ENVIRONMENTAL SETTING

General Description of Watershed

The Eel River Basin contains 3,684 square miles. A sub-basin of this unit is the Van Duzen watershed which contains 430 square miles. Another sub-unit, the South Fork Eel River, drains 690 square miles.

This region is known for its high rainfall and high erosion rates. The average annual precipitation for the Eel River basin is approximately 59 inches (Brown & Ritter, 1971). The average annual precipitation for the Van Duzen River basin is 64 inches. The average annual precipitation in the vicinity of this project is approximately 40 inches (US Army Corps of Engineers, 1980).

The headwaters of the Eel River occur in Mendocino County on the slopes of Bald Mountain. From there the river flows south through Lake Pillsbury, thence west to the Van Arsdale Reservoir on the main stem, and continues for 100 miles to the Pacific Ocean.

The geology of the Eel River is well known and contains a complex system of Franciscan type rocks with related landslides which tend to cause the watershed to generate some of the highest suspended sediment loads of any river in the world. For example, from one of the main sub-basins following the 1964 flood, the suspended sediment production rate was 9,759 tons per square mile from 1966 to 1976.

Much has been written on the geology of the Eel River basin. For a detailed account the reader is referred to pages 29 through 46 in Middle Fork Eel River Watershed Erosion Investigation by the Department of Water Resources Northern District, dated October 1982, and the 348 page Ph.D. thesis by Harvey Kelsey on the Van Duzen River basin in June 1977. Kelsey states that the Eel River basin is a mountainous area uplifted in recent geologic time (post-Miocene) and underlain by a deformed, faulted, locally sheared, and, in part, metamorphosed accumulation of subducted continental margin deposits. The deposits consist of mixed units of melange and coherent sandstones.

The Lower Eel River Delta was heavily influenced by sea level. Between 10,000 to 7,500 years before present the ocean level rose at a rate greater than 10 meters/1,000 years. After the melting of the Wisconsin-aged continental ice sheets the rate slowed to 1.5 meters/1,000 years. The level has remained relatively static for the past 3,000 years. The Eel River Basin has subsided at a rate of 2.8 meters/1,000 years through the late quaternary. The average rate of uplift for the Cape Mendocino coast just to the south is 1.0 meter/1,000 years.

On April 25, 1992, it raised one meter during the 7.1 earthquake.

The high rate of uplift of the upper watershed combined with a crushing force from the west due to the subducted Gorda plate, has created a youthful highly erodible topography. The high rate of precipitation produces runoff flowing down steep narrow canyons generating large amounts of sediment much of which is deposited throughout the project area while enroute to the ocean.

It is known that the project area is part of a drowned river valley caused by the rise in ocean level to its approximate current level 3,000 to 5,000 years ago and subsidence of the Eel River basin. Tremendous loads of material have historically moved down off of the 3,700 square mile highly erodible watershed of the Eel River for the past 5,000 years filling in the entire Eel River Delta. The depth of gravel and silts is reported to be 200 feet at the project area.

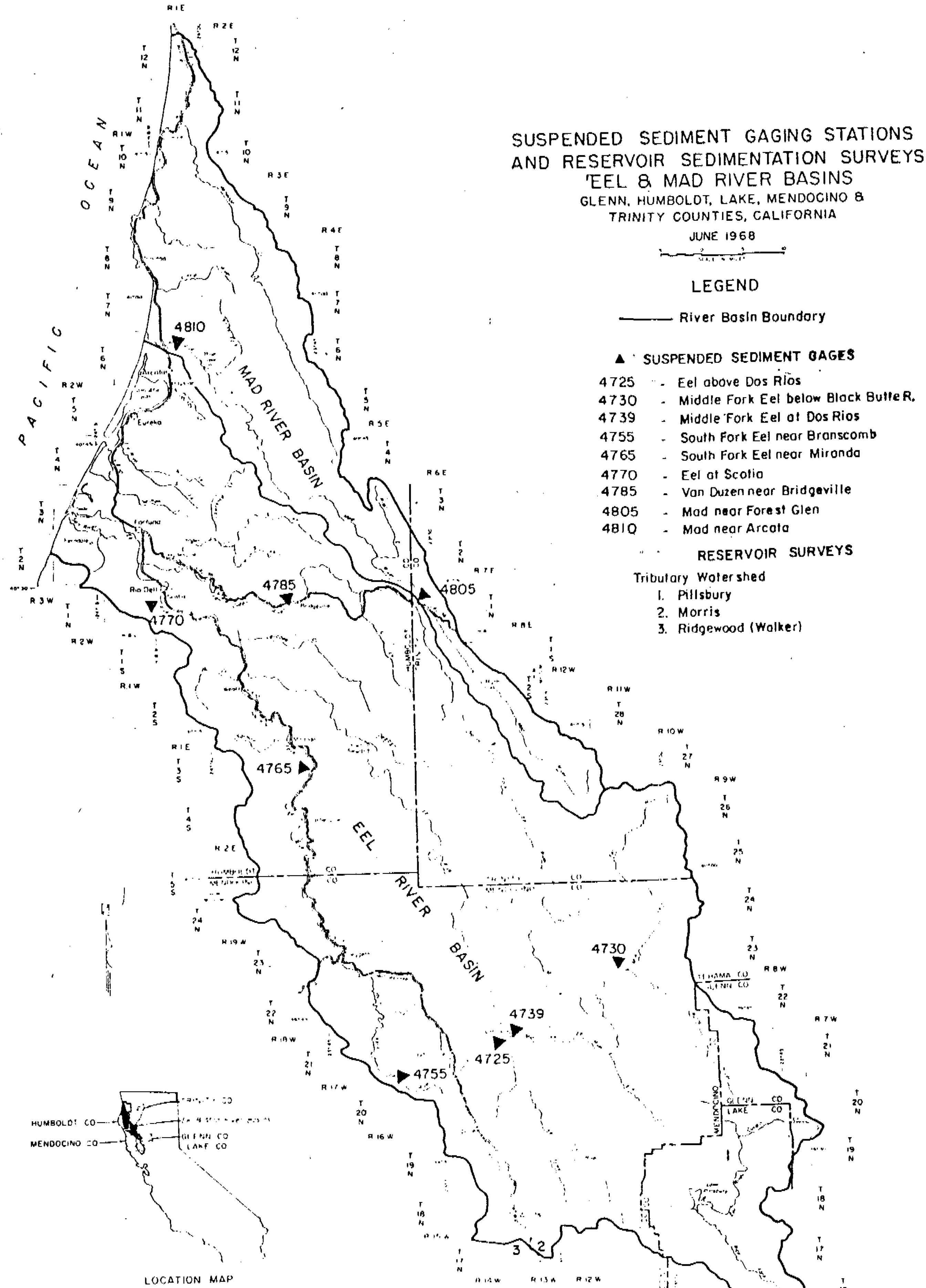
<u>Flows and Sediment Discharges</u>

Sediment is transported through a river system by various processes. Sand and gravel extraction operations are primarily replenished by bedload transport. Bedload transport is often estimated to be some percentage of suspended sediment discharge. Suspended sediment discharge calculations require periodic measurements of suspended sediment concentrations and continuous measurements of streamflow.

Flow information on the Eel River is available at Scotia since October 1910 as recorded at U.S. Geological Survey, Station 11477000. This station six miles upstream from the mouth of the Van Duzen River has a drainage area of 3,113 square miles (see Map No. 24). Sediment discharge has been measured at this station since October 1954. There was a station at Ft. Seward, No. 11475000, from 1956-1980 that recorded flows from 2,107 square miles of the watershed.

At Scotia the Dec. 23, 1964, flood of record measured 752,000 cfs with a recurrence interval of 290 years. This flow created the highest water mark at the staff gage at Fernbridge, which has been observed since 1938. The Corps of Engineers (COE) measured high water marks in the project area after the 1964 flood. At Site No. 1, 200 ft downstream of Fernbridge, the water surface was recorded as 33.00 feet. Sixty feet upstream of Fernbridge it was 34.15 feet. At Site No. 3 it was 38.50 ft. Near Site No. 7 at the intersection of highway 101 and Drake Hill, it was 56.09 ft.

At the peak flow the difference in water surface elevation between Drake Hill Road and Fernbridge was about 22 ft. over a distance of about 24250 ft. This is a slope of 0.000907



Map #24 This map shows the location of suspended sediment gages in the Eel and Mad River Basins. Source: Appendix #1, Sediment Yield and Land Treatment, June 1970, USDA-SCS, Portland.

ft/ft or 4.8 ft/mile or 0.09%, which is pretty flat. It does indicate the available driving force through the project area at the peak of the 1964 storm.

Flows on the Van Duzen River have been measured since 1940 at a station five miles west of Bridgeville. This U.S. Geological Survey Station is designated 1147500, and records the flow from a 222 square mile drainage area. The 1964 flow at this station was 48,000 cfs with a recurrence interval of 90 years. The January 16, 1974 flow was 34,600 cfs with a recurrence interval of 12 years.

The Corps of Engineers (COE) measured high water marks attained at the peak of the 1964 flood flow along the Van Duzen. Those in the Van Duzen project area were 65.40 ft, 75 ft. upstream of the 101 bridge and 76.81 ft near Jack Noble's Site No. 10.

To gain a feel for magnitudes of flows through the project area, the reader is referred to Table 8. The flows are those developed by FEMA in their Flood Insurance Study dated Aug. 5, 1986. The flow of interest for the Eel River is 390,000 cfs with a recurrence interval of once every ten years. This flow would be smaller than the Jan. 16, 1974 flood flow that most of the local gravel operators can remember. The 390,000 cfs at the mouth would provide a bank full flow, producing an adequate shear stress on the bed to move large amounts of sediments into and through the project area.

The COE determined the once in 10 year discharge at Fernbridge to be about 370,000 cfs. Their estimate was based on data gathered at Scotia prior to 1968 and transposed to Fernbridge.

Dames & Moore prepared a Hydraulic Study on the project area from the mouth of the Van Duzen to Fernbridge for Winzler & Kelly Consulting Engineers in February 24, 1991. This study is contained as Appendix "B" in a preliminary engineering design report by Winzler & Kelly dated March 8, 1991. The design report was for a proposed gas transmission pipeline to cross the Eel River near Drake Hill Boulevard, and the project was proposed by ARCO Gas Company. Several commentaries on the Draft EIR stated the Dames & Moore study should not be used in this EIR to determine bed load movement through the project area. Therefore, much of the study results have been removed in this Final EIR. Portions of this study remain useful for the purposes of this Program EIR.

