Subbasin Profiles and Synthesis

Coastal Subbasin

The Coastal Subbasin includes all of the watershed area of the mainstem Big River just below its confluence with Peterson Gulch (Figure 57). This encompasses all of the Big River Estuary. Stream elevations across the subbasin range from sea level to 40 feet at the boundary with the Middle Subbasin. The highest point is above Kidwell Gulch on the border with the Middle Subbasin, at 1,235 feet. The subbasin encompasses 32.5 square miles and occupies 17.9% of the total basin area. The Big River Estuary is large relative to the size of the basin, with tidal influence extending approximately 8.3 miles upstream from the ocean. The estuary is the longest undeveloped estuary in California (Warrick and Wilcox 1981). The mouth of the river is an opening along the north side of Mendocino Bay. The bay is protected by rocky headlands, which minimize wave-induced longshore sediment transport and help the mouth to remain open to the sea year round. The town of Mendocino lies just outside of the Big River Basin, north of the river mouth.

Climate

The climate of the Coastal Subbasin is characterized by a pattern of low-intensity rainfall in the winter and cool, dry summers with coastal fog. Average annual rainfalls range from 40 inches near the coast to 55 inches further inland. Air temperatures are moderated by the ocean influence and average 40 to 47°F.

Hydrology

The Coastal Subbasin is made up of three CalWater Units (Figure 57). There are 24.5 perennial stream miles in 14 perennial tributaries in this subbasin (Table 70). There are an additional 17.9 miles of the mainstem Big River. The mainstem Big River in the Coastal Subbasin is a fourth order system using the Strahler (1964) classification. The tributaries to the mainstem in this subbasin are first and second order streams with drainage areas ranging from less than one square mile to 14 square miles (Figure 56).

Table 70. Tributaries to the Big River in the Coastal Subbasin by river mile from 7.5 minute topographic maps.

CalWater Planning Watershed	River Mile	Bank (L,R)	Stream	Perennial (Miles)	Intermittent (Miles)	Stream Order
Mouth of Big River	0.4	R	Unnamed Tributary		0.9	Intermittent
	2.3	R	Unnamed Tributary		0.8	Intermittent
	3.2	R	Unnamed Tributary	0.6		1
	3.6	L	Unnamed Tributary		0.6	Intermittent
	4.1	R	Unnamed Tributary		1.3	Intermittent
	5.1	L	Unnamed Tributary	0.5	0.3	1
	5.3	L	Dry Dock Gulch	1.2	0.1	1
	5.6	L	Unnamed Tributary	0.5	0.4	1
	7.3	R	Unnamed Tributary	0.3	0.3	1
	8.0	L	Unnamed Tributary	0.5	0.3	1
Laguna Creek	9.2	R	Big River Laguna	5.6	0.8	1
Mouth of Big River	12.2	L	Railroad Gulch		2.7	1
Berry Gulch	12.4	L	Little North Fork Big River	8.4	0.1	2
			Unnamed Tributary to Little North Fork Big River/Cook House Gulch		1.0	1
			Rocky Gulch	0.5	0.7	1
			Manly Gulch		1.1	1
			Thompson Gulch	1.9		1
			East Branch Little North Fork Big River	1.1	1.7	1
			Berry Gulch	2.6	0.4	1
			Berry Gulch Tributary		1.8	1
Mouth of Big River	13.9	R	Unnamed Tributary	0.4	0.3	Intermittent
	14.4	R	Unnamed Tributary		0.6	Intermittent
	15.2	L	Unnamed Tributary		1.0	Intermittent
	15.8	L	Wheel Gulch		0.9	Intermittent
	15.9	R	Unnamed Tributary		0.5	Intermittent
	16.1	R	Unnamed Tributary	0.5	0.1	1
	17.9	R	Unnamed Tributary		1.3	Intermittent

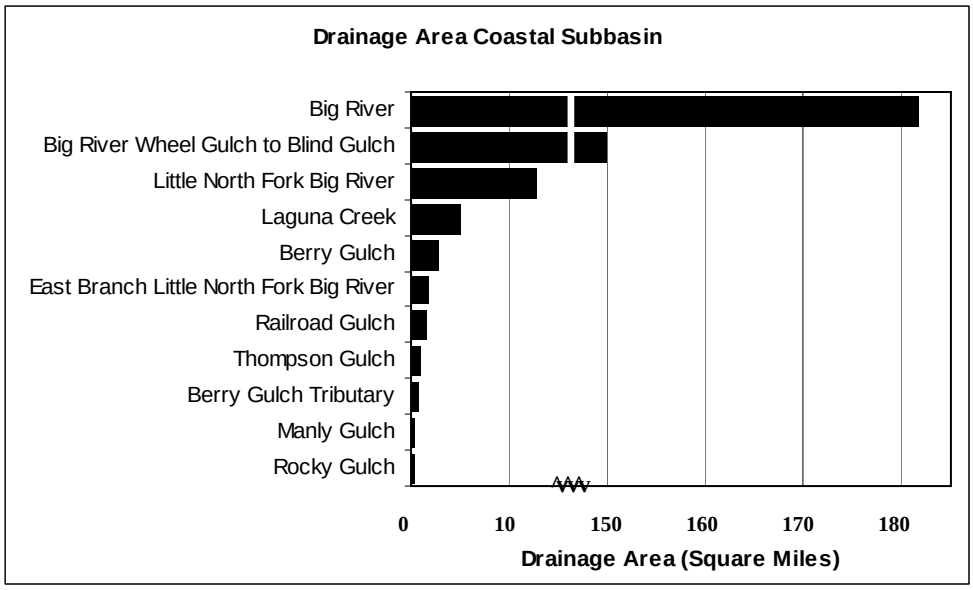

Figure 56. Drainage area of streams surveyed by CDFG in the Coastal Subbasin.

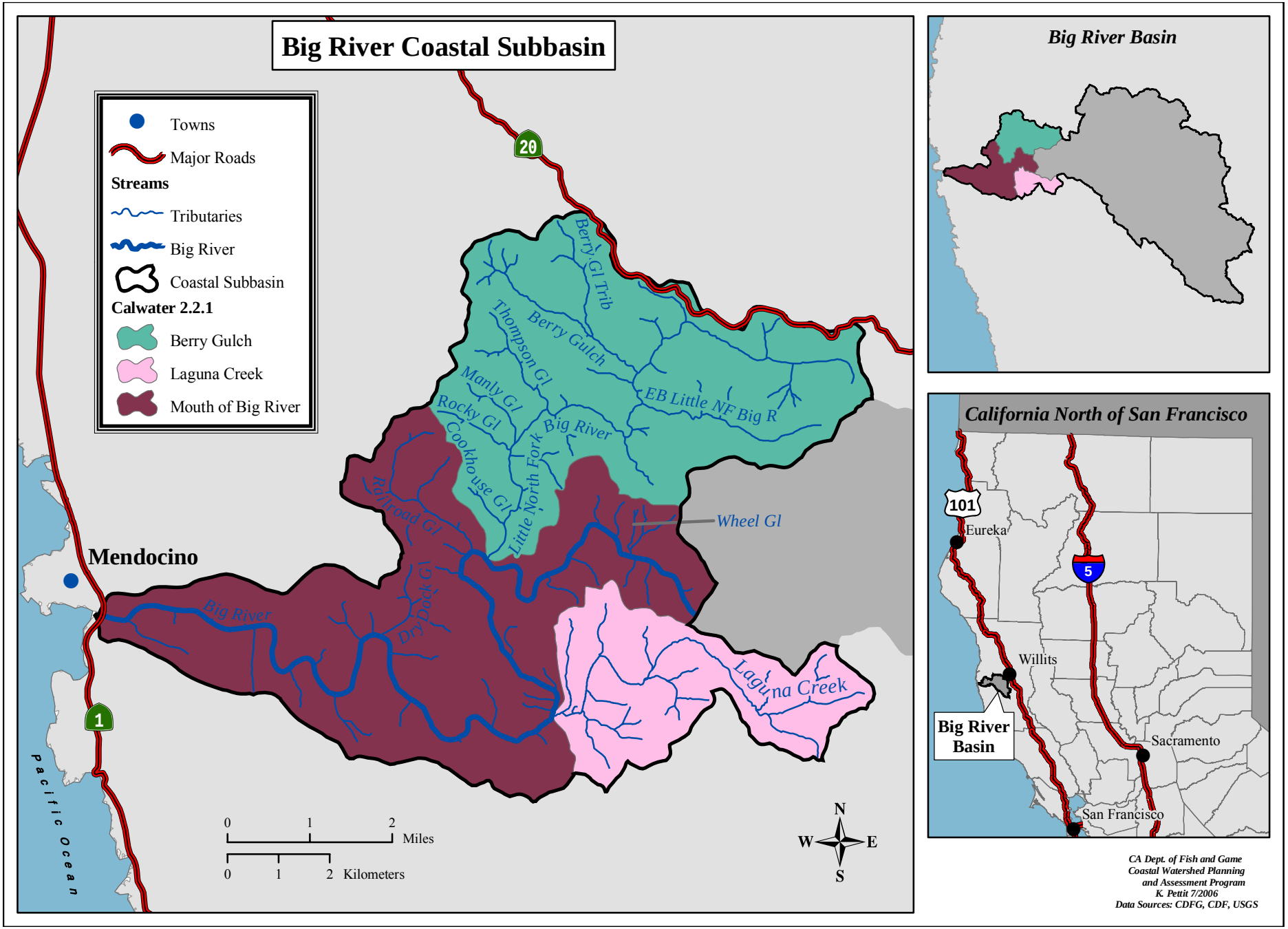

Figure 57. Coastal Subbasin and CalWater2.2a planning watersheds.

Estuary

The mouth of the Big River remains open year-round and forms a large estuary. Unlike many estuaries, Big River Estuary is not lagoonal but instead has a long linear channel. During high spring tides, the tidal influence extends up to 8.3 miles upstream, while during the winter tides extend 3 miles upstream (GMA 2001a). Crescent-shaped tidal flats alternate on either side of the channel corresponding with the alluvial deposits of the river (Marcus and Reneau 1981). Wetlands in the lower reaches of Coastal Subbasin tributaries suggest that the estuary may have extended further up-river in the past (GMA 2001a).

A coastal wetland survey of the estuary was completed by CDFG in 1978 (Dana). The study found the estuary consisted of approximately 106 acres under marine water at mean low tide and approximately 191 acres of marsh and mud flats. Associated marshes are salt (63 acres), brackish (33 acres), and freshwater (59 acres). There were about 15 acres of mudflats and 2 acres of eelgrass beds (*Zostera*). Hypersaline ponds that dry up occasionally during the summer were interspersed throughout the salt marshes. Riparian vegetation was permanent and consisted mainly of alders and willows (Dana 1978). A series of eight salt marsh flats border the lower three miles of the estuary (Figure 58, Marcus and Reneau 1981).

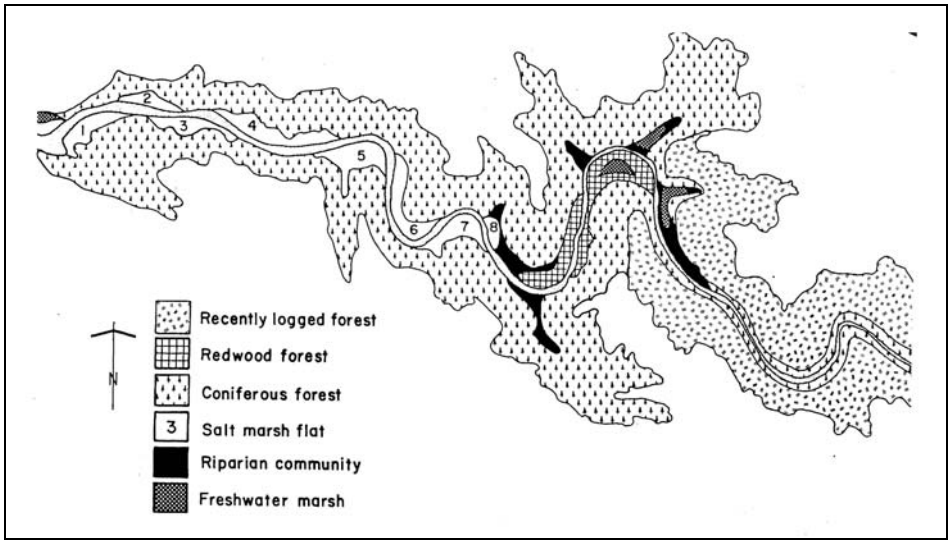

Figure 58. Map of salt marsh flats in the Big River Estuary in 1981 from Marcus and Reneau.

Upstream from the mouth, the floodplain narrows abruptly and adjacent slopes are vegetated with second growth redwood and mixed conifer forest. The hillslopes on either side of the river are steep, with occasional remnants of the river's former floodplain with stands of alder.

About eight miles inland the river is joined by Laguna Creek, where a large freshwater lagoon exists. This wetland is surrounded by freshwater marsh containing rushes (*Juncus*), cattails (*Typha*), and cowlily (*Nuphar*). Tidal influence in the summer extends as far as 8.5 miles upstream with ranges of two to four miles in the winter. Rockweed (*Fucus*), marine algae, has been found as far as four miles upriver (Dana 1978). More information about vegetation in and along the estuary is discussed in the Riparian Conditions section of this subbasin.

Many animal species are found in the estuary in addition to the salmonids that utilize the estuary as a migration corridor and as a nursery area for juveniles. Species of importance to fisherman include Dungeness crab, surfperch, flatfish, and surf smelt. Soft shell clams occur in intertidal flats. Old pilings in the estuary are covered in tunicates, nudibranches, barnacles, and mussels. Opossum shrimp (*Neomysis*) are found in the estuary and freshwater mollusks (*Goniobasis*) are found in the river (Dana 1978). More information about fish in the estuary is discussed in the Fish History and Status section of this subbasin.

Mammals found in the estuary include river otter, deer, mink, sea lions, and harbor seals. Sandflats at the mouth of Big River are used as rest areas by shorebirds that feed on invertebrates in the mudflats. Diving ducks, dabbling ducks, and black brant are also found. Virginia and sora rail are expected to occur in marsh areas. Woodduck nests were located in the Laguna Creek marsh in 1978, but no use was reported (Dana 1978). Twenty-four additional woodduck boxes were installed in Dry Dock Gulch and Laguna Creek in December

2002 and January 2003 (SONAR 2003). Boxes were checked for nesting success between March 11, and May 29, 2003. Two boxes out of nine were used at Dry Dock Gulch and eleven out of 15 were used at Laguna Gulch (Kight and Waldman 2003). Other birds observed in the estuary include uncommon pileated woodpeckers, osprey, great blue herons, and spotted owls (Dana 1978).

Geology

The Coastal Subbasin has a high percentage of area in low slope classes. The Big River Estuary is a drowned Pleistocene river valley that cuts through a Franciscan sandstone formation. The most recent parent material is sandstones, shales, and thick deposits of alluvium. The predominant soil type is Hugo, interspersed with Josephine and Empire (Soil-Vegetation Maps of California, and supplements, 1975, as cited in English 1979).

Landsliding

CGS (2004) examined landsliding in the Big River State Park as a part of their Engineering Resource Assessment. The entire park is underlain by Franciscan Coastal Belt geology. In the western part of the park, wave action has eroded the rocks and reduced their relief, marine terrace rocks have mantled the rock, and the Big River has caused incision. In the eastern section of the park, rocks have not been subject to wave action and thus have a much higher relief. Therefore, the western part of the park has steeper slopes, whereas the eastern part has longer slopes. Debris slide slopes are common in the steep streamside slopes next to the Big River and larger deep-seated landslides occur in the eastern upland sections of the park. The greatest amount of small active debris slides and small landslides occur in debris-slide slope areas. Inner gorges also occur along some of the eastern Big River tributaries within the park.

A GMA (2001) analysis of landslides across the entire subbasin by time period found that about 10% of the number of slides across the Big River Basin were in this subbasin. The Berry Gulch PW had the highest number of slides in the subbasin, while the period from 1937 to 1952 had the highest number of landslides.

Table 71. Coastal Subbasin number of delivering slides by study period and PW (GMA 2001a).

Planning Watershed	1937-1952		1953-1965		1966-1978		1979-1988		1989-2000		Total All Periods	
	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)
Mouth of Big River	24	22.6	27	35.1	2	20.0	1	4.3	16	50.0	70	28.2
Berry Gulch	64	60.4	44	57.1	8	80.0	17	73.9	9	28.1	142	57.3
Laguna Creek	18	17.0	6	7.8	0	0.0	5	21.7	7	21.9	36	14.5
Coastal Subbasin	**106**	**42.7**	**77**	**31.0**	**10**	**4.0**	**23**	**9.3**	**32**	**12.9**	**248**	**100**

Landslide volume estimates from the same time periods showed that 10.5% of sediment delivered to streams across the Big River Basin occurred in the Coastal Subbasin (GMA 2001a) (Table 72). The highest volumes of sediment in this subbasin were delivered in the Mouth of Big River PW.

Table 72. Volume of delivering slides by study period by PW in the Coastal Subbasin (GMA 2001a).

Subbasin	1937-1952		1953-1965		1966-1978		1979-1988		1989-2000		Total	
	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	(%f or Entire Watershed For Entire Period)
Mouth of Big River	408,001	86.1	82,624	63.3	26,832	93.7	33,980	67.9	60,903	53.2	612,340	8.1
Berry Gulch	49,694	10.5	2,449	1.9	0	0.0	16,061	32.1	12,589	11.0	80,792	1.1
Big River Estuary	16,350	3.4	45,304	34.7	1,811	6.3	0	0.0	40,970	35.8	104,435	1.4
Total	474,045	59.4	130,376	16.3	28,643	3.6	50,041	6.3	114,463	14.4	797,567	10.5

The CGS (2005) landslide potential map classified 39% of the Coastal Subbasin in the high and very high potential categories (Table 73).

Table 73. Landslide Potential in the Coastal Subbasin.

Landslide Potential Category	Area (square miles)	% of Subbasin
Very Low	5.4	17
Low	7.6	23
Moderate	7.0	22
High	9.6	30
Very High	2.8	39

Fluvial Geomorphology

The Big River Estuary and immediate upstream area are comprised of:

- A series of oxbows and old river channels in the floodplain;
- Old river terraces next to the floodplain; and
- Ancient sea terraces occurring between 200-300 feet in elevation (English 1979).

The estuary is the repository of watershed sediment carried downstream by the river and sand carried upstream by the tide. Therefore, estuaries are sites of active sedimentation. During floods, high tide waters mix with slow, silt laden river water in the estuary - resulting in sediment deposition. Large river sediment loads cause greater deposition in the estuary. Consequently an examination of geomorphic patterns in an estuary can reflect erosional processes occurring in the watershed (Marcus and Reneau 1981).

A 1981 study of the historic sedimentation in the Big River Estuary found that the estuary has experienced a rapid sedimentation of its channel and salt marshes since the advent of logging in the watershed (Marcus and Reneau 1981). The study mapped the distribution of vegetation along the estuarine channel (Figure 58) and looked at historic photos as well. The estuary was also found to exhibit an unusual pattern of deposition. The most obvious indicator of accelerated sedimentation in the Big River Estuary was the occurrence of levees along the estuary channel. Levees form as silt laden flood waters are slowed along the edges of the channel. Coarser, heavier sediments settle out and form an embankment along tidal flats and estuary channels. The result is the storage of sediment in natural levees and on tidal flats.

Levees in the estuary extend along the channel to 1.7 miles above the river mouth and display a regular decrease in height. They vary in width from 40 feet in the upper estuary to 10 feet and less in the lower region. These levees record the transition in the estuary from primarily tidal influences (salt marsh and mudflat) to primarily river influences (floodplains).

The estuary channel has narrowed and the floodplain has grown at the expense of mudflat and subtidal areas as estuary banks have prograded. Blockage or reduction in tidal influence has occurred in the upper flats while a filling of sloughs and increase in mudflat height is found in the lower flats.

Marcus and Reneau used several examples to illustrate these estuarine processes:

> A railroad system was used to transport logs to the estuary during the early logging. A log dump located 3.8 miles upriver served as a spur of the railroad where logs could be dumped directly into the water. This log dump is shown in a historic photograph taken in the 1920s as standing in open water (Jackson 1975). The border of Flat 8 sloped gently away from the water. Today the pilings of this log dump stand adjacent to Flat 8, bordered by a levee 4 feet in height. The historic development of this levee records a major change in the hydraulic conditions of the estuary. Winter floods were not able to deposit enough sediment to build levees at the site of the log dump prior to 1900. Since the photograph was taken, levees have developed 2 miles further down the estuary.
>
> Once the logs were dumped into the estuary, they were rafted down to the sawmill at the mouth. To avoid stranding the logs on the tidal flats, rows of pilings were placed at the lower low tide line (Jackson 1975). Chains were stretched between these pilings and acted as a barrier to the floating logs. Presently in Flat 4, two sets of pilings occur, the outer one at approximately low tide line and the inner one trending back into the salt marsh. Two sets of pilings were installed during the logging operations before 1938 indicating that heavy sedimentation had extended the low tide line out into the channel, thus rendering the original set obsolete.
>
> The filling of these tidal sloughs by sediment is demonstrated by the presence of several barges, buried in Flat 4. These barges were used for transport in the estuary. The barges are 42 feet in width and were moored in the tidal slough, indicating the original slough was at least this wide. Presently the same slough is 7 feet in width and [one] barge is buried adjacent to the bank.

CGS photo mapping found that within the Mouth of Big River PW, the main channel gained negative channel features between 1984 and 2000, due to accumulation of sediment that was visible in plan view in relatively small-scale aerial photographs (Figure 59). The year 1984 showed 2.8 miles of negative channel features; 2000 showed 5.3 miles of negative channel features, consisting of lateral bars and a few mid-channel bars. The length of negative channel features grew significantly from 18.5% (1984) to 34.7% (2000) of the length of the blue-line stream representing the lower mainstem channel in the Mouth of Big River PW.

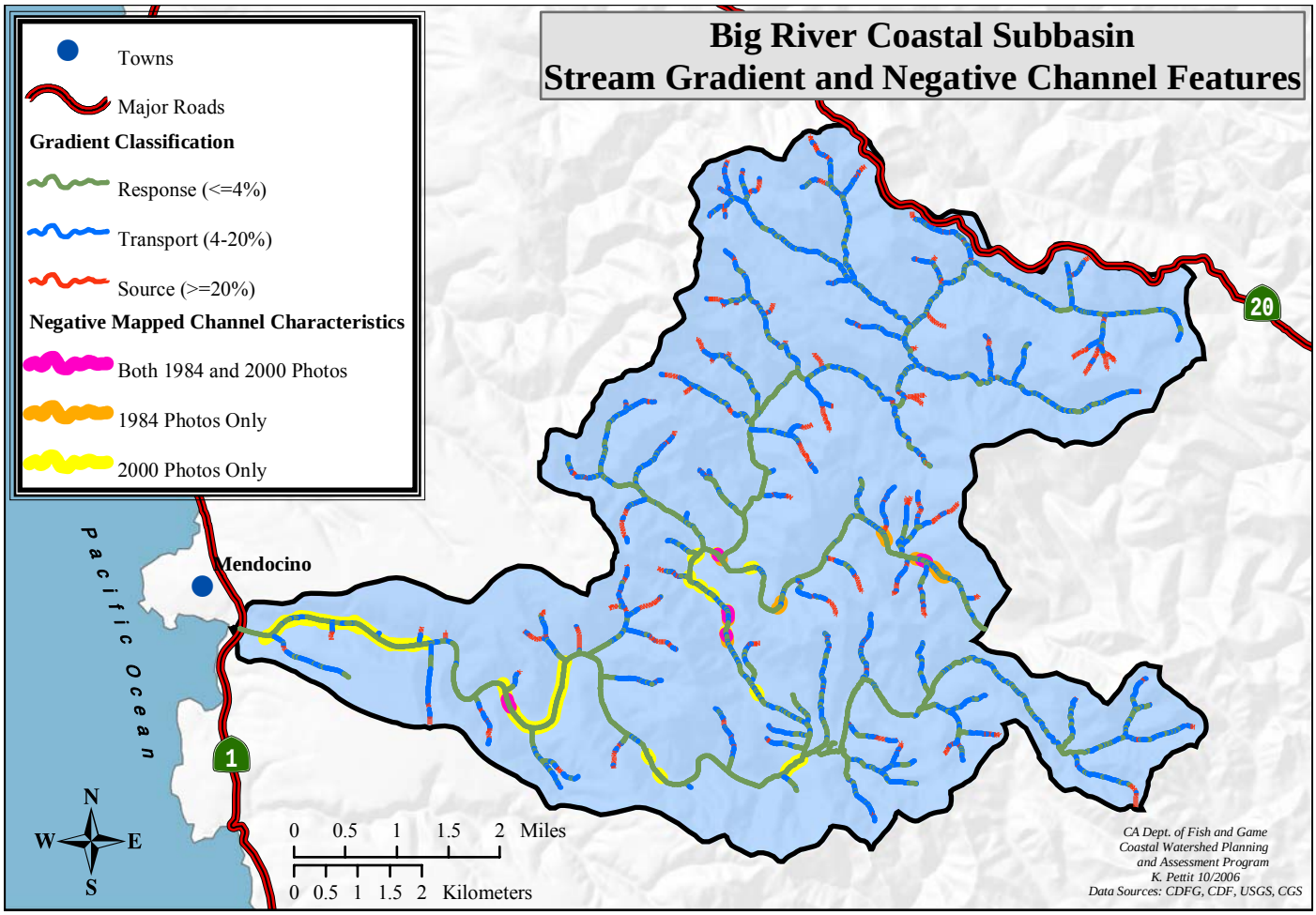

Figure 59. Map showing the relatively shallow gradient (<0.1%) of the lower Big River, where sediment appears to have accumulated between photo years 1984 and 2000.

CGS prepared an Engineering Geologic Resource Assessment for DPR in 2004. As part of their analysis, CGS identified stream channel conditions and sediment sources within the 7,315-acre Big River State Park. The Big River's gradient through the park is approximately 0.0475 percent, making the Big River a Rosgen type C channel. CGS was able to separate the channel in the park into four different reaches based on changes in sinuosity (Table 74). CGS found that from the mouth of Big River to RM 6.7, tidal influences and estuarine processes appear to mask fluvial processes. Reneau (1981) estimated that over 100 feet of sediment has accumulated in the estuary by the mouth of Big River over the past 9,000 years - or approximately 3 millimeters of sediment per year. This is considered the natural background sedimentation rate in the estuary.

Table 74. Channel reaches of different sinuousity and possible geologic/geomorphic controls within the Big River State Park (from CGS 2004).

RM	Reach Name	Sinuosity	Valley Flat/Flood Prone Width (feet)	Most Commonly Measured Widths (feet)	Possible Geologic and/or Geomorphic Controls
0.0-2.2	Tidal	1.06	350:1,000	600	Drowned river mouth where tidal and estuary processes (sedimentation) dominate
2.2-8.0	Meanders	1.66	300:850	550	Incised antecedent meanders
8.0-10.6	Wonder Plot	1.18	400:1,400	600-800	General linear trend at ~N40W that parallels the structural grain of folding and faulting along California's coastline
10.6-13.4	Woodlands	1.52	275:900	400-600	Return to antecedent meanders

Within the boundaries of the park, Big River meanders through a flat-floored valley with a bottom made up of alluvial sediment. About 85% of the river banks along the park are formed within this alluvial sediment, while the other 15% are eroded into steep valley floors underlain by colluviums or sandstone bedrock. The alluvial valley ranges from 275 to 1,400 feet wide at the confluence with Laguna Creek. The most common valley width within the park is 600 feet. The mainstem Big River is incised into the valley alluvium and has nearly vertical three to 20 foot high stream banks in most places. Banks are generally composed of weakly consolidated and uncemented silt and fine sand. When the stream banks exceed 6 feet in height, the banks slump and slough. Water levels in the late summer are between three and six feet in the tidal reach and between six and 20 feet in the upstream reaches below the valley flat (CGS 2004).

Old tidal mudflats and estuarine deposits of fine silt interlaminated with thin layers of peat have developed into salt marshes along the tidal reach. Upstream of this reach, mixed conifer forest has developed on valley flats composed of fine sand and silt deposited by the river. These valley flats are fluvial terraces and gently undulate to flat, slope down away from the channel, and usually contain a closed linear depression near the base of the adjacent hillslope. This is likely the result of natural levee formation (CGS 2004).

