PRELIMINARY REPORT

ON

RUSSIAN RIVER FLOOD CONTROL

SUBMITTED TO

UNITED STATES ARMY ENGINEERS

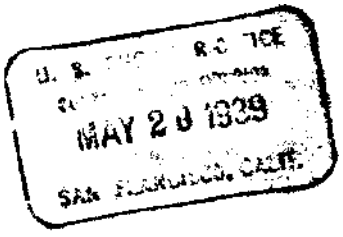
AT PRELIMINARY HEARING

SEPTEMBER 13, 1938

AT SANTA ROSA, CALIF.

PREPARED BY

GERALD McKINLAY, R.E. 5485 ENGINEER IN CHARGE



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LETTER OF TRANSMITTAL

September 13, 1938

Mr. V. M. Moir, Secretary
Russian River Flood Control Association
Santa Rosa, California

Dear Mr. Moir:

Submitted herewith is a preliminary report on the Russian River Flood Control problem covering studies and investigations which I have made, at your request, during the past two months.

Owing to the large amount of territory involved, the variety of existing conditions and the magnitude of the problem as a whole, only the high lights are here presented. A complete engineering report treating all the phases of flood control, conservation and soil erosion prevention would take many months to prepare and would cost many thousands of dollars.

It is hoped that what this report lacks will be more than offset by the enthusiasm and cooperative attitude of the communities, institutions and individuals who will receive vast benefits from a coordinated flood control program.

Very truly yours,
Gerard McKinlay
Engineer in Charge
Russian River Flood Control Association
R. E. 5485

LIST OF PLATES

INTRODUCTION

Initiative of Investigation and Financing of Same.

Russian River, through legislation enacted by Congressman Clarence F. Lea, was designated as one of the rivers upon which the War Department should conduct investigations in the Amendment approved August 28, 1937, to the Federal Flood Control Bill which was approved June 22, 1936.

As a result of severe flood damage throughout the whole basin, several individual groups initiated measures tending toward flood control. These included the Dry Creek area, the Healdsburg - Geyserville area, sections of the resort district between Mirabel and Jenner, individual ranch owners between Mirabel and Healdsburg, as well as groups in Mendocino County.

Farm organizations (in particular, the Farm Bureau of Mendocino County) as well as the Healdsburg Chamber of Commerce and officials of the California State Chamber of Commerce approached State authorities and the Boards of Supervisors and County Engineers in Mendocino and Sonoma Counties. As a result resolutions were forwarded to Federal and State agencies asking for assistance in developing flood control plans.

At the same time (and in order to coordinate this work) an organization was created called the Russian River Flood Control Association. This association consists of fifteen directors who are property owners in the basin and represent the principal interests involved. Ex-officio members of this association are committees of the two Boards of Supervisors and the County Engineers of each of the two counties involved - namely, Mendocino and Sonoma Counties, respectively. This

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California State Chamber of Commerce, and the official address is 309 B Street, Santa Rosa.

Funds were then raised amongst the interests effected and contacts were made with necessary Federal and State agencies. It developed that the Dry Creek area within the basin proceeded with certain repair work and the Counties of Mendocino and Sonoma, through their officials, secured emergency funds for similar repair work to publicly owned structures within the basin that were damaged by floods. It was soon learned that emergency appropriations by the State Legislature of California would not be available for research or projects of work other than replacement of structures already damaged. In other words, the full range long-time project would be the only apparent solution. In order to achieve this goal the writer was engaged, after being granted a leave of absence from the Sonoma County Engineer's office, and this work has been financed jointly by the Russian River Flood Control Association and the Counties of Sonoma and Mendocino. The results of these studies are herewith made available to the War Department, United States Department of Agriculture and any other federal and State agencies involved in the project.

