the ocean and spawning again in subsequent years, although some die after the first year of spawning.

Fry emerge from egg pockets with egg sacks on their ventral surface ranging from 25 to 30 mm in length. During this time, areas of low velocity and shallow water habitats such as stream margins and low gradient riffles are preferred. Foraging takes place in open areas lacking instream cover (Hartman 1965; Everest et al. 1986; Fontaine 1988). In the late summer and fall, fry increase in size, and habitat preference changes to higher velocity, deeper mid-channel pools (Hartman 1965; Everest and Chapman 1972; Fontaine 1988). Juvenile steelhead, also called parr, rear in freshwater from one to four years before migrating to the ocean as smolts. Parr show a preference for habitat with rocky substrates (Hartman 1965; Fausch 1993) because boulders and rocks create shelter in the form of shadows, white water, and cracks to hide in. Foraging typically occurs in scour and plunge pools where there is cover and high velocity. Steelhead are opportunistic feeders, utilizing the roughness element provided by boulders and log clusters to rest and pick off food as it drifts in the current (Fontaine 1988; Bisson et al. 1988).

During the winter, steelhead prefer pool habitats, especially deeper low velocity pools with rocky substrate and LWD for cover (Hartman 1965; Fontaine 1988). The size of substrate preferred differs depending on age class. Fry are able to make use of small to large cobble substrate for cover while parr tend to use larger cobbles and boulders (Everest et al. 1986). During the winter months deeper pools with cover are preferred because they prevent displacement of fish during high flows.

Coho Salmon

Coho salmon (*O. kisutch*) begin entering streams in mid-December and continue through mid-February. Similar to steelhead habitat requirements, the mainstem and major tributaries provide a majority of the Coho habitat because steep channel gradients and high confinement limit habitat in smaller tributaries. Lack of LWD, high summer stream water temperatures and low structural complexity are factors that limit the ability of coho to establish viable populations.

Females arriving on spawning grounds select redd sites and defend the area against other females. Like other salmonids, females excavate a depression in the gravel by using their tail. The preferred spawning location for coho are low gradient (<3%) tributary streams. Egg pockets in coho are 20" to 47" wide and 4" to 9" deep (Tautz 1977; van den Berghe and Gross 1989). Optimum gravel particle size is 1.3 to 10.2 cm. (Stillwater 1998). Females continue to guard the redd against other females until they are too weak to maintain position in the current (Briggs 1953). Males and females die soon after spawning. Coho salmon eggs incubate from 35 to 50 days at temperatures of 9°C to 11°C (Shapovalov and Taft 1954).

Juvenile coho salmon select habitat primarily based on water velocity, although light intensity and depth are also considerations (Shirvell 1990). After emergence, fry disperse upstream and downstream into areas of suitable habitat. Usually, side channels and backwaters or other areas of slow velocity and low light intensity are utilized during the rearing period (Stillwater 1998). Coho juveniles typically prefer woody debris as cover, rather than rock and other substrate which is the preferred cover of steelhead parr (Bugert 1985).

LWD in streams is a primary component of coho rearing habitat. In addition to providing shelter, LWD promotes scour which leads to deeper pools. In coastal northern California streams, the presence or absence of LWD plays a key role in influencing the suitability for rearing coho habitat. McMahon and Reeves (1989) have suggested that LWD is a "keystone" feature for salmonids because of its predominating influence on stream morphology (e.g., bank condition, pool creation), sediment and organic matter retention, water velocity, and shelter (Stillwater 1998).

Deep pools provide key habitat for juvenile coho salmon in the summer months in the form of cold water refugia. In the winter months, deep pools prevent displacement of young fish. The ideal pools for coho have slow areas with woody cover, logs, rootwads, and flooded brush. Deep pools which are structurally complex offer juveniles the most protection from predation and displacement in swiftly moving current.

Methods

To identify study sites stream gradient was the primary criterion utilized. Other factors included the presence of fish (data obtained from the Louisiana-Pacific fish distribution surveys of 1994-1996), accessibility, stream channel type (response, transport or source reach), and representative segments that were likely to respond similar to other stream channel types within the watershed. Since high gradient streams were likely to be non-fish bearing, survey efforts were concentrated on major streams.

The fish habitat assessment was conducted during low flow conditions in June of 1998. Habitat inventory methods were modified from the California Salmonid Stream Restoration Manual (Flosi et al., 1998), and utilized to describe 100% of the wetted width. A distance of 20-30 bankfull widths determined the survey length to ensure at least two meander bends of the stream channel were observed. Data collected during the fish habitat and stream channel surveys provided information on pool frequency, pool spacing, spawning gravel quantity and quality, overwintering substrate, shelter complexity, and large woody debris (LWD); frequency, condition and future recruitment.

A survey was conducted within each habitat unit. Table F-1 displays the indices used for rating measured parameters. To combine the measured parameters into a quality rating for individual life history stages (spawning, summer rearing, and overwintering habitat), a subset of the parameters for each life history stage was weighted and given a numeric score. The parameters were scored as follows: 1 (poor), 2 (fair), and 3 (good). Parameter weights were applied to the total score calculated as shown below. The parameter numbers are in bold and the weights in parentheses.

Spawning Habitat
E (0.25) + **F** (0.25) + **G** (0.25) + **H** (0.25)

Summer Rearing Habitat
A (0.20) + **B** (0.15) + **C** (0.15) + **D** (0.15) + **F** (0.15) + **I** (0.20)

Overwintering Habitat
A (0.20) + **B** (0.15) + **C** (0.15) + **D** (0.10) + **I** (0.20) + **J** (0.20)

The overall score would be rated as follows:
1.00 - 1.66 = Poor
1.67 - 2.33 = Fair
2.34 - 3.00 = Good

To cover the greatest geographical area, a hierarchical framework was used to select locations of fish distribution sites in each river or stream. The primary focus was on anadromous reaches within the Noyo River WAU. The mainstem and larger tributaries were segmented into upper, middle and lower segments. The smaller tributaries were divided into upper and lower segments. Surveys were conducted during low flow conditions during late summer and early fall. If a survey site was determined to be non fish-bearing at the time of survey the site was dropped from coverage in the preceding year. The number of sites increased annually. The primary method was electrofishing using a Smith-Root Model 12 backpack electrofisher. Multiple habitat units were fished and stunned fish were netted and placed in holding buckets. Captured fish and other aquatic species were identified and enumerated into abundance categories. Fish were then released back into the habitat units from which they were captured.

Steam gravel permeability and bulk gravel samples were collected on several established stream monitoring segments (similar segments for thalweg profile and cross section surveys). These stream segments in the Noyo WAU were segments 1, 23, 106, 159 lower section and 153 upper section (see Section E - Stream Channel Condition, Map E-1 for exact locations).

The stream gravel permeability was measured using a 1 inch diameter stand-pipe similar to the stand-pipe discussed in Terhune (1958) and Barnard and McBain (1994) with the exception that our stand-pipe is smaller in diameter. We used the smaller diameter stand-pipe because we hypothesize that it will create less disturbance to the stream gravels when inserted. Bulk stream gravel samples were taken with a 12 inch diameter McNeil sampler as described in Platts, Megahan and Minshall (1983).

The permeability and bulk gravel samples were taken in 4 pool tail-out sections of the stream monitoring segment, which was approximately 20-30 bankfull channel widths in length. These 4 pool tail-out locations were randomly selected in the stream monitoring segment. At each pool tail-out sampled permeability was measured at 3 sites across the channel, the ¼, ½ and ¾ mark of the wetted channel. Permeability measurements were taken at a depth of 12.5 cm and 25 cm at each site. A bulk gravel sample was taken on the permeability site closest to the thalwag of the channel (the deepest spot). The bulk gravel sample was stratified by depth to correspond to the two depths of permeability measurements.

After the bulk gravel samples were collected the gravel is dried and sieved through 7 different size-class screens (50, 25, 12.5, 6.3, 4.75, 2.36, 0.85 mm). The weight each gravel size class was determined for each of the bulk gravel samples using a commercial quality scale.