To characterize the make-up of the materials in the bed of the Eel River through the project area Dames & Moore took six samples which were analyzed for particle size distribution. The particle sizes were divided into 12 class intervals to be compatible with the input requirements of the HEC-6 Model.

This is a model developed by the U.S. Army Corps of Engineers in 1977 and the U.S. Bureau of Reclamation in 1984. It is used for calculating the potential for bed changes.

Looking at Table 4 one can add the last four lines to get an indication of the percent of bed material that is gravel For the six samples the gravel fraction appears to be 54.4% at cross-section No. 1, 58.6% at No. 7, 54.4% at No. 12, 55.5% at No. 13, 78.7% at No. 15, and 72% at No. 16. The percentage of gravel in the streambed tends to decrease in a downstream direction. Map No. 25 shows the location of the cross-sections.

Table 5 shows typical stream flows and sediment discharges for the Eel River as measured at Scotia. Sediment discharge is closely related to the higher flows. Major floods will carry large volumes of sediment into the lower Eel project area and may result in channel aggradation through out much of the project area.

To get an estimate of bedload Dames & Moore used U.S. Geological Survey data as guide and assumed that bedload represented 18% of the total measured sediment discharge load. For example, note 1964 flow of 752,000 cfs on December 23, 1964. The U.S.G.S. measured the sediment discharge to be 57 million tons per day. At 18% the bedload would be 10,260,000 tons per day. Assuming a unit weight of bedload of 165 pounds per cubic foot, the bedload at Scotia would have been 4,606,527 cubic yards per day. This figure is very high and should not be misinterpreted. First the discharge was the highest momentary peak flow rate ever recorded at Scotia. Second, the 18 percent figure is quite high for a station like Scotia. Reputable researchers have estimated the average annual percent bedload at Scotia to be between 1 and 6 percent, not 18 percent.

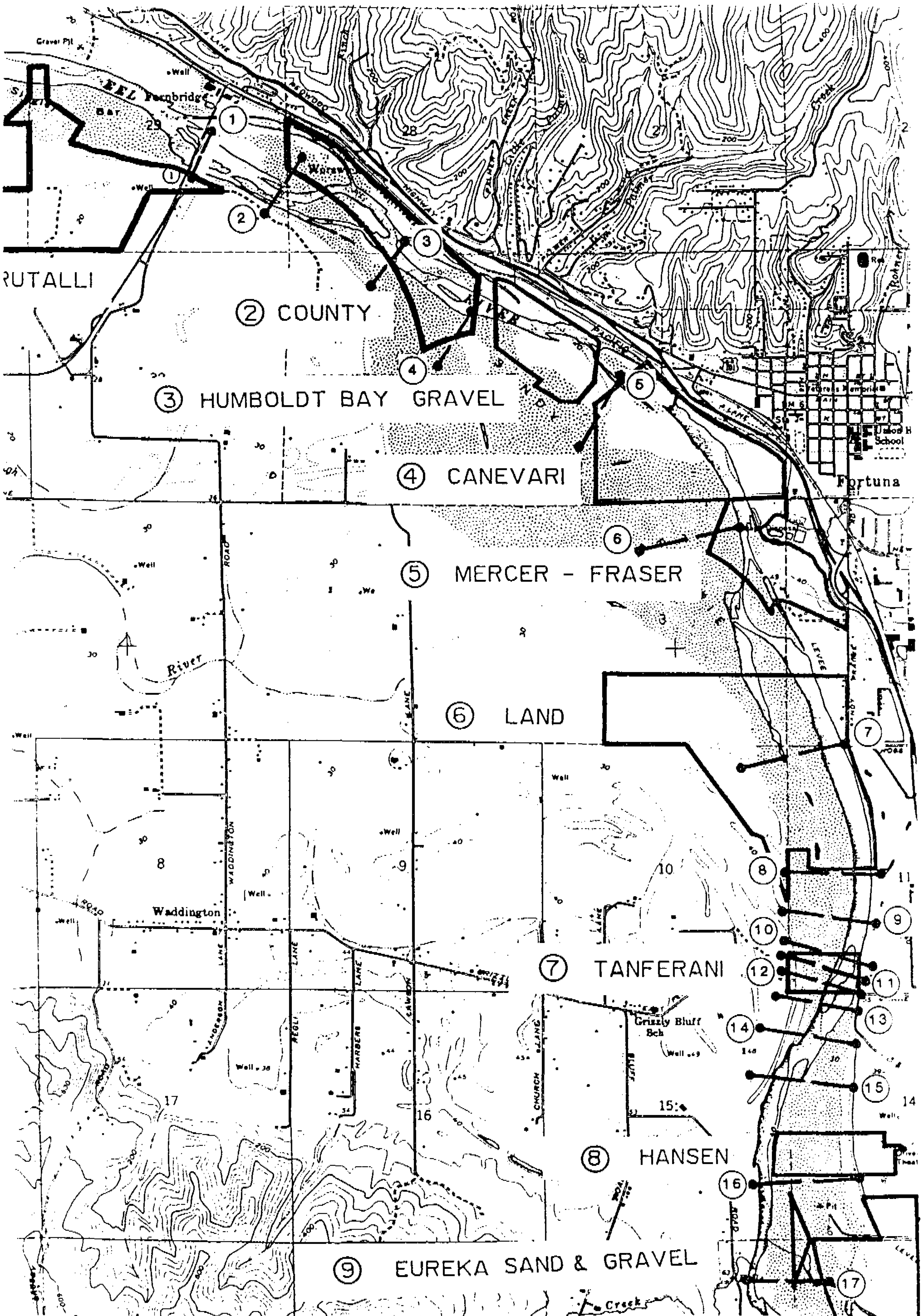
An estimate by the Department of Water Resources of average annual sediment discharge was made for the Middle Fork Eel River which drains 745 square miles. The result was 160,000 tons per year which equals about 107,000 cubic yards per year (page 123 in <u>Middle Fork Eel River Watershed Erosion and Investigation</u>, October 1982, DWR). Another estimate by Hawley & Jones (1969) showed 600,000 tons of bedload per year at Scotia. This was four percent of the suspended load measured at Scotia. Ritter (1972) assumed that most of this 600,000 tons was sand. Authors of the U.S. Army Engineer District report of August 1980 titled, <u>Eel River Basin Resource Analysis</u>, noted Anderson's (1971) conclusion that much of the downstream increase in suspended sediment in the Eel River drainage results from the abrasion of bedload.

TABLE 4
PARTICLE SIZE DISTRIBUTION OF RIVERBED MATERIAL
(FRACTIONS IN DIFFERENT SIZE RANGES)

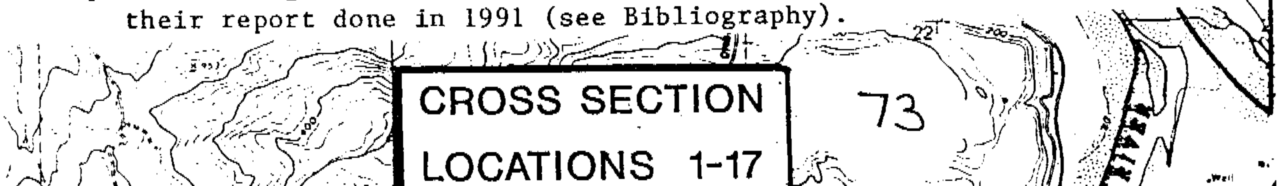
MATERIAL	SIZE RANGE (mm)	CROSS-SECTION[a]					
		1[b]	7[c]	12[d]	13[e]	15	16[f]
Medium Silt	0.016-0.031	0.001	0.001	0.010	0.001	0.010	0.0005
Coarse Silt	0.031-0.0625	0.001	0.001	0.010	0.001	0.010	0.0005
Very Fine Sand	0.0625-0.125	0.003	0.003	0.020	0.002	0.020	0.001
Fine Sand	0.125-0.25	0.031	0.004	0.015	0.017	0.027	0.002
Medium Sand	0.25-0.50	0.107	0.060	0.053	0.132	0.016	0.009
Coarse Sand	0.50-1.0	0.100	0.096	0.125	0.110	0.007	0.047
Very Coarse Sand	1.0-2.0	0.108	0.136	0.130	0.091	0.026	0.110
Very Fine Gravel	2.0-4.0	0.104	0.112	0.092	0.090	0.096	0.109
Fine Gravel	4.0-8.0	0.129	0.133	0.125	0.129	0.174	0.139
Medium Gravel	8.0-16.0	0.187	0.152	0.178	0.174	0.203	0.205
Coarse Gravel	16.0-32.0	0.188	0.142	0.171	0.198	0.106	0.300
Very Coarse Gravel	32.0-64.0	0.040	0.159	0.070	0.054	0.304	0.076

[a]See Figure 1.
[b]Used to represent bed material for cross-sections 1-5.
[c]Used to represent bed material for cross-sections 6-10.
[d]Used to represent bed material for cross-sections 11-12.
[e]Used to represent bed material for cross-sections 13-14.
[f]Used to represent bed material for cross-sections 16-17.

Source: Winzler & Kelly 1991



Map #25 showing locations of 17 cross-sections made by Winzler & Kelly for their report done in 1991 (see Bibliography).



In appendix No. 1 of, Sediment Yield and Land Treatment- Eel and Mad River Basins June 1970, an estimate for bedload was obtained with an assumption that one percent of the suspended load measured at the Scotia gauge was bedload. Utilizing this assumption results in an annual bedload at Scotia of 123,800 cubic yards. For other sub-basins of the Eel River this report assumed the bedload equaled 15% of the suspended load. Therefore, to determine the bedload passing Bridgeville on the Van Duzen River, 15% of the suspended load results in 110,600 cubic yards. Adding this to the 123,800 cubic yards at Scotia results in 234,400 cubic yards per year in the lower Eel.

Kelsey (1977) noted that during the 1964 storm major mass wasting occurrences of episodic nature put huge amounts of sediment into the tributaries and main stem channels of the Van Duzen River. This caused scour and aggradation of stream channels, undercutting of banks and slopes resulting in additional sliding and sediment input. This landsliding caused 3 to 15 feet of aggradation in major stream channels in the Van Duzen River. Bank erosion that occurred during the flood reactivated earth flows resulting in suspended sediment discharge above pre-flood levels for at least seven years. The channel aggradation initiated extensive floodplain bank erosion which persisted for at least a decade following the flood. He stated that the 1964 storm caused 49% more sediment to enter the Van Duzen River in the period from 1941 to 1975 than would have been the case without the storm.