Acknowledgements

Congressman Clarence F. Lea
Board of Supervisors of Sonoma County
Board of Supervisors of Mendocino County
Sonoma County Engineers and staff
Mendocino County Engineer and staff
Edward Hyatt, State Engineer and staff
North Coast District Office, California State Chamber of Commerce
Fred C. Cairns

Senator Herbert W. Slater
Assemblyman Hubert B. Scudder
Mendocino County Farm Bureau
Russian River Recreational Region.
Chambers of Commerce of Healdsburg, Cloverdale, Guerneville,
Ukiah and Monte Rio
Russian River Sportsmans Club
Russian River Flood Control Association
Harvey Frost, President
Everett Cox, Vice President
Donald Gray, Treasurer
V. M. Moir, Secretary
Gerald McKinlay, Engineer
Will Chaney, Assistant Engineer

Directors

L. E. Crawford	Percy Pascoe
Alex R. Thomas	Ralph Belden
Judge George Sturtevant	Dallas Wagers
J. C. Johnson	Lee Shelford
F. A. Bartlett	Pressley Abshire
Lee Torr, Jr.	L. D. Gilbert

Ex-Officio

Supervisors Joseph D. Cox and E. J. "Nin" Guidotti, Sonoma County
Supervisors Ed Haehl and Duane Bittenbender, Mendocino County
County Engineer Marshall M. Wallace, Sonoma County
County Engineer Ed Smith, Mendocino County
Farm Advisor H. A. Weinland, Sonoma County
Farm Advisor C. S. Myszka, Mendocino County

GENERAL DESCRIPTION OF THE RUSSIAN RIVER BASIN.

The Russian River, with a total drainage area of 1508 square miles, rises in Central Mendocino County, the three principal tributaries being the East Fork which flows through the Potter Valley, the Main Fork which originates West of Potter Valley, and Forsythe Creek with its sub-tributary Mill Creek which rises in the mountains to the West. These streams converge at a point about three miles North of the town of Ukiah, at which point the total width across the drainage basin is about twelve miles.

From Ukiah South to Hopland, a distance of about fourteen miles the margins of the watershed are approximately straight and parallel and about twelve miles apart. There are no streams of any appreciable size contributing to this stretch of the river but rather numerous short streams, only a few miles in length.

From Hopland to Cloverdale the river flows through a gorge of rather steep gradient, averaging about twelve feet to the mile. At Cloverdale, Sulphur Creek with 81 square miles of drainage area empties into the Russian River, the largest single contributing area up to this point.

From Cloverdale to Healdsburg the river flows in a general South-easterly direction through rich farming country for about seventeen miles where it enters another gorge about ten miles long making many windings and sharp turns. Maacama Creek with a drainage area of 83 square miles empties into this gorge.

About two miles below Healdsburg is the mouth of Dry Creek which has a drainage area of 214 square miles, the largest tributary in the Russian River basin. After flowing practically due South for six miles from the mouth of Dry Creek the river swings West and flows in a general Westerly direction to the Ocean.

The principal tributaries from the East and South are Mark West Creek, drainage area 84 square miles; Santa Rosa Creek, drainage area 53 square miles; the Lagunas, drainage area 100 square miles; Green Valley Creek, drainage area 42 square miles; while on the North the contributing streams are Mill, Potter and Austin Creeks with a total drainage area of 156 square miles.

On an East and West line drawn through the City of Santa Rosa, the basin is about thirty miles across. The extreme Southern limit is a low pass one mile South of the town of Cotati.

The physical characteristics of the various watersheds included within the Russian River Basin vary greatly. Those to the North, in Mendocino County are rugged, mountainous country, lying between elevations 1000 and 3000. Those to the South, especially the Lagunas area, are flat, level farming land at a general elevation of 100.

Dry Creek, with its long, narrow basin converging on a highly developed farming area, offers a distinct problem, due to the high intensities of precipitation occurring in its upper reaches, and the steep gradient of its channel. Many destructive floods occur in this area when the Russian River proper does not even reach the state of a medium flood.

The following tabulation gives the approximate area under cultivation in the Russian River Basin and its tributaries.