CGS (2004) examined silt lines on tree trunks on the fluvial terraces in the park. These lines are caused by regular inundation and have been described in historical accounts. Lines range from three to six feet above the terrace surface. Fritz (1923) described the lines in the Wonder Plot, a six-acre parcel of second growth redwoods set aside as a long term scientific experiment in redwood growth rates (Figure 60):

> The site is on a high river bench of fine silt that is reported to be inundated once every four or five years. The mud line on the trees is in many cases 7 feet off the ground.

Another description of the same plot in 1945 states:

> The sample plot, a square figure of one full acre, lies on a "flat" or a bench on the left bank of Big River. The soil is very deep silt, and, although about 20 feet above the bed of the river, is subject to inundation in occasional years. Mud lines on the trees indicate the level to have been 5 feet above the ground at the highest point of the plot.

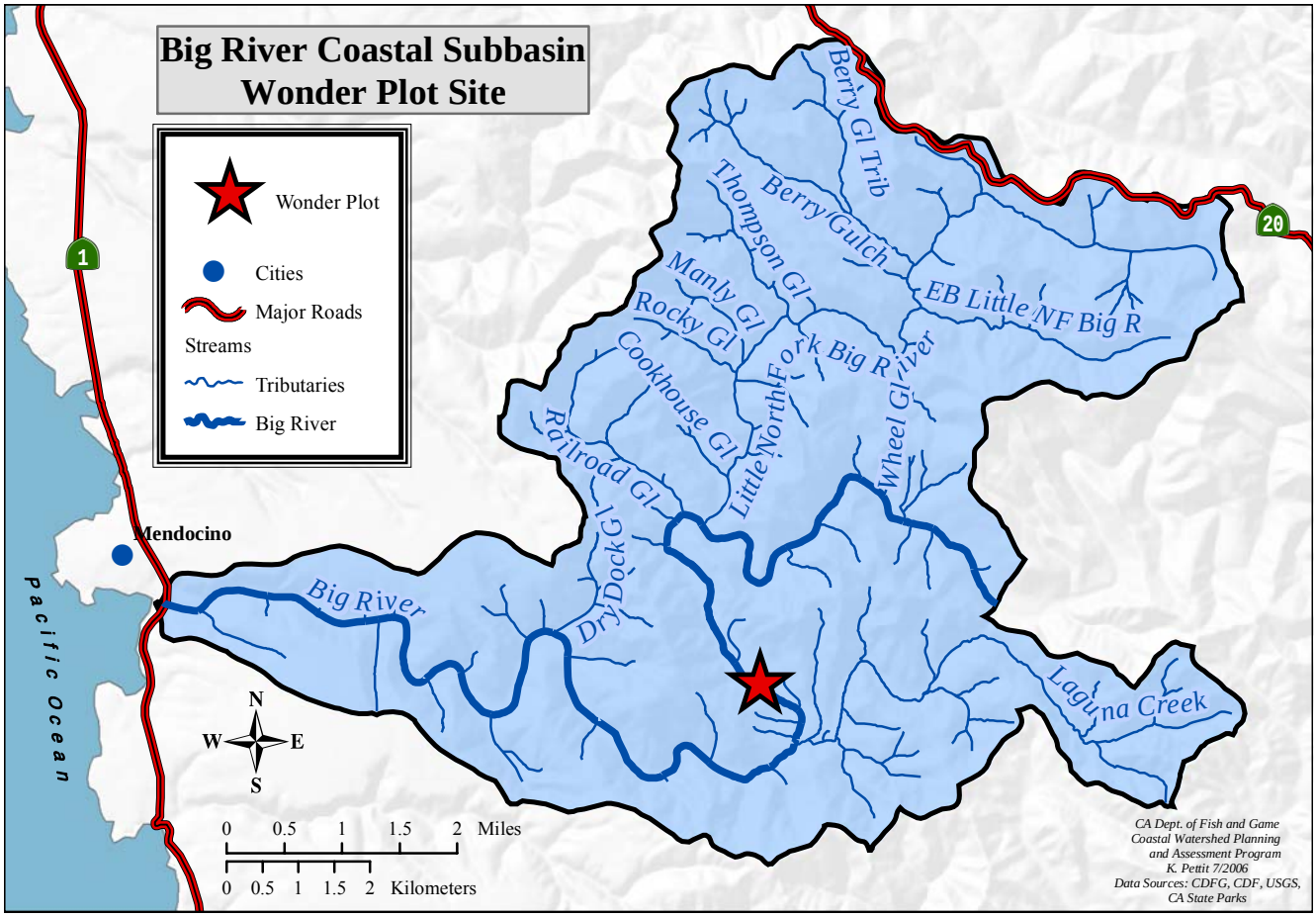

Figure 60. Wonder plot experimental site.

CGS (2004) surveyed a cross-section near the Wonder Plot, at RM 8.7. The cross-section showed the level of the terrace surface to be 25 feet above the river bed, with silt lines on tree trunks at four to five feet above the ground surface. Thus the observations made by CGS in 2004 were very similar to those made by Fritz in 1923 and 1945. This indicates that the topographic relationship between the terrace surface and the active channel has not changed substantially in the past 80 years during the period of intense timber harvesting throughout the upper watershed (CGS 2004).

However, other aspects of channel morphology have changed. The 40 to 50 years of splash dam logging across the basin likely had an effect on stream channels. Channel clearing, artificial flooding, and battering by logs in transport likely greatly accelerated erosion and widened the width of the channel (CGS 2004). However, significant bed lowering along the lowermost reaches of Big River associated with splash dams is considered unlikely (CGS 2004). The very shallow gradient of the river inhibits stream power and the close proximity of the ocean provides ultimate control of base level. The remains of old log pilings and the foundation of a pier or log deflection wall within the channel from the early 1900s also support this idea. If bed adjustments had occurred in this section of the river, such old structures in the river would have been destroyed by annual and high flows over the past century (CGS 2004).

CGS (2004) examined the channel narrowing phenomenon documented by Reneau (1981) for most of the 20th century. They found that Reaneau had failed to discuss his findings within the context of "a river channel reclaiming itself after the multiple decades of channel clearing, splash dam flooding, and battering by logs in transport" (CGS 2004). CGS found it likely that channel conditions of the early 1900s documented by Marcus and Reneau (1981) were in fact an artifact of the splash dam era and represented a much wider channel. Therefore, channel narrowing seen since 1900 likely represents the channel re-adjusting to a more natural discharge regime (CGS 2004).

Out of 21 stream reaches surveyed by CDFG in the Coastal Subbasin, the most common Rosgen channel type was F4 (Table 75). There were nine different channel types present.

Table 75. Channel types in surveyed streams of the Coastal Subbasin.

Stream	Reach	Survey Length (Miles)	Channel Type
Big River	1	8.1	F4
	2	5.0	F4
	3	1.9	F4
	4	1.8	F3
	5	3.5	B2
Laguna Creek	1	1.9	C3
Railroad Gulch	1	1.1	F4
Little North Fork Big River	1	3.7	G4
Rocky Gulch	1	0.1	E4
	2	0.1	A3
Manly Gulch	1	0.7	G4
Thompson Gulch	1	0.7	B4
	2	0.4	F4
East Branch Little North Fork Big River	1	0.9	A4
	2	1.5	B4
Berry Gulch	1	0.1	F3
	2	1.3	F4
	3	0.2	B2
	4	0.6	F4
Berry Gulch Tributary	1	1.1	F4
Big River Wheel Gulch to Blind Gulch	1	5.0	F4

Vegetation

Redwood-Douglas-fir forests cover 91% of the Coastal Subbasin, with the remainder made up mostly of various other tree species and blueblossom (*Ceanothus spp.*) shrubs (Table 76). Blueblossom is usually a result of a clearcut where slash has been burned as it reseeds through fire and prefers disturbed areas. Tree stands are mostly composed of small to medium/large trees (Table 77). Almost half of the subbasin is covered by trees with 90% crown canopy density, although 6% is not covered by canopy (Table 78).

Table 76. Acreage and proportion of area of vegetation classes in the Coastal Subbasin.

Class	Acres	%
Redwood - Douglas-fir	18,824	91
Douglas-fir		
Tan oak, Madrone, Alder	363	2
White, Black or Live oak & Bay laurel		
Blueblossom Ceanothus	645	3
Manzanita, Chamise, Scrub oak		
Bishop Pine, Pygmy cypress, Willow	429	2
Grass	283	1
Wet Meadows	31	
Water	176	1
Barren/Rock	26	
Urban/Developed	2	
Totals	**20,779**	**100%**

Table 77. Vegetation size class in the Coastal Subbasin by planning watershed.

Planning Watersheds	Sapling (<6 inches dbh)		Pole (6-11 inches dbh)		Small Tree (12-24 inches dbh)		Medium/Large Tree (24-40 inches dbh)		Large Tree (>40 inches dbh)	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Mouth of Big River	357	4.0	383	4.2	4,647	51.5	3,493	38.7	152	1.7
Berry Gulch	56	0.7	194	2.5	2,608	33.9	4,671	60.7	161	2.1
Laguna Creek	0	0.0	76	2.6	1,816	62.7	999	34.5	4	0.1
Total Coastal	**413**	**2.1**	**653**	**3.3**	**9,071**	**46.2**	**9,162**	**46.7**	**317**	**1.6**

Table 78. Density of vegetation in the Coastal Subbasin by planning watershed.

Planning Watersheds	Percent Crown Canopy Density										Total Acres
	0%		10-69%		70%		80%		90%		
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	
Mouth of Big River	511	5	585	6	1,866	20	2,310	24	4,270	45	9,542
Berry Gulch	304	4	518	6	2,197	27	943	12	4,032	50	7,993
Laguna Creek	349	11	279	9	482	15	452	14	1,683	52	3,244
Total Coastal	**1,163**	**6**	**1,379**	**7**	**4,546**	**22**	**3,705**	**18**	**9,984**	**48**	**20,779**

Total density of all species - conifers and hardwoods.
Most of the 0% density crown canopy is grasslands, water, and shrub species.

Fire and Fuels

Areas of high fuel rank dominate the Coastal Subbasin, with small discontinuous zones of very high fuel rank scattered throughout. There were no records of large wildfires in this subbasin.

Land Use

The Coastal Subbasin is composed of various sized parcels with smaller parcels clustered around the north and south boundaries near the mouth- close to the towns of Mendocino and Little River. The three largest landholders in this subbasin are California State Parks, JDSF, and Hawthorne Timber Company, LLC.

Interest in purchasing lands around the Big River Estuary for conservation purposes first came under serious consideration in the late 1970s when USFWS prepared an environmental assessment to examine options for protecting the area. In 2002, a local citizens' group purchased a 7,334-acre parcel in the Big River Basin from the Hawthorne Timber Company. Money was raised from public agencies and private donations. The Mendocino Land Trust acted as the lead organization in the fund raising effort. On July 1, 2002, this parcel, known as the Big River Unit, was added to Mendocino Headlands State Park. This new State Park unit makes up 32% of the Coastal Subbasin.

The Big River acquisition includes 50 miles of mainstem Big River and its tributaries. It includes the entire tidal estuary and 1,500 acres of wetlands. The Big River property is connected to Van Damme State Park on the south, and JSDF and Russian Gulch State Park to the north. This created 60,000 acres of connected wildlife corridors and trail systems. Mendocino Headlands State Park is currently managed for preserving biological diversity, protecting valued natural and cultural resources, and creating opportunities for high-quality outdoor recreation. A preliminary management plan for the new state park unit has been developed.

A CDFG coastal wetland survey conducted in 1978 (Dana) recommended that the estuary be managed with a watershed management plan including three key elements:

- Protection of habitat elements such as riparian woodland, marshes, snags, and nesting trees;
- Avoidance of erosion through proper timber harvest techniques, such as no clear-cutting along the floodplain or immediate watershed, proper operation of equipment on steep slopes, erosion control at stream crossings, and post-timber clean-ups;
- Not increasing recreational activities.

California State Parks also owns and manages the 720-acre Mendocino Woodlands State Park. This land is surrounded by a 2550-acre special treatment area managed by CDF.

JDSF owns 32% of the Coastal Subbasin area. The State of California owns and manages JDSF for demonstrating forest management principles, recreation, and environmental conservation.

Highway 1 crosses the Big River near its mouth across a high bridge. The current bridge was built in 1960. Prior to the current bridge, a series of five low bridges were built at various times, each with a slightly different abutment. The first bridge was completed in 1860. Today's high bridge was built to replace the flood prone lower bridge.

Big River Flat, east of present Highway 1, near the mouth of the river is currently an unpaved parking lot. In the past, however, this flat was the site of a timber mill complex. The complex included a mill, mill hands' cabins, and several family dwellings. Four lumber companies operated mills at the complex or in the town of

Mendocino: California Lumber Manufacturing Co., Mendocino Mill Co., Mendocino Saw Mills, and the Mendocino Lumber Co.

The estuary was used extensively as a mill pond from the 1850s to 1938. Logs were transported downstream via splash-damming or railroads and stored in the estuary. Booms were built along the low-tide lines to keep logs from getting stranded as the tides changed.

In 1852 surveying began for a railroad across the beach at the mouth of Big River. The railroad was used as a tramway between the mill, built in 1854, and the east end of the Big River beach. Logs were stored at an enclosure in the river until they were milled. A second mill, closer to the log enclosure, was built in 1855. Timber framed piers were built in the river 3.5 miles upstream from the mill for stopping logs going downstream in 1858.

The second mill burned down in 1863 (Figure 61). It was rebuilt immediately and the need for large timbers for rebuilding induced the logging company to reserve nearby large trees in Reserve Gulch. In 1889 the mill was shut down temporarily to institute a new sawdust disposal system at the instigation of the County's Fish Commissioner. The commissioner ordered the closure to stop the sumping of waste products into the river. A new sawdust disposal system was constructed, which moved sawdust to a burning area away from the mill and river.

Figure 61. The ruins of Big River Mill after it burned in 1863.

In 1900, the paddleboat Maru was launched at the mill. The Maru was used to maneuver logs around the Big River Estuary. On April 18, 1906 the mill was heavily damaged by the San Francisco earthquake and was out of commission for a month. In 1926 the last of four piers of the old boom were removed from the river after the log storage area had filled with debris after 60 year of holding logs. A new boom was constructed. The mill closed on November 30, 1938 and was eventually dismantled.

Additional land uses in the Coastal Subbasin include a canoe rental facility located on the south bank of Big River near the Highway 101 Bridge (Dana 1978) and six gravel quarries (2005b). One recent quarry located on the left bank of the mainstem Big River at approximately RM 0.6 extracted and processed up to 8,000 cubic

yards of rock per year from 1992 to 2002 (Mendocino County Department of Planning and Building Services 1992a and b) but was closed when DPR acquired the property.

Forest Management

Timber harvesting has dominated the history of the Coastal Subbasin for the past 150 years. Almost the entire subbasin was harvested by 1944 (Table 79). Hawthorne Timber Company currently owns 22% of the subbasin. Additionally, timber companies previously owned and harvested land now owned and managed by State Parks and JDSF.

Table 79. Timber harvest in the Coastal Subbasin.

Time Period	Acres Harvested	Percent of Subbasin Harvested
1852-1944	19,470	93.7
1945-1964	1,363	6.6
1965-1974	2,299	11.1
1975-1984	2,030	9.8
1985-1992	6,278	30.2
1993-2001	8,071	38.8
Total	**39,512**	**190**

Early timber harvest activities across the subbasin consisted of clear cuts and conversion of land, while most recent harvests are single or group tree selections (Figure 62). Yarding methods have also changed over time, from predominantly cable ground before World War II, to tractor yarding in the post war years, and increasingly towards cable suspended since 1985 (Figure 63).

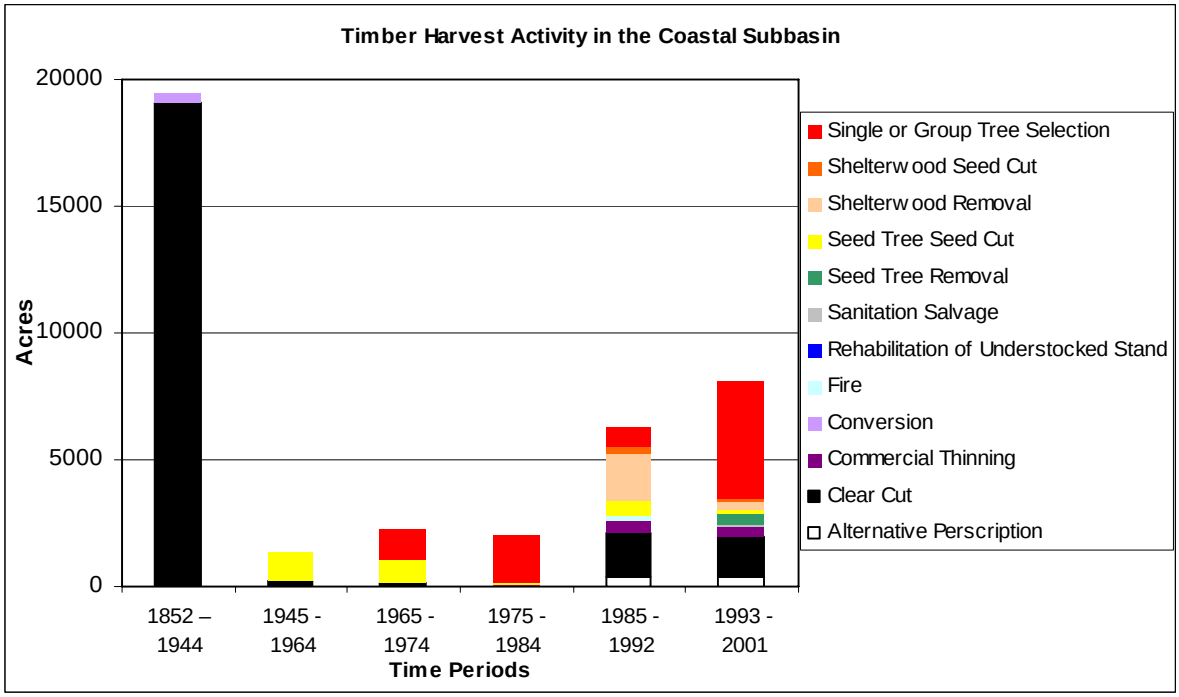

Figure 62. Acres of timber harvest activities in the Coastal Subbasin.

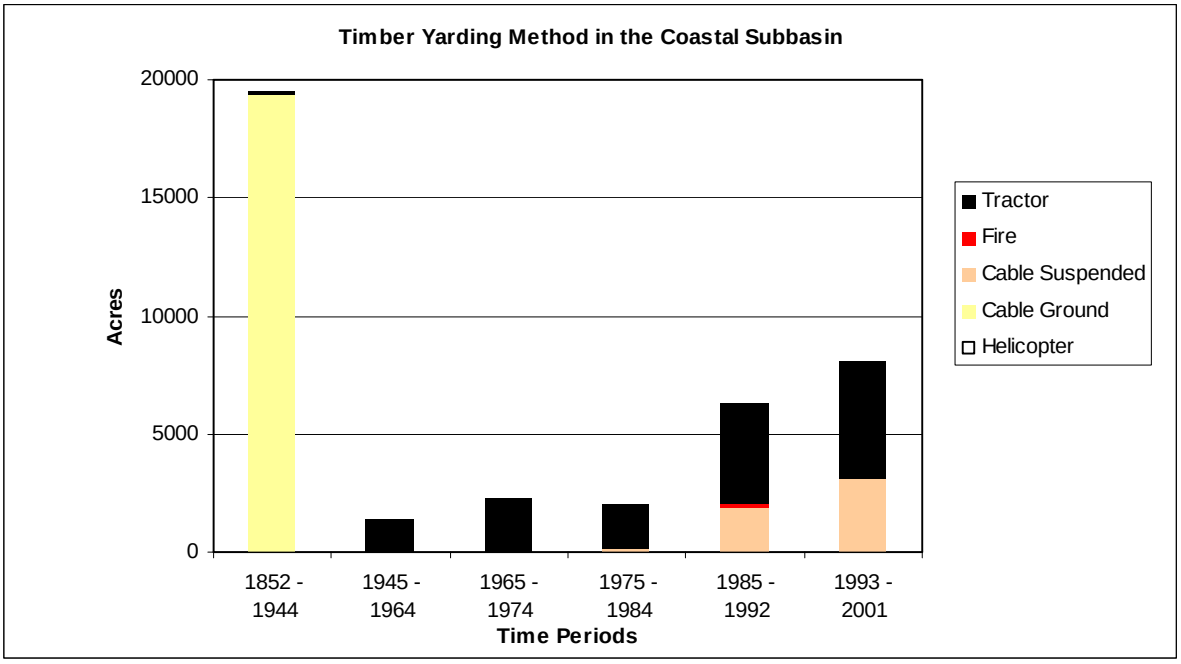

Figure 63. Acres of timber harvest yarding methods in the Coastal Subbasin.

GMA (2001) calculated the harvest density, a measure of the acres of timber harvested in a given time period divided by the total acreage in the watershed, for 1937-1951, 1952-1964, 1965-1977, 1978-1987, and 1988-2001. The harvest density was 51 acre/acre for 1989 to 2000 (or 51% of the watershed). This was the most intense harvesting during any of the time periods studied. Over the entire study period, an estimated 133% of the Coastal Subbasin was harvested, with roughly 38% of that happening from 1989-2000. The percentage harvest exceeds 100% in part because some areas were harvested multiple times. Of the harvesting that occurred in the 1989-2000 time period, it was reported that approximately 23% was clear-cut and 77% partial cut, with less than one percent skid trails.

The remains of giant stumps, railroad beds, splash dams, and booms from the heydays of logging throughout the Big River Basin are still present in the estuary.

A CDF analysis of disturbance levels across this subbasin found high disturbance level activities on many acres before 1944 (Figure 64). Activities appeared to decrease from 1944 to 1984, when moderate level activities were present over more acres than high disturbance activities. After 1985, all activities were low or moderate disturbance, but occurred over more acres than the time period from 1945 through 1984.

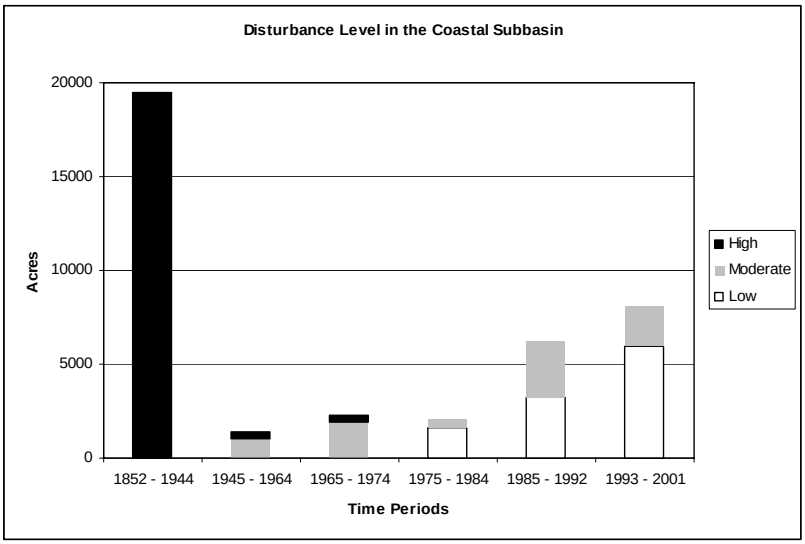

Figure 64. Acres by disturbance level in the Coastal Subbasin.

Roads

The Coastal Subbasin has a total of 248.4 miles of roads, the vast majority of which are not paved (Table 80). Overall road density is 7.7 miles per square mile and was estimated to be 4% paved and 96% rocked or native. A logging road parallels the river near the mouth and provides access to the estuary. Road construction has been at its highest levels since 1989, with increased timber harvest of second growth.

Table 80. Length of truck roads by period and road surface.

Period	Total Length in Miles				Length in Miles per Sq Mile			
	Native	Paved	Rocked	Total	Native	Paved	Rocked	Total
Up thru 1936	33.3	8.3	7.2	48.8	1.0	0.3	0.2	1.5
1937 - 1952	22.1	1.7	6.6	30.3	0.7	0.1	0.2	0.9
1953 - 1965	19.1	0.2	3.2	22.5	0.6	0.0	0.1	0.7
1966 - 1978	26.9		9.2	36.2	0.8		0.3	1.1
1979 - 1988	27.9		10.9	38.8	0.9		0.3	1.2
1989 - 2000	62.9	0.1	8.8	71.8	1.9	0.0	0.3	2.2
Total	**192.2**	**10.3**	**45.9**	**248.4**	**5.9**	**0.3**	**1.4**	**7.7**

Lengths are roads constructed in time period, not cumulative.

Water Quality

Estuary

During periods of low flow and high tide, the estuarine influence on the Big River can extend approximately 8.3 miles from the mouth of the Big River to roughly the confluence of Laguna Creek. For the water quality assessment, the boundaries of the Big River estuary were not specifically delineated, but were treated as a subset of the Coastal Subbasin. This area is discussed separately because of the estuarine influence on water quality in this portion of the Big River Basin. Larger features included in the Big River estuary are the mouth of the Big River, and Dry Dock Gulch.

There was no information available for temperature in the Big River Estuary, probably reflective of the difficulty in sampling estuarine areas with ever-changing physical and chemical conditions. Physical-chemical information is also largely lacking, as noted by the presence of only two sampling events, once each during 1993, and 1994, in an unnamed tributary to the Big River.

Sediment

Turbidity samples were available for one small, unnamed tributary in the Big River Estuary. It should be noted that there are not sufficient turbidity data to make more than broad statements about this constituent. In the two samples collected, the turbidity levels in the water were very low, ranging from 0.8 to 6.0 NTU. However, more sampling is needed to begin to characterize the turbidity conditions in this stream.

Water Column Chemistry

Overall, little is known about water quality in the Big River Estuary. Searches for available water quality data revealed only two water quality sampling locations: at the Highway 1 Bridge and in what appears to be a small unnamed tributary near the mouth of the Big River (Table 81). The Highway 1 bridge sampling location was established in a WDR permit issued to the California Department of Transportation for water quality monitoring during bridge retrofit activities. However, no data associated with this permit were discovered and it is unclear if any water quality monitoring has occurred to date.

The sampling associated with the unnamed tributary to the Big River (R.M. 0.4) occurred as part of routine testing for California Department of Health Services in a cistern well that is now inactive. A cistern well is a shallow well, typically set in a creek or spring that primarily draws surface water. In this case, the description of the source was a “cistern well, creek diversion.” Based on the water quality and the fact that this site was used as a drinking water source, it is most likely not representative of the more saline water found in the Big River Estuary. Therefore, because of the limited amount of data associated with this site and unknowns about data quality, data from the cistern well were used for screening purposes only.

The cistern well was operated by the Big River Vista Mutual Water Company and was sampled on three occasions; once in 1988, 1993, and 1994. The well itself was physically located approximately 0.5 miles

upstream from the Highway 1 Bridge, along what appears to be an intermittent stream on the south bank of the Big River.

The analysis of water column chemistry is divided into parameters with numeric water quality objectives in the Basin Plan, parameters with narrative water quality objectives in the Basin Plan (which can be quantified using numeric criteria found in the literature), and other important parameters that may have applicable narrative water quality objectives, but no available numeric criteria.

Basic water chemistry data, including specific conductance, and hydrogen ion concentration (pH) were compared to numeric water quality objectives in the Basin Plan. Dissolved oxygen and total dissolved solids were not sampled at this site. The summary data for basic water quality at the Vista Mutual Water Company site are shown below.

Table 81. Basic water chemistry, Big River Estuary.

Parameter	Count All	Count Detects	Min.	Date Min[1]	Max.	Date Max	Average.	WQ Objectives	
								MIN	MAX
Site Name, Location: Vista Water Company, unnamed tributary to Big River estuary									
pH, Lab (pH units)	2	2	6.3	1/26/93	6.3	1/26/93	NA	6.5	8.5
Specific Conductance (µS/cm)	2	2	115	1/26/93	117	6/8/94	NA	NA	300[2] / 195[3]

[1] Date on which the minimum value occurred is the first date that the value occurred. For example, if there were several "non-detects", represented here as a zero, the date given is the first instance of non-detect (chronologically).
[2] Value represents the 90th percentile upper limit. 90% of the values in a calendar year must be equal to or less than the 90% upper limit.
[3] Value represents the 50th percentile (median) upper limit. 50% of the monthly means in a calendar year must be equal to or less than the 50% upper limit.