From the sieved bulk gravel samples the fredle index, geometric mean and percent fine particles less than sieve size classes were determined. The survival index for steelhead trout was calculated from the bulk gravel samples using the method described in Tappel and Bjorn (1983). Permeability at the bulk gravel sample location and the mean permeability coefficient for each tail-out depth is calculated.

Table F-1. Fish Habitat Condition Indices For Measured Parameters

Fish Habitat Parameter	Feature	Fish Habitat Quality: Poor	Fair	Good
Percent Pool (of survey site length) **(A)**	Anadromous Salmonid Streams	<25%	25-50%	>50%
Pool Spacing (reach length/bankfull/#pools) **(B)**	Anadromous Salmonid Streams	≥ 6.0	3.0 - 5.9	≤ 2.9
Shelter Rating (shelter value x % of habitat covered) **(C)**	Pools	<60	60-120	>120
% of Pools that are ≥3 ft. residual depth **(D)**	Pools	<25%	25-50%	>50%
Spawning Gravel **(E)**	Pool Tail-outs Quantity	<1.5%	1.5-3%	>3%
Percent Embeddedness **(F)**	Pool Tail-outs	>50%	25-50%	<25%
Subsurface Fines (L-P watershed analysis manual) **(G)**	Pool Tail-outs	poor	fair	good
Gravel Quality Rating (L-P watershed analysis manual) **(H)**	Pool Tail-outs	poor	fair	good
Key LWD +Rootwads / 328 ft. of Stream **(I)**	Streams≤40 ft. BFW	<3.3	3.4-6.7	>6.8
	Streams ≥40 ft. BFW	<5	5.1-10	>10.1
Substrate for over-wintering **(J)**	All Habitat Types	<20% of Units Cobble or Boulder Dominated	20-40% of Units Cobble or Boulder Dominated	>40% of Units Cobble or Boulder Dominated

Results and Discussion

A total of 24 segments, ranging between 0% and 8% slope were field evaluated. The majority of the Noyo River WAU is between 0-2% slope, and 58% of the segments surveyed were from these categories. The subset of parameters for individual segments can be found in Table F-2. Each parameter is assigned two values: score and rating. The 'score', column I, is the value assigned to the habitat characteristic in the field. The 'rating', column II, is the corresponding value from calculation of habitat parameter weightings. Ratings were used in the overall equation for each life history stage. A summary of the habitat ratings corresponding to each life history stage can be found in Table F-3.

Fish distribution surveys were conducted from 1994-1996. A total of fifty-five sites were surveyed in the three year period. Twenty-five sites were surveyed in 1994, twenty-nine sites in 1995, and fifty-two sites in 1996. Fifty-one sites had steelhead present and twenty-one sites had coho salmon. Map F-1 illustrates the distribution of steelhead trout, coho salmon, resident trout, and other non-salmonid fish species (sculpin, stickleback, and Pacific lamprey) in the Noyo River WAU. Both steelhead and coho salmon were present in the mainstem and major tributaries, while steelhead but not coho were found inhabiting smaller, high gradient tributaries. Coho salmon were found in the highest densities in Redwood Creek. Map F-2 depicts potential spawning, summer rearing and overwintering habitats for steelhead and coho. The habitat usage by life history stages is extrapolated from field evaluation, fish survey data, and results of Noyo fish habitat assessment.

The results from the bulk gravel samples and permeability measurements are presented in Table F-4. Percent survival-to-emergence indices for spawning gravel were calculated from the bulk gravel and permeability data for samples taken at the 18-30 cm depth. The Tappel/Bjorn index (1983) was used to calculate survival-to-emergence from the bulk gravel samples. The index for percent survival of steelhead was used because Tappel and Bjorn (1983) only present two survival indices for chinook salmon and steelhead trout. The steelhead index was used because it more closely approximates the fishery in the Noyo WAU, coho salmon and steelhead trout. Chinook salmon are larger fish than coho or steelhead and can spawn in larger substrate making the index based on Chinook salmon impractical for the Noyo WAU. An index calculated from data from Tagart (1976) and McCuddin (1977) (Stillwater Sciences, 2000) was used to estimate survival to emergence from permeability data. This index is not robust and additional work is needed, but it is useful for interpreting permeability information.

The estimated percent survival of emerging steelhead, from Tappel and Bjorn (1983), varied from 10% to 83% in the sampled locations (Table F-4). The survival-to-emergence index calculated for the permeability data showed lower survival rates (Table F-4). The range of survival percentages from permeability data ranged from 4% to 62%. These survival indices reflect conditions at pool tail-outs where a spawning fish has not worked the gravels into a redd. Therefore they reflect the relative quality of stream gravels that a spawning fish has to work with. Areas of stream gravels with a high survival percentage would likely be preferred by spawning fish and likely have better survival success for emerging fish. Areas of stream gravels with a low survival index percentage may not be completely poor quality, particularly because they will have permeability and gravel quality improved following redd development, but likely will not be the preferred condition.

Generally, the percentage of fine sediment (<0.85 mm and <6.3 mm) was not found to be high in the Noyo WAU. Almost all of the locations sampled had percent fine particles less than 0.85 mm under 14-20 percent, which is considered within a properly functioning range, especially considering that when a fish spawns a significant portion of these fines will be cleaned. Fredle indices and the geometric means for the sampled locations varied throughout the Noyo WAU, however, when a spawning fish works stream gravels these values will change.

We feel the use of permeability as the indicator of current stream gravel quality is the better indicator of conditions necessary for developing fish embryos. In most of the laboratory studies of fish emergence from incubating eggs, survival is related to the proportion of fine particles or the size class distribution of the gravel fish embryos are developed in. These measures are used to indicate the ability of water borne nutrients and dissolved oxygen to reach the embryos. Therefore, measures of fine particles or size class distribution indices, etc. are surrogates for gravel permeability. Direct measure of the permeability conditions that occur in the stream gravels is the best indication of this quality. When using permeability as an indicator of spawning gravel quality in the Noyo WAU, the results suggest improvement needed for the quality of spawning gravels.

Table F-2. Summary of Fish Habitat Parameters, with Field Scores and Corresponding Ratings. Noyo River Watershed Analysis Unit, Mendocino, CA. July, 1998.

	A. % Pool by stream length		**B.** Pool Spacing		**C**. Shelter rating		**D.** % of all pools with residual depth ≥3 ft.		**E.** Spawning gravel quantity		**F.** % Embeddedness		**G.** Sub-surface fines		**H.** Gravel Quality		**I**. Key LWD + rootwads / 328 ft.		**J.** % Over-wintering substrate	
Segment	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating
1	42	2	7.4	1	27	1	81	3	3	3	Fair	2	1.6	3	2.8	3	2.3	1	20	2
3	34	2	4.9	2	14	1	20	1	2	2	Fair	3	2.5	1	1.7	2	1.8	1	37	2
23	50	2	2.9	3	25	1	13	1	2.2	2	Good	3	2.6	1	2.3	2	3.2	1	11	1
48	26	2	3.4	2	11	1	0	1	3	3	Good	3	2.9	1	2.3	2	14.5	3	0	1
56	38	2	5.3	2	55	2	16	1	3	3	Good	3	1.7	2	2.6	2	1.0	1	73	3
57	23	1	7.2	1	34	2	31	2	3	3	Good	3	2.2	2	2.1	2	1.1	1	60	3
63	37	2	4.2	2	30	2	0	1	2	2	Good	3	1.7	2	2.0	2	11.1	3	89	3
64	2	1	10.4	1	25	1	0	1	1.7	2	Good	3	2.0	2	2.0	2	7.7	3	75	3
80	5	1	10.3	1	150	3	0	1	1	1	Good	3	1.3	3	1.7	2	3.3	1	78	3
92	55	3	2.5	3	30	2	13	1	3	3	Fair	2	1.6	3	2.3	2	5.4	2	64	3
92(2)	64	3	2.5	3	16	1	89	3	3	3	Good	3	1.7	2	2.5	3	11.1	3	63	3
104	63	3	3.0	2	93	3	59	3	1.4	2	Good	3	2.4	1	2.5	3	0	1	54	3
106	61	3	3.8	2	36	2	7	1	2.5	2	Fair	2	2.3	2	2.5	3	1.0	1	100	3
112	50	2	5.0	2	90	3	0	1	1	1	Fair	2	2.6	1	2.0	2	1.0	1	100	3
118	32	2	3.1	2	17	1	0	1	1.2	1	Fair	2	1.5	3	2.4	3	4.4	2	67	3
119	31	2	3.8	2	25	1	0	1	0.9	1	Good	3	2.5	1	1.5	1	36.1	3	45	3
152	79	3	3.2	2	39	2	21	1	0.5	1	Good	3	2.0	2	2.0	2	2.0	1	50	3
152(2)	45	2	3.1	2	86	3	12	1	2.5	2	Fair	2	2.1	2	2.0	2	3.5	1	76	3
153	34	2	4.4	2	15	1	0	1	2.8	2	Good	3	2.5	1	2.7	3	8.7	2	88	3
153(2)	26	1	4.2	2	43	2	0	1	2.8	2	Fair	2	2.0	2	1.3	1	9.3	2	73	3
156	70	3	2.6	3	34	2	0	1	2	2	Good	3	2.1	2	1.9	2	7.3	2	70	3
159	24	1	5.7	2	24	1	0	1	3	3	Fair	2	2.2	2	2.7	3	3.6	1	10	1
159(2)	23	1	5.7	2	45	2	0	1	1.5	2	Fair	2	2.2	2	2.5	3	14.7	3	40	2
161	39	2	15.2	1	53	2	9	1	2.7	2	Poor	1	2.9	1	1.3	1	33.5	3	44	3