The U.S. Department of Agriculture in 1970, estimated the sediment yield per year for the Eel River Basin equaled 12,361 acre feet. This is equal to 19,942,412 cubic yards per year. If one assumes that one percent of that was bedload, it would result in a annual average of 199,424 cubic yards of bedload per year. This, of course, does not happen each year and appears to be too low to use as an approximation of volumes of bedload that may move in the river during various storms.

The last significant flow in the Eel River occurred February 16, 1986. There have been five low flow years since that time and therefore very little replenishment has occurred.

Total sediment and bedload transport and deposition varies from year to year and estimates of future average annual bedload are not reliable predictors of replenishment or allowable gravel extraction rates. The wide discrepancy observed in the various estimates of bedload transport emphasizes the need to monitor sediment recruitment and gravel extraction as well as other river resource values in the Lower Eel in order to periodically calculate the actual amount of sand and gravel that can be safely extracted from the project area without damaging river resource values.

Regardless of the variability in sediment transport that occurs each year at Scotia, it is known that the sediment production per unit area of the Eel River watershed is among the highest in the world. If managed properly this resource can continue to be a major source of sand and gravel for the North Coast Region.

Table 5. Typical Streamflows and Suspended Sediment Discharges for the Eel River at Scotia (Winzler & Kelly, 1991).

Date	Discharge (cfs)	Suspended Sediment Discharge (tons/day)
11/01/88	87	0.23
05/18/89	1,480	16
01/18/89	6,560	443
03/23/89	18,400	15,003
02/11/60	57,740	502,000
02/08/60	271,470	5,380,000
12/23/64	725,000[a/]	57,000,000

a/ Instantaneous peak flow

Flood Frequency on Eel River

The Eel River experiences floods on the average of once every six years (Jones & Ekman 1980). The shortest period between floods was one year and the longest period was 23 years for the period 1900 through 1974.

Floods have occurred on the Eel River in the years 1852, 1861/62, 1879, 1888, 1890, 1904, 1906, 1907, 1911, 1914, 1915, 1927, 1937, 1940, 1943, 1953, 1955, 1960, 1963, 1964, 1972, 1974, and 1986. The 1986 flood peak at Scotia was less than half that measured for the 1964 flood. There has not been a significant flow in the Eel River since the 1986 flood. Five years of drought have resulted in very little bedload movement into the project area.

The Sandy Prairie Levee was completed in 1959 and was designed to protect the town of Fortuna from flood flows equal to that experienced in the 1955 flood.

A chronological list of maximum annual peak flows for the Eel River at Scotia is shown in Table 6. A Log-Pearson Type III flood frequency analysis was performed on the data of Table 6. The results are shown in Table 7.

An annual series of momentary flood peaks illustrates some differences between wet and dry years but it does not tell the total picture regarding potential for gravel replenishment. A bank full flow that lasts for days may be much more significant regarding gravel transport and recruitment compared to an over bank flow that quickly recedes to low water conditions. Regardless, an annual series flood frequency analysis does provide some indication for the recurrence intervals between flows of various magnitudes.

The results from flood frequency analyses vary depending on methodology, return period, and period of record. Statistically, as the return period increases, the results become less reliable. The values in Table 7 are based only on an objective analysis of the period of record (1911-1990) and the higher return periods would be considerably different if historical data were subjectively incorporated into the analysis. Refer to Table 8 for an alternate analysis of Eel River flood frequency.

Table 6 Annual series of peak momentary discharges for Eel River at Scotia. Drainage area equals 3,113 square miles. Flow slightly regulated at Lake Pillsbury.

Water Year	Date	Annual Peak Momentary Discharge (cfs)	Water Year	Date	Annual Peak Momentary Discharge (cfs)
1911	01/20/11	136,000	1951	01/02/51	249,000
1912	01/26/12	170,000	1952	12/27/51	262,000
1913	01/18/13	150,000	1953	01/09/53	215,000
1914	01/22/14	309,000	1954	01/17/54	245,000
1915	02/02/15	351,000	1955	12/31/54	52,400
1916	01/05/16	330,000	1956	12/22/55	341,000
1917	02/25/17	292,000	1957	02/25/57	153,000
1918	02/07/18	78,600	1958	02/25/58	202,000
1919	01/17/19	149,000	1959	01/12/59	145,000
1920	04/16/20	62,000	1960	02/08/60	343,000
1921	11/19/20	148,000	1961	02/11/61	113,000
1922	02/19/22	123,000	1962	02/14/62	107,000
1923	12/23/22	73,400	1963	02/01/63	252,000
1924	02/08/24	73,400	1964	01/21/64	178,000
1925	02/06/25	127,000	1965	12/23/64	752,000
1926	02/04/26	176,000	1966	01/05/66	311,000
1927	02/21/27	221,000	1967	12/05/66	154,000
1928	03/27/28	233,000	1968	01/15/68	148,000
1929	02/04/29	41,000	1969	01/13/69	223,000
1930	12/15/29	120,000	1970	01/24/70	310,000
1931	01/23/31	87,000	1971	12/04/70	234,000
1932	12/27/31	127,000	1972	01/23/72	133,000
1933	03/17/33	58,100	1973	01/16/73	152,000
1934	03/29/34	50,900	1974	01/16/74	387,000
1935	04/08/35	79,900	1975	03/18/75	231,000
1936	01/16/36	216,000	1976	02/26/76	109,000
1937	02/05/37	134,000	1977	03/10/87	5,790
1938	12/11/37	345,000	1978	01/17/78	169,000
1939	12/03/38	133,000	1979	01/11/79	96,100
1940	02/28/40	305,000	1980	01/14/90	226,000
1941	12/24/40	150,000	1981	01/28/81	98,700
1942	02/06/42	209,000	1982	12/20/81	300,000
1943	01/21/43	315,000	1983	01/27/83	296,000
1944	03/04/44	57,800	1984	12/09/83	112,000
1945	02/03/45	99,100	1985	11/12/84	133,000
1946	12/27/45	239,000	1986	02/17/86	364,000
1947	02/12/47	86,100	1987	03/13/87	94,500
1948	01/08/48	114,000	1988	12/10/87	118,000
1949	03/18/49	140,000	1989	11/23/88	137,000
1950	01/18/50	117,000	1990	01/08/90	102,000

Table 7. Log Pearson Type III Flood Frequency Analysis of Annual Maximum Floods at Scotia for the 1911-1990 period of record.

Return Period (years)	Momentary Annual Peak Flow (cfs)
2	176,000
5	265,000
10	305,000
25	339,000
50	356,000
100	368,000

Table 8. Summary of peak flows and return periods for Eel River at Scotia and at the Mouth of the Eel River (FEMA, 1986).

Return Period (years)	Peak Discharges (cfs) At Scotia	At Mouth
10	331,000	390,000
50	521,000	601,000
100	680,000	695,000
500	820,000	924,000

Table 9. Summary of peak flows and return periods for Van Duzen River above Yager Creek and at the Mouth of the Van Duzen River (FEMA, 1986).

Return Period (years)	Peak Discharges (cfs) Above Yager Creek	At Mouth
10	39,000	60,000
50	54,000	84,000
100	60,000	94,000
500	75,000	117,000

Fishery Habitat and Fish that Utilize the Project Area

The Eel River and its tributaries are ranked among the most significant anadromous fisheries in Northern California. The Eel River has a mean annual discharge of 5 million acre feet from a drainage area of 3,700 square miles.

Seven species of anadromous fish have been reported in the Eel River Basin (Table 10). Three of these, namely the chinook salmon (also known as king salmon), coho salmon (also known as silver salmon) and steelhead trout are the most important species with regard to the commercial and sport fisheries.

The Lower Eel River, including the project area is of little or no significance as spawning ground for these fishes. The area is important for them primarily as a migration route to upstream spawning grounds and as a return route to the ocean for surviving adult steelhead, juvenile trout and salmon. In addition, salmon utilize the downstream pools as holding areas until there is sufficient flow from fall rains to permit passage upstream.

It is likely that some downstream juvenile migrants use the estuary as a nursery area throughout much of the year since juvenile chinook salmon and steelhead have been found there during fall, winter and spring months. It is not clear in the literature, however, whether their presence indicates long-term nursery use or simply that they were on their way to the ocean.

Anderson (1972) stated that the Eel River ranked second in California in the production of both coho salmon and steelhead and third in production of chinook salmon.

As shown in Figure 1B, there is probably some migration occurring during every month of the year with peak spawning runs occurring in October and November for salmon, late January and early February for winter-run steelhead, and mid-May for summer steelhead. Smolt migration downstream peaks in April for steelhead and in May for salmon.

In 1980 the annual run of chinook salmon was estimated to be 103,000 fish. They enter the estuary in late August and September, lie in the pools below Fernbridge until the first fall storm raises the river sufficiently to permit them to move upstream through the project area. Peak migration of these adult chinook salmon occur in October and early November. They utilize the main stem Eel River, Van Duzen River, the north, south and middle forks, and large and small tributaries for spawning.

Young chinook salmon move downstream soon after they emerge from the gravel. Downstream migration at Dos Rios begins in late February or March and reaches a peak in April or May and is normally completed by late July.

Chinook salmon spawn at the head of riffles in gravel six inches in diameter or a little smaller. The female will not choose a substrate with more than 10% or the material over six inches, nor will she select a mud, silt or sandy bottom. Adequate water flow through the gravel and sufficient dissolved oxygen are necessary for survival. Mortality is high when excessive erosion results in fine materials being deposited over the stream bed resulting in a loss of permeability in the gravel substrate.

The coho salmon spawning run begins in September to mid-October and tapers off in December. Spawning is predominantly confined to the South Fork and lower tributaries of the Eel River main stem as far down as the Van Duzen River. These fish spawn at heads of riffles in water that is shallower with smaller gravel than that used by chinook salmon. The young emerge in February or March and have a year or more of stream residence before migrating to the ocean the following spring. The annual run of coho salmon in the Eel River has been estimated at 42,000, which makes the Eel River second in production in the state.

Steelhead enter the Eel River in varying numbers throughout the year. Lee and Baker (1975) reported that these fish entered the estuary in late summer and began to migrate upstream as early as August. This early run is composed mainly of half pounders which are steelhead that have spent two years in freshwater and only one single season in the ocean. Larger steelhead migrate from October onward. Another run of spring run steelhead starts in April and May. Steelhead spawn in many of the areas used by coho salmon, but can also ascend streams with steeper gradients and utilize smaller gravel.