As can be seen in Table 81, the pH of the water was detected at 6.3 in both sampling events, which is lower than the minimum Basin Plan water quality objective. Specific conductance appeared to be within the acceptable range in both samples.

Narrative water quality objectives in the Basin Plan apply to a variety of metals and other constituents that were detected during the sampling events. This includes alkalinity, chloride, iron, sodium, and sulfate. However, unlike the constituents shown in Table 81, the numeric criteria for these parameters are derived from the literature to support the narrative water quality objectives. These constituents and the most conservative applicable criteria are shown in Table 82.

Table 82. General water column chemistry, Big River Estuary.

Parameter	Count All	Count Detects	Min.	Max.	Average	Criteria	Criteria Exceeded?	Comments on Criteria[1]
Site Name, Location: Vista Water Company, unnamed tributary to Big River estuary								
Total Alkalinity (mg/L as CaCO3)	2	2	7.0	14.0	NA	≥ 20 mg/L	Yes	Protection of freshwater aquatic life
Chloride, Dissolved (mg/L)	2	2	29.0	32.0	NA	≤ 106 mg/L	No	Protection of agricultural water uses
Iron, Dissolved (µg/L as Fe)	2	1	0	120.0	NA	≤ 300 µg/L	No	Secondary California MCL for drinking water
Sodium, Dissolved (mg/L as Na)	2	2	17.0	17.0	NA	≤ 2 mg/L	Yes	SNARL for drinking water toxicity other than cancer risk, US EPA[2]
Sulfate, Dissolved (mg/L as SO4)	2	1	0	3.7	NA	≤ 250 mg/L	No	Secondary California MCL for Drinking Water

[1] See the Water Column Chemistry section for description of criteria.
[2] Assumes a relative source contribution of 10% from drinking water and 90% from other dietary sources.

As can be seen in Table 82, most of the constituents did not exceed their respective criteria, with the exception of sodium and total alkalinity (which was below the criteria). No other criteria were found in Marshack (2000) relating to either sodium or total alkalinity. It is not clear if these water samples were filtered or not filtered, and how they were collected and analyzed. Each of these factors could affect the extent to which the sample results are representative of the true concentrations. Finally, with only two samples collected on what appears to be a small intermittent stream near the mouth of the Big River, these results are only a beginning of the sample set that is needed to characterize the surface water in this tributary. Therefore, these values are useful as screening values only and additional sampling should occur if the water quality in this tributary is to be characterized.

Total hardness was also reported in the water quality sampling, but does not have water quality criteria at this time. However, it can affect the toxicity of metals to aquatic life and is therefore important beyond just being a

basic water quality indicator. Samples for total hardness as calcium carbonate ($CaCO_3$) were collected on two occasions. The first sample, collected on January 26, 1993, was reported to be 20 mg/L. The second sample, collected on June 8, 1994, was reported to be 18 mg/L.

No anthropogenic chemicals were detected in any of the samples.

Estuary Discussion

As seen in the preceding sections, there is very little water quality information available for the estuarine reaches and its associated tributaries to the Big River. The lack of data for water temperature, in-stream sediment, as well as the data results from the physical-chemical water sampling during 1996 and 1997 in the unnamed tributary to Big River by the Vista Water Co. are insufficient to fully characterize historical and/or future water quality conditions, either in the tributary or those portions of the Big River Estuary that may be influenced by tributary runoff.

Tributaries and Mainstem

Water temperature information for the Coastal Subbasin is fairly complete, particularly for subbasin tributaries, due to participation by local landowners such as Hawthorne Timber Company (HTC) and the CDF at JSDF.

Recent bulk sediment records, along with older V* and pebble counts conducted in 1992 were available. GMA was responsible for a portion of the bulk sediment data that was gravimetrically analyzed. HTC also collected bulk sediment data but used volumetric collection and analytical methods, the same method prescribed for those watersheds having TMDLs in place or under consideration by the Regional Water Board.

Mainstem Big River physical-chemical information is fairly representative, with sampling conducted by the Regional Water Board through the efforts of the SWAMP during two sampling events in 2001 in the mainstem below the Little North Fork. Joint Regional Water Board and USGS sampling also occurred in the mainstem upstream of the Little North Fork from 1959-1988. Unlike the mainstem Big River, there were no physical-chemical sampling records uncovered during the data-gathering phase of the assessment for subbasin tributaries.

Water Temperature

Continuous water temperature data logging devices were deployed by HTC and JDSF at a total of twelve (12) locations in the Coastal Subbasin (Figure 65). In general, water temperature was monitored in one or more locations in the subbasin during the years 1993 to 2001.

There are a total of four monitoring sites on the Little North Fork (JSF 541, JSF 542, HTC BIG10, and HTC BIG8). These monitoring sites are all located in the upper and middle reaches of the Little North Fork. JSF 541 was monitored for two years, JSF 542 was monitored for two years, HTC BIG10 was monitored for seven years, and HTC BIG8 was monitored for seven years. Based on data from these sites, the water temperature varies between fully suitable with a minimum observed MWAT of 57ºF, to moderately suitable with a maximum observed MWAT of 61ºF. As would be expected, the water temperatures appear to gradually increase further downstream, as evident in Figure 66. None of the tributaries that were monitored appear to significantly alter the water temperatures in the Little North Fork. This includes the East Branch Little North Fork (HTC BIG9), which was monitored for six years, Berry Gulch (JSF 543), which was monitored for two years, and Thompson Gulch (JSF 544) which was monitored for one year. Based on the data from these sites, the maximum observed MWATs varied from 57-60°F. Furthermore, most of the Little North Fork and tributary monitoring sites exhibited low diurnal fluctuations suggesting good shading, and/or good flow conditions and/or a tempering marine influence. As listed in Table 83, the sites which exhibited the highest diurnal fluctuations were HTC BIG8, HTC BIG9, and HTC BIG10. These three sites also appear to have a downward trend in the MWAT values, which may reflect re-growth of canopy. Available THP maps (KRIS Big River) indicate that harvesting occurred in the vicinity of these sites in approximately 1989. A 1994 Landsat map (KRIS Big River) shows open areas and small trees near these monitoring sites, but a map of the change in vegetation between 1994 and 1998 did not indicate a loss or gain of vegetation.

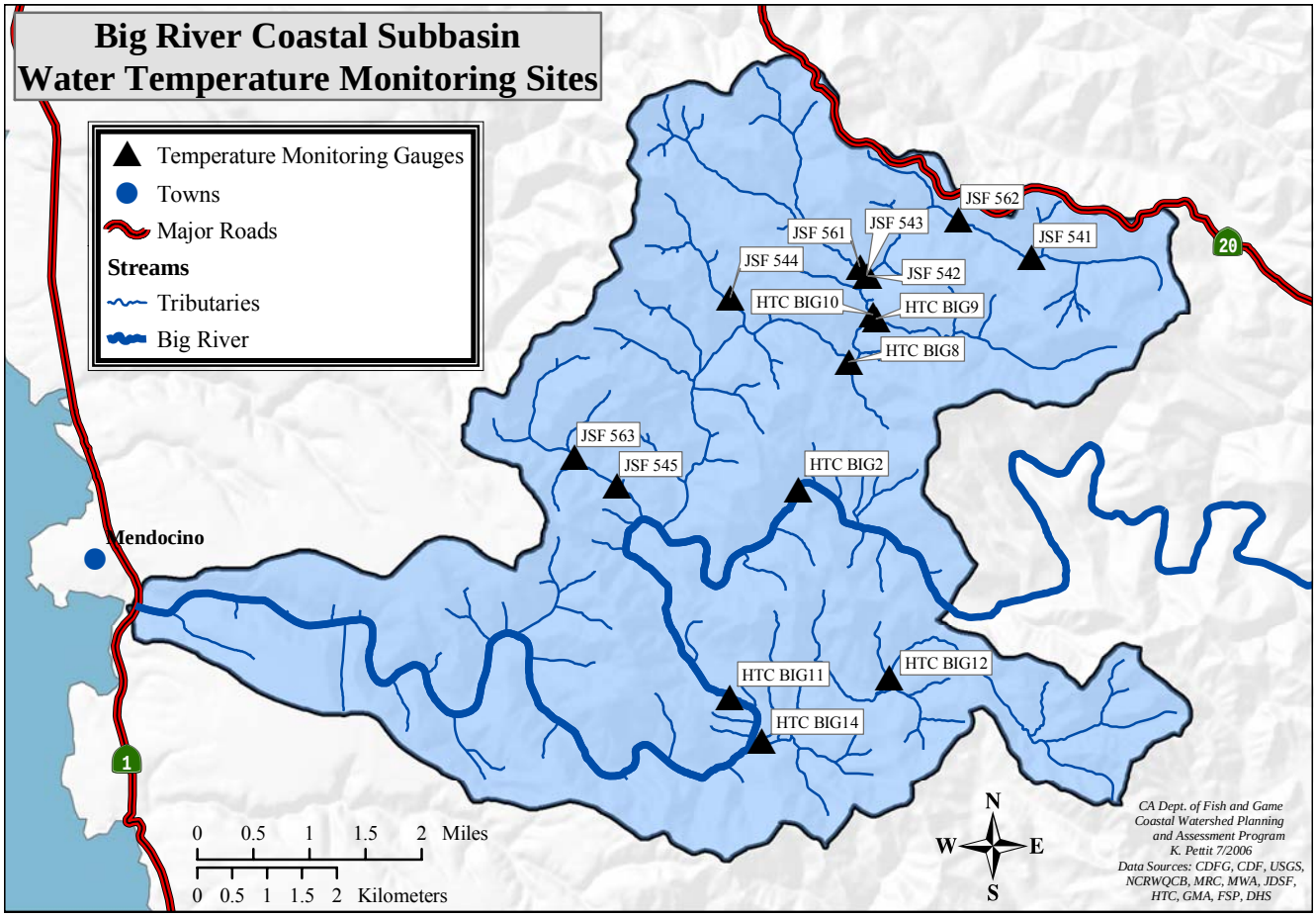

Figure 65. Water temperature monitoring sites, Coastal Subbasin.

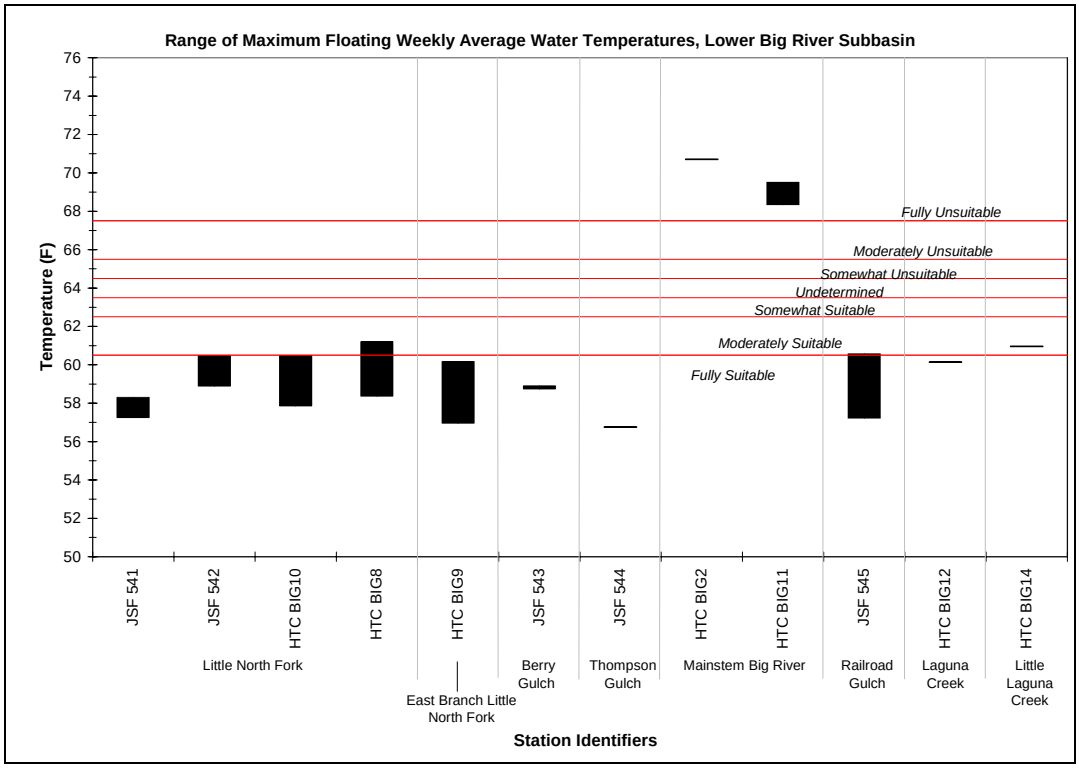

Figure 66. Range of MWATs, Coastal Subbasin.

Table 83. Water temperature summary, Coastal Subbasin.

Site	Max MWAT	MWAT Trend	Range of max diurnal Fluctuations		Seasonal Max	Years of Data
Fully Suitable (50-60°F)						
JSF 544	57	NA	2.5	2.5	58	1
JSF 541	58	1.0	2.8	3.1	60	2
JSF 543	59	-0.2	4.8	4.8	61	2
HTC BIG 12	60	NA	4.0	4.0	62	1
HTC BIG 9	60	-3.2	4.7	7.2	64	6
JSF 542	60	0.9	4.8	5.6	62	2
HTC BIG 10	60	-2.6	4.3	6.8	65	7
Moderately Suitable (61-62°F)						
JSF 545	61	0.6	4.5	5.0	62	3
HTC BIG 14	61	NA	5.7	5.7	64	1
HTC BIG 8	61	-2.8	6.2	8.1	66	7
Somewhat Suitable (63°F)						
--	--	--	--	--	--	--
Undetermined (64°F)						
--	--	--	--	--	--	--
Somewhat Unsuitable (65°F)						
--	--	--	--	--	--	--
Moderately Unsuitable (66-67°F)						
--	--	--	--	--	--	--
Fully Unsuitable (68°F)						
HTC BIG 11	70	-1.2	7.9	9.5	75	2
HTC BIG 2	71	NA	9.9	9.9	76	1

The one site in Railroad Gulch (JSF 545), a tributary to the mainstem Big River, was monitored for three years. During the three years monitored, the water temperature varied between fully suitable with a minimum observed MWAT of 57°F to moderately suitable with an observed MWAT of 61ºF. Diurnal fluctuations were minimal and there was no apparent trend in MWAT values. Available THP maps (KRIS Big River) of Railroad Gulch indicate no harvesting near the stream during the period of 1987-1999.

Laguna Creek, a tributary to the mainstem Big River, was also monitored at one location (HTC BIG12) in the middle portion of the stream for one year. During the one year monitored, the water temperature was fully suitable with a maximum observed MWAT of 60ºF. A tributary to Laguna Creek, Little Laguna Creek, was monitored at one location (HTC BIG14) in the lower portion of the stream for one year. During the one year monitored, the water temperature was moderately suitable with a maximum observed MWAT of 61ºF. Based on the available data, it appears as though Little Laguna Creek has no significant effect on the water temperature of Laguna Creek. Diurnal fluctuations were minimal and there was insufficient data to establish a trend at either site.

There are a total of two monitoring sites on mainstem Big River (HTC BIG2 and HTC BIG11). One site is located before the confluence with the Little North Fork (HTC BIG2) and was monitored for one year. The other site is located above the confluence with Laguna Creek (HTC BIG11) and was monitored for two years.

The monitoring site above the confluence with the Little North Fork (HTC BIG2) recorded water temperatures that were fully unsuitable with a maximum observed MWAT of 71ºF. In addition, the maximum water temperature recorded was 76ºF, over the lethal limit for salmonids (75ºF). The diurnal fluctuations (9.9ºF) at this site also suggest moderate to poor cover and/or low flows.

The monitoring site on the mainstem Big River above Laguna Creek (HTC BIG11) recorded water temperatures that were fully unsuitable with a maximum observed MWAT of 70ºF. In addition, the maximum water temperature recorded was 75ºF, the lethal limit for salmonids (75ºF). The diurnal fluctuations at this site (7.9-9.5°F) suggest poor canopy and/or flow conditions.

USFWS monitored one site on the mainstem Big River at the confluence with the Little North Fork Big River in 1973 (Perry 1974). This site was approximately halfway between the two more recent monitoring sites (HTC BIG2 and HTC BIG11). The 1973 monitoring site recorded water temperatures that were moderately unsuitable with a MWAT of 67ºF. In addition, the maximum water temperature recorded was 74ºF, close to the lethal limit for salmonids (75ºF). Comparison of 1973 data with recent monitoring along the mainstem Big River appears to

show an increase in water temperature. However, the 1973 monitoring site was at the confluence with the Little North Fork Big River, which recent data have shown to have cooler water than the mainstem Big River and may be exerting a cooling influence.

Sediment

There is not sufficient data to make more than broad statements about turbidity in the Coastal Subbasin (Table 84). Of the 87 samples collected with the Hach turbidimeter, 90% of the samples were equal to or less than 51.6 NTU, with a maximum recorded value of 600 NTU. In addition, at the SWAMP station located downstream of the Little North Fork Big River confluence, one turbidity sample was collected that had turbidity level of 0.19 NTU.

Another set of 96 turbidity samples collected at the same location indicated that 90% of the samples were equal to or less than 40 ppm as SiO_2, with a maximum recorded value of 340 ppm as SiO_2. However, Hellige turbidity samples (measured as ppm as SiO_2) cannot be directly compared to the other turbidity measurements.

Table 84. Turbidity summary, Coastal Subbasin.

Parameter	Count All	Count Detects	Min.	Date Min[1]	Max.	Date Max	Average	50th Percentile	90th Percentile
Site Name, Location: RWQCB 1 & USGS, Mainstem Big River upstream of LNF Big River									
Turbidity, Hellige (ppm as Silicon Dioxide)	96	94	0	9/16/70	340.0	1/23/69	20.7	3.0	40.0
Turbidity, HACH Turbidimeter (NTU)	87	76	0	5/4/72	600.0	2/13/75	33.4	1.0	51.6
Site Name, Location: SWAMP BIGMWD, Mainstem Big River downstream of LNF Big River									
Turbidity (NTU)	1	1	0.19	06/28/01	0.19	06/28/01	NA	NA	NA

[1] Date on which the minimum value occurred is the first date that the value occurred. For example, if there were several "non-detects", represented here as a zero, the date given is the first instance of non-detect (chronologically).

Turbidity that is significantly elevated above background levels can impede the ability of salmonids to feed and can be an indicator of potential problems with suspended sediment. This in turn may point to potential problems with heavy sediment loads. The turbidity sampling conducted at these sites, combined with additional sampling, can eventually establish the range of background levels.

Pebble counts and V* measurements were conducted by Chris Knopp (Knopp 1993) in Berry Gulch, a tributary to the Little North Fork Big River in 1992. Berry Gulch was selected as a "highly disturbed watershed," indicating that it exhibited large areas of disturbed soil, unpaved, low-slope roads, inconsistent or poor stream course protection, and inconsistent avoidance of unstable terrain during the last 40 years. This site was one of 21 sites chosen by Knopp that were highly disturbed.

The pebble count conducted in Berry Gulch had a median pebble size that was calculated to be 28 mm. This value is significantly lower than the 69 mm median particle size from the combined "index yes" and "index no" streams (Knopp 1993). However, even when compared to the median pebble sizes from the other highly disturbed streams measured by Knopp (1993), Berry Gulch was significantly lower. For example, the average of all median pebble sizes in highly disturbed streams was 38 mm compared to the 28 measured at Berry Gulch. For salmonids, the smaller the median pebble size, the more potentially detrimental during the early life stages.

V* is a measure of fine sediments that occupy the scoured residual volume of a pool. This is measured as the depth of the sediment layer in a pool from the apparent bottom of the pool to the armor layer beneath the loose sediment. As the amount of sediment in transport increases, the amount of sediment deposition in pools should increase. For the reach measured in Berry Gulch, the V* was calculated to be 38%. In other words, 38% of the scoured residual pool volume was filled with sediment. The target value for this measurement is less than an average of 21% or maximum of less than 45% sediment for Franciscan formations. While a measurement of 38% is on the high side, it is only one measurement during one year. Further sampling is necessary to confirm the results of this measurement.

In 1996 and 1997, the Hawthorne Timber Company collected McNeil samples at one site in the Coastal Subbasin (BIG 8), located on the Little North Fork Big River below the confluence with the East Branch Little North Fork. These McNeil core samples were collected using a volumetric method, and are therefore directly comparable to the Big River TMDL targets. In general, four McNeil cores were collected at each of the two riffles sampled. A summary of McNeil data collected at BIG 8 is shown in Table 85. Raw data were not available for this assessment.

Table 85. Bulk sediment data summary (volumetric), LNF Big River (HTC).

Site Name	Site Location	Year	Sieve Size (mm)	Median Percent Less Than
BIG 8	Little North Fork Big River	1996	4.0	32.8%
			0.85	18.3%
		1997	4.0	28.1%
			0.85	17.1%

Based on the summary data shown in Table 85, the sediment in the sub 6.5 mm size class exceeded the Big River TMDL target of ≤ 30% in 1996 and may have exceeded it in 1997. Because a 4-mm sieve was used, the comparison was made with the 4-mm value instead of 6.5 mm. Therefore, for comparisons to the TMDL target, it is conservative. The sediment in the sub 0.85 mm size class exceeded the Big River TMDL target of ≤ 14% in both 1996 and 1997. In both size classes, the sediment values improved from 1996 to 1997. However not enough data are available and the apparent improvement could be due to sample variability.

In 2001, Graham Matthews & Associates collected McNeil core samples in the Coastal Subbasin at one site located approximately 150 feet downstream of the confluence with Railroad Gulch. However, since the core samples were collected using the gravimetric method (dry sieve), it is not comparable to the Big River TMDL target for fine sediment.

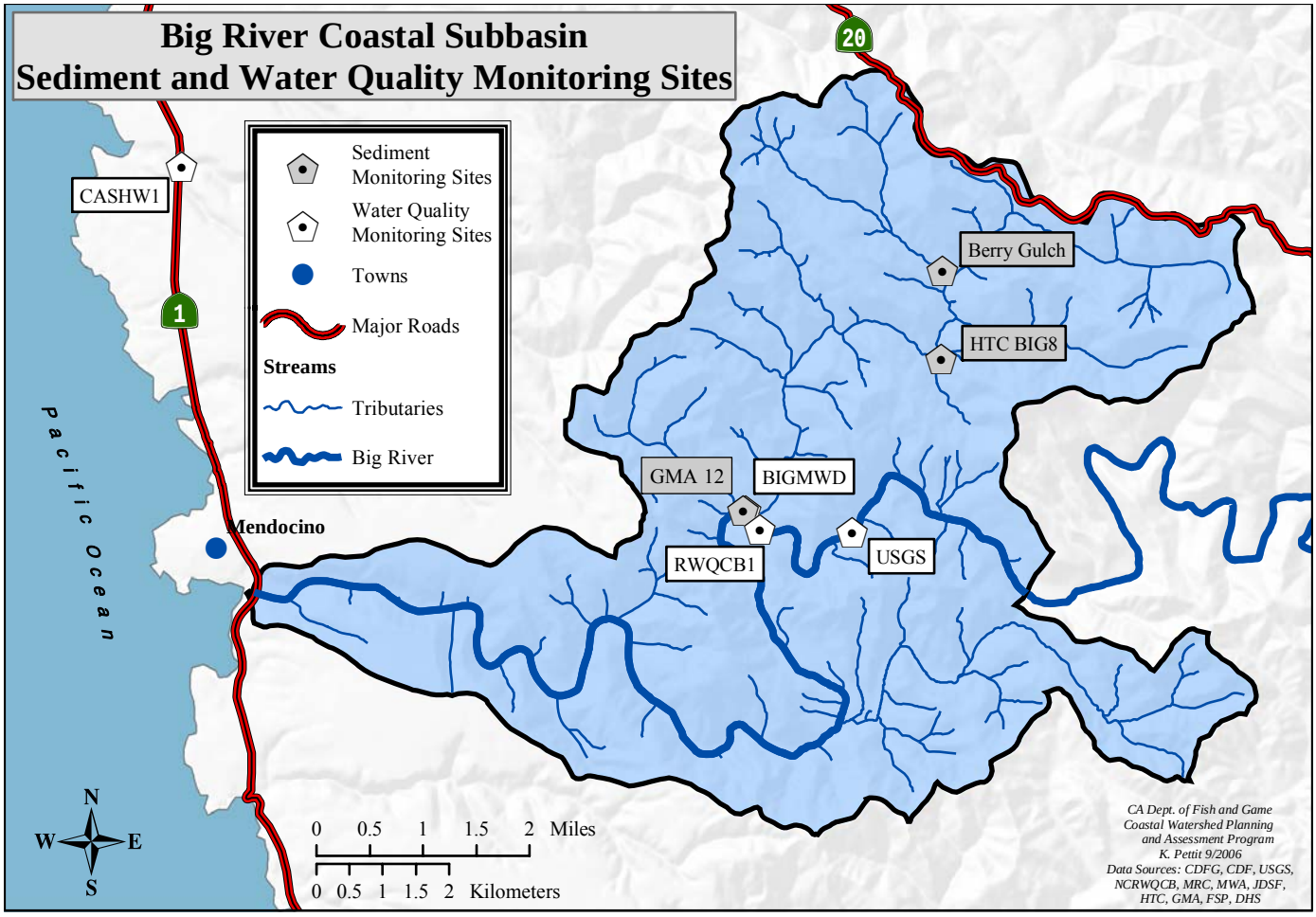

Figure 67. In-stream sediment and water quality monitoring sites, Coastal Subbasin.

Water Column Chemistry

Water chemistry data were collected at three closely spaced surface water locations in the Coastal Subbasin. The first sampling site is located on the Big River, immediately downstream of the confluence with the Little North Fork of the Big River. This site was sampled by the Regional Water Board (under the SWAMP program) on two occasions in 2001. The second sampling site is located on the Big River, immediately upstream of the Little North Fork of the Big River confluence near the Mendocino Woodlands. Established by the Regional Water Board in 1959, it was generally sampled monthly until about 1966 and then typically sampled every two months from 1968 until 1988. The third surface water-sampling site, located approximately 1.5 miles upstream

from the Regional Water Board site, was sampled by the USGS. Originally established in 1960, it was generally sampled monthly through 1966, and then once in 1977.

Other than what appears to be one short unnamed tributary, there are no streams converging with the Big River between the Regional Water Board and USGS locations, and therefore the water chemistry should be similar and comparable between these sites. Thus, these data sets were combined and treated as a single data set for this assessment.

The analysis of water column chemistry is divided into parameters with numeric water quality objectives in the Basin Plan, parameters with narrative water quality objectives in the Basin Plan (which can be quantified using numeric criteria found in the literature), and other important parameters that may have applicable narrative water quality objectives, but no available numeric criteria.

Basic water chemistry data, including specific conductance, total dissolved solids, dissolved oxygen, and hydrogen ion concentration (pH) were compared to numeric water quality objectives in the Basin Plan. The summary data for basic water quality at all sites in the Coastal Subbasin are shown in Table 86.

Table 86. Basic physical water parameters, Coastal Subbasin.