Area	Total Area Sq. Miles	Cultivated Area Sq. Miles
East Fork (Potter Valley)	105	20
Main Fork above East Fork	39	10
Forsythe Creek	58	3
Russian River Gorge, Forsythe to Sulphur Creek	324	35
Sulphur Creek	84	0
Russian River, Sulphur to Maacama Creek	96	33
Maacama Creek	83	4
Dry Creek	214	14
Russian River from Maacama to Mark West Creek	20	10
Mill, Potter and Austin Creeks	156	10
Mark West Creek	84	30
Santa Rosa Creek	63	16
The Lagunas	100	85
Green Valley Creek	42	30
Green Valley Creek to Mouth of River	40	5
Total	1508	305

Of these 305 square miles or 195,800 acres of cultivated area it is estimated that 34,900 acres, or 17.8% of the total, were inundated by the flood of December 1937. They were divided between the two counties as follows:

Sonoma County	27,800 acres
Mendocino County	7,100 acres
Total	34,900 acres

These areas are delineated on the accompanying maps, entitled "Russian River Watershed, Sonoma and Mendocino Counties, California, Map Showing Extent and Location of Flood Damage", Sheets 1, 2 and 3, the areas inundated being shown by shading.

The boundaries of these areas have been determined by various leans, the principal ones being,

1. Use of aerial photographs taken by U. S. Army Engineers at the time of the flood peak, Dec. 12, 1937.
2. Field surveys of high water marks.
3. Testimony of inhabitants.

Owing to the great extent of this area and the limited time and funds available for this study, it is impossible to submit full information as to the value and productivity of the inundated lands. Every conceivable type of farm, business, industry and recreational region is represented. The towns in which water actually covered the streets were Geyserville, Healdsburg, Sebastapol, Guerneville and Monte Rio. The recreational regions in the vicinity of Healdsburg and from Forestville to Monte Rio were among the greatest sufferers. The character of the farming land varies from pasture land at about *(sic)* per acre to the highest type of orchard or vineyard at $2000 per acre. If an average value of $1000 per acre is taken for the total

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History of Flood Damage.

The story of flood damage on the Russian River can best be presented through the testimony of "Old Timers." No governmental agency has maintained any means or method of measurement of the main stream or any of its tributaries.

It is a matter of vital concern to be able to distinguish between river flows which, at one time, might have been classified as "normal high water" and those which might reasonably be placed in the category of "flood flows".

Coincident with the progress of civilization, growth of industry, and extension of agriculture that accompanies increase in population, man and his improvements encroach upon new lands hitherto unoccupied. On areas of recent encroachment, attracted by the superior fertility of the farming lands, the farmers of Sonoma and Mendocino Counties are waging a contest with the waters of nature for the occupancy of thousands of acres of river bottom soil.

But always, at intervals, huge volumes of water are poured into the stream channel from climaxes of precipitation, both prolonged and severe, and these waters, too great to be confined between the low banks of the river bottom lands, renew the strife with man for occupancy by threatened inundation of these areas.

Using the only means of information available, that of testimony of old time inhabitants of the basin, it developed that damaging floods have occurred on the Russian River or its tributaries during the past sixty years as follows:

1877 - 1885 - 1889 - 1893 - 1903 - 1909 - 1911 - 1915 - 1925 -1937.

It is impossible to estimate what the floods were during these years, but it is believed that some were greater in magnitude than

that of December, 1937. On the authority of "Old Timers" the water has been higher in Guerneville than it was last year. On the other hand it is believed that the high water in Alexander Valley of last year was four feet higher than it has ever been before. Five or six miles South of Healdsburg the river was eight inches to a foot higher in 1893 than it was in 1937, and around the City of Healdsburg the high water levels of 1893 and 1937 are about the same.

The Dry Creek Basin, aggregating 214 square miles, presents a distinct problem. Floods have occurred here which were entirely independent of the flow in the Russian River, or in other words inundation was not the result of backwater conditions.

The "Estimate of Probable Flood Flows" submitted as a part of this report, indicates a once in ten-year flow of approximately 50,000 second feet. Without being able to justify the assumption by mathematical analysis it is the conviction of the writer that this amount of water discharging down the Russian River Channel, especially below Healdsburg, would constitute a "damaging" flood.

If the flood of December 1937 is taken as typical or representative of the once in ten year flood, as it might well be in view of the tendency towards encroachment on levels hitherto unoccupied, the average annual damage would be somewhere in the neighborhood of $100,000.

It is hoped that those to whom this report is submitted will realize that its incompleteness is due to an inadequacy of basic information which would have been obtainable only through the expenditure of funds and time not available for the purposes of this report.