Table F-3. Summary of Fish Habitat Ratings for Three Life History Stages. Noyo River Watershed Analysis Unit, Mendocino County, Ca., 1998.

Segment	Slope gradient class (percent)	Spawning habitat score	Spawning habitat rating	Rearing habitat score	Rearing habitat rating	Over-wintering habitat score	Over-wintering habitat rating
1	0-1	2.75	Good	1.65	Poor	1.60	Poor
3	0-1	2.00	Fair	1.65	Poor	1.55	Poor
23	1-2	2.00	Fair	1.80	Fair	1.50	Poor
48	2-4	2.25	Fair	2.05	Fair	2.15	Fair
56	0-1	2.50	Good	1.80	Fair	1.90	Fair
57	1-2	2.50	Good	1.60	Poor	1.65	Poor
63	2-4	2.25	Fair	2.20	Fair	2.30	Fair
64	2-4	2.25	Fair	1.30	Poor	1.40	Poor
80	1-2	2.25	Fair	1.60	Poor	1.70	Fair
92	1-2	2.50	Good	2.20	Fair	2.45	Good
92(2)	1-2	2.75	Good	2.70	Good	2.70	Good
104	0-1	2.25	Fair	2.45	Good	2.45	Good
106	1-2	2.25	Fair	1.85	Fair	2.10	Fair
112	4-8	1.50	Poor	1.80	Fair	2.05	Fair
118	2-4	2.25	Fair	1.70	Fair	1.95	Fair
119	4-8	1.50	Poor	2.05	Fair	2.15	Fair
152	1-2	2.00	Fair	2.00	Fair	2.10	Fair
152(2)	1-2	2.00	Fair	1.80	Fair	2.05	Fair
153	2-4	2.25	Fair	1.85	Fair	1.95	Fair
153(2)	2-4	1.75	Fair	1.65	Poor	1.90	Fair
156	4-8	2.25	Fair	2.35	Good	2.45	Good
159	1-2	2.50	Good	1.30	Poor	1.15	Poor
159(2)	1-2	2.25	Fair	1.85	Fair	1.90	Fair
161	4-8	1.25	Poor	1.75	Fair	2.15	Fair

Table F-4. Permeability and Bulk Gravel Sample Results for Select Stream Segments of the Noyo WAU.

Location, Depth	Geometric Mean	Fredle Index	Percent <0.85 mm	Percent <6.3 mm	Permeability at McNeil Site (cm/hr)	Tappel/Bjorn Index (% survival)	Tail-out Mean Permeability (cm/h)	Percent Survival Permeability
Seg 106 Tail-out # 5, 0-18 cm	35	6.8	2%	8%	11681		13769	
Seg 106 Tail-out # 5, 18-30 cm	22	3.1	6%	16%	5173	83%	2808	36%
Seg 106 Tail-out # 7, 0-18 cm	48	19.7	3%	8%	12037		10421	
Seg 106 Tail-out # 7, 18-30 cm	17	2.0	10%	22%	4573	66%	2090	31%
Seg 106 Tail-out # 8, 0-18 cm	19	1.7	5%	25%	2704		1727	
Seg 106 Tail-out # 8, 18-30 cm	10	0.8	11%	38%	243	54%	568	12%
Seg 106 Tail-out # 4, 0-18 cm	21	2.0	3%	11%	924		8259	
Seg 106 Tail-out # 4, 18-30 cm	8	0.4	18%	42%	405	10%	672	14%
Seg 159(Lower) Tail-out # 1, 0-18 cm	8	0.7	14%	42%	4430		4166	
Seg 159(Lower) Tail-out # 1, 18-30 cm	10	1.0	12%	35%	3699	49%	3907	41%
Seg 159(Lower) Tail-out # 2, 0-18 cm	23	3.5	5%	18%	3044		2028	
Seg 159(Lower) Tail-out # 2, 18-30 cm	9	0.8	11%	40%	732	51%	604	13%
Seg 159(Lower) Tail-out # 4, 0-18 cm	12	1.2	10%	31%	1726		1642	
Seg 159(Lower) Tail-out # 4, 18-30 cm	28	2.9	8%	21%	614	77%	491	10%
Seg 159(Lower) Tail-out # 5, 0-18 cm	19	1.5	8%	25%	2876		6438	
Seg 159(Lower) Tail-out # 5, 18-30 cm	15	0.8	12%	30%	257	53%	332	4%
Seg 1 Tail-out # 3, 0-18 cm	20	3.6	6%	20%	23553		10505	
Seg 1 Tail-out # 3, 18-30 cm	12	1.0	11%	32%	2080	59%	7523	50%
Seg 1 Tail-out # 4, 0-18 cm	31	5.9	4%	14%	9492		4984	
Seg 1 Tail-out # 4, 18-30 cm	12	0.9	8%	34%	5692	66%	3225	38%
Seg 1 Tail-out # 5, 0-18 cm	20	2.0	7%	23%	3803		2236	
Seg 1 Tail-out # 5, 18-30 cm	9	0.6	11%	40%	4966	48%	16546	62%
Seg 1 Tail-out # 6, 0-18 cm	37	8.2	3%	13%	5093		3835	
Seg 1 Tail-out # 6, 18-30 cm	16	1.3	7%	27%	2122	73%	4245	42%
Seg 23 Tail-out # 4, 0-18 cm	18	2.3	7%	22%	4718		3209	
Seg 23 Tail-out # 4, 18-30 cm	9	1.0	13%	35%	2977	41%	1723	28%
Seg 23 Tail-out # 5, 0-18 cm	24	3.5	4%	18%	2066		13615	
Seg 23 Tail-out # 5, 18-30 cm	26	3.5	4%	17%	1127	88%	966	20%
Seg 23 Tail-out. # 6, 0-18 cm	18	2.1	7%	23%	3957		8781	
Seg 23 Tail-out # 6, 18-30 cm	35	7.3	4%	13%	2122	88%	1623	27%
Seg 153(Upper) Tail-out # 2, 0-18 cm	39	9.0	3%	11%	3869		4025	
Seg 153(Upper) Tail-out # 2, 18-30 cm	14	0.8	13%	32%	866	46%	369	5%
Seg 153(Upper) Tail-out # 5, 0-18 cm	19	1.9	5%	29%	2595		3778	
Seg 153(Upper) Tail-out # 5, 18-30 cm	17	1.5	11%	26%	575	62%	1341	25%
Seg 153(Upper) Tail-out # 6, 0-18 cm	31	8.7	7%	13%	7626		8880	
Seg 153(Upper) Tail-out # 6, 18-30 cm	18	1.9	14%	24%	426	55%	480	9%
Seg 153(Upper) Tail-out # 7, 0-18 cm	23	2.7	8%	21%	2749		22258	

The following discussion of results is separated into the six planning watersheds of the Noyo WAU. Each planning watershed contained 1 to 8 survey segments.