Juvenile steelhead migrate downstream at all times of the year, but most the them migrate in the spring and early summer. The older fish normally migrate first and are followed by progressively younger and smaller fish.

According to a 1972/73 survey by Puckett (1975) the most popular stretch of the Lower Eel River for sport fishermen was between the mouth and the Van Duzen River, which is the project area of this Program EIR. He noted the fishing effort was greatest in that area from September through early November. The fishermen were seeking half-pound steelhead, fall run chinook salmon, winter run steelhead and coho salmon.

The abundance of salmon and steelhead in the Eel River system has been declining over the past 50 years. The primary causes for this decline are not certain. Many reports state that factors contributing to the decline are habitat loss caused by timber harvesting practices, and associated road building following World War II, as well as certain types of grazing practices, water diversion, and over-fishing.

A more recent threat to the salmonid production of the Eel River has been the illegal introduction of Sacramento squawfish into the basin in 1979 or 1980. Their preferred prey are uncommon in the Eel River system so they eat young salmon and steelhead. Squawfish have been observed all the way down in the Eel River system near Benbow Dam on the South Fork and at a couple of points up the Van Duzen River. A recent study by Larry Brown (1987) was inconclusive whether squawfish will negatively effect the production of anadromous salmonids in the Eel. However, squawfish predation is considered a major threat to young salmonid survival in other river systems.

In Figure 1B showing the time of migrations and spawning of Eel River salmon and steelhead, it can be seen that July and August are the two months of the year that migration is minimal. Historically gravel operators attempt to begin gravel extraction operations as early as possible after the river flows decrease and expose the bars. This has occurred as early as late April or early May in some years. In looking at the graph, it can be seen that the downstream migration of young salmon and winter steelhead are peaking in mid to late April and therefore could be passing through the project area during placement of flatcars for summer bridge crossings. Historically gravel extraction has continued through October into November. Again looking at Figure 1B, it can be seen that the peak migration of adult chinook salmon occurs in October and November.

The Eel River estuary downstream from Fernbridge is a spawning and nursery area for several anadromous species. It has been reported that the Eel River estuary is a nursery area for dungeness crab as well as various other marine invertebrates. The estuary has decreased in areal extent and volume substantially since 1880 due to the diking off of several thousand acres of the original salt marshes which lay within the tidal prism, and to massive amounts of sediment which have moved into the Lower Eel River system since the 1955 and 1964 floods.

<u>Birds and Mammals</u>

The project area lies at the easterly end of the 33,000 acre Eel River Delta. The riparian corridors along both sides of the river mentioned earlier provide habitat for most of the birds and mammals in the project area. They also provide protection of water quality, streambank stabilization through root penetration, matting and protection of some stream side structures, and items from flood damage.

Over 200 different species of birds have been observed utilizing the Eel River Delta. The delta is considered a vital link in the coastal flyway. The riparian corridor attracts many types of land birds including song birds, upland game birds, and raptors.

The riparian habitat along with the other woodlands in and adjacent to the delta is essential to raptors for roosting and nesting cover. Included among the raptors known to occur in the Eel River Delta are two endangered or threatened species; namely the bald eagle and peregrine falcon. Of interest, in 1975 there were only 60 pair of peregrine falcon in the wild in the U.S. By 1991 there were 700 pair (p. 54, January-February 1992 issue, Audubon Magazine). The riparian habitat is also extensively used by many species of songbirds.

Forty different species of mammals have been observed in the Eel River Delta. Those that could be expected to utilize portions of the riparian corridor along the project area include black tailed deer, beaver, mink, otter, gray fox, ring tailed cats, raccoons, skunks, weasels, coyote, bobcats, rabbits, squirrels, gophers and mice.

Biological Field Surveys were conducted on June 23 and June 27, 1992 by Ron LeValley, biologist assessing the presence of appropriate habitat for Western Pond Turtle (Clemmys marmorate) and Red-legged Frog (Rana aurora). Both species are typically found in ponds and slow moving water with well-developed emergent vegetation. The area surveyed was the lower Eel River between the mouth of the Van Duzen River and one mile downstream from Fernbridge. The survey was carried out by walking the length of the river, concentrating especially on small side channels and ponds, as well as the slower reaches of the river. A list of vertebrate species detected June 23 and 27, 1992, during the field surveys is contained in Table 11.

Small side-channels and embayments were common in the first mile below the mouth of the Van Duzen River. See Photo No. 10. Both adult and larval western toads (Bufo boreas), yellow-legged frogs (Rana boylii), and Pacific treefrogs (Hyla regilla) were detected in these channels with the Yellow-legged frog being the most evident. The quietest waters at the upper reaches of these embayments and channels where aquatic and emergent vegetation had devolved was the prime location for amphibians.

Table 11. Vertebrate Species Detected June 23 and 27, 1992

BIRDS

GREAT BLUE HERON
GREAT EGRET
CANADA GOOSE
HOODED MERGANSER
COMMON MERGANSER
TURKEY VULTURE
OSPREY
RED-TAILED HAWK
CALIFORNIA QUAIL
KILLDEER
SPOTTED SANDPIPER
CALIFORNIA GULL
CASPIAN TERN
MOURNING DOVE
Selasphorous HUMMINGBIRD
DOWNY WOODPECKER
NORTHERN FLICKER
"RED-SHAFTED" FLICKER
BLACK PHOEBE
TREE SWALLOW
N. ROUGH-WINGED SWALLOW
CLIFF SWALLOW
BARN SWALLOW
AMERICAN CROW
COMMON RAVEN
CHESTNUT-BACKED CHICKADEE
BUSHTIT
BEWICK'S WREN
SWAINSON'S THRUSH
AMERICAN ROBIN
WRENTIT
NORTHERN MOCKINGBIRD
CEDAR WAXWING
ORANGE-CROWNED WARBLER
YELLOW WARBLER
WILSON'S WARBLER
YELLOW-BREASTED CHAT
BLACK-HEADED GROSBEAK
SONG SPARROW
WHITE-CROWNED SPARROW
TRICOLORED BLACKBIRD
BREWER'S BLACKBIRD
BROWN-HEADED COWBIRD
"BULLOCK'S" ORIOLE
LESSER GOLDFINCH
AMERICAN GOLDFINCH

AMPHIBIANS

WESTERN TOAD
PACIFIC TREE FROG
RED-LEGGED FROG
FOOTHILL YELLOW-LEGGED FROG
BULLFROG

REPTILES

COMMON GARTER SNAKE

MAMMALS

BLACK-TAILED JACKRABBIT
RACCOON
BLACK-TAILED DEER
STRIPED SKUNK

Further downstream the river has less of a meandering quality and is deeper and more channelized. In this region the only amphibians found were larval western toads in the quiet, shallow waters along the edge of the river.

At and below Fernbridge the river is mostly channelized with two large backwater embayments on the east (north) bank. See Photo No. 1. Substantial aquatic and emergent vegetation is present in these embayments, but they were not visited.

Approximately 3/4 mile downstream from Fernbridge and in the gravel section just downstream from the active gravel mining operation, were a series of small ponds. See Photo No. 1. These were well away from the main stem of the river near the western levee. One of these ponds was characterized by well-developed aquatic and emergent vegetation and the presence of four species of amphibians. Bullfrogs (Rana catesbeiana), and red-legged frogs were conspicuous and an adult Pacific Treefrog was seen. A dead adult western toad and larval toads were also present. The only reptile detected in the two days of surveying was a common garter snake (Thamnophis sirtalis) near this pond.

Rare and Endangered Species

There are no rare, threatened, or endangered species of fish, mammals, insects, or natural communities in the project area. The bald eagle and peregrine falcon have been seen in the project area. Both species are on the Federal and State endangered species lists. These birds do not build nests in the project area.

In checking the 1975 set of maps of rare plants by the California Native Plant Society, it was noted that a small glandular dwarf flax (Hesperolinon adenophyllum) occurs near the mouth of the Van Duzen River. This plant was also found in the list of special plants of the Department of Fish & Game's Natural Diversity Data Base dated May 5, 1984 on page 16. It was normally found in Mendocino and Lake County on dry brushy hills and woods, chaparral and northern oak woodlands, sometimes on serpentine at elevation 1,500 to 4,500 feet.

The North Coast riparian forest has a high inventory priority as designated in the List of Communities of the Natural Diversity Data Base. It was noted that the North Coast riparian forest may possibly be threatened, but that more information was needed in order to give it a proper designation.

In checking with the Department of Fish & Game, the last update in their computer indicates there is one species of fish, one mammal and 11 birds that are designated as species of special concern.

The fish is locally known as Coastal Cutthroat Trout (Oncorhynchus clarki). Their presence in the Lower Eel River was noted in 1951 by Murphy and Dewitt, and they noted the fish was observed primarily in the Salt River which is a tributary of the Lower Eel River. They are considered uncommon in the Lower Eel River.

The mammal is the White Footed Vole (Arborimus albipes). This species would not occupy gravel bars and would more likely be found in the riparian corridor of the project area.

The 11 birds of concern are the osprey, cooper's hawk, sharpshin hawk, yellow breasted chat, yellow warbler, harrier, golden eagle merlin, common loon, prairie falcon, and short eared owl. All these species could be expected to use the riparian corridor along both sides of the project area.

In mid-January 1992, the U.S. Fish & Wildlife Service (USFWS) proposed listing the western snowy plover as a threatened species. The USFWS found that the critical habitat is undeterminable at this time. In a 1989 study 10 pairs of adult birds were found at Humboldt Bay. These birds are threatened by human disturbance, loss of nesting habitat (beach areas), and predation. J. Sterling is noted in Stan Harris' new book. Northwestern California Birds, as having observed a snowy plover utilizing the gravel bars below Fernbridge.

The snowy plover forages on invertebrates in the sand in the intertidal zone and above the high tide line. Nest sites are usually in open sandy areas.

The northwestern pond turtle is secretive, likes lagoon systems, ponds, intermittent stock ponds, and lower river areas. They can withstand salt water for short periods and are known to move around. They are omnivores. While gravel bars are not nesting habitat nor foraging habitat for these turtles, any intermittent ponds along the base of the river bank with overhanging trees might be. (Jennings, pers. comm.)

The U.S. Fish and Wildlife Service submitted a sheet on Jan. 24, 1992, that contained species listed as endangered and threatened, and those listed as candidate species. Two birds were listed as endangered, namely the bald eagle and peregrine falcon. They may occur in the project area but do not build nests there.