Parameter	Count All	Count Detects	Min.	Date Min	Max.	Date Max	Average	WQ objectives	
								Min	Max
Site Name, Location: SWAMP BIGMWD, Mainstem Big River downstream of LNF Big River									
Dissolved Oxygen, Field (mg/l)	2	2	8.96	06/28/01	9.38	05/10/01	NA	7.0 / 7.5[1] / 10.0[2]	NA
pH (pH units)	2	2	8	05/10/01	8	05/10/01	NA	6.5	8.5
pH, Field (pH units)	2	2	7.79	06/28/01	7.81	05/10/01	NA	6.5	8.5
Specific Conductance (uS/cm)	1	1	190	06/28/01	190	06/28/01	NA	NA	300[3] / 195[4]
Specific Conductance, Field (uS/cm)	2	2	195	06/28/01	203	05/10/01	NA	NA	300[3] / 195[4]
Total Dissolved Solids (mg/l)	**2**	**2**	**110**	**05/10/01**	**140**	**06/28/01**	**NA**	**NA**	**190[3] / 130[4]**
Site Name, Location: RWQCB 1 & USGS, Mainstem Big River upstream of LNF Big River									
Dissolved Oxygen (mg/L)	207	207	4.5	10/13/82	13.0	1/5/67	10.1	7.0 / 7.5[1] / 10.0[2]	NA
pH (pH units)	269	269	0.76	12/5/60	8.4	6/4/65	7.4	6.5	8.5
pH, Lab (pH units)	135	135	7.0	1/6/59	8.4	6/4/65	7.8	6.5	8.5
Specific Conductance (uS/cm)	202	202	76.0	2/13/75	292.0	6/12/63	182.6	NA	300[3] / 195[4]
Specific Conductance, Field (uS/cm)	95	95	79.0	2/13/75	581.0	8/30/77	184.6	NA	3003 / 195[4]
Total Dissolved Solids (mg/l)	**9**	**9**	**107.0**	**5/7/63**	**136.0**	**9/13/63**	**123.8**	**NA**	**190[3] / 130[4]**

[1] Value represents the 90th percentile lower limit. 90% of the values in a calendar year must be equal to or greater than the 90% lower limit.
[2] Value represents the 50th percentile (median) lower limit. 50% of the monthly means in a calendar year must be equal to or greater than the 50% lower limit.
[3] Value represents the 90th percentile upper limit. 90% of the values in a calendar year must be equal to or less than the 90% upper limit.
[4] Value represents the 50th percentile (median) upper limit. 50% of the monthly means in a calendar year must be equal to or less than the 50% upper limit.

Given the limited data that are available, it does not appear any of the basic water column chemistry parameters at the site downstream of the confluence with the Little North Fork (SWAMP BIGMWD) are significantly outside of the range of Basin Plan water quality objectives.

At sites upstream of the Little North Fork (RWQCB 1 and USGS), two dissolved oxygen points, and one pH data point fall outside of the numeric Basin Plan water quality objectives. However, given that these skewed data points are from a data set of 207 and 269 points, respectively, it is unlikely that these are significant. The specific conductance and total dissolved solids values appear to be within the numeric Basin Plan water quality objectives.

Narrative water quality objectives in the Basin Plan apply to a variety of metals and other constituents that were detected during sampling events. This includes alkalinity, ammonia, boron, chloride, copper, iron, nitrate, sodium, sulfate, turbidity, and zinc. However, unlike the constituents shown in Table 86, the numeric criteria for these parameters are derived from the literature to support the narrative water quality objectives. These constituents and the most conservative applicable criteria are shown in Table 87.

Table 87. General water column chemistry, Coastal Subbasin.

Parameter	Count All	Count Detects	Min.	Max.	Average	Criteria	Criteria exceeded?	comments on CRITERIA[1]
Site Name, Location: SWAMP BIGMWD, Mainstem Big River downstream of LNF Big River								
Total Alkalinity (mg/L as CaCO3)	2	2	82	84	NA	≥ 20 mg/L	No	Protection of freshwater aquatic life
Boron (µg/L)	2	2	250	330	NA	≤ 630 µg/L	No	IRIS reference dose for drinking water, US EPA
Chloride (mg/L)	1	1	6.5	6.5	NA	≤ 106 mg/L	No	Protection of agricultural water uses
Copper (µg/L)	2	0	NA	NA	NA	≤ 7.0 µg/L	No	Protection of freshwater aquatic life with a hardness of 75 mg/L[2]
Iron (µg/L)	2	1	0	190	NA	≤ 300 µg/L	No	Secondary California MCL for drinking water
Nitrate/Nitrite as N (mg/L)	2	0	NA	NA	NA	≤ 10 mg/L	No	Primary US EPA MCL for drinking water
Sodium (mg/L)	2	2	12	12	NA	≤ 2 mg/L	Yes	SNARL for drinking water toxicity other than cancer risk, US EPA[3]
Sulfate as SO4 (mg/L)	1	1	7.1	7.1	NA	≤ 250 mg/L	No	Secondary California MCL for drinking water
Zinc (µg/L)	2	0	0	0	NA	≤ 93 µg/L	No	Protection of freshwater aquatic life with a hardness of 75 mg/L[2]
Site Name, Location: RWQCB 1 & USGS, Mainstem Big River upstream of LNF Big River								
Total Alkalinity (mg/L as CaCO3)	103	103	30.0	103.0	76.8	≥ 20 mg/L	No	Protection of freshwater aquatic life
Chloride, Dissolved (mg/L)	136	136	1.0	19.0	7.1	≤ 106 mg/L	No	Protection of agricultural water uses
Copper (µg/L)	7	2	0	10.0	NA	≤ 6.8 µg/L	Yes	Protection of freshwater aquatic life with a hardness of 73 mg/L[2]
Iron, Dissolved (µg/L as Fe)	8	4	0	130.0	36.3	≤ 300 µg/L	No	Secondary California MCL for drinking water
Nitrate, Dissolved (mg/L as NO3)	44	34	0	1.7	0.35	≤ 10 mg/L	No	Primary US EPA MCL for drinking water
Sodium, Dissolved (mg/L as Na)	201	201	4.5	17.0	10.4	≤ 2 mg/L	Yes	SNARL for drinking water toxicity other than cancer risk, US EPA[3]
Sulfate, Dissolved (mg/L as SO4)	37	37	0.8	15.0	6.4	≤ 250 mg/L	No	Secondary California MCL for drinking water
Zinc (µg/L)	7	3	0	70.0	22.9	≤ 90 µg/L	No	Protection of freshwater aquatic life with a hardness of 73 mg/L[2]

[1] See the Water Column Chemistry section for description of criteria.
[2] See text below for details on derivation of criteria.
[3] Assumes a relative source contribution of 10% from drinking water and 90% from other dietary sources.

As can be seen in Table 87, all of the constituents that have numeric criteria did not exceed their respective criteria, with the exception of sodium at both sites and copper at the site upstream of the Little North Fork (RWQCB 1 & USGS). No other criteria were found in Marshack (2000) relating to sodium or copper. It should also be noted that in the downstream site (SWAMP BIGMWD), alkalinity was speciated into carbonate, bicarbonate, and hydroxide alkalinity. At SWAMP BIGMWD, the alkalinity was entirely bicarbonate alkalinity. In the upstream water samples (RWQCB 1 & USGS), it is not clear if the water samples were filtered or not filtered, and how they were collected and analyzed. Each of these factors could affect the extent to which the sample results are representative of the true concentrations of dissolved sodium in the water column. While this should be investigated further, it is probable that sodium in the water is naturally occurring and not anthropogenic pollution. All of these sites are also outside of the estuary area, and therefore should not be saline.

Some constituents, including copper and zinc, vary in toxicity depending on the hardness of the water and therefore have hardness dependant criteria. At the upstream sampling sites (RWQCB1 & USGS), a total of 199 samples were analyzed for hardness with an average hardness of 73 mg/L as calcium carbonate ($CaCO_3$). This value was used to determine the toxicity criteria for copper and zinc. However, it should be noted that the sampling for hardness and these metals did not necessary coincide.

On two occasions, dissolved copper concentrations were reported as 10 µg/L, with the remaining five samples reported as zero. Presumably, the sample detections reported as zero were in fact "non-detects," below some unknown detection limit less than 10 µg/L. Given an average hardness of the 73 mg/L, the maximum one-hour average concentration of dissolved copper is 10 µg/L. Based on the two positive detections out of a total of

seven samples, copper concentrations at the upstream sites appear to be at or below the criteria to protect freshwater aquatic life.

Surface water at the downstream site (SWAMP BIGMWD) was also analyzed for copper on two occasions. Hardness at this site averaged 75 mg/L. Copper samples were reported as "non-detect," at or above the laboratory detection limit of 10 µg/L. Therefore, if copper did exist in the downstream samples, the concentrations were below the detection limits.

Dissolved zinc concentrations were reported as 30, 60, and 70 µg/L at the upstream sites (RWQCB 1 & USGS), with the remaining four samples reported as zero. Presumably, the sample detections reported as zero were in fact "non-detects", below some unknown detection limit less than 30 µg/L. Given an average hardness of 73 mg/L, the criteria for the maximum one-hour average concentration of dissolved zinc is 90 µg/L. Based on the three positive detections out of a total of seven samples, zinc concentrations in the Big River appear to be below the criteria to protect freshwater aquatic life.

Surface water at the downstream site (SWAMP BIGMWD) was also sampled for zinc on two occasions. Both samples were reported as "non-detect" at or above the laboratory detection limit of 20 µg/L. Therefore, if zinc did exist in the downstream samples, the concentrations were below the detection limits.

Other constituents, such as ammonia, vary in toxicity depending on the temperature and pH of the water. Ammonia was only sampled at the downstream site (SWAMP BIGMWD) on two occasions. On both occasions, no ammonia (as nitrogen) was detected at or above the laboratory detection limit of 0.05 mg/L.

Phosphorus and chlorophyll-a were also reported, but neither have specific numeric criteria at this time. However, they are broken out separately because they are a significant constituent of water quality.

Phosphorus can enter surface water bodies through fertilizer run-off or from the natural weathering of rocks in some watersheds. Phosphorus is a biostimulatory substance for algae, and excessive amounts can lead to algae blooms which can impact other aquatic life by negatively affecting dissolved oxygen concentrations. The summary data for phosphorus samples are shown in Table 88.

Table 88. Phosphorus summary, Coastal Subbasin.

Parameter	Count All	Count Detects	Min.	Date Min[1]	Max.	Date Max	AvG.
Site Name, Location: SWAMP BIGMWD, Mainstem Big River downstream of LNF Big River							
Phosphorus (mg/L)	2	0	0	NA	0	NA	NA
Orthophosphate as P (mg/L)	2	0	0	NA	0	NA	NA
Site Name, Location: RWQCB 1 & USGS, Mainstem Big River upstream of LNF Big River							
Total Phosphorus (mg/L as P)	4	4	0.03	5/5/76	0.07	2/5/86	0.04
Orthophosphate, Dissolved (mg/L as P)	19	17	0	5/13/64	0.07	9/5/61	0.02

Date on which the minimum value occurred is the first date that the value occurred. For example, if there were several "non-detects", represented here as a zero, the date given is the first instance of non-detect (chronologically)

There are not sufficient data to make more than broad statements about phosphorus. However, there was not an apparent problem with elevated phosphorus levels in the samples that were collected at the upstream sites (RWQCB 1 & USGS). Although both phosphorus and orthophosphate samples were collected at the downstream site (SWAMP BIGMWD) on two occasions for each analyte, it was not detected at or above the laboratory detection limits of 0.05 mg/L.

Chlorophyll-a was also sampled once at the downstream site (SWAMP BIGMWD) and was detected with a concentration of 0.00071 mg/L. Chlorophyll-a is a measurement of the chlorophyll in the suspended algae in the water column. High chlorophyll-a content, which directly relates to high algal concentrations in freshwater, can be an indicator of nutrient contamination of the surface water (such as in fertilizer run-off). However, there are no water quality criteria for this constituent and therefore it is used primarily to screen for other potential water quality problems.

In the upstream sites (RWQCB1 & USGS), total and fecal coliform bacteria were detected at a maximum most probable number (MPN) of 900/100 ml and 30/100 ml, respectively. While total coliform bacteria can come from a variety of sources, the presence of the fecal coliform subset in aquatic environments indicates that the water has been contaminated with the fecal material of humans or other animals. At the time this occurred, the source water may have been contaminated by pathogens or disease producing bacteria or viruses which can also

exist in fecal material. Some waterborne pathogenic diseases include typhoid fever, viral and bacterial gastroenteritis, and hepatitis A. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water. Fecal coliform bacteria may occur in ambient water as a result of the overflow of domestic sewage or nonpoint sources of human and animal waste.

The Basin Plan water quality objective for fecal coliform states that "the median fecal coliform concentration based on a minimum of not less than five samples for any 30-day period shall not exceed 50/100 ml, nor shall more than ten percent of total samples during any 30-day period exceed 400/100 ml" (RWQCB 2001). While not directly comparable, fecal coliform appears to be within the water quality objective.

Discussion

Collectively, temperature data show that the Coastal Subbasin is mostly unsuitable for MWATs in the mainstem and also when peak maximum temperature thresholds are considered. However, there were only three thermograph records at two stations along the mainstem. Big River tributary temperature records are nearly all suitable for both seasonally sampled MWATs and peak maximum temperatures. Both temperature metrics for the Coastal Subbasin reflect similar findings in all of the other subbasins for the mainstem and its tributaries.

Bulk sediment sampling was conducted during 1996 and 1997 by HTC and in 2001 by GMA in the Little North Fork and the mainstem Big River, respectively. The Little North Fork bulk sample results, except for the 1997 <6.4 mm = 28.1%, were unsuitable. Both GMA results are above thresholds for incubation and survival to emergence of salmonids from their redds. However, one result that was 14.5% was barely below threshold for salmonid incubation in fine sediment <0.85 mm = 14%. As noted in the tables for GMAs bulk sampling the gravimetric method used is not recognized as an acceptable methodology under current and/or prospective TMDLs for the North Coast Region to characterize subsurface spawning gravel suitability.

The data results from the two days of physical-chemical sampling during 2001 by the Regional Water Board under the SWAMP are insufficient to fully characterize historical and/or future water quality conditions in the lower Big River. The more extensive data sets from 1959-1988 are useful to reasonably extrapolate that, for the most part, physical chemical conditions of the mainstem Big River for some distance upstream from the Little North Fork are suitable. The single exceedance for copper appears to be an isolated incident, considering the 29 years that sampling took place. Excess sodium analyses were also experienced in other subbasins and in all likelihood sodium is a naturally occurring mineral in isolated reaches of the mainstem and tributary watercourses.

Riparian Conditions

There are 2,455 acres in the Coastal Subbasin in stream buffers, which includes the areas between the water and gravel bars in the lower reaches (Table 89). Across the subbasin, the area around the watercourses is well vegetated, as indicated by the 70 to 100% density class which accounts for 83% of the area (Table 89) Also 64% of the buffer area is in 80% canopy density or better, and 48% of the area is in the 90-100% canopy closure class. These numbers are substantiated by high canopy densities found along stream reaches surveyed by CDFG and discussed in *Fish Habitat Relationships*.

Table 89. Density of riparian vegetation in the Coastal Subbasin by planning watershed.

Planning Watersheds	Acres by Percent Crown Canopy Density										Acres in Buffer
	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	
Mouth of Big River	241	1		68	5	3	3	221	264	500	1,308
Berry Gulch	12		17	8			3	208	88	473	809
Laguna Creek	44		2	8		6	1	25	55	199	338
Total Coastal	**297**	**2**	**18**	**84**	**5**	**9**	**7**	**454**	**407**	**1,172**	**2,455**

Table 90. Percentage of stream buffer area in higher canopy closure classes in the Coastal Subbasin.

Planning Watersheds	Percent of Buffer Area by Crown Canopy Density				
	70%	80%	90%	70%+	80%+
Mouth of Big River	17	20	38	75	58
Berry Gulch	26	11	58	95	69
Laguna Creek	7	16	59	83	75
Total Coastal	**18**	**17**	**48**	**83**	**64**

As shown in Table 91, the majority of the trees in the watercourse buffer zone are small to medium/large, which are 12 to 40 inch dbh trees. Small, medium/large and large trees (>12 inches dbh) could be recruited to streams as large woody debris. Overall, 94% of the buffer zone area in the basin is in these size classes. At the PW level, the percentage area in these three size classes varies from 73% in the Mouth of Big River PW to 98% in the Berry Gulch PW.

Table 91. Acres and percentage of vegetation size classes in the watercourse buffer zone in the Coastal Subbasin.

Planning Watersheds	Sapling (<6 inches dbh)		Pole (6-11 inches dbh)		Small Tree (12-24 inches dbh)		Medium/Large Tree (24-40 inches dbh)		Large Tree (>40 inches dbh)	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Mouth of Big River	77	6	35	3	550	42	384	29	21	2
Berry Gulch	0	0	6	1	244	30	518	64	29	4
Laguna Creek	0	0	1	0	176	52	118	35	0	0
Total Coastal	**77**	**3**	**42**	**2**	**969**	**39**	**1,020**	**42**	**50**	**2**

The long estuary is flanked by mudflats, eelgrass beds, wetlands, and riparian forests. A Mendocino High School of Natural Resources (SONAR) survey of plants found in a mudflat in the estuary in 2002 found 28 species (Table 92Table 92). The valley flat in the first 2.2 river miles supports salt marshes, which are covered by high river flows and saturated at high tide. Upstream of this reach, the valley flat is well vegetated with mixed conifer forest (CGS 2004).

Table 92. Mendocino High School of Natural Resources estuary study plant species list for mud flat #1 (after SONAR 2002).

Scientific Name	Common Name
Atriplex triangularis	Fat-hen saltweed
Carex obnuta	Slough sedge
Castilleja ambigua humboldtinensis	Humboldt Bay owl's clover
Conioselinum pacificum	Hemlock-parsley
Cotula coronopifolia	Brass buttons
Cuscuta salina	Dodder
Deschampsia cespitosa cespitosa	Tufted hairgrass
Distichli spicata	Saltgrass
Eleocharis macrostachya	Spike rush
Frankenia salina	Alkali heath
Galium trifidum pacificum	Bedstraw
Grindelia stricta stricta	Gum weed
Holcus lanatus	Velvet grass
Hordeum brachyantherum	Barley
Jaumea carnosa	Fleshy jaumea
Juncus mexicanus	Mexican rush
Oenanthe sarmentosa	Water parsley
Plantago maritime	Beach plantain
Polygonum punctatum	Dotted smartweed
Potentilla anserine pacifica	Silverweed
Pucinellia pumila	Dwarf alkali grass
Rumex salicifolius	Willow dock
Salicornia virginica	Pickleweed
Scirpus cernuus	Low bulrush
Scirpus microcarpus	Small-fruit bulrush
Trifolium wormskioldii	Cows clover
Triglochin matima	Seaside arrow grass
Typha latifolia	Cat-tail

Changes in the vegetative composition of mud flats surrounding the Big River Estuary have occurred at the same time as the levee build-up and siltation of slough systems discussed in the Fluvial Geomorphology section. Rapid vegetative succession from salt tolerant plants to non salt-tolerant plants has occurred as tidewater inflow to mudflats has been blocked. This successional scheme is unusual for salt marshes and represents a significant loss of wetland habitat in the estuary (Marcus and Reneau 1981, Seacat et al. 1981).

Big River's estuarine flats contain branched drainage sloughs that were formed by tidal erosion (Figure 58). These slough channels are the only conduit for tidewater inflows to the estuarine flats; however, the flats are not completely flooded by tidewater. Therefore, the distribution of slough channels and their proportionate area within each flat is directly related to saline influence to each marsh. Channel systems are extensive in the lower three flats and are reduced to non-functional in the upper flats (Marcus and Reneau 1981). These changes in slough channels and vegetation are likely related to stream channels re-adjusting to a more natural discharge regime after the effects of splash damming.

Vegetation patterns in the estuary are related to these slough channel systems. Various plant associations, or vegetation types, defined by their dominant plant species (e.g. pickleweed, rushes) have developed in the estuarine flats (Table 93Table 93). Salt marsh plants are specifically adapted for saline soils and when saline inflows are reduced to marsh soils, as in the upper estuarine flats, salt-loving plants are replaced by other vegetation types.

Table 93. Freshwater and salt marsh plant associations (from Seacat et al. 1981).

Vegetation Type	Species Composition	
	Scientific Name	**Common Name**
Pickleweed	*Salicornia virginica*	Pickleweed*
	Triglochin striata	Arrow grass*
	Jaumea carnosa	
	Cuscuta salina	Parasitic dodder
Rushes	*Juncus lesueurii*	Rush*
	Distichlis spicata	Salt grass
	Gramineae spp.	Grasses
	Holcus lanatus	Velvet grass
	Hierochloe occidentalis	Vanilla grass
Alders	*Alnus rubra*	Red alder
	Salix lasiolepis	Willow
Coastal scrub	*Baccharis pilularis*	Coyote brush*
	Lupinus rivularis	Lupine*
	Rubus ursinus	California blackberry*
	Anaphalis margaritacea	Pearly everlasting*
	Senecio jacobaea	Ragwort
	Foeniculum vulgare	Sweet fennel
	Erechtites arguta	Fire weed
	Rumex crassus	Dock
	Carex salinaeformis	Sedge
	Orthocarpus castillejoides	Owl's clover
	Pteridium aquilinum	Bracken fern
	Rhus diversiloba	Poison oak
	Convolvulus occidentalis	Morning glory
	Geranium molle	Cranesbill
	Gentiana amarella	Felwort
Freshwater or brackish water marsh species	*Typha latifolia*	Cattails*
	Scirpus robustus	Bulrush*
	Cicuta douglasii	Water hemlock
	Torilis arvensis	Hedge parsley
	Juncus effusus	Rush
	Scirpus arnuus	Bulrush
	Carex obnupta	Slough sedge
	Plantago hirtella	Plantain
	Potentilla egedei	Pacific silverweed

*indicates dominant species

The various flats along the estuary have distinctly different vegetation. Marcus and Reneau (1981) found that vegetation had changed substantially over time as well in their study of historic photos:

> Historic photographs (circa 1900) of Flat 1 reveal a mudflat with no vegetation of any type. Presently about half of this flat is covered with halophytic plants indicating a substantial rise in height of the flat. In addition this flat was across the channel from the logging mill pond. A row of old pilings still crosses its reaches diagonally. These pilings are the remnants of a wingdam, built in 1884 and used to direct the river's current toward the mill to flush sawdust and other debris (Jackson 1975). If the placement of these pilings in 1884 was such as to direct current movements then it may be assumed that they were placed in areas covered by water most of the time. At present, these pilings can have no effect on channel water currents, for they are located in a slough surrounded by islands of vegetation.

Marcus and Reneau found an unusual change in the Big River Estuary's salt marsh succession: the direct replacement of rushes by alder and coastal scrub. Usually, salt marsh is replaced by freshwater marsh. In Big River, wetlands were being replaced by riparian woodlands.

Once slough systems are reduced and marshes are isolated from tidal influences, their productive capacity is lost. Opportunities for juvenile estuarine fish, benthic invertebrates, and algal blooms usually common in the backwaters of tidal sloughs are greatly reduced. The long-term effects upon Big River Estuary of this sedimentation and loss of salt marsh is not known (Marcus and Reneau 1981). However, Marcus and Reneau failed to take the effects of historic splash dam logging into account during their analyses. Therefore, it is important to look at their findings whilst remembering that a more natural discharge regime is re-establishing itself since the end of splash damming.

Fish Habitat Relationship

Estuaries and coastal lagoons are critical habitats for anadromous salmonids. The mixing of sea and fresh waters creates conditions well suited for the anadromous life history strategies of salmonids. Salmonids pass through the estuary as juveniles during their seaward migrations and again as adults, swimming upstream to their freshwater spawning grounds. The brackish water of the estuary provides salmonids with an important area to acclimate to changes in salinity as they move between the freshwater and marine environments. Estuaries also are important nursery grounds due to high productivity of nutrients and relative isolation from predators.

During seaward migrations, all juvenile salmonids utilize at least a brief estuarine residence while they undergo physiological adaptations to salt water and imprint on their natal stream. Juvenile salmonids may also extend their estuarine residency to utilize the sheltered, food rich environments before entering the ocean. Studies have revealed that juvenile salmonids utilizing estuaries for three months or more return to their natal stream at a higher rate than non-estuarine reared members of their cohort (Reimers 1973; Nicholas and Hankin 1988). Estuarine reared salmonids may be at an advantage because they enter the ocean at a larger size or during conditions that are more favorable. Entering the ocean at a larger size may be advantageous by allowing juvenile salmonids to avoid predation or by increasing the variety and number of their prey items.

Salmonid utilization of the estuarine environment is a strategy that adds diversity to juvenile salmonid life history patterns and increases the odds for survival of a species encountering a wide range of environmental conditions in both the freshwater and marine environment. Additionally, an extended estuarine residency may be especially beneficial for salmonids from rivers where low summer flows or warm water temperatures severely limit summer rearing habitat. These benefits are enhanced by the estuary retaining its connection with cool, nutrient rich seawater, maintaining adequate depth and subsurface shelter complexity, and containing enough vegetation density (both in and out of the water), to supply temperature moderation, nutrition and cover.

Past Conditions

CDFG conducted stream surveys on six tributaries and the mainstem Big River in the Coastal Subbasin from 1959 to 1966. Three stream surveys were also conducted by the Center for Education and Manpower Resources (CEMR) in 1979. The results of the historic stream surveys are not quantitative and cannot be used in comparative analyses with current habitat inventories; however, they do provide a description of habitat

conditions. The data from these stream surveys provide a snapshot of the conditions at the time of the survey. Terms such as excellent, good, fair and poor were based upon the opinion of the biologist or scientific aid conducting the survey.

Surveys describe some good spawning habitat, abundant smaller pools, and good cover in Railroad Gulch and the Little North Fork Big River (Table 94). However, the surveyed tributaries to the Little North Fork Big River were described as having poor salmonid habitat. Many debris jams were described on the Little North Fork Big River. A 1958 CDFG flyover survey (Elwell) of four tributaries found no significant fish passage barriers.

Table 94. Habitat comments from surveys conducted in the Coastal Subbasin from 1959-1979.

Tributary	Date Surveyed	Habitat Comments	Barrier Comments
Mainstem Big River	7/27/1959	Mostly poor to fair spawning areas with a few areas approaching good; Pools uncommon in the lower half of the river, becoming more common in the upper half of the river, averaging 10 feet long, 4 feet wide, and 10 inches deep; the lower 2/3 of the river very open, with only undercut bank and log jams for cover; the upper 1/3 of this river area more contained and large boulders and some riparian growth afford fair shelter	Many barriers; many log jams, scattered debris, and slash; old flush dam located one mile above the mouth of Valentine Creek a complete barrier with a 14 foot drop in the streambed; log jam barrier 0.4 miles upstream of the mouth of Rice Creek; boulder-log jam barrier 0.7 miles upstream of the mouth of Rice Creek; Log and dirt filled jam and barrier 0.9 miles upstream of the mouth of Rice Creek; Anadromy ends at a 12 foot high natural rock falls
Laguna Creek	10/16/1958 (flyover)	Appeared to have little fisheries value due to marshy characteristics	
Railroad Gulch	1979 (Center for Education and Manpower Resources)	A few pockets of good spawning gravel observed, totaling 100 yards; many small pools, totaling 50% of stream, but few that were more than 2 feet deep; good shelter, behind numerous logs and boulders	Culvert at mouth 72 feet long, blocked at upper end by log and small debris; in swamp many logs would prevent easy passage; 1.25 mile upstream a few small jams at 100 yard intervals; limited passage 1.5 mile upstream 100 feet above 35 foot culvert crossing road are 4 foot falls with 4 foot pool below; 100 yards above this another small falls with jam; difficult passage follows; after this, road crosses river with old wooden culvert which is caving in; 200 yards above this, total blockage with fallen tree stump; 100 yards above this more falls
Little North Fork Big River	10/16/1958 (flyover)	Appeared to have considerable fisheries value as a spawning and nursery stream	Streambed in the lower end of the drainage not visible. Old logging debris noted in the upper end of the drainage
	3/8/1959	The lower stream has several miles of very good spawning gravels, the upper stream might be of some value if it were cleaned up; pools are common and abundant; shelter is common throughout, mostly pools, logs and undercut banks; there are very few large boulders and very little low-growing riparian growth	Although there are many extensive log-jams, are not barriers because of the tendency of the stream to flood around them; a beaver dam across the main channel near the mouth; this dam, except for seepage, has closed the main stream channel; this has forced the water into at least four separate meandering channels, and is flooding the canyon; the resultant cutgrass and cattails make it difficult to see that there is more than a swamp here; anadromous fish must find this a difficult egress; many down stream migrants must be lost in drying pools and side streams; there is a concrete dam before the 5th tributary
	4/2/1979 (Center for Education and Manpower Resources)	95% gravel bottom; suitable spawning areas for salmon and trout throughout the stream; mostly good spawning gravel with some silt from erosion of old road following stream; riffles 50%, pools 45%, cascades 5%; good shelter caused by old logging debris and logs and overhanging banks; resting pools intermittently up to 6 feet deep all along stream; temperature 40°F	Log jam #1, 2 miles upstream from swamp, 40-50feet wide, 90feet long, 10feet high, appears to be a floater although further collection of upstream debris could make it impassable in near future; the jam causes water to divert into bank with some resultant erosion; silt build-up on upper side of jam; log jam #2 is ½ mile from the first jam, 100feet long, 75feet wide, 6-8feet high, again it is barely passable for fish with further debris probable near future blockage; with removal of strategic pieces on upstream part of jam it could be fully passable and would stop further erosion and silt deposit into the stream; log jam #3 is 1/3 mile above 2nd jam, 40feet long, 30feet wide, 10feet high with passage under logs; just above swampy area near fork with Big River were fallen logs causing some blockage
Unnamed Tributary to Little North Fork Big River/Cook House Gulch	3/8/1959 - Note in the Little North Fork Big River Survey	Not of sufficient value to justify a survey; mouth not seen; area flooded with water impounded by a beaver dam	

Tributary	Date Surveyed	Habitat Comments	Barrier Comments
Rocky Gulch	3/8/1959 - Note in the Little North Fork Big River Survey	May have been a good, small spawning tributary; may still supply some spawning near the mouth; however, has been destroyed by gravel taking operations a few hundred feet above the mouth	
Manly Gulch	3/8/1959 - Note in the Little North Fork Big River Survey	Mud bottom, swampy, and probably dry during the summer	
Thompson Gulch	3/8/1959 - Note in the Little North Fork Big River Survey	May provide some spawning near its mouth	About 100 yards upstream from mouth there is a 3 foot falls
	4/15/1979 (Center for Education and Manpower Resources)	Substrate medium to small gravel overall (60%), although perhaps 10% more than 3 inches; 50% of stream suitable for steelhead spawning, 10% for salmon spawning; numerous pools below the many small falls on this stream, although few are deeper than 3 feet; good shelter, behind logs and undercut banks; temperature at mouth 49°F	7 log jams and 6 main falls; several impassable.
Berry Gulch	10/16/1958 (flyover)	Streambed not visible due to heavy conifer cover	
	3/8/1959 - Note in the Little North Fork Big River Survey	Insignificant at its mouth; flow negligible	

Current Conditions

Habitat Inventory Surveys

CDFG stream inventories were conducted for 39.7 miles on 21 reaches of nine tributaries and the mainstem Big River in the Coastal Subbasin since 1993 (Table 95, Figure 68). Additionally, the East Branch Little North Fork Big River was surveyed in 1996 as well as 2002. Stream attributes that were collected during stream inventories included canopy cover, embeddedness, percent pools, pool depth, and pool shelter.