North Fork Noyo

The segments surveyed (1, 3, 23, and 48) in the North Fork Noyo planning watershed range between 0% and 4% slope. Geomorphic Units 1-3 are associated with these segments. These Geomorphic Units are depositional with varying confinement associated with strath terraces. Coho and steelhead were found in all segments except 48 which had only steelhead. Spawning habitat rated 'Fair' in all segments except segment 1, which rated 'Good'. All of the segments exhibited an abundance of spawning gravel with low levels of embeddedness, and a high amount of fine sediment. Segment 1 had a low amount of fine sediment present, raising the overall rating for measured parameters to 'Good.' Rearing habitat in segments 1 and 3 rated 'Poor', while 23 and 48 rated 'Fair'. Fewer pools, a lower amount of wood, and a higher percentage of embeddedness contributed to the 'Poor' rating. Segments 23 and 48 had a higher frequency of pools which increased their rating to 'Fair', however all segments lacked instream cover and pool depth which prevented ratings from being 'Good'. The overwintering habitats in these segments all rated 'Poor' except for 48 which received a 'fair' rating. Overall these units had a fair amount of pools per stream length, yet lacked LWD, substrate roughness, and other elements of shelter complexity. Segment 48 had adequate LWD and received a 'Good' rating in that category.

Olds Creek

The segments surveyed (56, 57, 63, and 64) in the Olds Creek planning watershed ranged from 0% to 4% slope. These segments are in Geomorphic Units 1-3. These Geomorphic Units are depositional with varying confinement associated with strath terraces. Steelhead were present in all segments, and coho were found in segments 63 and 64. Spawning habitat rated 'Good' in segments 56 and 57, and 'Fair' in segments 63 and 64. There were low levels of embeddedness and fine sediment in all of the segments. Gravel quantity decreased in segments 63 and 64, lowering the overall quality. Segments 57 and 64 were assigned 'Poor' ratings for both rearing and overwintering habitat due to the lack of pools, low pool frequency and poor pool depth. In addition, little LWD was present. All segments had sufficient amounts of overwintering substrate which provides an element of roughness, but this alone does not warrant 'Good' overwintering habitat ratings for these units.

McMullen Creek

Only segment 80 was surveyed in this planning watershed. This segment is within Geomorphic Unit 3. Geomorhic Unit 3 is characterized by slightly entrenched depositional channels within strath terraces and 'U'-shaped canyons. Segment 80 has a slope of 1% to 2%, and both coho and steelhead were present. Spawning habitat consisted of low amounts of gravel, low embeddedness, and low levels of fines. The overall rating was 'Fair'. Rearing habitat was 'Poor' due to the lack of pools and LWD. Overwintering habitat was characterized by low amounts of pools, but high levels of substrate roughness, shelter, and small woody debris, which creates refuges for young fish. The overall rating was 'Fair'.

Redwood Creek

The two segments surveyed (92(lower) and 92(upper)) in this planning watershed had slope gradients of 1% to 2%. These segments are within Geomorphic Unit 3. Geomorphic Unit 3 is characterized as a slightly entrenched depositional channel within strath terraces and 'U'-shaped canyons. Both coho and steelhead are found throughout these segments. These segments rated 'Good' for spawning habitat. Gravel quantity was abundant in these sections with low levels of fine sediment associated with them. Embeddedness was slightly higher in segment 92(lower). Rearing rated 'Good' for the upstream segment, 92(upper), and 'Fair' for the lower segment of 92. Overwintering habitat was rated 'Good' for both of these segments. The lower segment had 50% less LWD and fewer pools than the upstream segment. Of the pools that were present in segment 92(lower), only 13% were greater than 3 ft. in depth. Eighty-nine percent of the pools in Segment 92(upper) were greater than 3 ft. deep. Redwood Creek had the highest densities of juvenile coho salmon than any other planning watershed in the Noyo River WAU.

Hayworth Creek

The five segments surveyed (104, 106, 112, 118, and 119) in the Hayworth Creek planning watershed had slopes ranging from 0% to 8%. Segment 104 is in Geomorphic Unit 1 and segments 106 and 118 are in Geomorphic Unit 2. These geomorphic units are depositional with varying confinement associated with strath terraces. Segments 112 and 119 are in Geomorphic Unit 4. This Unit is characterized as a moderate gradient transport segment of 'V'-shaped canyons. Steelhead were found in all segments and coho were found in segments 104 and 106. Spawning habitat was assigned a rating of 'Fair' in segments 104, 106, and 118. The other two segments, 112 and 119, had the highest amount of subsurface fines and the least amount of spawning gravel. Segment 112 was entirely boulder dominated. These factors lead to a rating of 'Poor' for spawning habitat quality for segments 112 and 119. Rearing habitat for segments 106, 112, 118, and 119 was 'Fair'. Segment 104 was 'Good' for rearing habitat. Segment 119 had the fewest amount of pools, the lowest value of shelter complexity, and no pools greater than 3 ft. deep. Overwintering habitat was rated 'Fair' in all segments except 104, which was 'Good'. Of the four 'Fair' segments, only one, segment 106, had pools with a residual depth greater than 3 ft. Segment 104 had the highest shelter value, highest amount of pools by stream length, and 59% of the pools were greater than 3 ft. in residual depth.

Middle Fork North Fork Noyo

The eight segments surveyed (152(lower), 152(upper), 153(lower), 153(upper), 156, 159(lower), 159(upper), and 161) in the Middle Fork Noyo Planning Watershed had slope gradients ranging from 1% to 8%. Segments 152, 153, and 159 are within Geomorphic Units 1-3. These geomorphic units are depositional with varying confinement associated with strath terraces. Segments 156 and 161 are in Geomorphic Unit 4. This Unit is characterized as a moderate gradient transport segment of 'V'-shaped canyons. Segments 156, 159(lower), 159(upper) and 161 had only steelhead present while steelhead and coho were found in all other segments. The spawning habitat was rated as 'Fair' for all but two segments, 159(lower) and 161. Segment 159(lower) was rated as 'Good' and segment 161 was rated as 'Poor'. The 'Poor' rating was attributed to higher amounts of subsurface fines which lead to an increased amount of embeddedness. Segments 153(upper) and 159(lower) rated 'Poor' for rearing habitat. These two units had the least amount of pools per stream length, no pools greater than 3 ft. deep, and a decreased pool frequency. Segments 153(lower) and 159(upper) rated 'Fair' for rearing habitat. For overwintering habitat, six of the eight segments were rated as 'Fair'. Segment 156, which had the greatest number of pools and the highest frequency of pool spacing, was the only 'Good' rating for overwintering habitat. Segment 159(lower) received the only 'Poor' overwintering rating due to a lack of pool frequency, pool shelter complexity, and lack of large substrate.

Large Woody Debris Removal

Fifty percent of the units surveyed within these planning watersheds were deficient in LWD and only twenty-five percent had optimal LWD. LWD provides cover for fish, increases shelter complexity and scours the channel aiding in pool formation and depth. LWD also controls stored sediment as it meters through the stream system developing spawning habitat.

In the late 1950s and early 1960s it was the belief of California Department of Fish and Games (CDFG) that removal of LWD improved habitat. By removing LWD scouring winter flows would remove silt and gravel deposited behind log jams. Thus improving spawning conditions and food production increasing beneficial uses for anadromous fishes. Between 1959 and 1964 CDFG removed LWD accumulations by burning in channel and cutting material and placing it above the floodplain. Approximately four million six hundred and sixty-one thousand six hundred and sixty-eight board feet were removed from the Noyo River during this time period. The quantities of material (in board feet (bf)) removed from the tributaries is listed below.