The northern spotted owl is listed as threatened. They do not use gravel bars nor nest in narrow riparian areas along freeways. The inventory of spotted owl sightings was checked by the Department of Fish and Game and came up with no sightings in the project area on the Eel River and Van Duzen River.

Under candidate species there is one fish, two amphibians, one reptile, and three mammals. The green sturgeon is recommended for category 2 status. Burns, et. al. (1972) noted there was once an important fishery for these in the Eel River. Young sturgeon ranging from 63-178 mm FL were captured during downstream migration in June, July, and August. Murphy and Dewitt (1955) saw them in the lower estuary. In 1976 Puckett trapped some downstream migrants. However, in 1977 Puckett did not see any.

Green sturgeon spawn in deep pools (30 feet) along the thalweg of a river and may live up to 60 years. They need clean fast water over a spawning substrate. This type of habitat does not occur in the project area and is rare, if present at all, in the Eel River today. Historically this habitat was common and green sturgeon were plentiful. The 1955-56 floods filled in many deep pools, removing most of the sturgeon spawning habitat.

Two amphibians are listed as candidate species. The Calif. red-legged frog is listed as category 1. In 1992 they were observed in one of a series of small ponds along the west bank of the river just downstream of Trutalli's gravel operation at Site No. 1. This pond has well-developed aquatic and emergent vegetation.

The second amphibian, the foothill yellow-legged frog, is listed as category 2. This is one of two subspecies of the red-legged frog. This frog was seen during a 1992 field inspection near Sites No. 8 and No. 9. It is usually found near riffles and is closely restricted to water. It would not be found far away from water on the gravel bars.

Three mammals are listed as candidate species. The white-footed vole has a category 2 designation and was discussed above. They would not be out on the gravel bars.

The second mammal listed is the Pacific western big-eared bat. It is designated under category 2. It would tend to use the project area at night or dusk. One would not expect to find them on the gravel bar during daylight. Their habitat are caves and mine tunnels.

The third mammal listed is the Pacific fisher. It has a category 2 destination. Their habitat consists of extensive mixed hardwood forest and cut over wilderness areas. None were observed by the biologist during the 1992 field inspection .

Air Quality

The air quality along the Eel River in the project area and on the Van Duzen River at Sites No. 10 and No. 11 is very good most of the year. Sometimes during the months of July/August strong upstream winds occur in the delta which blow silt and small sand grains upstream generating particulate matter in the air.

At each processing site sprayers are used to control dust that is generated during the crushing operation. The asphalt plants and concrete batch plants are all under the jurisdiction of the North Coast Unified Air Quality Management District.

Minor air pollution is generated by equipment during the gravel extraction process, and from exhaust fumes of the engines running the crusher and related conveyor belts.

Existing Noise Levels

During the winter season when gravel extraction has ceased, noise levels out on the bar near the waters edge are quite low (45 to 50 dBA). The sites which have gravel processing plants generate noise levels of approximately 90 dBA at 50 feet. At most of the sites, these processing plants have been used off and on for several years, namely Worswick, Humboldt Bay Gravel, Mercer-Fraser, Charlie Hansen, Eureka Sand & Gravel, and Tom Bess on the Van Duzen River. These gravel processing plants often run year-round from about 8:00 a.m. to 4:00 p.m.

Sites No. 3, No. 4 and No. 5 have asphalt batching plants which can generate approximately 80 dBA at 50 feet. These run only when there is a job calling for asphalt.

Changes in River Bed Elevation and Channel Morphology
The question has continued to come up as to what the morphology of the river was in the 1850's and 1860's to ascertain what the so-called natural condition of the river was at that time. The following statement is a description of the Eel River delta in 1851:

> From the face of the plateau, above and near the forks of the river (Van Duzen and Eel), the view was perhaps the most favorable we could have had. It embraced the mountains and the sea. Below us meandered through rich bottoms, the clear Eel river sinuous as its name, all the alluvial margin fringed with a growth of alder. The Eel river is at present quite a slender stream, averaging about 40 yards in width and fordable in places. Near its mouth it opens into a lagoon of considerable size, constituting something of a harbor. (The Daily Alta California, 26 Aug. 1851).

It is of interest to read testimony of old timers given December 16, 1937, at a public hearing held in Ferndale on a flood control project proposed by the Corps of Engineers.

Mr. M. L. Clausen testified that he had been there for 50 years (before 1937) and when he first came to the County, the Eel River was a narrow deep channel. During the 50 years he observed the river constantly filling with gravel. He noted the delta was originally covered with trees and following settlement all were removed because the settlers wanted to use the land.

Mr. G. A. Dungan stated he was a pioneer and believed the trouble could be traced from the time the brush was removed allowing the water to leave the banks or channel of the river.

Mr. Fred Sundberg stated there were trees a couple of thousand years old on the river banks and when the center of the river filled with silt and gravel, the river spread out, scoured the banks, and cleared off and scoured the edges that contained the trees.

Mr. J. A. Shaw stated he had been there for 77 years and he could remember when the river at Singley's in 1868 to 1870 was about 100 yards wide. He also stated in the summer time at Fernbridge the depth of the river was 20 to 30 feet. He further stated the river was narrow and there were trees and brush on both sides of the banks.

An affidavit submitted by M. L. Clausen stated he came to the County in 1887 at age 16. He stated the Eel River flowed almost in a straight line from Fernbridge to the mouth, was narrow and deep (25 to 30 feet), was a quarter mile wide between river banks, the channel was 600 feet wide, and that brush and willows grew along the banks forming a protection to them.

Frank Kelly, surveyor for Humboldt County, prepared a map in May 1938 which also is on file in the State Lands Commission file under LRA361. This map shows the original river banks as they occurred in 1857. The channel width west of Fernbridge in the old original channel was 1,500 feet. Upstream of Site No. 2 there was a 20 acre island and the channel banks were 1,500 feet wide on a bend at the south end of where the current bar is located. At Site No. 3 the banks were 1,800 feet wide, at Site No. 4 the banks ranged from 600 to 900 feet in width, at Site No. 5 the banks were 1,500 feet wide. Of interest at Site No. 6 the original banks were 2,000 feet wide. This area widened to 6,400 feet in 1938 and is the braided portion where massive amounts of gravel are stored. Sites No. 7, No. 8 and No. 9 had a channel bank-to-bank width ranging from 1,200 to 1,400 feet. Of interest, the width of the mouth of the Eel River on December 13, 1940 was 290 feet.

So it can be seen by 1938 major changes in the channel bed width had occurred. Looking at the measurements mentioned earlier in this report, it is noted that at Site No. 1 the width of the bed appears to have changed only about 100 feet. At Site No. 2 at Worswick the low flow channel in 1991 ranged from 250 to 450 feet in width. That is roughly 100 yards which is similar to what Mr. Shaw testified the width was in 1868 to 1870.

Comparing bank width at Site No. 3 today with that in 1857 it is seen today's width is about 300 feet wider. The largest change in bank width occurs between Sites No. 3 and No. 6. In 1857 it ranged from 1,500 to 2,000 feet. In 1991 it was 5,280 feet wide.

Based on the above testimony it would appear the that the channel in much of the project area was deeper than present in the 1860 through 1890 period. The situation at Fernbridge is interesting. When basic data was gathered for the design of the bridge at Fernbridge, the river bed as shown in the original cross-section had to be similar to that of today. No engineer would have designed the piers as they exist if the bed was much lower than it is today. So the question must be asked, did the river change dramatically from about 1890 to 1910? There were floods in 1852, 1861/62, 1879, 1888, 1890, 1904, 1906, and 1907. Did the river move 10 to 20 million cubic yards of sediment, filling in the channel some 20 feet? Historic accounts mentioned several acres of land were lost in the Pleasant Point area in 1906 and 1907.

To properly answer the question, accurate cross-sections must be located that were taken at that time and tied to a bench mark that can be identified today. New sections should be run at the same points today, and elevations of the bed compared.

Old cross sections and/or elevations were found on plans prepared by the Corps of Engineers in 1939 and 1942. A portion of these plans are shown in Maps 26 and 27. Map No. 26, dated January 6, 1937, shows the Arcata Readimix (Site No. 12) bar with elevations at 10 to 15 feet above MLLW. To convert these elevations to MSL data one has to subtract 3.66 feet. New cross sections were taken for the Arcata Readimix project. If they can be tied to the benchmark on the Fernbridge (east end) one could compare the bed in 1937 and 1992.