Table 95. Surveyed streams in the Coastal Subbasin.

Stream	Survey Date	Reach	Survey Length (Miles)
Big River	July 1996	1	8.1
	July 1996	2	5.0
	July 1996	3	1.9
	July 1996	4	1.8
	July 1996	5	3.5
Laguna Creek	July 1996	1	1.9
Railroad Gulch	October 1996	1	1.1
Little North Fork Big River	October 1995	1	3.7
Rocky Gulch	September 1997	1	0.1
	September 1997	2	0.1
Manly Gulch	June 1997	1	0.7
Thompson Gulch	June 1997	1	0.7
	June 1997	2	0.4
East Branch Little North Fork Big River	June 2002	1	0.9
	June 2002	2	1.5
Berry Gulch	June 1997	1	0.1
	June 1997	2	1.3
	June 1997	3	0.2
	June 1997	4	0.6
Berry Gulch Tributary	June 1997	1	1.1
Big River Wheel Gulch to Blind Gulch	July-August 2002	1	5.0

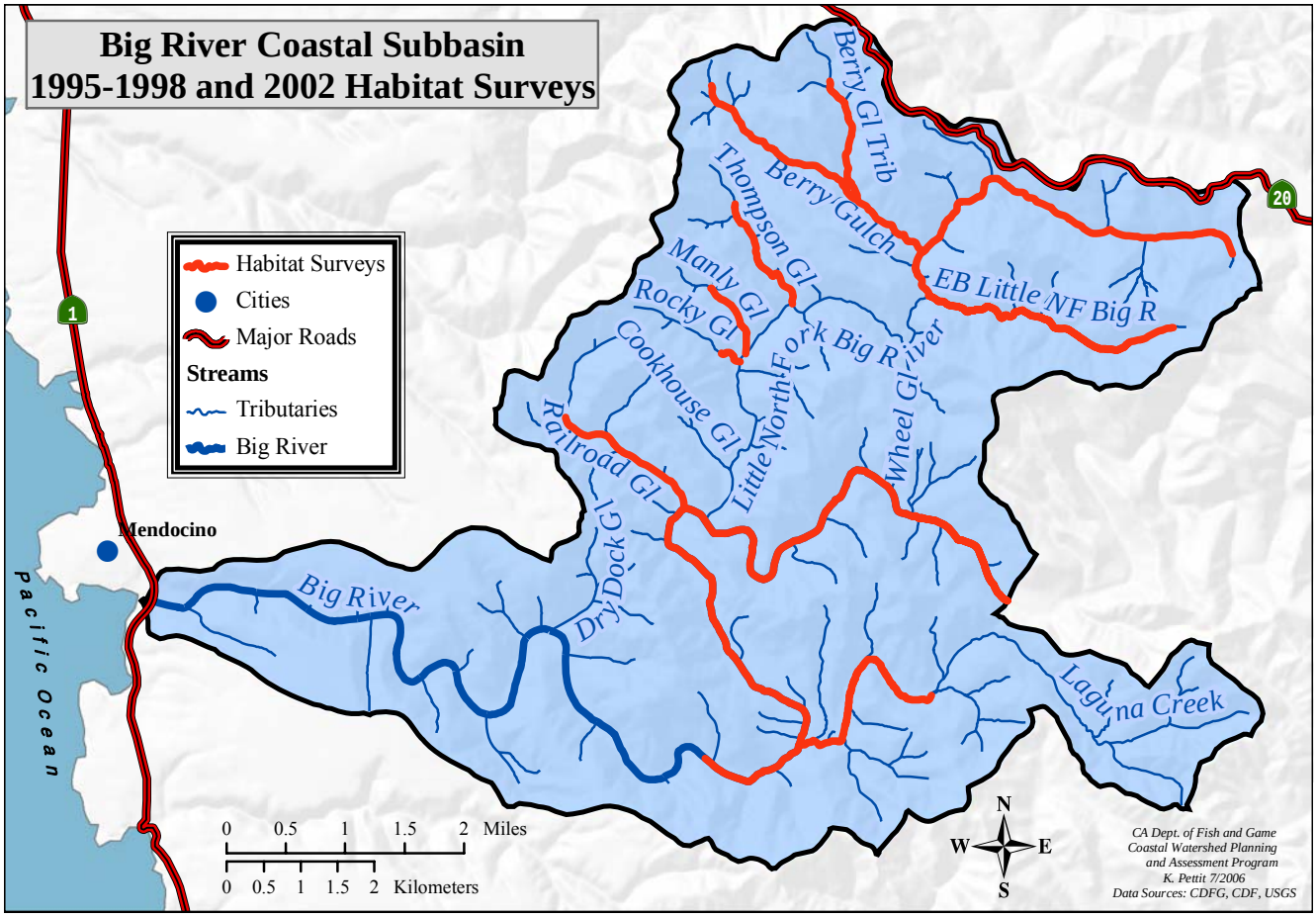

Figure 68. CDFG surveyed streams in the Coastal Subbasin.

Stream attributes tend to vary with stream size. For example, larger streams generally have more open canopy and deeper pools than small streams. This is partially a function of wider stream channels and greater stream energy due to higher discharge during storms. Surveyed streams in the Coastal Subbasin ranged in drainage area from 0.4 to 181.0 square miles.

Canopy cover, and relative canopy cover by coniferous versus deciduous trees were measured at each habitat unit during CDFG stream surveys. Near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Furthermore, canopy levels provide an indication of the potential present and future recruitment of large woody debris to the stream channel, as well as the insulating capacity of the stream and riparian areas during winter.

In general, the percentage of stream canopy cover increases as drainage area, and therefore channel width, decrease. Deviations from this trend in canopy may indicate streams with more suitable or unsuitable canopy relative to other streams of that subbasin. The surveyed tributary reaches of the Coastal Subbasin show percent canopy levels that meet target values for maintaining water temperature to support anadromous salmonid production (Figure 69). Canopy data collected on the lower mainstem of Big River, where the stream is fourth order, cannot be compared to target values. Rocky Gulch has the highest canopy cover values of Coastal Subbasin.

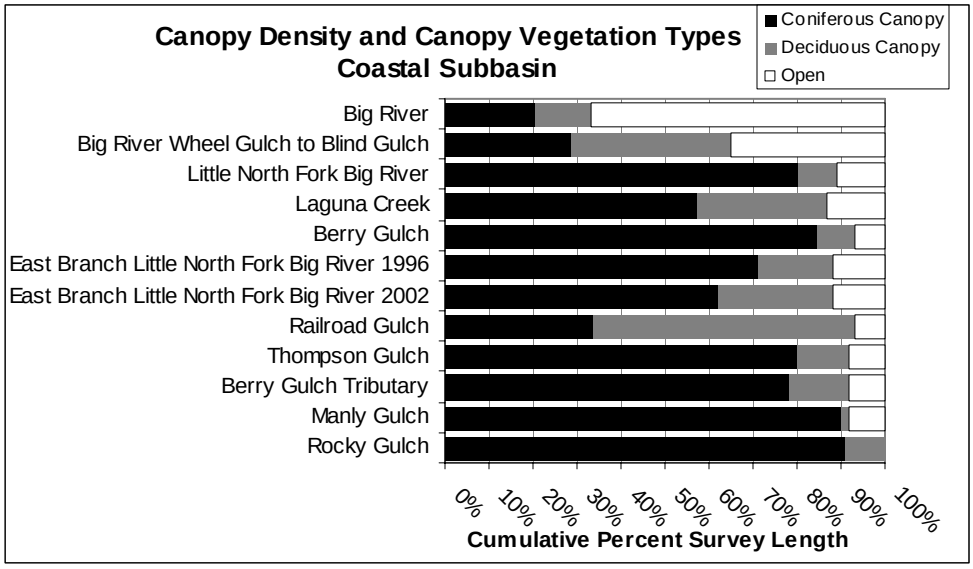

Figure 69. The relative percentage of coniferous, deciduous, and open canopy covering surveyed streams in the Coastal Subbasin.

Averages are weighted by unit length to give the most accurate representation of the percent of a stream under each type of canopy. Streams are listed in descending order by drainage area (largest at the top).

Cobble embeddedness was measured at each pool tail crest during CDFG stream surveys. Embeddedness values in the Coastal Subbasin generally do not meet target values for successful salmonid egg and embryo development. However, Figure 70 illustrates how stream reaches rated as unsuitable overall may actually have some suitable spawning gravel sites distributed through the stream reach. Additionally, cobble embeddedness meets target values in Rocky Gulch, Manly Gulch, and the mainstem Big River from Wheel Gulch to Blind Gulch.

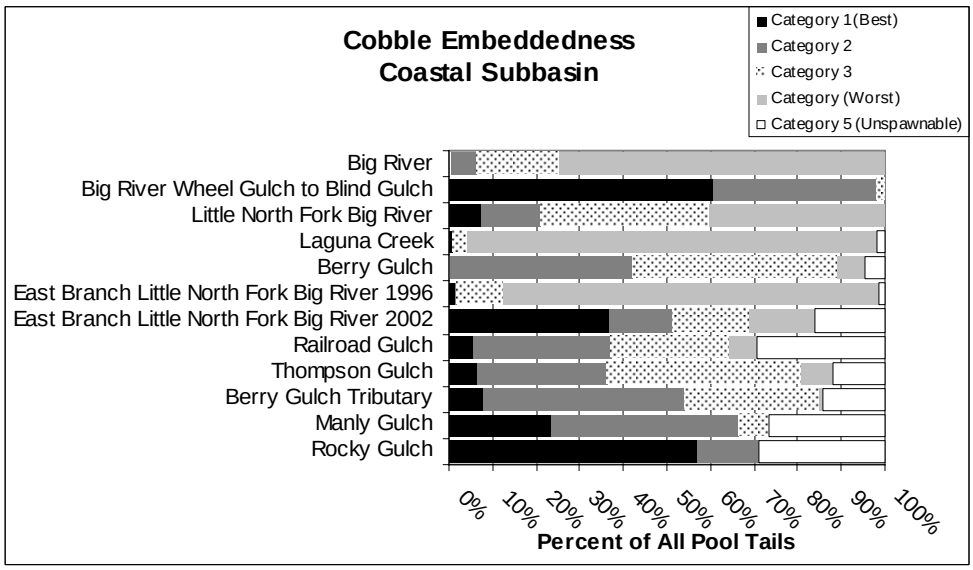

Figure 70. Cobble embeddedness categories as measured at every pool tail crest in surveyed streams in the Coastal Subbasin.

Cobble embeddedness is the % of an average sized cobble piece at a pool tail out that is embedded in fine substrate: Category 1 = 0-25% embedded, Category 2 = 26-50% embedded, Category 3 = 51-75% embedded, Category 4 = 76-100%, and Category 5 = unsuitable for spawning due to factors other than embeddedness (e.g. log, rocks). Streams are listed in descending order by drainage area (largest at the top).

Pool, flatwater, and riffle habitat units observed were measured, described, and recorded during CDFG stream surveys. During their life history, salmonids require access to all of these types of habitat. A balanced proportion of these habitat types is desirable. Most of the surveyed Coastal Subbasin streams have greater than

20% pool habitat by length (Figure 71). Dry units were measured and indicate a lack of habitat for fish. Culverts were also measured on four streams.

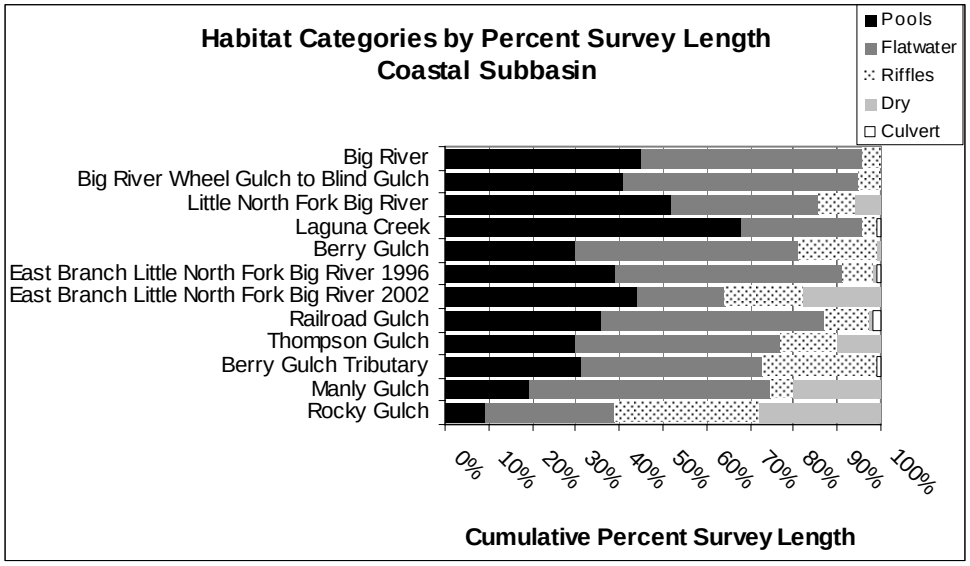

Figure 71. The percentage of pool habitat, flatwater habitat, riffle habitat, dewatered channel, and culverts by survey length in the Coastal Subbasin.

Streams are listed in descending order by drainage area (largest at the top).

Pool depths were measured during CDFG surveys. Primary pools are determined by a range of pool depths, depending on the order (size) of the stream. A reach must have 30 – 55% of its length in primary pools for its stream class to meet target values for supporting salmonids. Generally, larger streams have deeper pools. Deviations from the expected trend in pool depth may indicate streams with more suitable or unsuitable pool depth conditions relative to other streams of that subbasin. Most surveyed tributaries in this subbasin have less than 20% pools greater than two feet deep by length (Table 96). The mainstem Big River has the most pool habitat with maximum depth greater than two feet.

Table 96. Percent length of a survey composed of pools in the Coastal Subbasin.

Stream	Drainage Area (Sq. Mi.)	Stream Order	Percent Pools by Survey Length	Percent Pools > 2.0 by Survey Length	Perce3nt Pools >2.5 by Survey Length	Percent Pools >3.0 by Survey Length	Percent Pools >4.0 by Survey Length
Big River	181.0	4	44.9	44.3	44.1	43.5	36.3
Big River Wheel Gulch to Blind Gulch	149.2	4	39.9	39.9	39.9	37.6	27.2
Little North Fork Big River	12.8	2	52.4	32.7	21.7	10.3	2.8
Laguna Creek	5.1	1	68.2	38.7	29.5	21.1	8.4
Berry Gulch	2.8	1	27.3	10.8	4.4	2.8	0.3
East Branch Little North Fork Big River 2002	1.8	1	43.6	20.5	8.6	2.2	0.2
East Branch Little North Fork Big River 1996	1.8	1	39.7	15.4	7.7	2.3	0.0
Railroad Gulch	1.7	1	28.5	9.8	5.5	3.2	0.5
Thompson Gulch	1.1	2	29.5	4.7	1.9	1.4	0.5
Berry Gulch Tributary	0.9	1	33.8	10.7	6.0	5.1	5.1
Manly Gulch	0.5	1	19.4	4.2	1.3	0.9	0.0
Rocky Gulch	0.4	1	8.8	2.6	1.7	1.7	0.0

Streams are listed in descending order by drainage area (largest at the top).

Pool shelter was measured during CDFG surveys. Pool shelter rating illustrates relative pool complexity, another component of pool quality. Ratings range from 0-300. Shelter scores greater than 100 meet target values for supporting salmonids. Pool shelter ratings in the Coastal Subbasin do not meet target values (Figure 72).

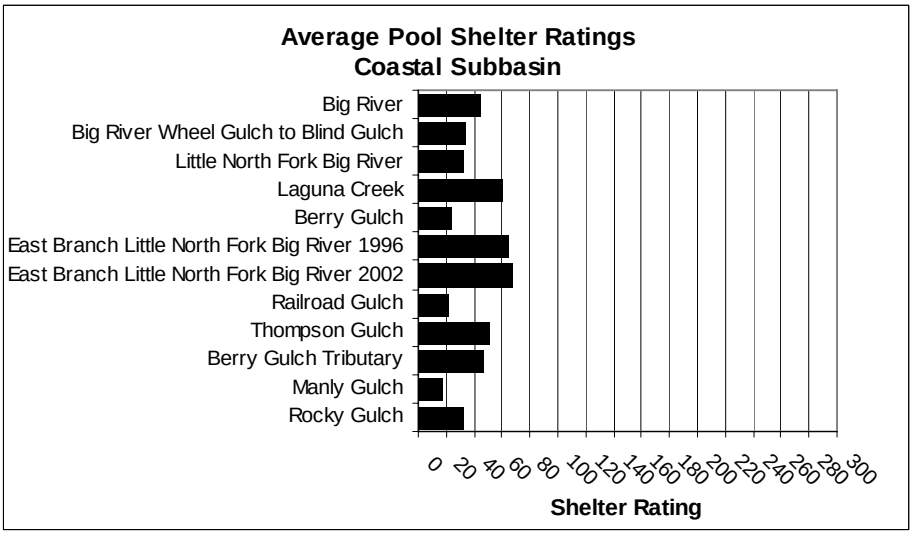

Figure 72. Average pool shelter ratings from CDFG stream surveys in the Coastal Subbasin.

Streams are listed in descending order by drainage area (largest at the top).

Pool shelter is composed of those elements within a stream channel that provide salmonids protection from predation, reduce water velocities so fish can rest and conserve energy, and allow separation of territorial units to reduce density related competition. Using an overhead view, a quantitative estimate of the percentage of the habitat unit covered by nine different cover types was made during stream surveys. The mean percent of pool shelter cover in each cover type was calculated for each surveyed stream. The predominant pool cover types in most Coastal Subbasin tributaries are woody debris, undercut banks, and root masses (Table 97).

Table 97. Mean percent of shelter cover types in pools for surveyed tributaries in the Coastal Subbasin.

Stream	Undercut Banks	Small Woodsy Debris	Large Woody Debris	Rootmass	Terrestrial Vegetation	Aquatic Vegetation	Whitewater	Boulders	Bedrock Ledges
Big River	9.4	25.3	16.3	23.6	2.7	0.1	0.0	8.3	14.3
Big River Wheel Gulch to Blind Gulch	6.2	15.3	16.8	22.4	19.6	12.2	0.0	6.1	1.2
Little North Fork Big River	3.0	21.2	39.4	4.0	19.2	3.0	0.0	4.0	6.1
Laguna Creek	30.0	19.0	11.0	5.0	24.0	3.0	0.0	8.0	0.0
Berry Gulch	25.4	8.1	29.1	5.4	0.7	7.4	1.1	11.3	11.5
East Branch Little North Fork Big River 1996	10.5	12.3	50	10	5	0	0.8	0.5	11
East Branch Little North Fork Big River 2002	17.5	21.4	30.4	5.3	5.6	12.5	0.8	5.1	0.6
Railroad Gulch	2.2	55.0	27.2	0.0	0.0	14.4	0.0	1.1	0.0
Thompson Gulch	35.8	28.6	16.4	4.4	9.2	0.0	2.8	3.6	0.0
Berry Gulch Tributary	14.6	28.9	42.1	2.9	7.9	1.1	2.5	0.0	0.0
Manly Gulch	0.0	24.2	5.0	14.2	49.2	0.0	0.0	7.5	0.0
Rocky Gulch	27.0	7.0	0.0	33.0	33.0	0.0	0.0	0.0	0.0

Streams are listed in descending order by drainage area (largest at the top).

Fish Passage Barriers

Stream Crossings

Although no stream crossings were surveyed in the Coastal Subbasin as a part of the coastal Mendocino County culvert inventory and fish passage evaluation conducted by Ross Taylor and Associates (2001), CDFG stream surveys noted culverts on four tributaries, Little North Fork Big River, Railroad Gulch, Berry Gulch, and Berry Gulch Tributary (Table 98).

Table 98. Culverts described on streams inventoried by CDFG in the Coastal Subbasin.

Stream Name	Number of Culverts	Feet of Culvert
Little North Fork Big River	2	104
Railroad Gulch	1	86
Berry Gulch	2	94
Berry Gulch Tributary	1	65

Additionally, in the stream tributary report for Manly Gulch in 1997 a recommendation was given to create a channel under the main road to connect Manly Gulch to Little North Fork Big River. Winter access problems for adult fish at a non-existent channel at Camp Three (near the mouth of the stream) may be stopping Manly Gulch from being utilized for habitat by salmonids. The available habitat is sufficient for use by steelhead and coho.

CGS (2004) identified five watercourse crossings on Class I streams in Big River State Park (Table 99) (Figure 73). Only the culvert on Dry Dock Gulch was found to be a fish barrier. This culvert's outlet is high above Big River, creating a high jump for adult fish. The culvert also backs up water into a large pond covered by lily pads. Though this pond creates wetland habitat, it is unclear if it would occur naturally without the presence of the culvert. In addition, there were 10 Class I or II tributaries entering the estuary channel with high priority for remediation. These streams have not been surveyed for fish presence.

Table 99. CGS evaluated watercourse crossings of Class I streams in Big River State Park (CGS 2004).

Stream Name	Road Name	Type of Crossing	Length of Culvert (feet)	Comments
Dry Dock Gulch	M 1.0	Culvert	>25	Large Class I drains directly into Big River, outlet fill slopes eroded to nearly vertical by river erosion, crossing disconnects stream from Big River, fish barrier, culverts set high backing stream up into lily pad lake
Little North Fork Big River	M 14.0	Bridge	50	Bridge is currently passable with ATV, but should be further evaluated for structural integrity prior to allowing heavier vehicles to travel
Scooter Gulch	L 1.0	Culvert	35	Much ground disturbance, culvert bottom is rusted out, and no low-flow connectivity through this culvert
Unnamed Tributary to Big River	L 4.0	Bridge	50	Bridge site is currently passable with an ATV, but should be further evaluated for structural integrity prior to allowing heavier vehicles to travel
Big River	LB 1.0			Historic bridge crossing site across Big River. Wet crossing possible on ATV during lowest flows; Ranked high priority because of historic/future importance of this site as a bridge crossing. Currently there is no crossing and relatively minor sediment delivery

Dry Channel

CDFG stream inventories were conducted for 39.7 miles on 21 reaches of nine tributaries and the mainstem Big River in the Coastal Subbasin. A main component of CDFG Stream Inventory Surveys is habitat typing, in which the amount and location of pools, flatwater, riffles, and dry channel is recorded. Although the habitat typing survey only records the dry channel present at the point in time when the survey was conducted, this measure of dry channel can give an indication of summer passage barriers to juvenile salmonids. Dry channel conditions in the Big River Basin generally become established from late July through early September. Therefore, CDFG stream surveys conducted outside this period are less likely to encounter dry channel.

Dry channel disrupts the ability of juvenile salmonids to move freely throughout stream systems. Juvenile salmonids need well-connected streams to allow free movement to find food, escape from high water temperatures, escape from predation, and migrate out of their stream of origin. The amount of dry channel reported in surveyed stream reaches in the Coastal Subbasin is 2.3% of the total length of streams surveyed. This dry channel was found in eight streams (Figure 73 and Table 100). Dry habitat units occurred near the mouth of two tributaries, in the middle reaches of five tributaries, and at the upper limit of anadromy in three tributaries. Dry channel at the mouth of a tributary disconnects that tributary from the mainstem Big River, which can disrupt the ability of juvenile salmonids to access tributary thermal refugia in the summer. Dry channel in the middle reaches of a stream disrupts the ability of juvenile salmonids to forage and escape predation. Lastly, dry channel in the upper reaches of a stream indicates the end of anadromy.

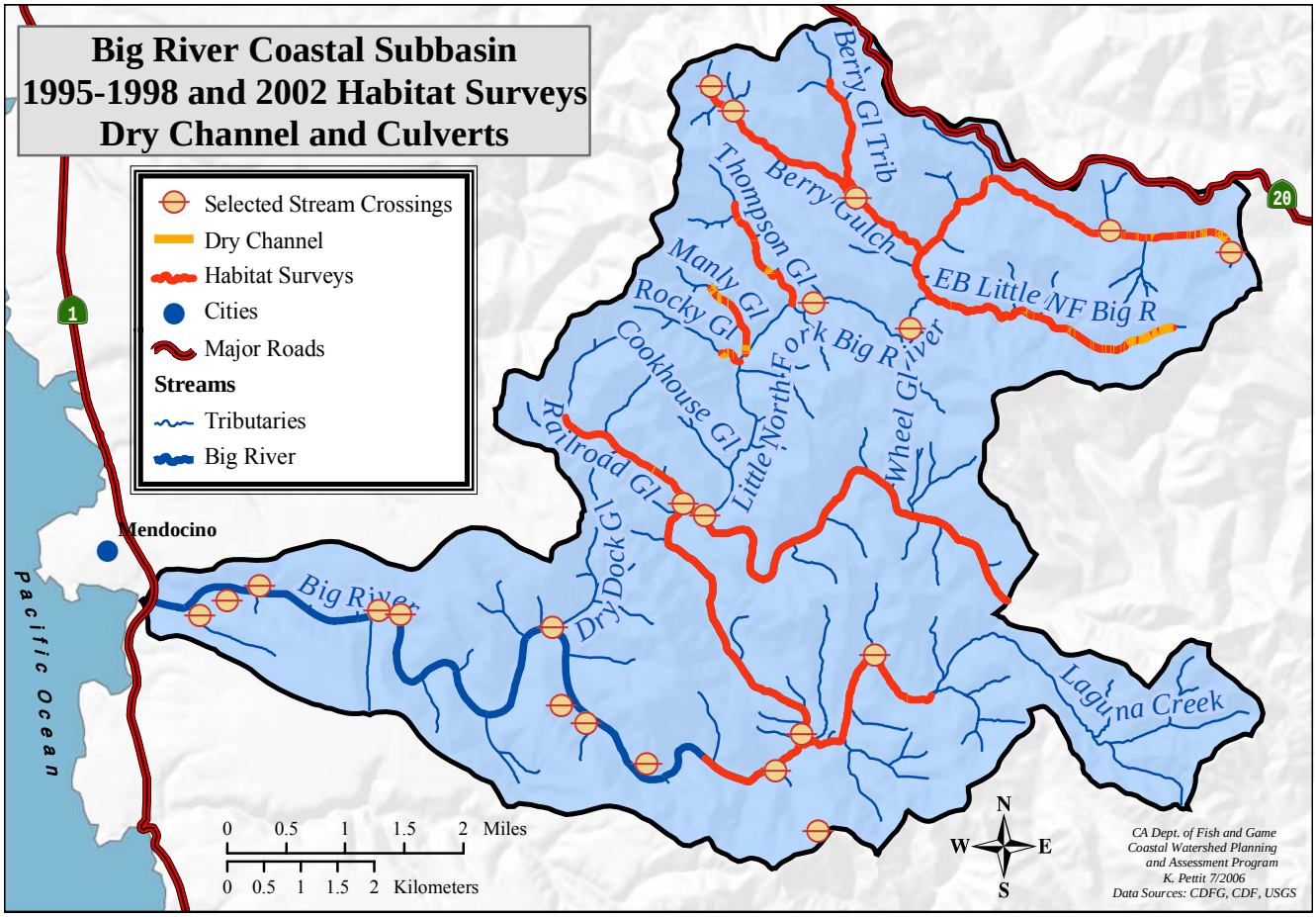

Figure 73. Dry and wetted channel and culverts reported during CDFG stream surveys in the Coastal Subbasin.