Tributary	LWD Removed
Little North Fork Noyo	201,420 bf.
North Fork Noyo	18,000 bf.
Hayworth Creek	2,232,480 bf.
Duffy Gulch	362,040 bf.
Burbeck Creek	67,800 bf.
Kass Creek (S.F. Noyo)	132,024 bf.
Marble Gulch	604,440 bf.
Olds Creek	153,900 bf.
Redwood Creek	590,244 bf.
McMullen Creek	299,340 bf.

The removal of LWD appears to have degraded the rearing and overwintering habitat. Spawning gravels were potentially lost in high water events when LWD otherwise could have stored these gravels, metering them through the Noyo River watershed through the course of its functional lifetime.

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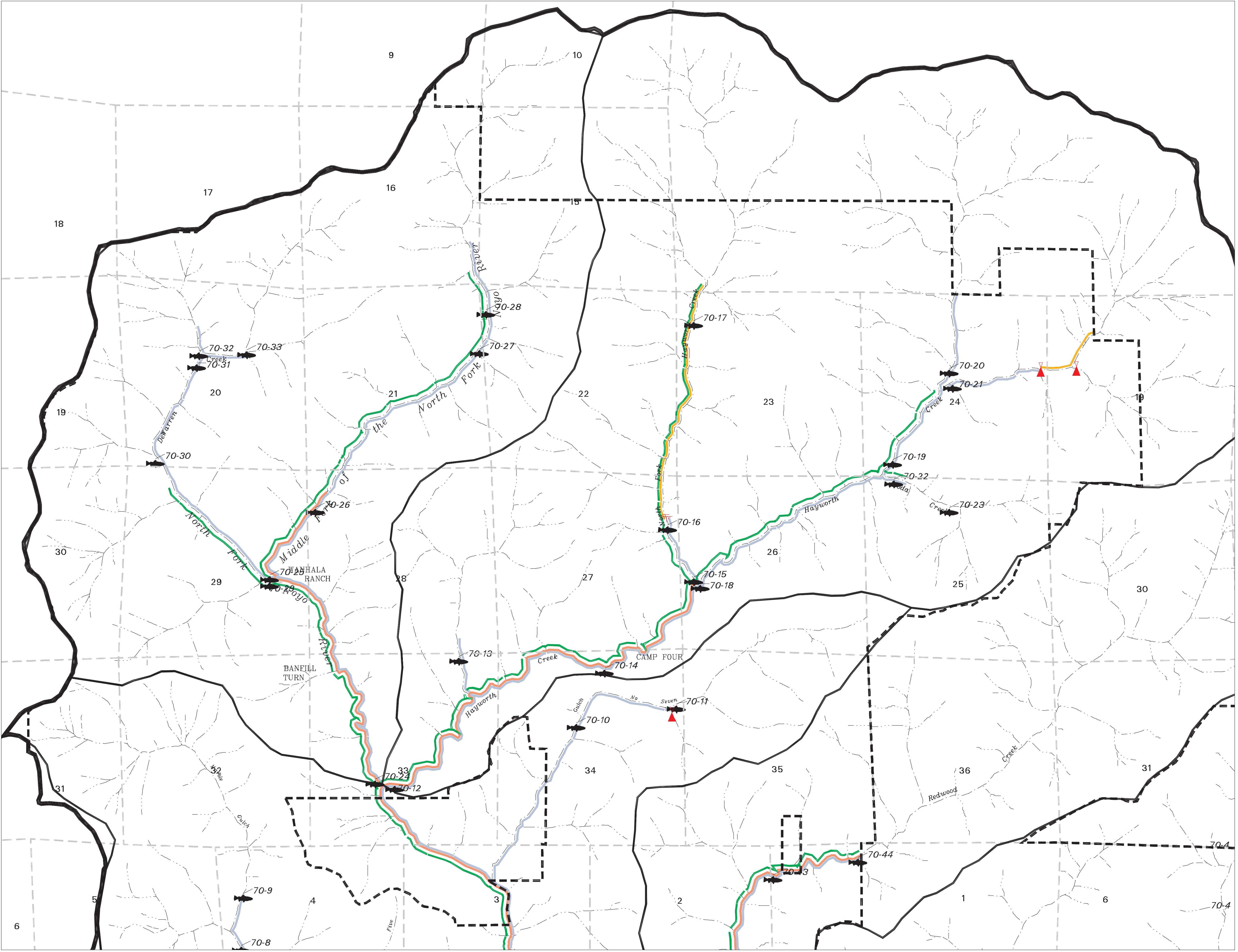


Noyo River Watershed Analysis Unit

Map F-1
Potential Fish Distribution

Potential Fish Distribution

- Coho Salmon Distribution
- Steelhead Distribution
- Rainbow Trout Distribution
- Non-Salmonid Fish Distribution
- Fish Distribution Sampling Locations

Barriers to Adult Migration

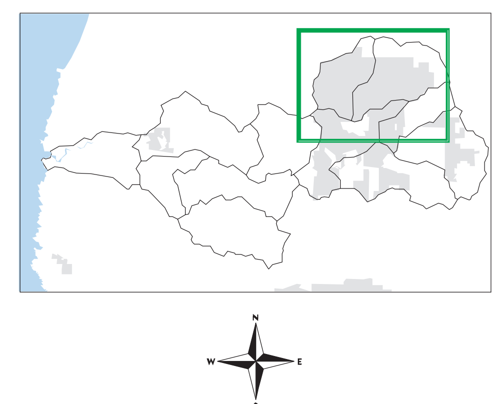
- Gradient
- Waterfall

Flow Class

- Class I
- Class II
- Class III

- MRC Ownership
- WWAA Boundary
- Planning Watershed Boundary

Sheet 1



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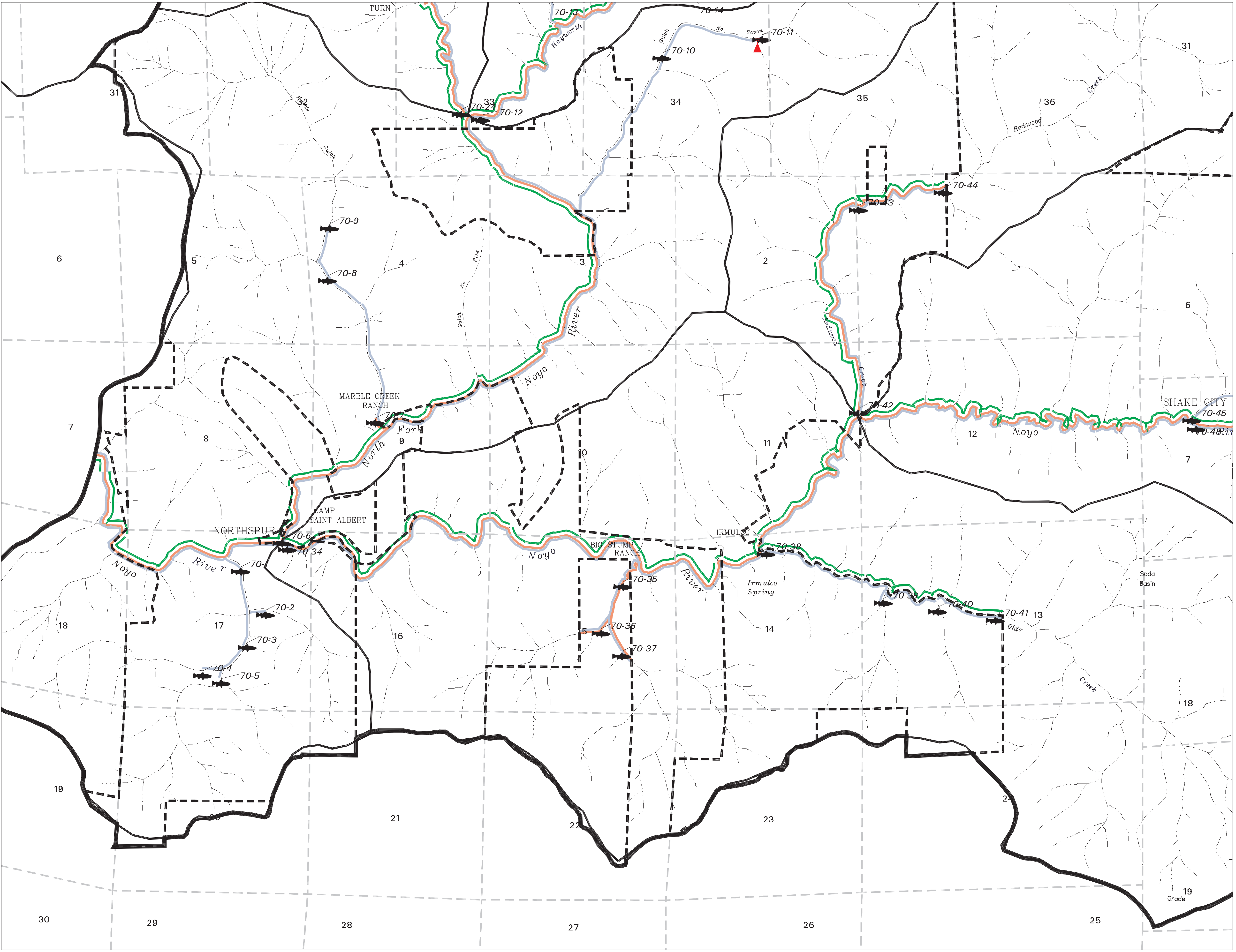