Probable size and frequency of flood flows.

Data available

This district is particularly unfortunate in having no records of flood flows on the Russian River or any of its tributaries. Neither the U.S. Geological Survey nor the State Division of Water Resources maintains a gaging station at any point in the basin. The Geological Survey kept a partial record of runoff at Geyserville from February 1 to September 30 for the year 1911 and for the full years of 1912 and 1913, which were all years of subnormal precipitation so that their value in any study of flood flows is small. These records were, however, used as a basis for the flood frequency curve which has been reproduced in this report.

The principal data used in this study is the records of the U.S. Weather Bureau for precipitation at seven stations in or near the Russian River Basin. The data for these stations has been assembled and is presented elsewhere in this report.

Use has also been made of Bulletin 5, "Flow in California Streams", a publication of the Division of Water Resources of the State Department of Public Works. Table 128 of that publication, "Seasonal Runoff Data for the Russian River", "Curve of Probable Runoff" and "Probable Frequency of Flood Discharge" are reproduced herein.

In January 1958 the Division of Water Resources of the U. S. Geological Survey attempted to measure the peak flow of December 1937 at two points, one on the Russian River about three miles above Healdsburg and one on Dry Creek about ten miles above Healdsburg, using the slope measurement and Kutter formula method. Great difficulty was experienced in finding straight stretches of channel with even approximately uniform cross sections.

A communication has been recently received from the U.S.G.S. stating that the results of their computations indicate that the peak flow in the Russian River was about 74,000 second feet. The flow in Dry Creek was not stated but computations made by the writer indicate a flow of about 15,000 second feet, making a total of about 89,000 second feet for the river below Dry Creek.

Method of analysis

Due to the entire lack of direct stream flow measurements the method of estimating the probable size and frequency of flood flows must necessarily be an indirect one. The process of analysis will be as follows:

1. The Weather Bureau records for seven stations in the Russian River basin, extending in the aggregate over 62 years are tabulated, plotted and examined for relative frequency of "wet" and "dry" years.

2. A "weight", corresponding to that percentage of the total drainage area of the Russian River watershed of which that station is typical is assigned to that station.

3. An approximate factor expressing the relation between runoff and precipitation is selected for each of the rainfall stations for varying intensities of precipitation. The factors are based on

   a. Topography
   b. Vegetation
   c. Elevation
   d. Extent of lakes, swamps or ground storage.
   e. By comparison with adjacent areas not in the Russian River basin where the factor has been obtained by direct measurement.

4. The probable intensity of precipitation in 24 hours for annual, 1/5. 1/10 and 1/100 years occurrence will be taken from the curves entitled "Probable Frequency of Occurrence of Daily Rainfall" which have just been completed and supplied to the writer by the Division of Water Resources of the State Department of Public Works. These cover six of the stations used, the missing one being Willits for which the period of record was too short.

5. The runoff factors above selected will be applied to these rainfall intensities, and the probable runoff computed.

6. These runoffs will be summated for the entire area and a frequency curve constructed by combining these estimates with the curve of Bulletin 5 of the Division of Water Resources.

Drainage areas

The drainage area of the Russian River watershed is divided between the main river and its tributaries as follows:

East Fork of Russian River (Potter Valley)	105 sq. mi.
Main Pork of Russian River above Junction of E. Pork	39
Forsythe Creek and tributaries	58
Russian River, Forsythe Creek to Sulphur Creek	324
Sulphur Creek	84
Russian River, Sulphur Creek to Maacama Creek	96
Maacama Creek	83
Dry Creek	214
Russian River, Maacama Creek to Mark West Creek	20
Mill, Porter and Austin Creeks	156
Mark West Creek	84
Santa Rosa Creek	63
The Lagunas	100
Green Valley Creek	42
Russian River, Green Valley Creek to Mouth	40
Total	1508 sq. mi.

Area in Sonoma County 930 sq. mi. or 61.7%
Area in Mendocino County 578 " " " 38.3%

These areas are outlined on the accompanying maps entitled "Map showing Extent and Location of Flood Damage."