Table 100. Dry channel recorded in CDFG stream surveys in the Coastal Subbasin.

Stream	Survey Period	# of Dry Units	Dry Unit Length (ft)	% of Survey Dry Channel
Big River	July 1996	0	0	0.0
Laguna Creek	July 1996	1	32	0.3
Railroad Gulch	October 1996	1	57	1.0
Little North Fork Big River	October 1995	39	1,121	5.8
Rocky Gulch	September 1997	3	312	28.4
Manly Gulch	June 1997	9	729	20.5
Thompson Gulch	June 1997	5	328	5.7
East Branch of the Little North Fork Big River	June 2002	22	2,194	17.7
Berry Gulch	June 1997	2	82	0.7
Berry Gulch Tributary	June 1997	0	0	0.0
Big River (Wheel Gulch to Blind Gulch)	July - August 2002	0	0	0.0

Restoration Programs

The CDFG Fisheries Restoration Grants Program has funded various projects in the Coastal Subbasin (Table 101). Projects include research, education, bank stabilization, and log jam removal.

Table 101. Restoration projects in the Coastal Subbasin.

Name	Years	Project Leader	Project
Big River Estuary Biodiversity Assessment	2001-2002	Mendocino Unified School District	Survey, study, research, education, training, workshops
Big River Restoration Project (near confluence with Laguna Creek)	1989-1991	Center for Education and Manpower Resources	Stream bank stabilized, log jam removed, grass planted
East Branch Little North Fork Log Jam Barrier Modification Projects	1984-1986	North coast Salmon Habitat Restoration Group	Log jams removed

DPR has proposed several restoration projects on their newly acquired lands in the Big River State Park. The main focus of the work will be road improvements to decrease sediment input to streams and remove fish passage barriers. Projects include road decommissioning, conversion of roads to recreational trails, skid trail stabilization and removal, road resurfacing, and removing debris from clogged culverts (DPR 2005a and b). In addition, Barber (2003 Draft) completed an Erosion Prevention and Implementation Plan for Mendocino Woodlands, which is in the Little North Fork Big River watershed. This plan prioritized corrective treatments for road and trail related sediment sources.

Changes in Habitat Conditions from 1960 to 2001

Streams surveyed in the 1950s and 1960s and habitat inventory surveyed in the 1990s or 2002 were compared to indicate changes between historic and current conditions. Data from 1960s stream surveys provide a snapshot of the conditions at the time of the survey. Terms such as excellent, good, fair, and poor are based on the judgment of the biologist or scientific aid who conducted the survey. The results of historic stream surveys are qualitative and cannot be used in comparative analyses with quantitative data provided by habitat inventory surveys with any degree of accuracy. However, the two data sets can be compared to show general trends.

Where habitat data were available from both older stream surveys and recent stream inventories it appeared that spawning habitat increased in two streams, decreased in one, and remained similar in others (Table 102). Pool habitat increased in the mainstem Big River, but decreased or remained similar elsewhere. Shelter decreased in two streams and remained similar in other streams.

Table 102. Comparison between historic habitat conditions with current habitat inventory surveys in the Coastal Subbasin.

Stream	Canopy Cover		Spawning Conditions		Pool Depth/Frequency		Shelter/Cover		Summary of Changes from Historic to Current
	Historic	Current	Historic	Current	Historic	Current	Historic	Current	
Big River	ND*	NA	Poor to fair	Unsuitable	Uncommon	Suitable	Only undercut banks and log jams for cover	Unsuitable	Pool habitat increased
Laguna Creek	ND	Fully suitable	ND	Fully unsuitable	ND	Suitable	ND	Suitable	ND
Railroad Gulch	ND	Fully suitable	Few pockets of good spawning gravel	Unsuitable	Many small pools, few more than 2 feet deep	Fully unsuitable	Good	Fully unsuitable	Pool habitat and shelter decreased
Little North Fork Big River	ND	Fully suitable	Very good in lower stream	Unsuitable	Common and abundant	Unsuitable	Common throughout	Unsuitable	Spawning habitat, pool habitat, and shelter decreased
Rocky Gulch	ND	Fully suitable	May provide some near mouth	Fully suitable	ND	Fully unsuitable	ND	Unsuitable	ND
Manly Gulch	ND	Fully suitable	Mud bottom	Suitable	ND	Fully unsuitable	ND	Fully unsuitable	Spawning habitat increased
Thompson Gulch	ND	Fully suitable	May provide some near mouth	Unsuitable	ND	Fully unsuitable	ND	Unsuitable	Habitat similar between years
East Branch Little North Fork Big River	ND	Fully suitable	ND	Unsuitable	ND	Fully unsuitable	ND	Suitable	ND
Berry Gulch	ND	Fully suitable	ND	Unsuitable	ND	Fully unsuitable	ND	Unsuitable	ND
Berry Gulch Tributary	ND	Fully suitable	ND	Unsuitable	ND	Fully unsuitable	ND	Unsuitable	ND
Big River Wheel Gulch to Blind Gulch	ND	Unsuitable	Poor to fair	Suitable	Uncommon	Suitable	Only undercut banks and log jams for cover	Unsuitable	Spawning habitat and pool habitat increased

*ND is no data available

Fish History and Status

Historically, the Coastal Subbasin supported runs of coho salmon, and steelhead trout. CDFG stream surveys were conducted for six tributaries and the mainstem Big River in the Coastal Subbasin from 1959 to 1966 (Table 103). The USFWS electrofished one transect in the mainstem Big River by Mendocino Woodlands State Park in 1973 (Perry 1974). Three stream surveys were also conducted by the CEMR in 1979. Out of the seven streams surveyed in the 1950s and 1960s, steelhead trout were found in the mainstem Big River and East Branch Little North Fork Big River, coho salmon were found in the Little North Fork Big River and East Branch Little North Fork Big River, and unidentified salmonids were found in two streams. USFWS found both coho salmon and steelhead trout in the mainstem Big River in 1973. Out of three streams surveyed in the 1979, steelhead trout were found in none and unidentified salmonids were reported in the Little North Fork Big River. Few salmonids were reported in these surveys.

Table 103. Summary of all electrofishing, snorkel survey, carcass survey, and bank observation surveys conducted in the Coastal Subbasin.

Stream	Year Surveyed	Data Source	Survey Method	Coho Salmon	Steelhead Trout	Unidentified Salmonids
Estuary channel Big River	2001	SONAR	Snorkel Survey	Present	Present	
	2002	SONAR	Snorkel Survey			Present
Mainstem Big River	1959	CDFG	Visual Observation		Present	
	1973	USFWS	Electrofishing	Present	Present	
	1994	NMFS	Electrofishing		Present	
	1995	NMFS	Electrofishing		Present	
	1996	NMFS	Electrofishing	Present	Present	
	1996	HTC	Visual Observation		Present	
	2001	CDFG	Coho Inventory	Present		
Laguna Creek	1996	HTC	Visual Observation			Present
Railroad Gulch	1979	CEMR	Visual Observation			
	1995	CDFG	Electrofishing	Present		
		NMFS	Electrofishing	Present		
	1996	HTC	Electrofishing	Present	Present	
		CDFG	Carcass Survey	Present	Present	
		NMFS	Electrofishing		Present	
	1997	NMFS	Electrofishing		Present	
Tributary to Railroad Gulch	1996	HTC	Electrofishing			
Little North Fork Big River	1959	CDFG	Visual Observation	Present		
	1979	CEMR	Visual Observation			
	1985	CDFG	Carcass Survey			
	1993	HTC	Electrofishing		Present	
	1994	HTC	Electrofishing		Present	
	1995	HTC	Electrofishing		Present	
		CDFG	Electrofishing	Present	Present	
		CDFG	Carcass Survey	Present	Present	
		NMFS	Electrofishing	Present	Present	
	1996	CDFG	Carcass Survey	Present	Present	
		HTC	Electrofishing		Present	
		NMFS	Electrofishing	Present	Present	
	1997	HTC	Electrofishing		Present	
		NMFS	Electrofishing	Present	Present	
	1998	HTC	Electrofishing		Present	
	1999	HTC	Electrofishing		Present	
		NMFS	Carcass Survey			Present
	2000	HTC	Electrofishing		Present	
		NMFS	Carcass Survey			Present
	2001	HTC	Electrofishing		Present	
		SONAR	Carcass Survey	Present	Present	
	2002	SONAR	Carcass Survey	Present	Present	
Rocky Gulch	1997	CDFG	Electrofishing	Present		
Manly Gulch	1997	CDFG	Electrofishing			Present
	1997	CDFG	Visual Observation			Present
Thompson Gulch	1979	CEMR	Visual Observation			
	1995	NMFS	Electrofishing	Present	Present	
	1996	NMFS	Electrofishing			
	1997	NMFS	Electrofishing		Present	

Stream	Year Surveyed	Data Source	Survey Method	Coho Salmon	Steelhead Trout	Unidentified Salmonids
		CDFG	Electrofishing	Present	Present	
East Branch Little North Fork Big River	1967	NMFS	Visual Observation	Present	Present	
	1985	CDFG	Carcass Survey			
	1986	CDFG	Electrofishing	Present	Present	
	1996	CDFG	Carcass Survey	Present	Present	
	2002	CDFG	Electrofishing	Present	Present	
Berry Gulch	1986	CDFG	Electrofishing	Present	Present	
	1995	CDFG	Electrofishing	Present	Present	
		NMFS	Electrofishing	Present	Present	
	1996	NMFS	Electrofishing	Present	Present	
	1997	CDFG	Electrofishing	Present	Present	
		NMFS	Electrofishing	Present	Present	
Berry Gulch Tributary	1997	CDFG	Electrofishing	Present	Present	
Big River from Wheel Gulch to Blind Gulch	2002	CDFG	Snorkel Survey	Present	Present	

* CDFG = Department of Fish and Game survey; CI = Department of Fish and Game Coho Inventory; CEMR = Center for Education and Manpower Resources; MRC = Mendocino Redwood Company Report; HTC = Hawthorne Timber Company; SONAR = School of Natural Resources at Mendocino High School; NMFS = National Marine Fisheries Service (Jones 2000)

Hawthorne Timber Company and CDFG studies have continued to document the presence of coho salmon and steelhead trout in the Coastal Subbasin.

Georgia Pacific began electrofishing surveys on the Little North Fork Big River as part of a monitoring program in 1993. The monitoring has been continued by the Hawthorne Timber Company. The sample site was electrofished annually and coho salmon and steelhead trout were consistently detected (Figure 74). Steelhead trout numbers show consistent multi-year class populations.

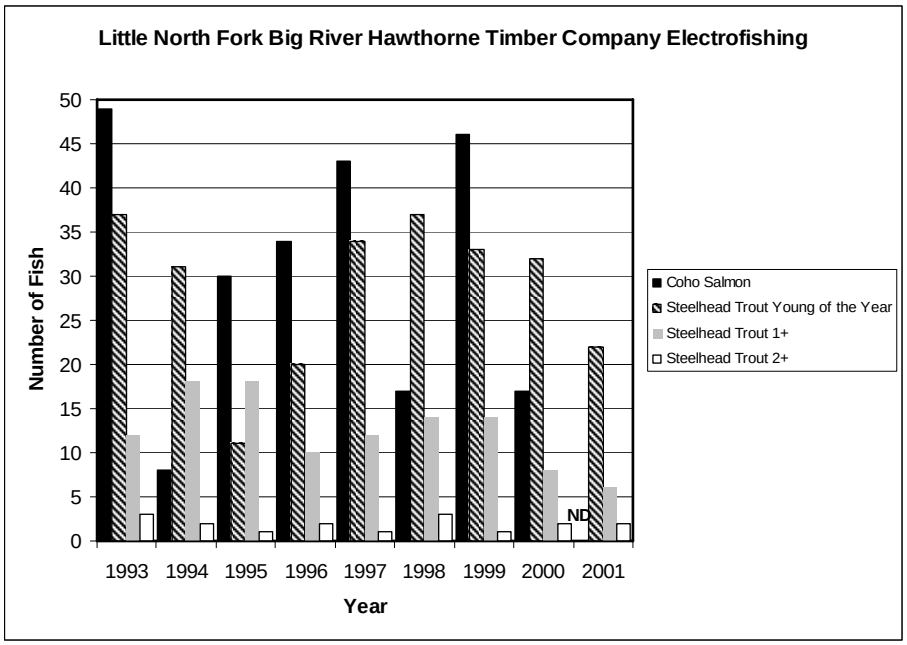

Figure 74. Electrofishing results from 1993-2001 for the Little North Fork Big River.

Surveys by Georgia-Pacific and Hawthorne Timber Company.

Georgia Pacific also used visual observation and electrofishing to detect salmonids during stream surveys conducted in mainstem Big River and three tributaries in 1996. Coho salmon were detected in Railroad Gulch, steelhead trout were detected in mainstem Big River and Railroad Gulch, and unidentified salmonids were detected in Laguna Creek.

Electrofishing documented by NMFS (Jones 2000) in five streams from 1995 to 1997 found coho salmon and steelhead trout in mainstem Big River, Railroad Gulch, Little North Fork Big River, Thompson Gulch, East Branch Little North Fork Big River, and Berry Gulch.

Carcass surveys conducted by CDFG in Little North Fork Big River detected 30 redds in 1995 and 26 redds in 1996. Numerous live coho salmon and coho salmon carcasses were also observed. A carcass survey in 1996 in Railroad Gulch found 26 redds, six live coho salmon, and one coho salmon carcass. The School of Natural Resources at Mendocino High School conducted carcass surveys in Railroad Creek in 2001 and Little North Fork Big River in the winters of 2001-2002 and 2002-2003 (SONAR 2001-2002, Sharples 2003). No fish or redds were observed in Railroad Creek. Thirty-three coho salmon and one steelhead trout were found in both years in Little North Fork Big River. Twenty six redds were observed in the 2001-2002 season and 16 redds were observed in the 2002-2003 season.

The 2001 CDFG Coho Inventory found coho salmon present in mainstem Big River. Snorkel surveys of the Big River Estuary conducted by the School of Natural Resources at Mendocino High School in 2001 and 2002 detected coho salmon and steelhead trout, as well as unidentified salmonids and surfperch (Clapsadle et al. 2001).

CDFG stream inventory surveys conducted across the subbasin also detected coho salmon and steelhead trout from 1995 through 2002. Coho salmon were detected in seven surveyed tributaries and the mainstem Big River from Wheel Gulch to Blind Gulch. Steelhead trout were detected in six surveyed tributaries and the mainstem Big River from Wheel Gulch to Blind Gulch. More detailed summaries of stream surveys and fisheries studies in the Coastal Subbasin are provided in the CDFG Appendix.

Coastal Subbasin Issues

From the various disciplines' assessments and constituent input, the following issues were developed for the Coastal Subbasin. These must be considered in context of the Big River Basin's Franciscan mélange geology, the many low gradient depositional reaches in this subbasin, and the 8.3 mile long Big River Estuary. In the Coastal Subbasin:

- Water temperatures are thought to be unsuitable for salmonids in the mainstem Big River;
- There is concern that road related failures are contributing large amounts of sediments to stream channels during major storms;
- There is evidence of channel narrowing and increased sediment deposition in the estuary; however, the channel could simply be recovering from the effects of extensive splash damming throughout the basin;
- Estuary conditions are thought to be impaired by sediment;
- Excessive amounts of fine material in streams are a concern;
- A large section of the Coastal Subbasin has recently become State Park and management decisions affecting this land are in progress.

Coastal Subbasin Integrated Analysis

The following section provides a dynamic, spatial picture of watershed conditions for the freshwater lifestages of salmon and steelhead. Different watershed factors are analyzed together to examine their combined effects on stream channels. The interactions between geology, vegetation, landuse, water quality, and stream channels indicate the quantity and quality of the freshwater habitat for salmon and steelhead.

Landsliding Interactions

GMA (2001) calculated the unit volume of delivering landslides, comprised of the total of delivering landslides in unmanaged forest, brush and grasslands, roads and timber harvest areas, to be 292 tons/square mile/year for 1989-2000. In the Coastal Subbasin, it was reported that 100% of the landslides occurred in timber harvest areas or were related to roads (Figure 75). Of the delivering landslides from harvest related activities and roads, it was estimated that 66% were related to roads and 34% were related to timber harvesting (including skid trails). Results over the entire study period (1937-2000) showed that 33% of the delivering landslides were road related, 67% were related to timber harvesting (including skid trails), and none were related to grassland areas or unmanaged forest.

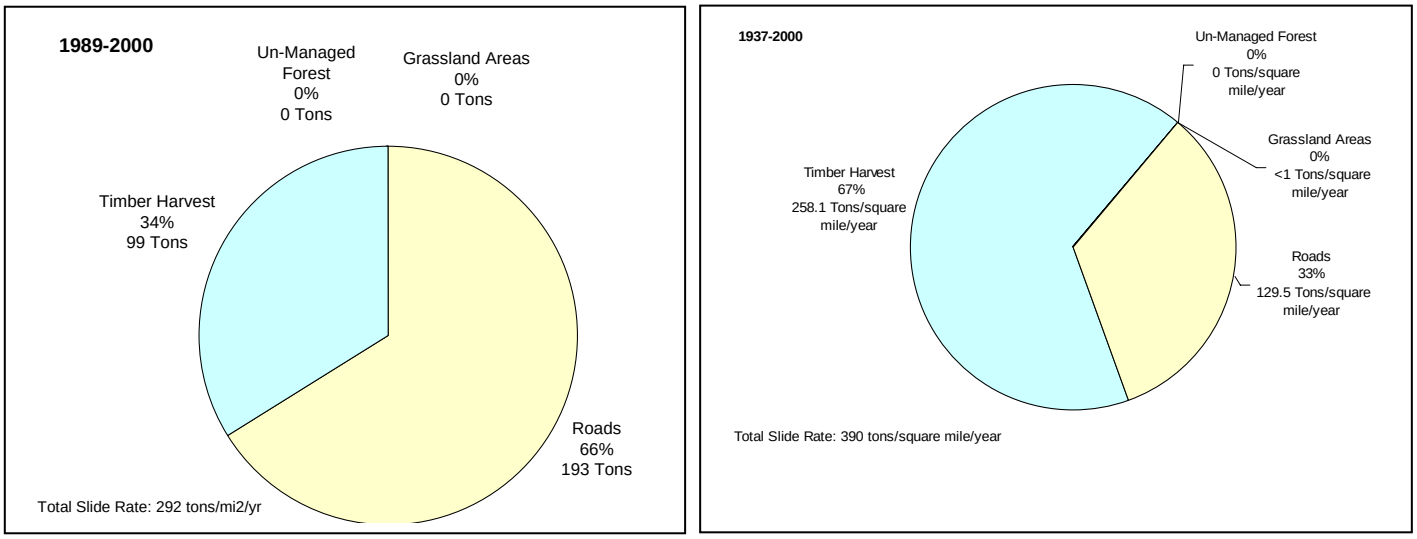

Figure 75. Delivering landslides by category, Coastal Subbasin (GMA 2001a).

Thus, when comparing the 1989-2000 time period to that of the entire study period, the percentage of delivering landslides due to roads versus timber harvesting was reversed. This switch in the primary cause of delivering landslides may be the result of timber harvesting methods that are less disruptive, or it may be the result of years of building roads that are now triggering more landslides. It is important to note that the total estimated slide rate decreased from 390 (1937-2000) to 292 tons/square mile/year (1989-2000), a moderate drop in sediment input by landslides.

When examining the three PWs in the Coastal Subbasin, the Berry Gulch PW had a higher percentage of harvest-related sediment delivered by landslides, while the Laguna Creek PW had a slightly higher percentage of sediment related to roads (Table 104).

Table 104. Volumes of delivering slides by land use by PW for 1937-2000 in the Coastal.

PW	Forest	Brush & Grassland	Harvest-Related					Road-Related	Total
			Partial Or Clear Cut	Harvest (<20 Yrs)	Harvest (>20 Yrs)	Skid Trails	Total		
Mouth of Big River	0 0.0%	0 0.0%	0 0.0%	14,367 6.7%	102,000 47.6%	1,389 0.6%	130,547 60.9%	83,928 39.1%	214,476
Berry Gulch	0 0.0%	54 <0.1%	9,410 1.9%	172,052 34.6%	165,187 33.2%	2,492 0.5%	349,141 70.2%	148,496 29.8%	497,692
Laguna Creek	0 0.0%	0 0.0%	2,421 3.0%	22,309 27.6%	23,518 29.1%	0 0.0%	48,248 59.7%	32,544 40.3%	80,792
Coastal Subbasin	0 **0.0%**	54 **<0.1%**	11,831 **1.5%**	208,727 **26.3%**	290,706 **36.7%**	3,882 **0.5%**	527,937**66** **.6%**	264,969 **33.4%**	792,960

Subbasin in tons and percentage of subbasin total (GMA 2001a).

All three PWs had a peak in sediment production in 1952 (Table 105). The highest peak sediment production was 345,779 tons in 1952 in the Berry Gulch Big PW. Harvest-related landslides provided more volume in the peak year for all PWs.

In the 2000 study period, sediment production from landslides ranged from 12,589 tons in the Laguna Creek PW to 63,653 tons in the Mouth of Big River PW. Harvest related landslides provided more volume in Laguna Creek and roads in Mouth of Big River and Berry Gulch.

Sediment production related to landsliding showed varying trends in different PWs from 1937 to 2000. All three PWs showed a decrease in sediment production from in 1965 and 1978, as they all showed peaks in sediment volume in 1952. Harvest-related landslides provided the most sediment in 1952 in all three PWs, Laguna Creek PW in 2000, and in Berry Gulch PW in 1978. Road-related sediment volumes appear to have gained relative importance in all PWs after 1965. The Mouth of Big River PW showed a decrease in sediment production from 1978 to 1988, while the other two PWs showed increases in this study period. In the last study period (1988 to 2000) sediment volume related to landslides decreased in the Laguna Creek PW and increased in the other PWs.

Table 105. Volume of delivering slides by land use, PW, and year in the Coastal Subbasin.

Year	PW	Forest	Brush & Grassland	Harvest-Related					Road-Related	Study Period Total
				Partial or Clear Cut	Harvest (< 20 Years)	Harvest (> 20 Years)	Skid Trail	Total		
1952	Mouth of Big River				1,775	64,026	0	65,800	12,366	78,166
1965					47	26,993	1,372	40,641	28,463	69,104
1978					1,635	106	0	1,741	1,811	3,552
1988					0	0	0	0	0	0
2000					10,910	10,876	17	22,364	41,288	63,653
Total:		0	0	0	14,367	102,000	1,389	130,547	83,928	214,476
1952	Berry Gulch		54	907	155,500	135,320		291,728	53,997	345,779
1965					4,817	22,561		27,377	27,794	55,172
1978				8,062		2,164	2,492	12,718	12,478	25,196
1988					5,637	4,220		9,857	24,017	33,874
2000				440	6,097	923		7,460	30,210	37,670
Total:		0	54	9,410	172,052	165,187	2,492	349,141	148,496	497,692
1952	Laguna Creek				13,395	23,133		36,528	13,166	49,694
1965					1,380	386		1,766	683	2,449
1978								0		0
1988				1,201				1,201	14,860	16,061
2000				1,220	7,534			8,754	3,835	12,589
Total:		0	0	2,421	22,309	23,518	0	48,248	32,544	80,792

It should be noted that background landslides, other than what was observed in unmanaged forest, has not been included in the direct comparisons discussed thus far (and shown in Figure 75). Background landslide estimates are discussed separately because they were estimated from past studies, rather than through direct observation in aerial photographs. Background landslide rates were estimated based on previous observation of natural "background" landslides in the South and North Fork of Caspar Creek (Matthews 2001). However, this presented a potentially significant difference in data quality and could be misleading if compared directly.

The background landslide rate for the 1989-2000 time period was estimated to be 159 tons/mi^2/yr. The background landslide rate for the 1921-2000 time period was estimated to be 175 tons/mi^2/yr. Regardless of data quality concerns, these estimates point to background landslides as a potentially significant component of sediment input. As a point of reference, all other landslides during the 1989-2000 time period contributed an estimated 292 tons/mi^2/yr. This would indicate that background landslides may have contributed roughly 35% of the total sediment input by all categories of landslides.

When compared to the TMDL load allocations for each category of landslide, there is no reduction needed for background landslides, as it is naturally occurring. However, each category of landslide that is related to human management has been assigned a load allocation (US EPA 2001). The overall goal of the load allocation is to limit sediment input to no more than 125% of naturally occurring background levels by reducing sediment input from the various categories accordingly. These are charted in Figure 76 for comparison to the estimated landsliding rates during the 1989-2000 time period. Note that estimated values and TMDL load allocations for timber harvest also include landslides related to skid trails. Based on these preliminary comparisons, it appears as though landsliding related to roads and timber harvesting needs to be addressed to meet the TMDL load allocation goals. Roads, in particular, seem to be a significant problem, but one that can be addressed with relative ease compared to landslides and other large natural disturbances.

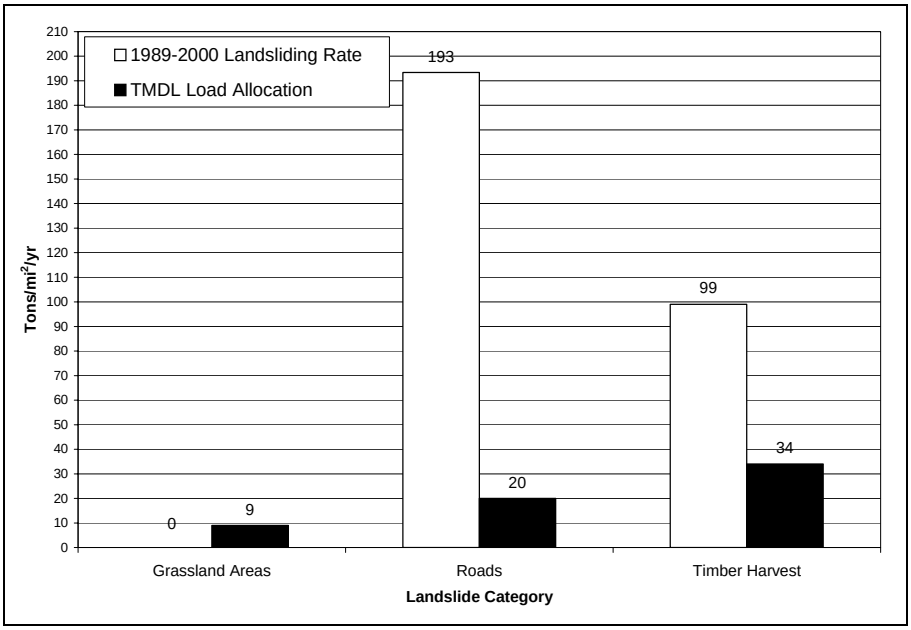

Figure 76. Landslide rate vs. TMDL load allocations, Coastal Subbasin (GMA).