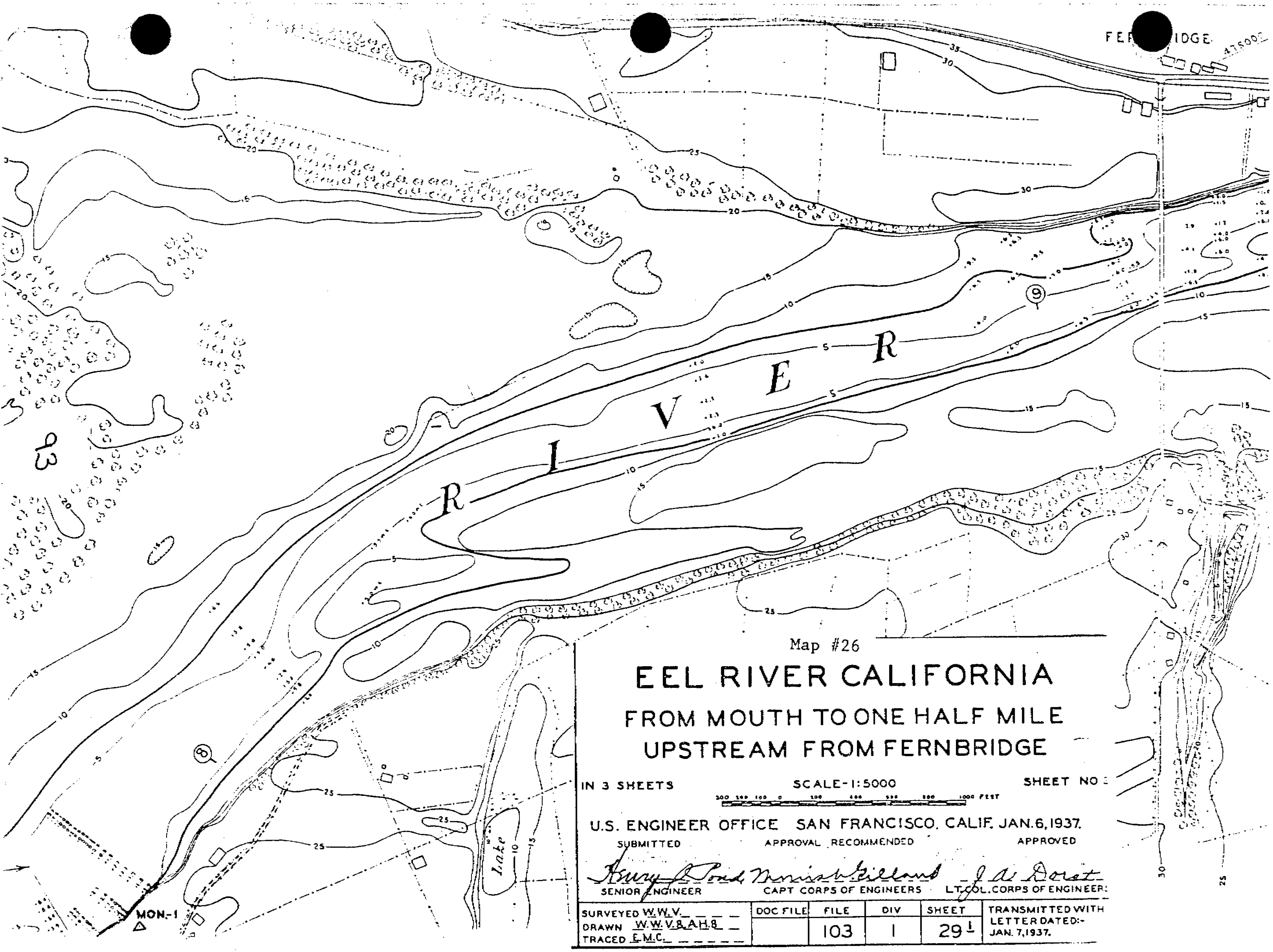
Map 27, dated June 20, 1942, gives contour elevations throughout the project area. These reflect the general elevations of the bed following the floods of December 1937. These could be compared to cross sections taken in 1992.

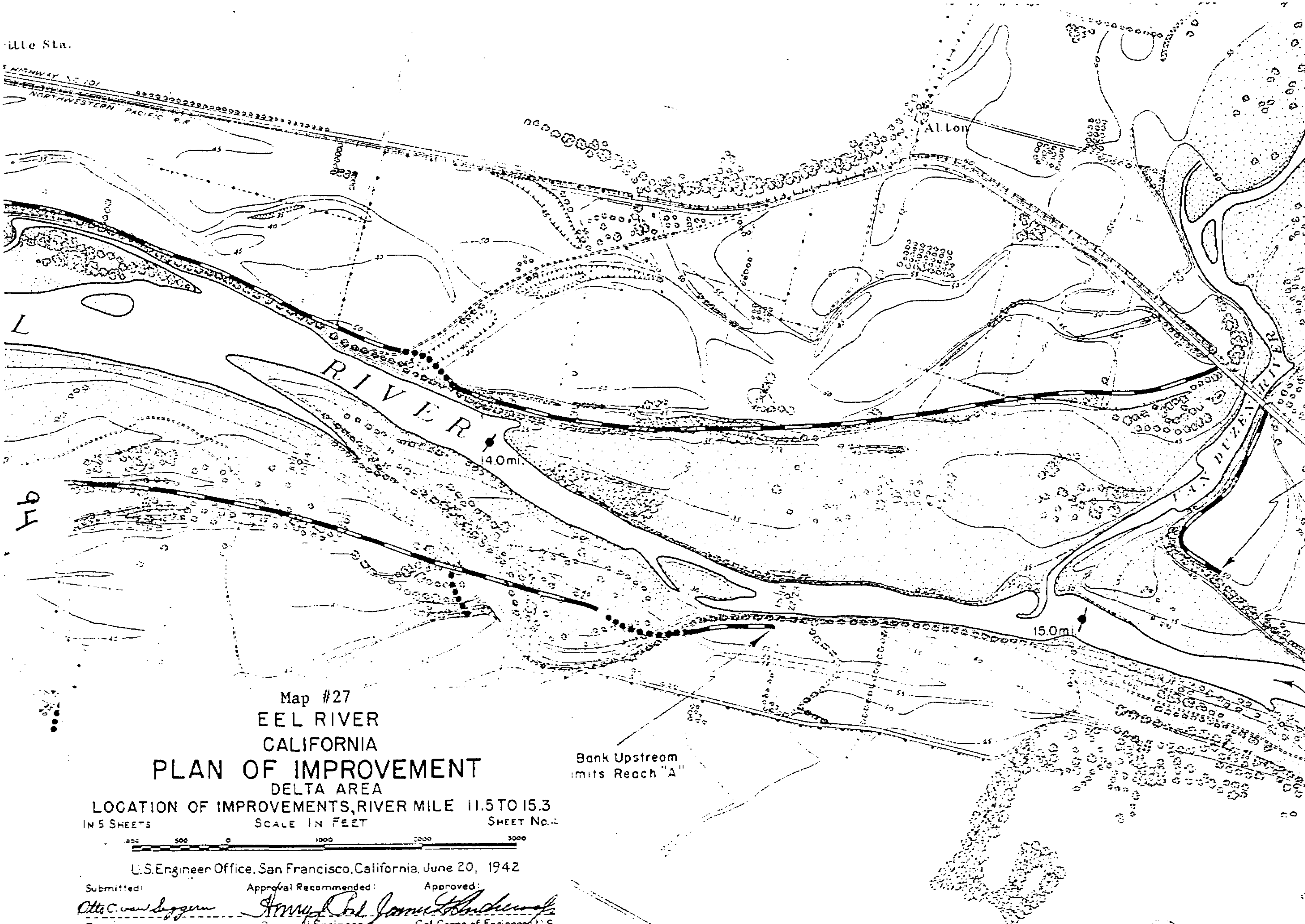
Looking at the channel gradient through the project area over time, it can be seen that from 1924 to 1935 between the Van Duzen River bridge and Fernbridge the gradient was 5.28 feet per mile. Following the 1964 flood, this gradient increased to 6.95 feet per mile. Twenty-six years later, in December of 1991, the gradient was measured at 4.44 feet per mile. These are fairly flat gradients of around one foot per thousand feet, but fairly representative of a drowned river valley.

The difference in the distance between riffles in December 1940 versus December 1991 is not great. For example distances between riffles throughout the project area in 1940 ranged from 5,000 feet to 7,500 feet. In 1991, the distances are around 7,400 feet.

In attempting to determine whether the bed of the river has changed within the last 100 years, cross sections and historic photographs at specific sites were analyzed. Cross-sections taken of the river bed at the Highway 101 bridge over the Van Duzen River, Highway 211 bridge at Fernbridge over the Eel River, and Cock Robin Island Bridge over the Eel River. Cross-sections were also analyzed at bridges on Highway 101 located at Rio Dell (bridge north of town), Stafford and at the mouth of the South Fork Eel River see Figures 2, 3, and 4.

Fernbridge:
At Fernbridge, cross-sectional data was available for the years of 1935, 1965 and 1991. Several photographs of Fernbridge, both under construction in 1911 and photos taken in 1912, 1915, and 1920 up through 1991 were analyzed. In


FERNBRIDGE
RIVER
Lake
MON-1
Map #26
EEL RIVER CALIFORNIA
FROM MOUTH TO ONE HALF MILE
UPSTREAM FROM FERNBRIDGE
IN 3 SHEETS
SCALE-1:5000
SHEET NO
U.S. ENGINEER OFFICE SAN FRANCISCO, CALIF. JAN. 6, 1937.
SUBMITTED
APPROVAL RECOMMENDED
APPROVED
SENIOR ENGINEER
CAPT CORPS OF ENGINEERS
LT. COL. CORPS OF ENGINEERS
SURVEYED W.W.V.
DRAWN W.W.V. & A.H.B.
TRACED E.M.C.
DOC FILE
FILE 103
DIV 1
SHEET 29 1
TRANSMITTED WITH LETTER DATED:- JAN. 7, 1937.



Map #27
EEL RIVER
CALIFORNIA
PLAN OF IMPROVEMENT
DELTA AREA
LOCATION OF IMPROVEMENTS, RIVER MILE 11.5 TO 15.3
IN 5 SHEETS SCALE IN FEET SHEET No. 4

U.S. Engineer Office, San Francisco, California, June 20, 1942

Submitted: Otto C. von Seggern, Engineer
Approval Recommended: Henry ... Principal Engineer
Approved: Col. James ..., Col. Corps of Engineers U.S.

Dr. ... H.E.P.
Tra. ... W.H.J.
Check ... O.v.S.