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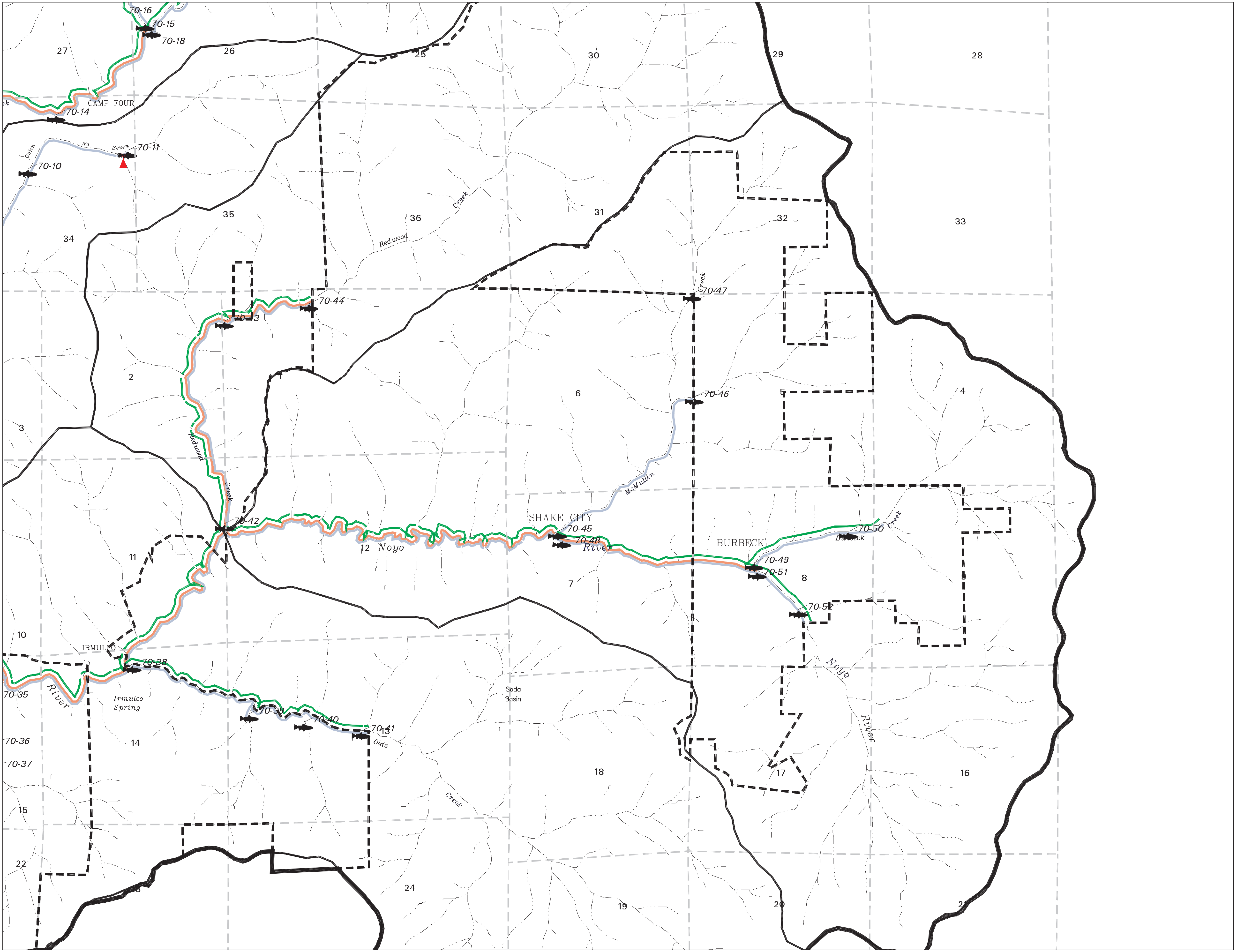
0 1/2 1 Mile

July 19, 2000

Noyo River Watershed Analysis Unit

Map F-1
Potential Fish Distribution



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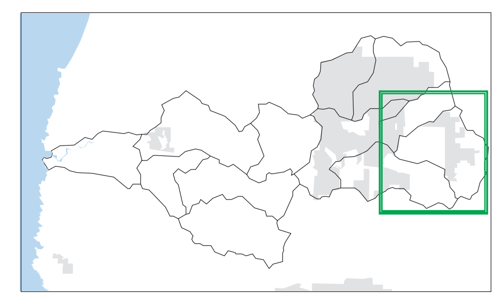

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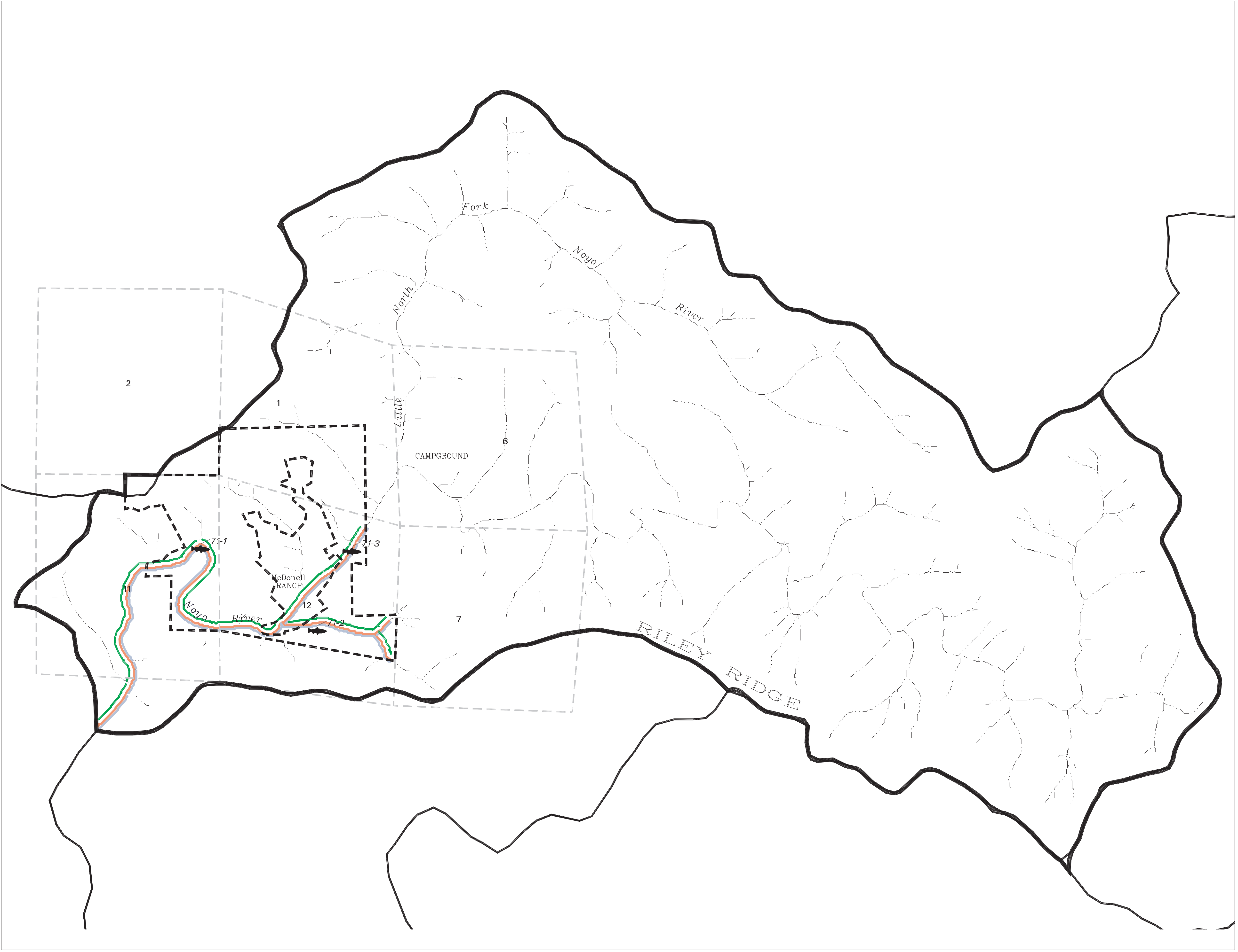