Slope Interactions

An analysis of different types of roads on slopes of varying percent showed that most road miles are on slopes from 31 to 50% in this subbasin (Table 106). When GMA (2001) grouped slopes into categories, they found that most of the roads are mid-slope, followed by riparian, and then ridge-top (Table 107). An estimated 21% of roads are located in the riparian zone. The proportion of roads in each location was similar in each PW (Table 108).

Table 106. Length of truck roads by side slope and road surface.

Side Slope in Percent	Total Length in Miles				Miles per Square Mile				Proportion of Length			
	Native	Paved	Rocked	Total	Native	Paved	Rocked	Total	Native	Paved	Rocked	Total
0 -15	50	4	16	71	1.5	0.1	0.5	2.2	20	2	7	28
16 - 30	55	5	11	70	1.7	0.1	0.3	2.1	22	2	4	28
31 - 50	65	1	13	79	2.0	0.0	0.4	2.4	26		5	32
51 - 65	17	0	4	22	0.5	0.0	0.1	0.7	7		2	9
Greater than 65	6		2	8	0.2		0.0	0.2	2		1	3
Total	**193**	**10**	**46**	**249**	**5.9**	**0.3**	**1.4**	**7.7**	**77**	**4**	**18**	**100**

Table 107. Coastal Subbasin roads by location and surface type.

	Paved	Rocked	Un-surfaced
Ridgetop			
Miles	2.4	7.0	39.5
% Total Basin Miles	1.0	2.8	15.9
Mid-slope			
Miles	7.5	29.4	111.5
% Total Basin Miles	3.0	11.8	44.9
Riparian			
Miles	0.5	9.5	41.2
% Total Basin Miles	0.2	3.8	16.6

Blue categories have the lowest potential for road surface erosion (6.8%). Orange categories have medium potential for surface erosion (27.9%). Magenta categories have the highest potential for surface erosion (65.3%). Road surface erosion is a source of fine sediment that can be delivered to streams, which is deleterious to fish habitat. Total subbasin roads = 248.4 miles, 7.7 miles/square mile.

Table 108. Existing miles of road in different road positions by types and PW in the Coastal Subbasin (from GMA 2001a).

Planning Watershed	Riparian			Mid-Slope			Ridge			Total By PW		
	Paved	Rocked	Native	Paved	Rocked	Native	Paved	Rocked	Native	Riparian	Mid-Slope	Ridge
Mouth of Big River	0.5	9.5	41.2	7.5	29.4	111.5	2.4	7.0	39.5	51.2	148.4	48.9
Berry Gulch		1.9	15.3	1.6	6.3	42.1	1.2	1.9	14.5	17.2	50.1	17.6
Laguna Creek		2.3	5.6	1.9	3.8	18.4	0.2	0.3	8.6	7.9	24.1	9.1

Road Interactions

GMA (2001) estimated that road surface erosion across the Coastal Subbasin increased significantly from 1937 to 2000, coinciding with an increased amount of roads, (Table 109). Roads in 2000 were estimated to produce 98.6 tons of sediment per square mile per year across the subbasin, an increase over 1936 rates. Existing road surface erosion in 2000 was highest in the Mouth of Big River PW and lowest in the Laguna Creek PW.

Table 109. Computed road surface erosion by study period by PW in the Coastal Subbasin (GMA 2001a).

PW	Computed Surface Erosion From Roads By Period (Tons/Yr)					Total By PW For Entire Period	% Total Watershed Road Surface Erosion	Entire Study Period Average Unit Area Road Surface Erosion	2000 Unit Area Road Surface Erosion
	1937-1952	1953-1965	1966-1978	1979-1988	1989-2000	(Tons)	(%)	(Tons/Mi2/Yr)	
Mouth of Big River	664.7	749.1	1047.4	1190.1	1505.6	64,500.5	9.7%	68.7	101.0
Berry Gulch	416.4	566.3	786.8	959.8	1227.2	48,834.5	7.4%	62.0	98.3
Laguna Creek	95.1	128.9	167.6	275.9	468.1	13,787.5	2.1%	42.9	92.3
Coastal Subbasin	1176.2 (36.7%)	1444.2 (45.1%)	2001.8 (62.5%)	2425.8 (75.8%)	3200.9 (100.0%)	127,122.5	19.2%	62.1	98.6

GMA (2001) estimated that sediment production from skid roads across the subbasin was small (Table 110). The analysis suggested a peak in surface erosion at the time of high harvest rates using high-density tractor logging methods from 1953-1978. Surface erosion from 1989 to 2000 was almost the same in the Berry Gulch and Laguna Creek PWs and twice that in the Mouth of Big River PW.

Table 110. Summary of surface erosion estimates from harvest areas by study period in the Coastal Subbasin (GMA 2001a).

PW	1937-1952 (Tons)	1953-1965 (Tons)	1966-1978 (Tons)	1979-1988 (Tons)	1989-2000 (Tons)	1921-2000 Total by PW or SW (Tons)
Mouth of Big River	0.0	526.5	2,551.2	1,791.1	2,026.9	6,895.7
Berry Gulch	1,495.4	2,586.2	1,681.7	484.6	1,052.3	7,300.2
Laguna Creek	0.0	436.4	0.0	1,455.7	1,072.8	2,964.8
Coastal Subbasin	1,495.4	3,549.1	4,232.9	3,731.4	4,152.0	17,160.6

As can be seen in Figure 77, estimates of surface erosion from roads and timber harvest areas (including skid trails) indicate that both also exceed the TMDL load allocation for surface erosion. The increase in surface erosion from roads in the 1989-2000 time period versus the entire study period (1937-2000) is likely due to continued road building through the years which has resulted in greater road surface area. CGS (2004) evaluated sediment yield from existing roads and culverts for the 3,715-acre Big River State Park.

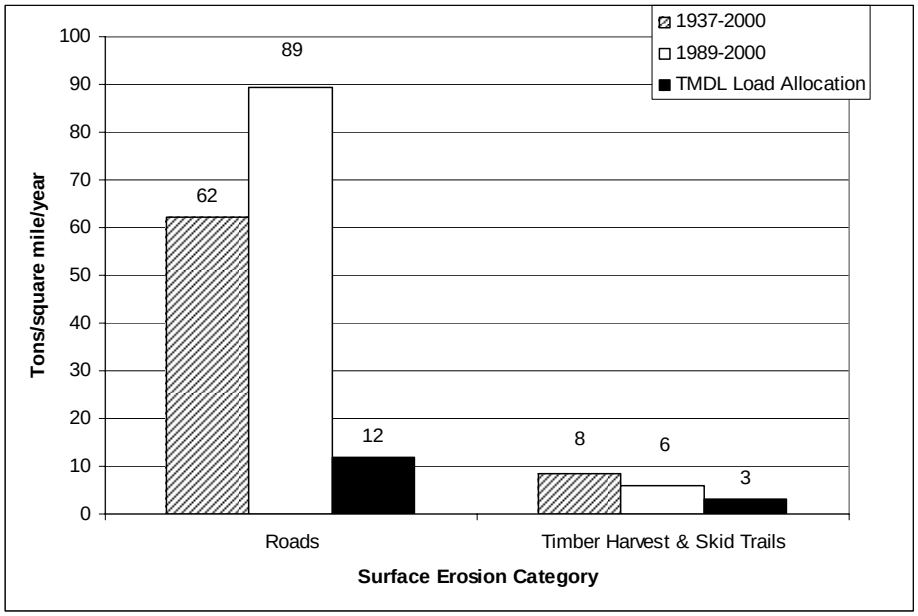

Figure 77. Surface erosion rate vs. TMDL load allocations, Coastal Subbasin (GMA 2001a).

Road Crossings

Today there are 38 miles of roads in the watercourse buffer zone (Table 111). Seventy five percent were built before 1979 (Table 112). While the data show 31 miles as native road surface, the Forest Practice Rules require that landowners that use roads for harvesting timber reduce the potential for sediment transport, so many are being surfaced with rock. There are almost 21 streams crossings per square mile in this subbasin (Table 113).

Table 111. Length of truck roads in near proximity to watercourse in miles by watercourse classification and road classification in the Coastal Subbasin.

Watercourse Class	Total Length in Miles				Length in Miles per Sq Mile			
	Native	Paved	Rocked	Total	Native	Paved	Rocked	Total
w/i 150' of FPR Class I or USGS Perennial	22.3	0.2	4.8	27.2	0.69	0.01	0.15	0.84
w/i 75' of FPR Class II or USGS Intermittent	5.2	0.2	1.2	6.5	0.16	0.01	0.04	0.20
w/i 25' of FPR Class III	3.4	0.0	0.9	4.3	0.11		0.03	0.13
Total	**30.9**	**0.4**	**6.8**	**38.1**	**0.95**	**0.01**	**0.21**	**1.17**

Table 112. Length of truck roads in near proximity to watercourse in miles by period of construction and road classification in the Coastal Subbasin.

Period	Total Length in Miles				Length in Miles per Sq Mile			
	Native	Paved	Rocked	Total	Native	Paved	Rocked	Total
pre - 1937	13.2	0.3	2.4	15.9	0.41	0.01	0.07	0.49
1937 - 1952	3.0		2.1	5.1	0.09		0.06	0.16
1953 - 1965	3.7	0.1	0.6	4.4	0.11		0.02	0.13
1966 - 1978	2.2		0.9	3.2	0.07		0.03	0.10
1979 - 1988	2.7		0.5	3.2	0.08		0.01	0.10
1989 - 2000	6.1		0.4	6.5	0.19		0.01	0.20
Total	**30.9**	**0.4**	**6.8**	**38.1**	**0.95**	**0.01**	**0.21**	**1.17**

Table 113. Number of watercourse truck road crossings by watercourse and road classification in the Coastal Subbasin.

Watercourse Class	Total Crossings				Crossings per Square Mile			
	Native	Paved	Rocked	Total	Native	Paved	Rocked	Total
FPR Class I or CFF Perennial	49	2	13	64	1.5	0.1	0.4	2
FPR Class II or CFF Intermittent	120	1	37	158	3.7	0	1.1	4.9
FPR Class III	372	3	81	456	11.5	0.1	2.5	14
Total	**541**	**6**	**131**	**678**	**16.7**	**0.2**	**4**	**20.9**

Fluvial Erosion

GMA (2001) estimates of bank erosion and small streamside mass wasting found little sediment from these sources.

Table 114. Bank erosion and small streamside mass wasting in the Coastal Subbasin.

Planning Watershed	Bank Erosion and Small Streamside Mass Wasting		Total
	Class 1 (Tons/Year)	Class 2 (Tons/Year)	(Tons/Year)
Mouth of Big River	457.35	555.62	1012.97
Berry Gulch	364	425	789
Laguna Creek	134	212	346
Coastal Subbasin	955	1,193	2,148

GMA 2001a

Stream Interactions

The products and effects of the watershed delivery processes examined in the geologic, slope, and landsliding Integrated Analyses tables are expressed in the stream habitats encountered by the organisms of the aquatic riparian community, including salmon and steelhead. Several key aspects of salmonid habitat in the Big River Basin are presented in the Stream Interactions Integrated Analysis. Channel and stream conditions are not necessarily exclusively linked to their immediate surrounding terrain, but may in fact be both spatially and temporally distanced from the sites of the processes and disturbance events that have been blended together over time to create the channel and stream's present conditions. Instream habitat data presented here were compiled from CDFG stream inventories described in more detail in the Fish Habitat Relationships sections of this report.

Primary Pools

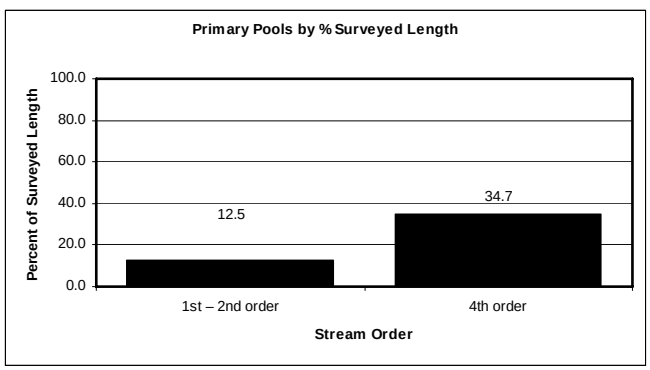

Figure 78. Primary pools in the Coastal Subbasin.

Pools greater than 2 feet deep in 1st and 2nd order streams and greater than 3 feet deep in 3rd and 4th order streams are considered primary pools.

Significance: Primary pools provide escape cover from high velocity flows, hiding areas from predators, and ambush sites for taking prey. Pools are also important juvenile rearing areas. Generally, a stream reach should have 30-55% of its length in primary pools to be suitable for salmonids. In first and second order streams, a primary pool is described as being at least two feet deep. In third and fourth order streams, a primary pool is described as being at least three feet deep.

Comments: The percent of primary pools by length in the Coastal Subbasin is generally below target values for salmonids in lower order streams and appears to be suitable in fourth order streams. This subbasin has the highest percent of primary pools in first and second order streams surveyed of any of the Big River Subbasins.

Spawning Gravel Quality

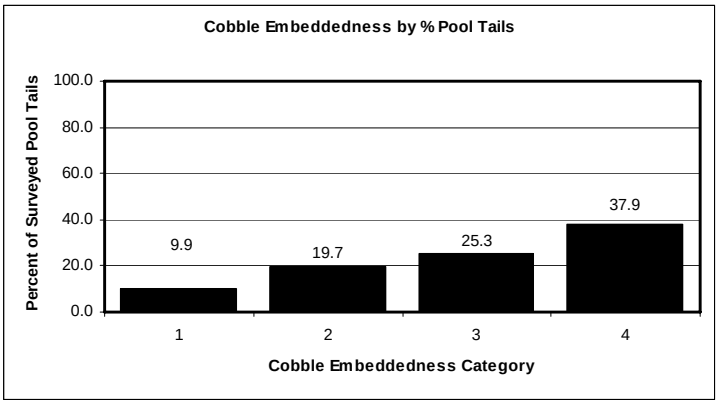

Figure 79. Cobble embeddedness in the Coastal Subbasin.

Cobble Embeddedness will not always sum to 100% because Category 5 (not suitable for spawning) is not included.

Significance: Successful salmonid egg and embryo survival diminishes when spawning occurs in streambeds with excessive silt, clay, and other fine sediment. Cobble embeddedness is the percentage of an average sized cobble at a pool tail out embedded in fine substrate. Category 1 is 0-25% embedded, category 2 is 26-50% embedded, category 3 is 51-75% embedded and category 4 is 76%-100% embedded. Cobble embeddedness categories 3 and 4 are not within the suitable range for successful use by salmonids. Category 5 describes pool tail outs with unspawnable substrate such as bedrock, log sills, or boulders.

Comments: More than one half of the surveyed stream lengths within the Coastal Subbasin, where the mainstem Big River is primarily a depositional reach, have cobble embeddedness in categories 3 and 4, which does not meet spawning gravel target values for salmonids. This subbasin has the highest percent of unsuitable cobble embeddedness values in surveyed streams of the Big River Subbasin.

Shade Canopy

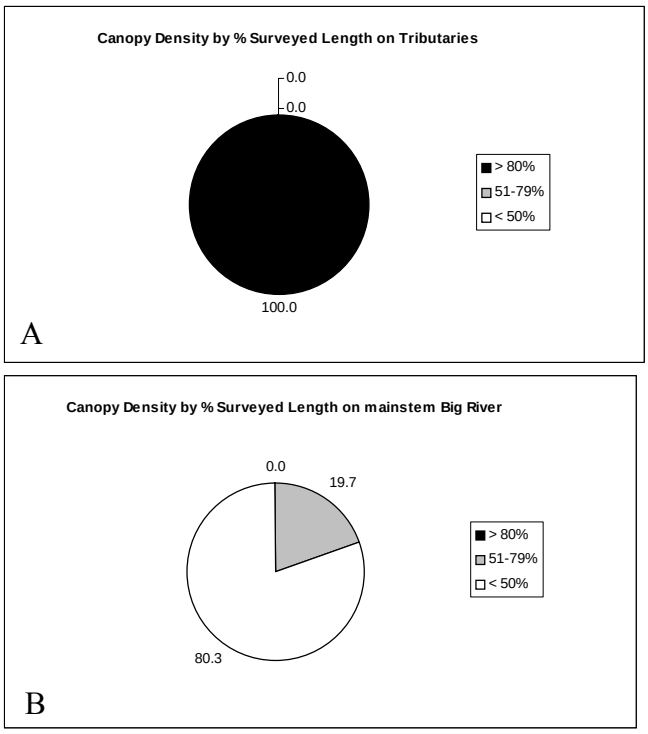

Figure 80. Canopy density in the Coastal Subbasin. A. Tributaries. B. Mainstem Big River.

Significance: Near-stream forest density and composition contribute to microclimate conditions that help regulate air temperature, which is an important factor in determining stream water temperature. Stream water temperature can be an important limiting factor of salmonids. Generally, canopy density less than 50% by survey length is unsuitable and greater than 80% is fully suitable.

Comments: All of the surveyed tributary lengths within the Coastal Subbasin have canopy densities greater than 80%. This is above the canopy density target values for salmonids. The mainstem Big River has lower canopy density values, as is expected on a forth order stream.

Fish Passage

Table 115. Juvenile salmonid passage in the Coastal Subbasin.

Feature		Significance	Comments
Juvenile Summer Passage	**Juvenile Winter Refugia**		
0.9 Miles of Surveyed Channel Dry	No Data	Dry channel disrupts the ability of juvenile salmonids to move freely throughout stream systems.	Dry channel recorded in the Coastal Subbasin during stream surveys has the potential to disrupt the ability of juvenile salmonids to forage and escape predation in eight tributaries. Juvenile salmonids seek refuge from high winter flows, flood events, and cold temperatures in the winter. Intermittent side pools, back channels, and other areas of relatively still water that become flooded by high flows provide valuable winter refugia.
2.3% of Surveyed Channel Dry			

1993-2002 CDFG Stream Surveys, CDFG Appendix

Pool Shelter

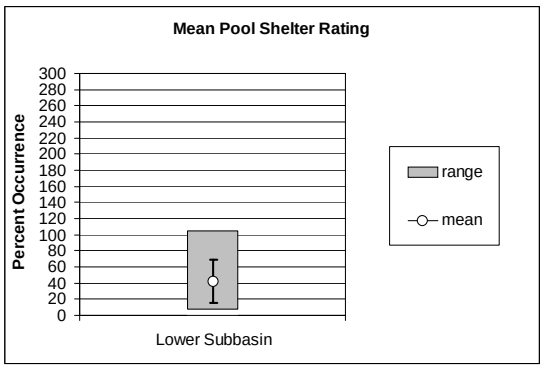

Figure 81. Pool shelter in the Coastal Subbasin.

Error bars represent the standard deviation. The percentage of shelter provided by various structures (i.e. undercut banks, woody debris, root masses, terrestrial vegetation, aquatic vegetation, bubble curtains, boulders, or bedrock ledges) is described and rated in CDFG surveys.

Significance: Pool shelter provides protection from predation and rest areas from high velocity flows for salmonids. Shelter ratings of 100 or less indicate that shelter/cover enhancement should be considered.

Comments: The average mean pool shelter rating in the Coastal Subbasin is 41.9. This is below the shelter target value for salmonids, but is the highest of the Big River subbasins.

Large Woody Debris

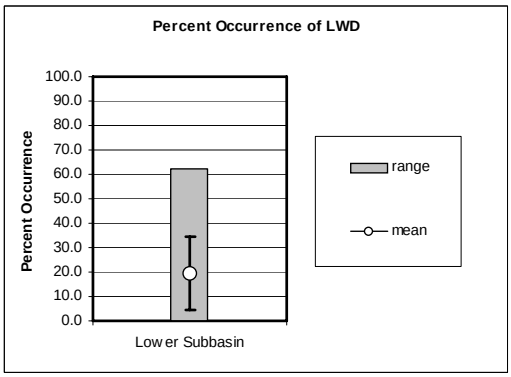

Figure 82. Large Woody Debris (LWD) in the Coastal Subbasin.

Error bars represent the standard deviation. The percentage of shelter provided by various structures (i.e. undercut banks, woody debris, root masses, terrestrial vegetation, aquatic vegetation, bubble curtains, boulders, or bedrock ledges) is described in CDFG surveys. The dominant shelter type is determined and then the percentage of a stream reach in which the dominant shelter type is provided by organic debris is calculated.

Significance: Large woody debris shapes channel morphology, helps a stream retain organic matter, and provides essential cover for salmonids. There are currently no target values established for the percent occurrence of LWD.

Comments: A 19.5 average percent occurrence of large woody debris is low compared to the range of values recorded throughout the entire Big River Basin, which is 0 to 62. The dominant shelter types recorded in most stream reaches were large woody debris, small woody debris, and terrestrial vegetation.

Although instream habitat conditions for salmonids varied across the Coastal Subbasin, several generalities can be made. Instream habitat conditions were generally good within this subbasin at the time of CDFG surveys. The percentage of primary pools by survey length was the most suitable for salmonids of any of the Big River Subbasins. Canopy density levels appear low in this subbasin, but the large proportion of surveyed stream length on the mainstem Big River (a fourth order stream) accounts for the low canopy density. All of the tributary reaches surveyed in this subbasin have canopy densities greater than 80%. However, embeddedness values were generally below target values as found in CDFGs California Salmonid Stream Habitat Restoration Manual and calculated by the EMDS. The percent occurrence of large woody debris was in the lower range of values recorded in the Big River Basin. In addition, dry channel occurred in 0.9 miles of surveyed stream (2.3% of the surveyed stream length).

Stream Reach Conditions EMDS

The anadromous reach condition EMDS evaluates the condition for salmonids in a stream reach based upon instantaneous water temperature, riparian vegetation, stream flow, and in channel characteristics. Data used in the Reach EMDS come from CDFG habitat inventory surveys. Currently, data exist in the Big River Basin to evaluate overall reach, water temperature, canopy, in channel, pool quality, pool depth, pool shelter, and embeddedness conditions for salmonids. Details on how the EMDS system calculates habitat variables are in the EMDS Appendix. EMDS calculations and conclusions are pertinent only to surveyed streams and are based on conditions present at the time surveyed.

EMDS stream reach scores were weighted by stream length to obtain overall scores for tributaries and the entire Coastal Subbasin. Weighted average reach conditions on surveyed streams in the Coastal Subbasin as evaluated by the EMDS are somewhat unsuitable for salmonids (Table 116, Figure 83). Suitable conditions exist for canopy across the subbasin except for the mainstem Big River. Laguna Creek has suitable conditions for pool quality, pool depth, and pool shelter. Suitable conditions also exist for pool quality and pool depth in Big River; pool shelter in East Branch Little North Fork Big River; and embeddedness in Rocky Gulch, Manly Gulch, and Big River from Wheel Gulch to Blind Gulch.

One tributary, East Branch Little North Fork Big River, had two years of data, 1996 and 2002. A comparison of the two years data shows an increase in the suitability of canopy and cobble embeddedness and a decline in the suitability of pool shelter.

Table 116. EMDS Anadromous Reach Condition Model results for the Coastal Subbasin.

Stream		Reach	Water Temperature	Canopy	Stream Flow	In Channel	Pool Quality	Pool Depth	Pool Shelter	Embeddedness
Coastal Subbasin (excluding the mainstem Big River)		- (-)	U (U)	- (+++)	U (U)	- (-)	- (--)	+ (--)	- (-)	-- (--)
Big River		-	U	---	U	-	+	++	-	--
Laguna Creek		+	U	+++	U	+	++	++	++	---
Railroad Gulch		-	U	+++	U	-	---	---	---	--
Little North Fork Big River		-	U	+++	U	-	--	--	--	--
Rocky Gulch		-	U	+++	U	-	--	---	--	+++
Manly Gulch		-	U	+++	U	-	---	---	---	+
Thompson Gulch		-	U	+++	U	-	--	---	-	--
East Branch of the Little North Fork Big River	1996	-	U	+	U	-	-	---	++	--
	2002	-	U	+++	U	-	-	---	+	-
Berry Gulch		-	U	+++	U	-	--	---	--	--
Berry Gulch Tributary		-	U	+++	U	-	--	---	--	-
Big River (Wheel Gulch to Blind Gulch)		-	U	-	U	-	-	+	--	++

Key: + ++ +++ Highest Suitability
U Insufficient Data or Undetermined
- -- --- Lowest Suitability

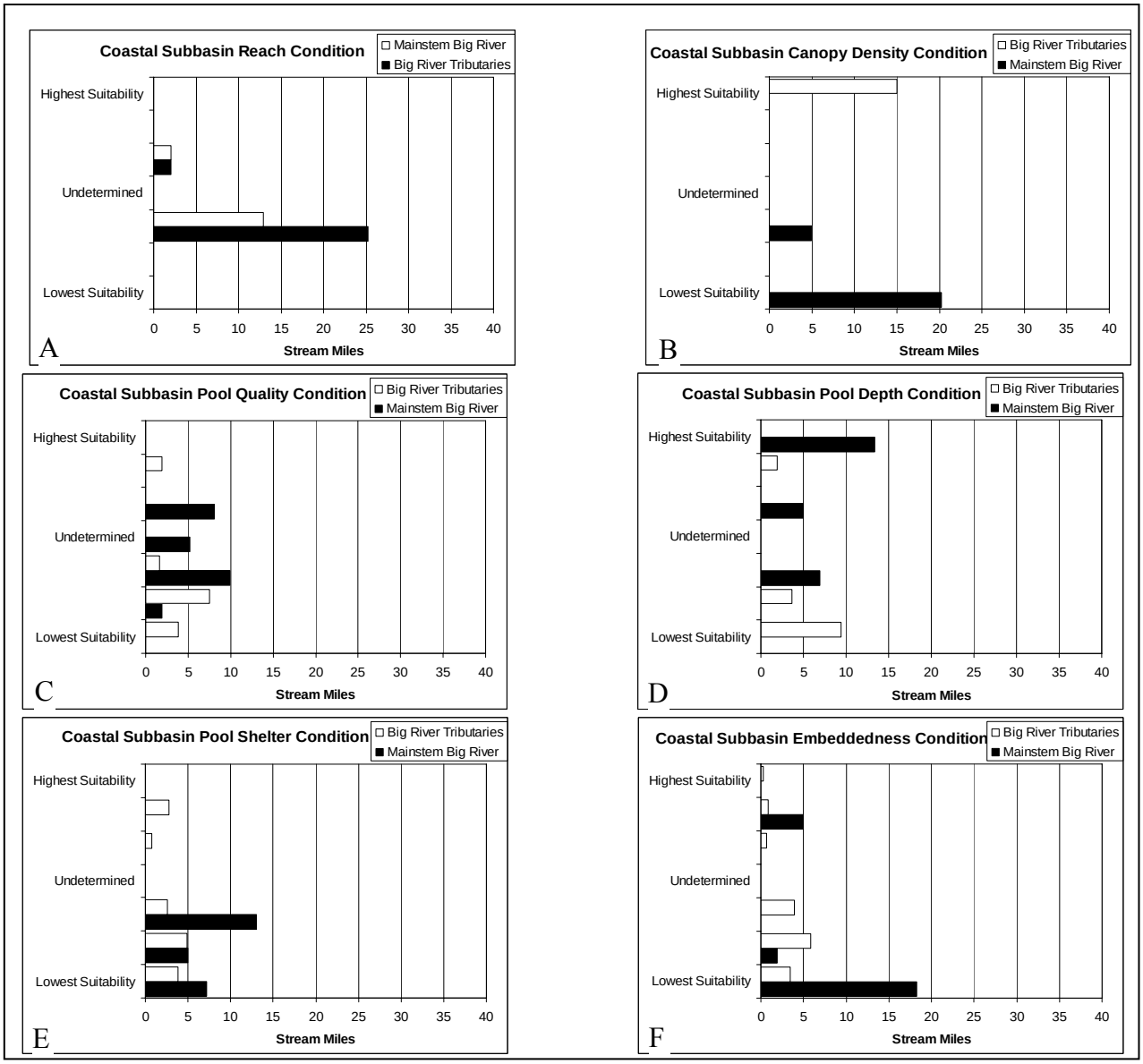

Figure 83. EMDS Reach Condition model results for the Coastal Subbasin by surveyed stream miles.

In streams with multiples years of data, the most current year was used. A. Overall reach condition. B. Canopy density. C. Pool quality. D. Pool depth. E. Pool shelter. F. Cobble embeddedness.