Description of Rainfall Stations

Station - Willits.
Elevation - 1,364 feet
Description - While this station is not actually located within the Russian River watershed it is but a few miles north of it, being separated from the headwaters of the Main Fork by a comparatively low ridge. The prevailing storms pass this station from the Northwest on their way to the Russian River basin.
Period of Record - 1878-1907. 29 years.
Area of which station is typical - 201 square miles.
Mean annual Precipitation - 55.91 inches.

Station - Ukiah.
Elevation - 650 feet.
Description - Located at the upper end of the narrow portion of the Russian River watershed which extends Southeasterly to Preston.
Period of Record - 1877-1938. 60.5 years.
Area of which Station is typical - 325 square miles.
Mean Annual Precipitation - 35.37 inches.

Station - Cloverdale
Elevation - 315 feet.
Description - Located at the junction of the Russian River and Sulphur Creek where the drainage basin begins to widen out.
Period of Record - 1883-1895 and 1902-1938. 38.5 years non continuous. Area of which station is typical - 180 square miles.
Mean annual precipitation - 37.1 inches.

Station - Healdsburg.
Elevation - 110 feet.
Description - Located approximately in the center of the lower section of the Russian River drainage basin.
Period of record - 1877-1938. 60.5 years.
Area of which station is typical - 317 square miles including Dry Creek
Mean annual precipitation - 39.71 inches.

Station - Santa Rosa.
Elevation - 167 feet.
Description - Located on the Eastern edge of the flat, swampy Laguna section.
Period of record - 1888-1938. 49.5 years
Area of which station is typical - 247 square miles.
Mean annual precipitation - 29.29 inches.

Station - Graton (Peachland)
Elevation - 190 feet.
Description - Located in the hills in the watershed of Green Valley Creek between the valley and the coast. Period of record - 1896-1938. 42.5 years.
Area of which station is typical - 82 square miles.
Mean annual precipitation - 37.90 inches.

Station - Fort Ross.
Elevation - 100 feet.
Description - Located on the coast eight miles North of the mouth of the Russian River at Jenner. While not actually in the basin, the precipitation is typical for that inside the basin to the East.
Period of record - 1875-1938. (one year missing) 61.5 years.
Area of which station is typical - 156 square miles.
Mean annual precipitation - 47.84 inches.

ANNUAL PRECIPITATION AT RUSSIAN RIVER BASIN STATIONS

	Willits	Ukiah	Cloverdale	Healdsburg	Santa Rosa	Graton	Ft. Ross	Average
1875-1876	-----	-----	-----	-----	-----	-----	58.28	58.28
1876-1677	-----	-----	-----	-----	-----	-----	31.42	31.42
1877-1878	-----	54.88	-----	67.27	-----	-----	92.86	71.67
1878-1879	87.34	36.23	-----	42.60	-----	-----	52.84	54.75
1879-1880	64.00	42.86	-----	45.11	-----	-----	67.27	54.31
1880-1881	54.31	29.49	-----	45.44	-----	-----	65.74	48.74
1881-1682	43.60	26.70	-----	31.35	-----	-----	44.20	36.46
1882-1883	37.20	23.93	-----	38.02	-----	-----	45.48	36.16
1883-1884	35.42	24.41	-----	31.14	-----	-----	48.54	34.88
1884-1885	31.35	19.88	-----	16.35	-----	-----	36.53	26.03
1885-1886	64.81	45.69	-----	54.05	-----	-----	56.00	55.14
1886-1887	38.54	22.33	-----	29.57	-----	-----	26.69	29.28
1887-1888	39.37	25.42	-----	34.86	-----	-----	28.50	32.04
1888-1889	39.53	30.82	-----	37.15	23.78	-----	29.46	32.15
1889-1890	83.21	60.48	-----	72.37	56.06	-----	59.27	66.28
1890-1891	37.17	24.50	-----	31.50	20.71	-----	29.75	28.73
1891-1892	51.75	29.49	-----	39.36	30.36	-----	57.55	41.70
1892-1893	63.63	43.53	-----	53.63	30.51	-----	60.45	50.35
1893-1894	68.25	47.93	43.87	36.85	27.12	-----	62.11	47.69
1894-1895	70.10	52.55	66.24	59.91	45.80	-----	75.68	61.71
1895-1896	64.41	40.85	-----	49.57	26.42	-----	57.51	47.75
1896-1897	48.57	43.34	-----	39.27	29.92	40.49	63.98	44.26
1897-1898	43.48	19.83	-----	23.31	22.64	24.89	39.07	28.87
1898-1899	45.73	27.60	-----	37.18	24.15	33.32	51.86	36.64
1899-1900	56.73	33.69	-----	42.33	29.37	40.83	53.54	42.75
1900-1901	60.61	37.09	-----	39.79	30.51	41.12	47.00	42.69
1901-1902	65.43	45.07	-----	52.22	33.93	47.68	63.63	51.33
190E-1903	55.50	34.55	38.20	39.17	29.21	42.61	59.37	42.66
1903-1904	86.60	54.73	53.78	63.20	44.11	63.65	79.17	63.60
1904-1905	57.38	42.93	50.60	52.98	35.99	48.07	69.14	51.04
1905-1903	65.74	44.75	46.28	52.12	33.18	49.47	62.43	50. 57