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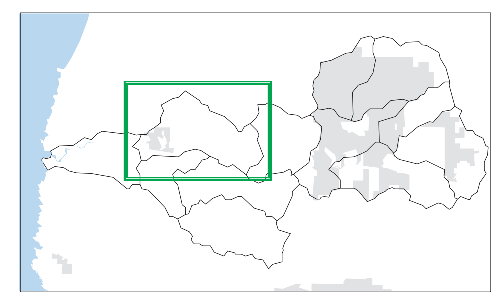
Sheet 4



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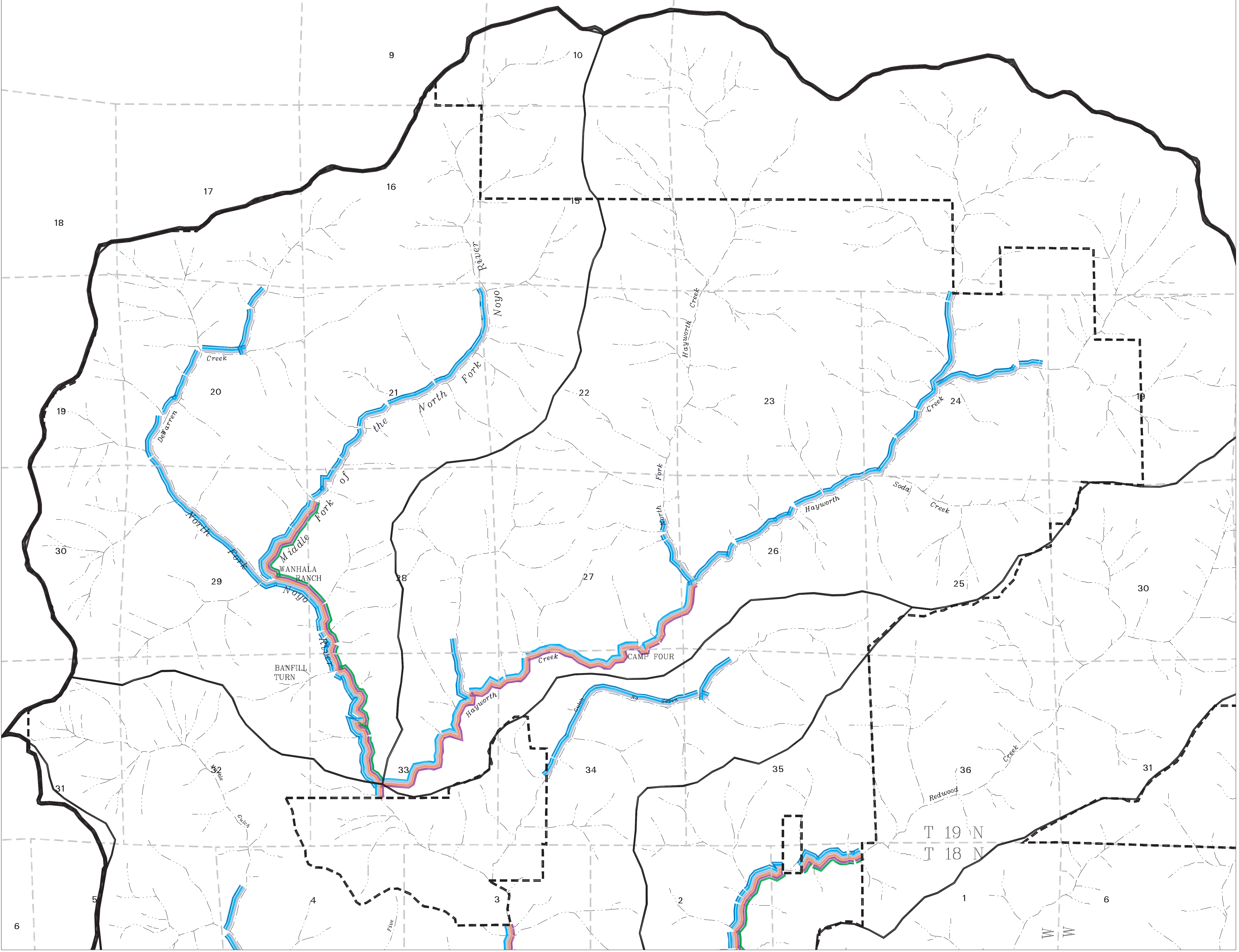


Noyo River Watershed Analysis Unit

Map F-2 Potential Anadromous Fish Habitat and Life History

Present Habitat Usage by Salmonid Life History Phases

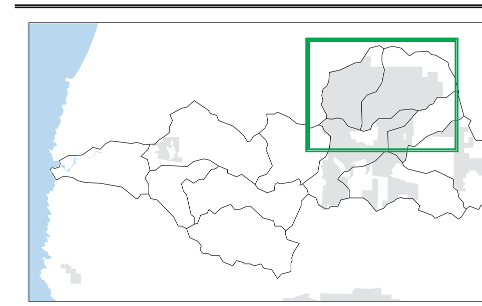
- Coho Spawning
- Coho Rearing
- Coho Over-Wintering
- Steelhead Spawning
- Steelhead Rearing
- Steelhead Over-Wintering