Analysis of Tributary Recommendations

CDFG inventoried 39.5 miles on nine tributaries and the mainstem Big River in the Coastal Subbasin. A CDFG biologist selected and ranked recommendations for each of the inventoried streams, based upon the results of these standard CDFG habitat inventories (Table 117). More details about the tributary recommendation process are given in the Big River Synthesis Section of the Watershed Profile.

Table 117. Ranked tributary recommendations summary in the Coastal Subbasin based on CDFG stream inventories.

Stream	# of Surveyed Stream Miles	Bank	Roads	Canopy	Temp	Pool	Cover	Spawning Gravel	LDA	Livestock	Fish Passage
Big River	20.3	1	2	4			3		5		
Laguna Creek	1.9	2	3			1	4		5		
Railroad Gulch	1.1		2			3	1				
Little North Fork Big River	3.7	3	1				2				
Rocky Gulch	0.2		2				1				
Manly Gulch	0.7		3				2				1
Thompson Gulch	1.1		2			3	1				
East Branch of the Little North Fork Big River	2.4		4		1	2	3				
Berry Gulch	2.2		2		4	3	1				
Berry Gulch Tributary	1.1		2				1				
Big River Wheel Gulch to Blind Gulch	5.0	3		4	1		2				

Temp = summer water temperatures seem to be above optimum for salmon and steelhead; **Pool** = pools are below target values in quantity and/or quality; **Cover** = escape cover is below target values; **Bank** = stream banks are failing and yielding fine sediment into the stream; **Roads** = fine sediment is entering the stream from the road system; **Canopy** = shade canopy is below target values; **Spawning Gravel** = spawning gravel is deficient in quality and/or quantity; **LDA** = large debris accumulations are retaining large amounts of gravel and could need modification; **Livestock** = there is evidence that stock is impacting the stream or riparian area and exclusion should be considered; **Fish Passage** = there are barriers to fish migration in the stream.

In order to further examine Coastal Subbasin issues through the tributary recommendations given in CDFG stream surveys, the top three ranking recommendations for each tributary were collapsed into five different recommendation categories: Erosion/Sediment, Riparian/Water Temp, Instream Habitat, Gravel/Substrate, and Other (Table 118). When examining recommendation categories by number of tributaries, the most important recommendation category in the Coastal Subbasin is Instream Habitat.

Table 118. Top three ranking recommendation categories by number of tributaries in the Coastal Subbasin.

Target Issue	Related Table Categories	Count
Erosion / Sediment	Bank / Roads	13
Riparian / Water Temp	Canopy / Temp	2
Instream Habitat	Pool / Cover	15
Gravel / Substrate	Spawning Gravel / LDA	0
Other	Livestock / Barrier	1

However, when comparing recommendation categories in the Coastal Subbasin by number of tributaries could be confounded by the differences in the number of stream miles surveyed on each tributary. Therefore, the number of stream miles in the subbasin assigned to various recommendation categories was calculated (Figure 84). When examining recommendation categories by number of stream miles, the most important recommendation categories in the Coastal Subbasin shift to Erosion/Sediment, Instream Habitat, and Riparian/Water Temperature. These comprise the top tier of recommended improvement activity focus areas.

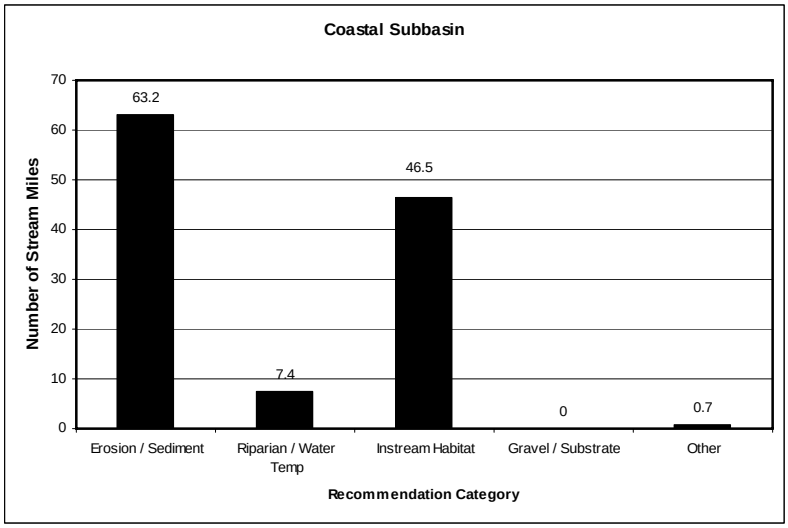

Figure 84. Recommendation categories by stream miles in the Coastal Subbasin.

The high number of Erosion/Sediment, Instream Habitat, and Riparian/Water Temperature recommendations across the Coastal Subbasin indicates that high priority should be given to restoration projects emphasizing sediment reduction, pools, cover, and riparian replanting.

Sediment Source Restoration Sites Within the Big River State Park

CGS evaluated approximately 36 miles of roads (44% of the length of roads) and 129 watercourse crossings (55% of potential crossing locations) within the Big River State Park. They prioritized roads and watercourse crossings for site remediation into three categories: high, moderate, and low (Figure 87). High priority sites were those that require immediate attention, moderate sites should be further investigated in the near-future, and low priority sites will probably require little more than regular maintenance.

Most of the roads evaluated were given a low priority ranking, with 26% receiving a moderate priority ranking, and 8% receiving a high priority ranking (Figure 85). High and moderate priority road segments are concentrated along riparian and mid-slope roads.

Most of the watercourse crossings evaluated were given a high priority ranking, with 27% receiving a moderate priority ranking, and 16% receiving a low priority ranking (Figure 86). All of the Class I stream crossings were given a high priority. Class I streams generally convey a substantial volume of perennial streamflow and have a great potential to deliver sediment to actual or potentially fish-bearing streams. All of the Class II stream crossings were given a high or moderate priority ranking. Class II streams transmit intermittent to perennial flow at a lower discharge than Class I streams and are positioned farther from actual or potential fish bearing streams. Class III streams were given varying priority rankings, though more were given high and moderate rankings than low rankings. Class III streams transmit intermittent or ephemeral flows, generally only following rainfall. They are typically positioned furthest from actual or potential fish bearing streams.

Since CGS's study was purposefully conducted in areas with the most significant erosion and/or mass wasting problems or potential for such problems, their results are biased towards sites with existing and potential problems. A randomly selected group of study sites would likely have found a larger range of conditions. However, these results indicate that roads and watercourse crossings have the greatest potential for erosion and sediment delivery within the park boundaries and will help pin-point high priority restoration sites.

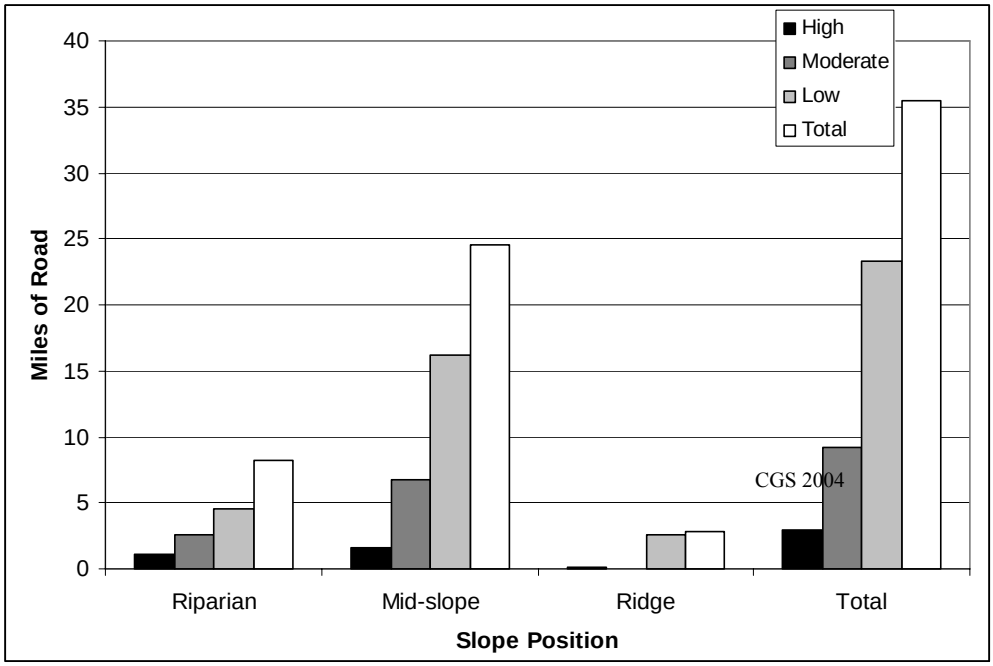

Figure 85. Miles of roads classified by slope position and priority ranking in Big River State Park.

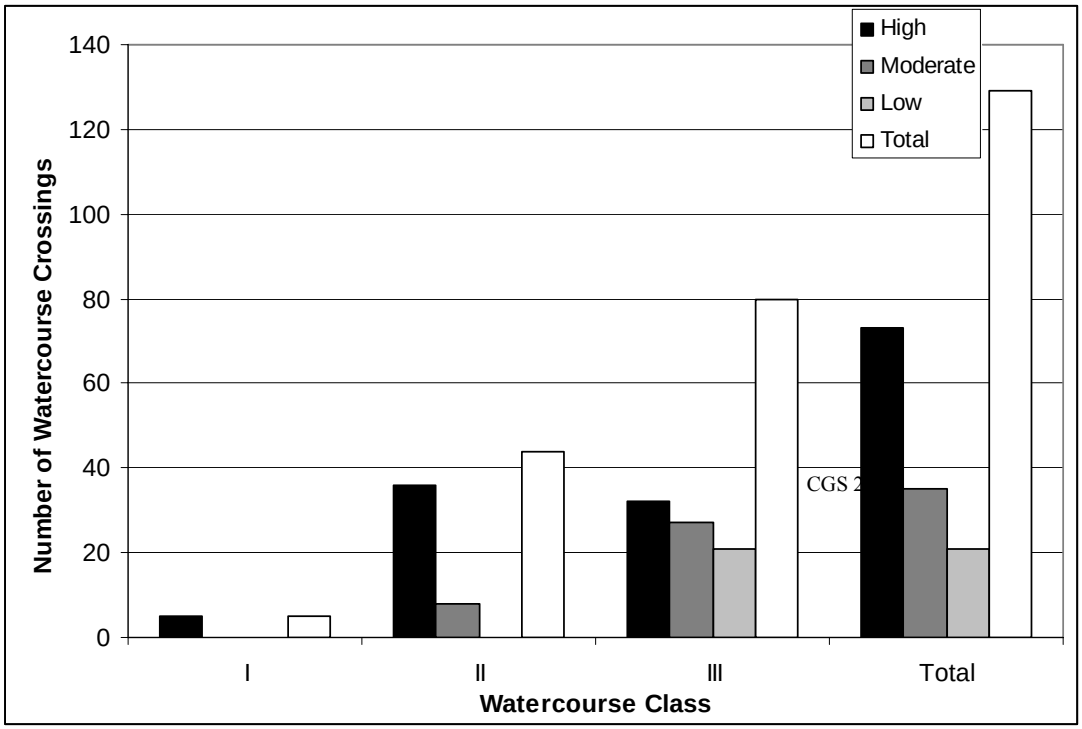

Figure 86. Number of watercourse crossings evaluated by watercourse class and priority ranking in Big River State Park.

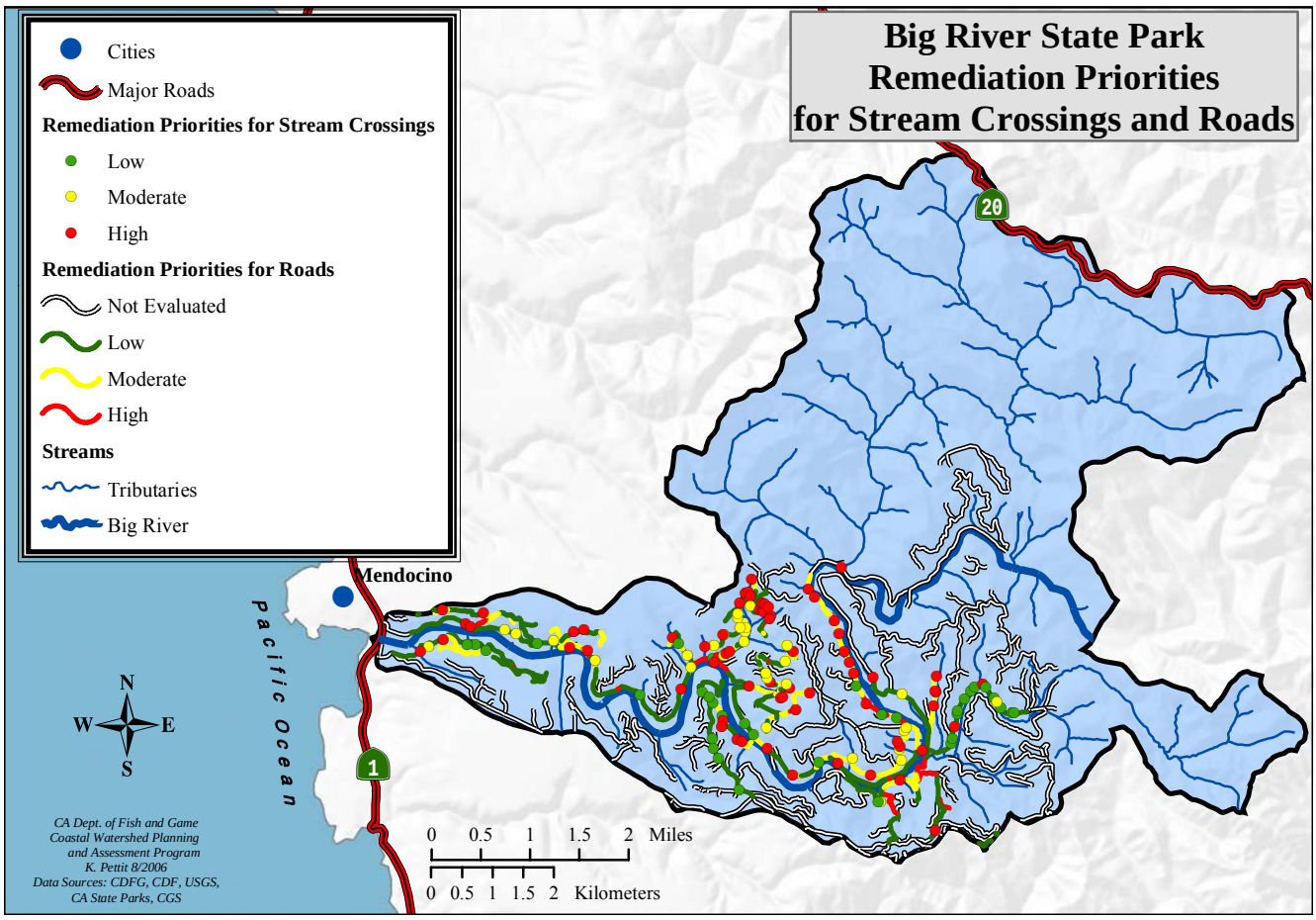

Figure 87. Map of roads and watercourse crossings prioritized by restoration by CGS in Big River State Park (CGS 2004).

Refugia Areas

The NCWAP interdisciplinary team identified and characterized refugia habitat in the Coastal Subbasin by using professional judgment and criteria developed for north coast watersheds. The criteria included measures of watershed and stream ecosystem processes, the presence and status of fishery resources, forestry and other land uses, land ownership, potential risk from sediment delivery, water quality, and other factors that may affect refugia productivity. The team also used results from information processed by the NCWAPs EMDS at the stream reach scale.

The most complete data available in the Coastal Subbasin were for tributaries surveyed by CDFG. However, many of these tributaries were still lacking data for some factors considered by the NCWAP team.

Salmonid habitat conditions in the Coastal Subbasin on surveyed streams are generally rated as high potential refugia. The Big River Estuary and the Little North Fork Big River provide the best salmonid habitat in this subbasin, while Cookhouse Gulch and Wheel Gulch provide low quality refugia. Additionally, the estuary, mainstem, and Little North Fork Big River serve as critical contributing areas. The following refugia area rating table summarizes subbasin salmonid refugia conditions.

Table 119. Tributary salmonid refugia area ratings in the Coastal Subbasin.

Stream	Refugia Categories*				Other Categories:		
	High Quality	High Potential	Medium Potential	Low Quality	Non-Anadromous	Critical Contributing Area/Function	Data Limited
Big River Estuary			X			X	X
Big River			X			X	X
Dry Dock Gulch				X			
Laguna Creek			X				X
Railroad Gulch		X					X
Little North Fork Big River		X				X	X
Cookhouse Gulch				X			X
Rocky Gulch		X					X
Manly Gulch				X			X
Thompson Gulch		X					X
East Branch of the Little North Fork Big River		X					X
Berry Gulch		X					X
Berry Gulch Tributary		X					X
Wheel Gulch				X			X
Subbasin Rating		X					X

*Ratings in this table are done on a sliding scale from best to worst. See page 45 in the Introduction and Overview section for a discussion of refugia criteria.

Responses to Assessment Questions

What are the history and trends of the sizes, range, and relative health and diversity of salmonid populations within the Coastal Subbasin?

Findings and Conclusions:

- Both historic and current data are limited. Little data are available on population trends, relative health, or diversity. According to NOAA Fisheries listing investigations, the populations of salmonids have likely decreased in the Big River Basin as they have elsewhere along California and the Pacific Coast;
- Based on limited CDFG, USFWS, HTC, and SONAR presence surveys and surveys documented by NMFS since the 1960s, the distributions of coho salmon and steelhead trout do not appear to have changed;
- Reaches surveyed by CDFG since 1990 that contained salmonids usually had both coho salmon and steelhead trout present;
- Six tributaries, the mainstem Big River, and the estuary had records of coho salmon and steelhead trout since 1990. One additional tributary also recorded only coho salmon.

What are the current salmonid habitat conditions in this subbasin? How do these conditions compare to desired conditions?

Findings and Conclusions:

Erosion/Sediment

- Pebble counts and V* measurements in one sampled tributary (Berry Gulch) and McNeil samples in the Little North Fork indicated excessive amounts of fine material in these streams. This could indicate unsuitable conditions for salmonids.

Riparian/Water Temperature

- There are no temperature data for the Big River Estuary; however, it is expected that the water temperatures in the mainstem Big River quickly cool once they reach the estuary due to the marine influence;
- Water temperatures at monitoring sites on the mainstem of the Big River in this subbasin were fully unsuitable in all years monitored with high diurnal fluctuations (7.9-9.9°F) and high maximum temperatures (75-76°F). This could indicate unsuitable conditions for salmonids in the mainstem upstream of the estuary;
- Most of the Little North Fork Big River and tributary monitoring sites exhibited low diurnal fluctuations suggesting good shading, and/or good flow conditions and/or a tempering marine influence. This indicates suitable conditions for salmonids;
- It is probable that the Little North Fork has a cooling effect on the mainstem Big River. However, the magnitude of that effect is unknown as it is dependant on the temperature differentials and flows;
- Canopy cover was suitable for salmonids on all surveyed tributary reaches within this subbasin, but unsuitable on surveyed reaches of the mainstem Big River as expected on a larger order stream with wide channels.

Instream Habitat

- In the estuary, escape and ambush cover are unsuitable for salmonids;
- A high incidence of shallow pools, and a lack of cover and large woody debris have contributed to a simplification of instream salmonid habitat in all nine surveyed tributary reaches;
- Areas of dry channel found during CDFG stream surveys on eight streams may indicate fish passage problems in some tributaries.

Gravel Substrate

- Cobble embeddedness values in most surveyed reaches were unsuitable for salmonid spawning success.

Refugia Areas

- Salmonid habitat conditions in this subbasin on surveyed streams are generally rated as high potential refugia;
- The Big River Estuary and the Little North Fork Big River provide the best salmonid refugia in this subbasin;
- The estuary, mainstem Big River, and Little North Fork Big River serve as critical contributing areas.

Other

- Winter access problems for adult fish at a non-existent channel near the mouth of Manly Gulch may be stopping it from being utilized for habitat by salmonids;
- Small tributaries along the estuary are blocked to fish passage by perched culverts;
- There are no water chemistry data for the estuary and little data for this subbasin as a whole;
- Water chemistry data available from a small stream near the estuary, but not related to the water chemistry in the estuary itself, indicated that alkalinity and sodium appeared to be below the minimum water quality criteria;

- Basic water chemistry on the mainstem Big River both upstream and downstream of the Little North Fork appear to be within applicable numeric Basin Plan water quality objectives. However, sodium at the mainstem sites upstream and downstream of the Little North Fork confluence exceeds its criteria. Additionally, copper exceeds its criteria at sites upstream of the Little North Fork. However, these findings may be artifacts of the type of sampling procedure used;
- Total and fecal coliform was detected on the mainstem at the sites upstream of the Little North Fork confluence. It appears as though the levels detected are not hazardous for humans.

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

Findings and Conclusions:

- Many of the tributaries in this subbasin are intermittent in their upper reaches and usually have summer and fall flows less than 1 cfs;
- This subbasin is underlain by Franciscan Coastal Belt geology. The western part of the subbasin has much lower relief and longer slopes than the eastern part. Debris slide slopes are common in the steep streamside slopes next to the Big River and larger deep-seated landslides occur in the eastern upland sections. Inner gorges also occur along some of the eastern Big River tributaries;
- About 10% of the slides found across the Big River Basin and 10% of sediment delivered in the basin were in this subbasin. The Little North Fork PW had the highest number of slides while the Lower Big River PW had the highest volumes of sediment delivered;
- Redwood and Douglas fir forest has historically and continues to dominate this subbasin. Additional vegetation includes tan oak, madrone, alder, bishop pine, pygmy cypress, willow, and blueblossom. Pre-European forests consisted of mostly large old-growth trees. Today, trees averaging 12-24 inches dbh cover 46% of the subbasin and trees averaging greater than 24-inch dbh cover 48%;
- The estuary is bordered by mudflats, eelgrass beds, and salt marshes as well as permanent riparian vegetation consisting mainly of alders and willows. Studies of the estuary and air photos document encroachment of forest vegetation on marshes and a decrease in marsh vegetation along the estuary over the past 100 years;
- Air photo analysis of the Big River Estuary since 1936 shows that the channel has narrowed and the floodplain has grown at the expense of mudflat and subtidal areas as estuary banks have prograded. Blockage or reduction in tidal influence has occurred in the upper flats while a filling of sloughs and increase in mudflat height is found in the lower flats;
- CGS found that the topographic relationship between the terrace surface and the active channel at the Wonder Plot (RM 9) has not changed substantially in the past 80 years;
- CGS found that channel narrowing seen since 1900 in the lower Big River is likely the result of a river channel reclaiming itself after the multiple decades of channel clearing, splash dam flooding, and battering by logs in transport;
- Photo mapping of channel fluvial features of the Mouth of Big River PW between 1984 and 2000 found that the main channel of Big River gained negative channel features due to accumulation of sediment. The length of negative channel features grew significantly from 18.5% (1984) to 34.7% (2000) of the length of the lower mainstem channel in this PW.

How has land use affected these natural processes?

Findings and Conclusions:

- Over 40 years of splash dam logging across the basin before 1920 likely greatly accelerated erosion and widened the width of the channels across the basin, though significant bed lowering along the lowermost reaches of Big River associated with splash dams is unlikely;
- Early splash damming and barrier removal projects starting in the 1950s cleared many streams in this subbasin of timber-related woody debris. The lack of instream complexity seen today likely resulted from these past practices;

- Construction of near stream railroads and roads constricted stream channels and destabilized streambanks throughout this subbasin;
- Most of the existing roads in Big River State Park are in satisfactory condition, but will deteriorate within five to ten years without annual maintenance, introducing sediment into stream channels;
- Wetland habitat was reduced by historic sawmill complexes on the Big River flats;
- Historic timber harvest activities reduced riparian canopy; however, canopy is currently suitable along surveyed tributary reaches in this subbasin;
- As a result of timber harvest, the current landscape is comprised of smaller diameter forest stands than in pre-European times (50% of trees in watercourse buffer zones have dbh less than 24 inches). The small diameter of near stream trees across this subbasin limits the recruitment potential of large woody debris to streams and contributes to the lack of instream habitat complexity;
- A lack of LWD throughout the Big River Basin also allows sediment to move more quickly through the stream system and move downstream in greater quantities than pre-disturbance.

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

- Based on the information available for this subbasin, it appears that salmonid populations are currently being limited by reduced habitat complexity, high water temperatures in the mainstem Big River, and embedded spawning gravels.

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

Recommendations:

Flow and Water Quality Improvement Activities

- Protect instream flows in Little North Fork Big River, Railroad Gulch, and Laguna Creek for thermal refugia from the warmer mainstem Big River in the summer.

Erosion and Sediment Delivery Reduction Activities

- Continue efforts such as road improvements, and decommissioning throughout this subbasin to reduce sediment delivery to Big River and its tributaries. CDFG stream surveys indicated that nine out of eleven surveyed tributaries in this subbasin had road sediment inventory and control as a top tier tributary recommendation;
- Continue to support and encourage current and future road management programs undertaken by California State Parks;
- California State Parks should follow the recommendations of CGS (2004) in treating identified sediment sources on roads and road crossings within Big River State Park;
- All roads within Big River State Park and their associated watercourse crossings required for public safety, existing easements, future restoration effort success, and public access must be maintained to high standards (CGS 2004);
- Encourage the use of appropriate Best Management Practices for all land use and development activities to minimize erosion and sediment delivery to streams. For example, low impact yarding systems should be used in timber harvest operations on steep and unstable slopes to reduce soil compaction, surface disturbance, and resultant sediment yield;
- California Department of Parks and Recreation should consult with appropriate resource professionals to assist in transitioning industrial timberlands on the Big River State Park to self-sustaining forest (CGS 2004).

Riparian and Instream Habitat Improvement Activities

- Where feasible, add LWD to develop habitat diversity in the main channel and to increase shelter complexity for salmonids. CDFG stream surveys indicated that all nine surveyed tributaries and the mainstem Big River have increase escape cover as a top tier tributary recommendation;

- Leave large wood in estuarine channels, on the beach, and on stream banks for potential recruitment into the estuary;
- Ensure that this high quality habitat is protected from degradation. The highest stream reach conditions as evaluated by the stream reach EMDS and refugia analysis were found in the Big River Estuary, mainstem Big River, Little North Fork Big River, Railroad Gulch, East Branch Little North Fork Big River, Berry Gulch Tributary, and Rocky, Thompson, and Berry gulches;
- Create a channel under the main road to connect Manly Gulch to Little North Fork Big River to address winter access problems for adult fish at the non-existent channel at Camp Three.

Education, Research, and Monitoring Activities

- Conduct surveys of ten small tributaries entering the estuary through blocked culverts in the Big River State Park to determine if they provide salmonid habitat;
- Establish monitoring stations to track instream sediment along the estuary;
- Continue water temperature monitoring at current locations where high temperatures have been detected on the mainstem Big River;
- Assess water temperature and dissolved oxygen in the estuary as there is currently no data on these indicators;
- Establish long-term water chemistry monitoring stations in the lower mainstem Big River. If there are indications of problems, monitoring should be implemented in tributaries as necessary to determine the source of the problem;
- Encourage the involvement of SONAR in fish and habitat monitoring activities.

Subbasin Conclusions

The Coastal Subbasin contains the Big River Estuary, which is of major importance to fish and wildlife along the Mendocino coast. The estuary provides a large area of wetlands that are essential habitat to many species including salmonids. Salmon and steelhead habitat conditions in the estuary, the mainstem Big River, and the tributaries of the Coastal Subbasin are generally in the early stages of recovery from past disturbance and suitable for salmonid production. Reduced habitat complexity, high water temperatures in the mainstem Big River, and embedded spawning substrate are limiting factors to salmonid populations in some parts of the subbasin.

There are many opportunities for improvements in conditions, especially with the recent creation of the Big River State Park. Water temperature monitoring, road maintenance and decommissioning, and adding LWD to improve channel complexity are examples of appropriate improvement activities that can be initiated in the park. However, aquatic and channel conditions at the most downstream section of a river system are a response to watershed products transported from throughout the basin. Fine sediment and warm water are two watershed products most deleterious to the estuary's fisheries. As such, long term improvements in the estuary must be produced by careful watershed stewardship throughout the Big River Basin.