To accompany report dated: June 20, 1942

DOC. FILE	FILE	DIV	SHEET
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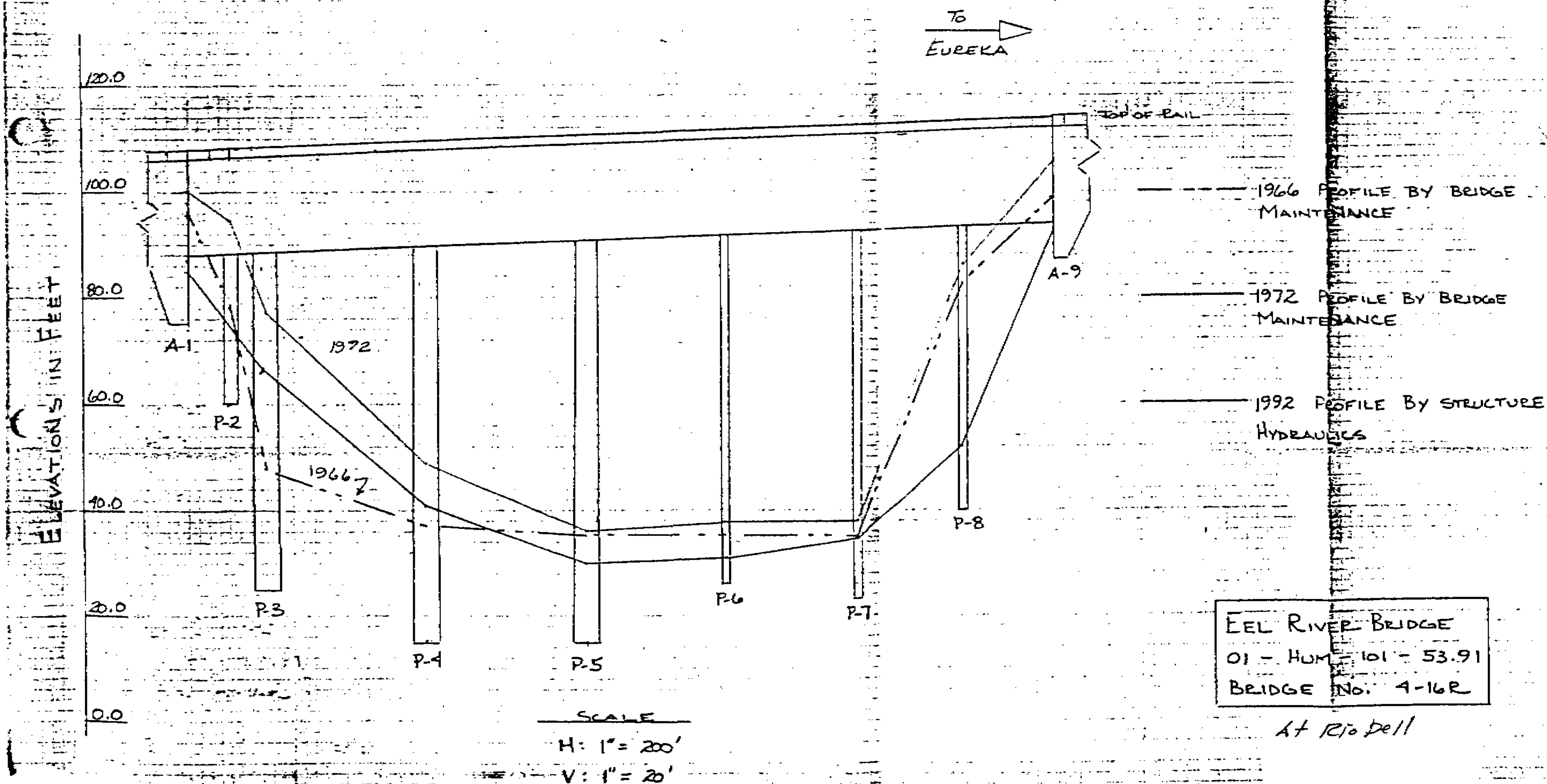
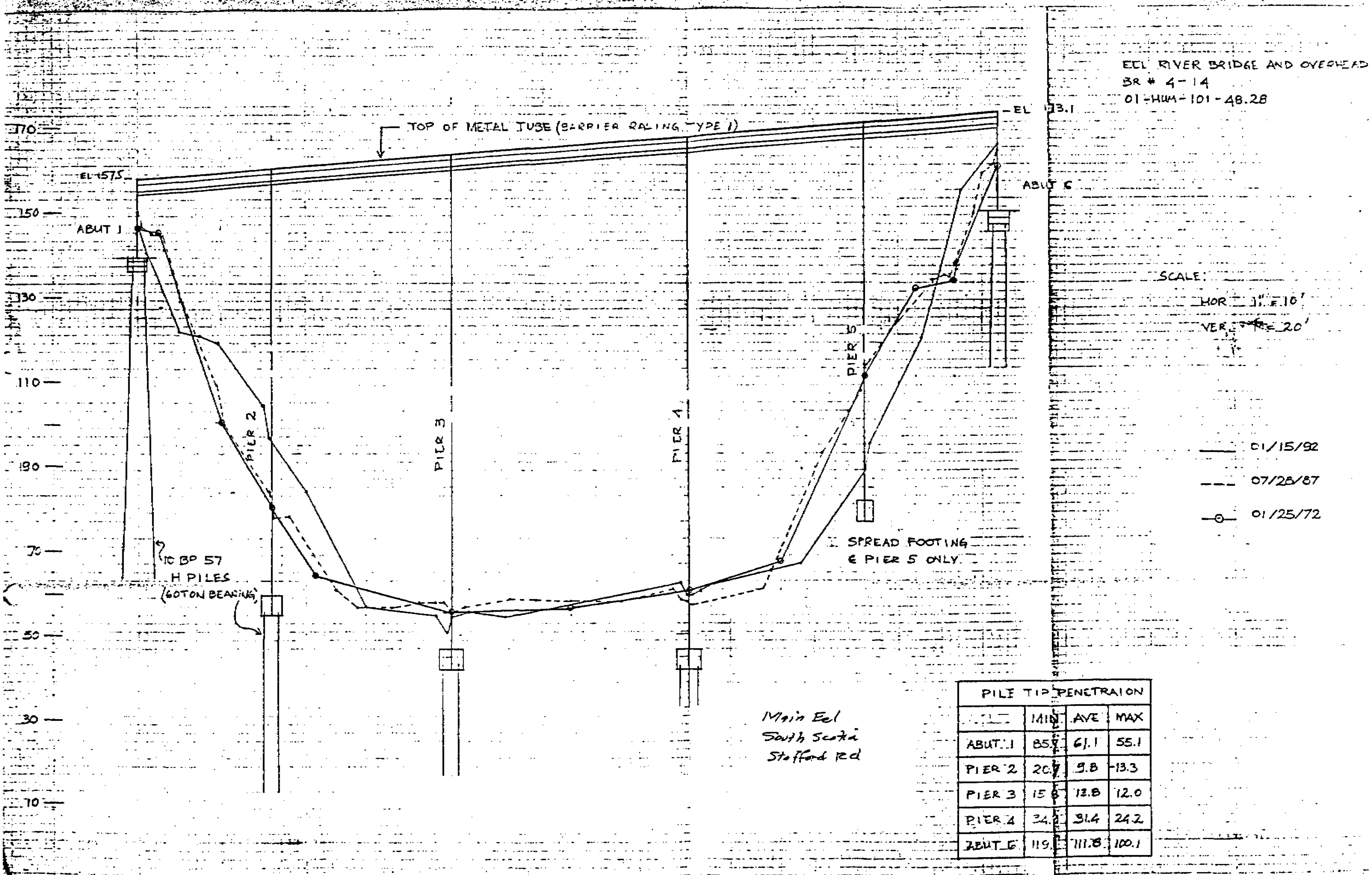


Figure 2 - Gross-sections of Eel River at Rio Dell under the bridge at the north end of town.



PILE TIP PENETRAION			
	MIN	AVE	MAX
ABUT 1	85.[illegible]	61.1	55.1
PIER 2	20.[illegible]	9.8	-13.3
PIER 3	15.[illegible]	13.8	12.0
PIER 4	34.[illegible]	31.4	24.2
ABUT 6	119.[illegible]	111.8	100.1

Figure 3 - Cross-sections of Eel River u[illegible] the bridge at the south end of Scotia.

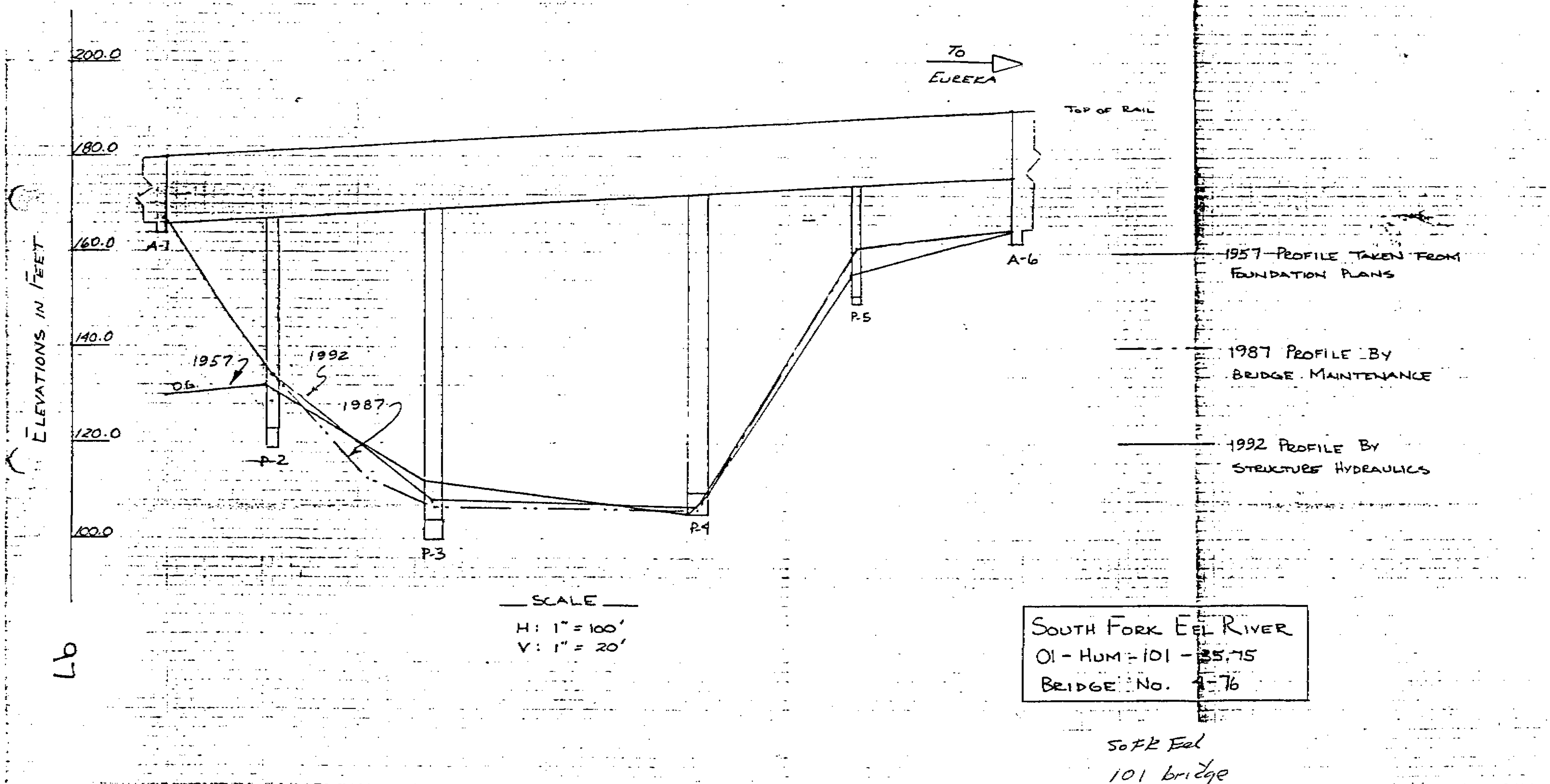


Figure 4 - Cross-sections of the South Fork Eel River under the bridge at mouth of South Fork under Highway 101.

most of the early photographs the south half of the river bed under the bridge appears several feet higher than the north half. In other words, the channel is always over on the north side. The amount of pier exposed above bed level in a 1927 to 1929 oblique aerial photo is similar to that shown in a July 18, 1948 oblique aerial photo.