Flow Class

- Class I
- Class II
- Class III

- MRC Ownership
- WWAA Boundary
- Planning Watershed Boundary

Sheet 1



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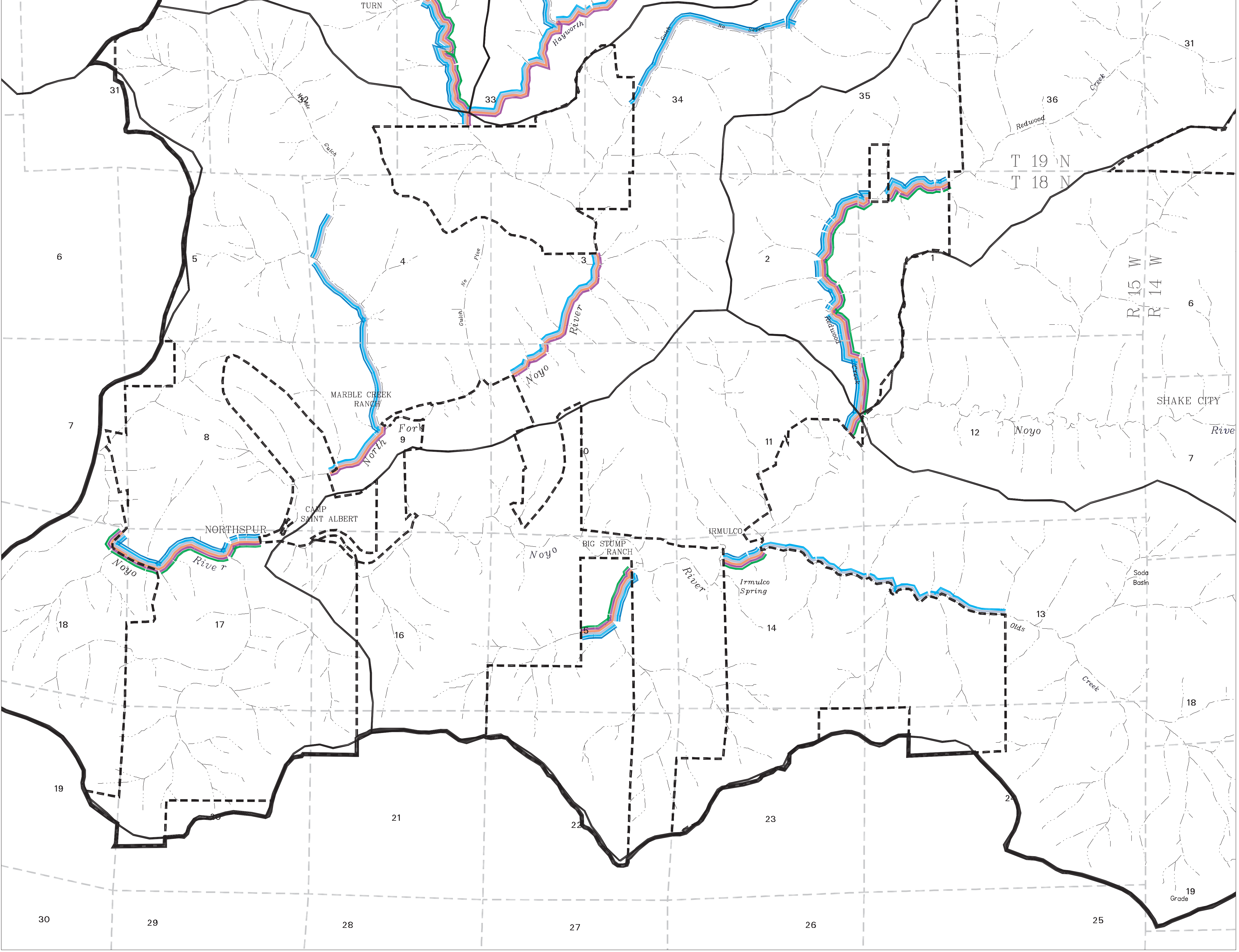

Noyo River Watershed Analysis Unit

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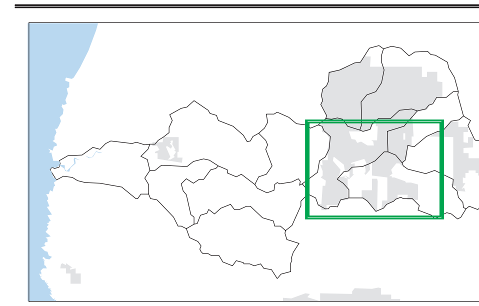
- Coho Rearing
- Coho Over-Wintering
- Steelhead Spawning
- Steelhead Rearing
- Steelhead Over-Wintering

Flow Class

- Class I
- Class II
- Class III

- MRC Ownership
- WWAA Boundary
- Planning Watershed Boundary

Sheet 2



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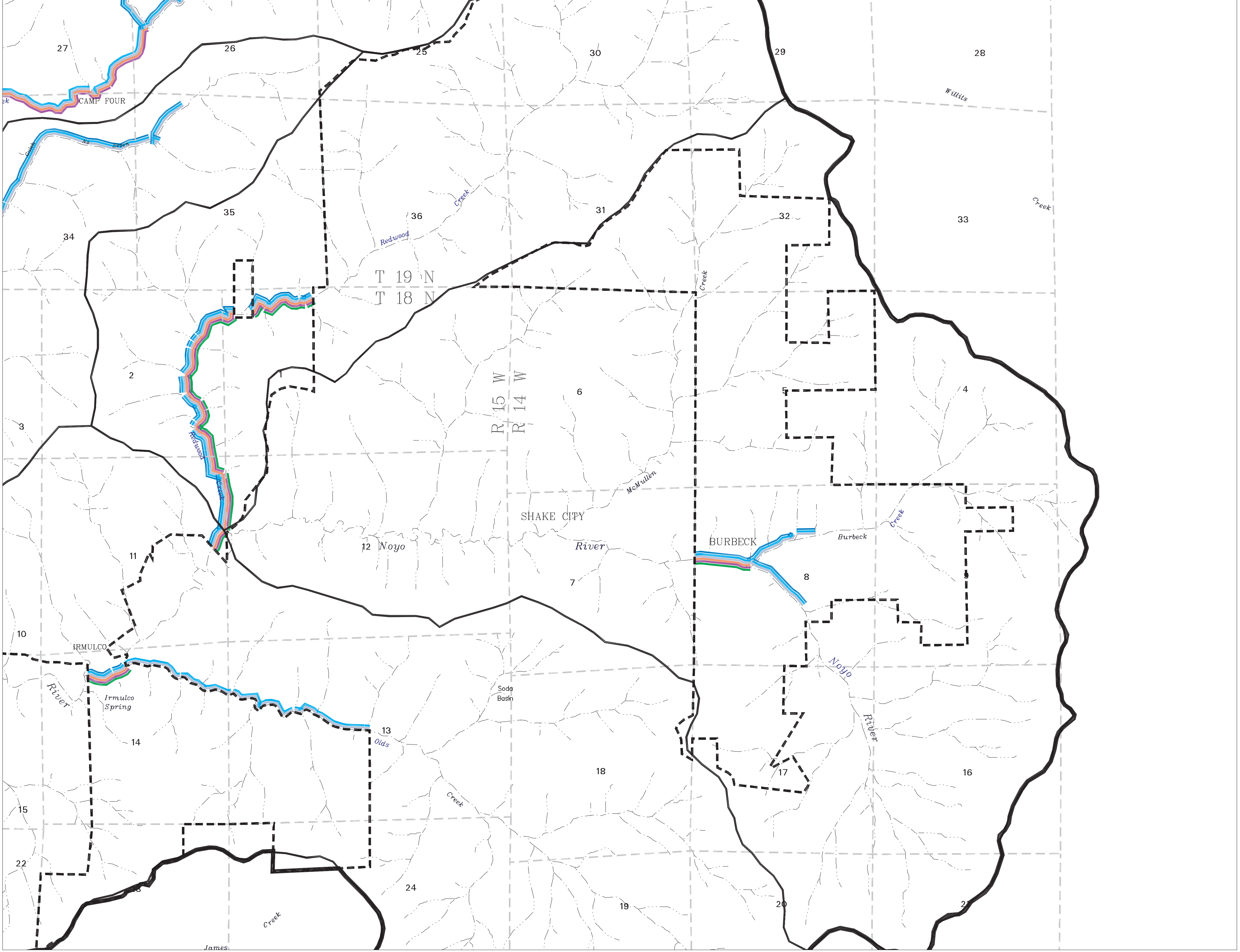

Noyo River Watershed Analysis Unit

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- Coho Rearing
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- Steelhead Over-Wintering

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- Class II
- Class III

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- WWAA Boundary
- Planning Watershed Boundary

Sheet 3

0 1/2 1 Mile

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Noyo River Watershed Analysis Unit

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- Coho Rearing
- Coho Over-Wintering
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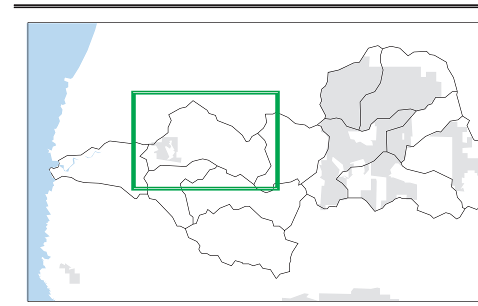

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