ANNUAL PRECIPITATION AT RUSSIAN RIVER BASIN STATIONS

	(sic)	(sic)	Clover-dale	Healds-burg	Santa Rosa	Graton	Ft. Ross	Average	
1906-1907	61.48	48.64	50.56	54.50	34.44	46.65	67.55	51.97	
1907-1908	-----	29.67	29.04	28.83	20.93	29.95	39.07	29.58	
1908-1909	-----	57.39	64.86	61.07	38.75	58.40	73.81	59.05	
1909-1910	-----	29.89	34.81	30.27	29.00	36.77	50.62	35.23	
1910-1911	-----	32.99	38.96	32.86	29.54	36.73	45.91	36.16	
1911-1912	-----	25.73	24.85	24.73	18.44	24.48	36.53	25.79	
1912-1913	-----	33.40	29.33	30.27	24.01	32.29	45.53	32.47	
1913-1914	-----	54.85	64.25	60.28	42.83	61.63	72.60	59.41	
1914-1915	-----	49.28	56.73	56.94	42.56	55.09	74.40	55.83	
1915-1916	-----	34.80	38.26	44.55	31.58	43.85	58.10	41.86	
1916-1917	-----	30.23	27.37	27.39	22.44	31.96	43.16	30.42	
1917-1918	-----	23.43	17.17	23.22	18.18	26.10		21.62	
1918-1919	-----	37.23	33.88	33.58	27.21	/////	46.66	35.86	
1919-1920	-----	19.05	19.04	19.25	13.25	23.63	28.48	20.48	
1920-1921	-----	47.94	48.23	55.40	35.70	51.22	66.26	50.79	
1921-1922	-----	28.74	28.08	29.21	23.99	28.79	29.94	28.12	
1922-1923	-----	30.35	29.31	30.55	27.91	36.79	32.57	31.25	
1923-1924	-----	16.19	15.75	16.86	15.91	19.93	19.10	17.22	
1924-1925	-----	47.44	44.67	49.31	41.17	54.42	49.00	47.67	
1925-1926	-----	26.33	35.13	35.84	32.45	35.10	26.29	31.86	
1926-1927	-----	47.32	49.67	51.26	42.72	53.64	48.33	48.82	
1927-1928	-----	34.94	31.34	36.21	28.93	36.22	34.32	33.66	
1928-1929	-----	24.44	24.11	24.33	19.23	27.03	25.05	24.03	
1929-1930	-----	31.08	27.91	38.82	26.50	36.06	31.41	31.88	
1930-1931	-----	20.06	25.81	24.16	16.72	23.58	22.67	22.17	
1931-1932	-----	27.67	27.83	30.36	24.19	29.15	28.69	27.98	
1932-1933	-----	24.71	25.72	26.46	20.73	25.71	23.29	24.44	
1933-1934	-----	25.21	33.89	31.32	21.04	28.83	27.66	27.99	
1934-1935	-----	33.05	40.32	45.44	34.99	43.24	37.87	39.15	
1935-1936	-----	37.83	40.37	37.52	30.36	43.60	39.34	38.17	
1936-1937	-----	29.24	32.31	34.05	26.33	38.19	35.17	38.55	
1937-1938	-----	23.02	24.15	20.57	13.98	23.23	19.30	20.78	To Jan 1
Average of all stations for 62.5 years (Index of Seasonal Wetness 100)								40.24	

ESTIMATE OF PROBABLE FLOOD FLOWS.