Comparison of the cross-sections and photographs shows very little change in the river bed at Fernbridge between 1911 and 1991. See Figure 7. Based on the above analysis, it appears that there has been very little net change in the river bed elevation over the past 80 years at Fernbridge.

Highway 101 over the Van Duzen:
Cross-sections were taken of the Van Duzen River bed under the Highway 101 bridges in 1924, 1940, 1952, 1957, 1987, 1991, and 1992. See Figures 5 & 6. The profile taken in 1924 of the bed under the bridge (northbound lane today) showed gravel at the two piers at elevation 43.7 ft. (MSL) and gravel at an elevation of 41.0 ft. between the two piers. This profile is on the original plans which are on microfilm. The base of the south pier is at an elevation of 24 feet. The north pier has a concrete seal down to elevation 20 feet. By 1940, a channel had developed on the south side, south of the south pier, to a depth of 28.0 feet. The bed level at the piers remained at 44 ft. and 46 ft., respectively. By 1951 the old 1940 channel had filled in and the bed was nearly level at elevations of 44 to 47 feet.

In December of 1955 there occurred a large flood. This may be reflected in the 1957 cross-section where by the bed had dropped 8 to 10 ft. to elevation 37 ft. at both piers.

The next cross-section, taken in 1987, showed the bed had dropped another 8 feet to an elevation of 29 feet at the south pier. The bed at the north pier dropped about 4 feet below the 1957 elevation, to an elevation of 33 feet.

The latest section under the south bound bridge was taken in 1992. It shows the bed dropped to elevation 34 in a channel along the south side of the river next to the bank. Much of the bed was at elevations ranging from 36 feet to 38 feet. The top of the foundation for this bridge (constructed in 1951-52) is at an elevation of 35.0 feet. From the analysis of the cross-sections one would conclude the bed has dropped from elevations of 44.0 to 47.0 feet that existed in 1924 and 1951 down to elevations ranging from a low of 34.0 feet to 38 feet in 1992.

Historic photographs taken in 1887 and 1925 were analyzed and compared to photos taken in 1991. Comparison of photographs dated April 1925 and December 12, 1991 of the south bridge

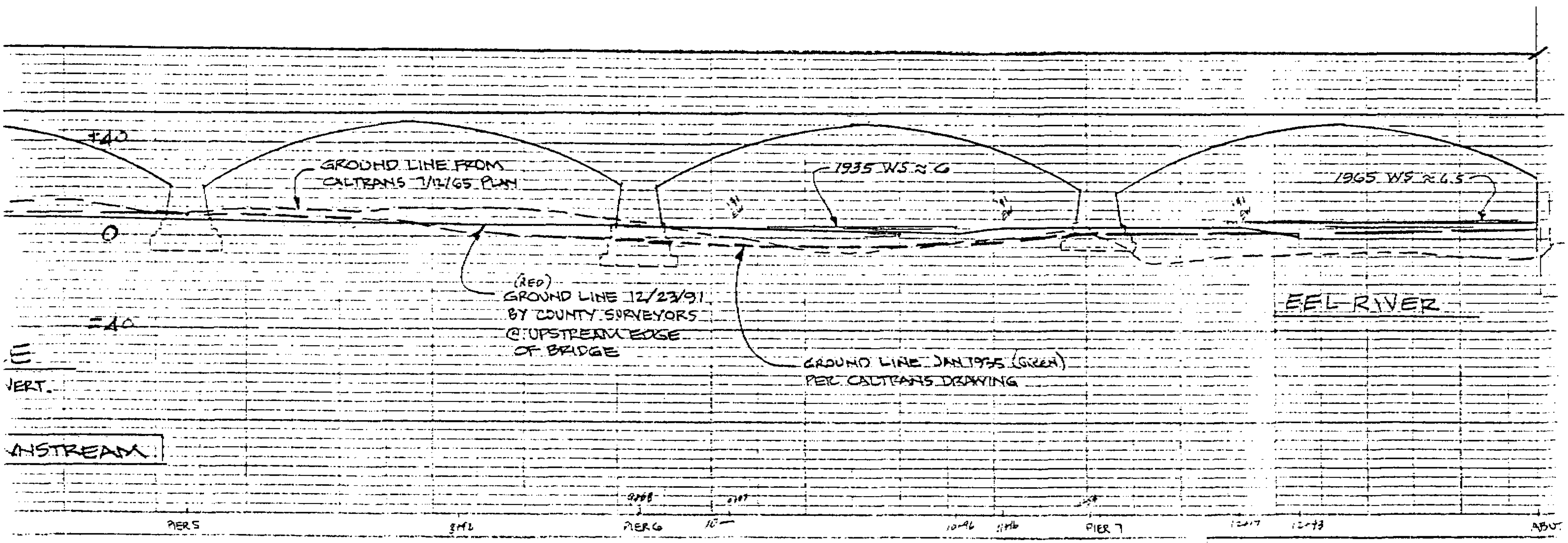


Figure 7 - Cross-sections at Fernbridge on Eel River.

pier of the Highway 101 bridge shows that the bed degraded 4.5 feet. This is perplexing. The cross-sections show a 10 foot to 11 foot drop. One photograph taken in 1887 of Pacific Lumber Company's railroad bridge over the Van Duzen River in this area, indicates the general elevation and width of the bed at that time. It appears similar to that observed in the 1925 photograph.

Based on the observations noted in the historic photographs and the data indicated in the cross-sections, the bed at the Van Duzen River bridge has dropped or degraded about 10 feet since 1940.

Highway 36 at Yager Creek:
Cal Trans, Division of Structures, has taken cross-sections of the bed of Yager Creek at the Highway 36 bridge. These cross-sections show very little change in bed elevation over time.

The State Highway 36 bridge over Yager Creek is over a mile north of the mouth of Yager Creek. Site No. 10 would involve gravel extraction both up and downstream of the mouth. Jack Noble has calculated that 730,000 cubic yards of gravel are stored on 75 acres above the mean high water at Site No. 10. He proposes to remove 40,000 cubic yards per year.

Cock Robin Island Bridge:
Cross-section elevations taken by the County at Cock Robin Island bridge in June 1972 were compared to those measured in May 1971. In that period the bed aggraded from 2 to 14 feet. However recent inspection shows the south pier and abutment area to be scoured to a significant level due to the formation of a localized hole.

Highway 101 at Rio Dell:
Cross-sections taken in 1966, 72, and 92 at the 101 bridge at Rio Dell (north of town) show a general lowering of the bed by about six feet since 1972.

Highway 101 at Stafford and South Fork:
Further upstream at Stafford the bed has changed very little according to sections taken in 1972, 87, and 92. The same can be said for the 101 bridge at the mouth of the South Fork Eel.

The construction of the Sandy Prairie Levee in 1959 and the Grizzly Bluff Levee following the 1964 flood, plus the cutting off of the old original river channel sometime in the 1860's at Fernbridge has changed the meandering ability of the river during high flow. Historically during floods much of the river overflowed into the Salt River channel. On the east side high flows reached the railroad grade adjacent to Fortuna.

Looking at the radius of old meander scars along the west bank on the 1940 aerial photos reveals radii of 1,445 feet opposite the Van Duzen River, 1,200 feet immediately downstream and 2,000 feet at the next meander. The old original channel that flowed west around Fernbridge had an outer radius of 2,000 feet. The next meander on the southwest side of the river downstream of Fernbridge has a 1,700 foot radius for the old scar and the channel as it existed in 1940. The next meander has a larger radius of 3,000 feet, followed by 2,300 feet for the meander at Cock Robin Island. The meander around the north side of the island has a radius of 1,700 feet. It can be seen that all of these meander radii are similar and tend to increase as one moves downstream and particularly into the area affected by tides.

These large meanders allowed the river to store many millions of tons gravel, sand and silt. These old meander scars can still be seen in 1991. Some people might look to these areas for potential sources of sand and gravel.

Essentially through the project area from the mouth of the Van Duzen River to Fernbridge, the high flow morphology of the river has been changed through flood control and erosion control efforts such as the construction of levees and bank rip rapping. Levees separate potential overflow areas from the main channel and concentrate the high-flow energy of floods to a narrower part of the river bed, thereby moving more bedload material through the project area. When the available sediment exceeds the channel carrying capacity sediment deposition (channel aggradation) occurs. The bed fills in and the low flow channel becomes unconfined, wide, and shallow. Channel braiding would likely occur at low flows and bank erosion will increase at higher flows. The braided section between Sites No. 3 and No. 7 contains the largest available area to store bedload during 50 to 100 year flows.

The low-flow river bed morphology appears visually similar to that which existed in 1940. Gravel has been removed from the project area for the past 30-years. The effect of that removal is not highly observable. The bed levels of the Van Duzen at Highway 101, of the Eel at Fernbridge carrying Highway 211, and of the Eel River at Cock Robin Island, show changes related mostly to flood events. The bed at Cock Robin Island bridge aggraded from 2 feet to 14 feet during the 1972 flood. Sediment moves in long linear waves. Measurements at one point such as a bridge may be misleading over time. One would see an aggrading bed at first as the front part of the wave reached the bridge, followed by degradation as the wave passed. This is why several cross-sections plus a profile of the thalweg are needed to monitor the bed.

Based on analysis of aerial photographs the general morphology of the river bed from the mouth of the Van Duzen River to a mile below Fernbridge has changed since 1956. The removal of about 500,000 to 700,000 cubic yards per year over the past five years has flattened the bed and caused the main low flow channel to split into two or three channels just below the mouth of the Van Duzen River. See Photo No. 10. Another area next to Sites No. 3 and No. 4 shows a broad low flow channel in Photo No. 3. Trenching may have partially caused this. Local fisherman noted some of the trenches dug last year filled with sand, rocks, and debris in the winter.

After 1987 the amount removed per year from the project area was probably around 700,000 cay. Much of the gravel stored on bars was removed and the low flow channel was degraded to the point that fisheries values would have been threatened if gravel skimming were to continue at some sites. Gravel was extracted from trenches at site specific locations during the last few years on the assumption that the trenches would not significantly degrade fisheries values and may, in fact, enhance the fishery habitat.