Station	Willits	Ukiah	Cloverdale	Healdsb'g	Santa Rosa	Graton	Ft. Ross
Mean annual precipitation. in.	55.91	35.37	37.01	39.71	29.29	37.90	47.84
Area of which Sta. is typical	201	325	180	317	247	82	156
Annual Precipitation intensity	3.60	2.40	2.80	3.15	2.20	3.00	3.50
Runoff factor	.15	.08	.10	.12	.08	.10	.13
Runoff intensity	.54	.19	.28	.38	.18	.30	.45
Mean daily flood flow	2900	1650	1350	3240	1190	660	1890
Peak flood flow	4350	2475	2025	4860	1785	990	2835
1/5 Yr.Precipitation intensity	5,70	3.80	4.40	4.80	3.40	4.60	5.40
Runoff factor	.25	.14	.17	.20	.12	.18	.23
Runoff intensity	1.42	.53	.75	.96	.41	.83	.80
Mean daily flood flow	7670	4620	3630	8180	2720	1830	3360
Peak flood flow	11505	6930	5445	12270	4080	2745	5040
1/10 Yr.Precipitation intensity	6.60	4.40	5.10	5.50	3.90	5.30	6.30
Runoff factor	.30	.17	.21	.23	.14	.22	.28
Runoff intensity	1.98	.75	1.07	1.26	.55	1.17	1.76
Mean daily flood flow	10700	6530	5180	10740	3650	2580	7380
Peak flood flow	16050	9795	7770	16110	5475	3870	11070
1/100 Yr.Precipitation intensity	9.75	6.50	7.60	8.00	5.80	7.80	9.50
Runoff factor	.50	.28	.35	.37	.25	.37	.47
Runoff intensity	4.88	1.82	2.66	2.96	1.45	2.88	4.46
Mean daily flood flow	26380	15860	12870	25230	9630	6350	18710
Peak flood flow	39579	23790	19305	37845	14445	9525	28065

	Annual	1/5 Yr.	1/10 Yr.	1/100 Yr.
Total mean daily flood flow at tidewater	12880	32010	46760	115030
Total peak flood flow at tidewater	19320	48015	70140	172545

Rainfall intensities from State Division of Water Resources curves "Probable Frequency of Occurrence of Daily Rainfall"

Economic Justification for the Expenditure Involved.

It can easily be established that the Russian River constitutes one of the most important factors in the agricultural, industrial and recreational life of the people of Mendocino and Sonoma Counties. To some extent the production of food and the supply of water for domestic use are dependent upon the flow in this stream. But most of all the recreational regions obtain their pleasures and benefits through the waters of this stream.

To discern the reliable amount which might be capitalized in terms of dollars and cents and which could be put to use in "controlling" the river so that the effects of its flow might at all times be beneficial would entail an expenditure of funds and research not available at the present time.

Incidental benefits will develop as thorough study progresses. Such a study is the proper function of the War Department in conjunction with the Department of Agriculture.

Character and location of improvements desired. Even a superficial investigation of the Russian River watershed produces the conclusion that "control" of the river such as would be effected by the construction of a storage dam or dams on the main river of such capacity that peak flood flows could be retained and let down the river gradually after the maximum runoff had subsided is pot physically possible or economically feasible. The only possible Bites for large storage dams are in such locations that the value of the lands which would be submerged would be many times greater than the capitalized value of the protection afforded to the lands below.

Some storage can be obtained on some of the tributaries which might reduce the peak flows on those tributaries although the effect on the peak flows in the main river would be small. There are possible small reservoir sites on Dry Creek, Mark West Creek, Maacama Creek and Austin Creek. The time and funds available have not made it possible to make any investigation of these sites other than a cursory one.

The principal methods proposed for the treatment of the flood problem on the Russian River are as follows:

a. Bank protection at various places along the river to reduce scouring at bends during maximum flood flows, and to eliminate the erosive action as flood waters recede from inundated lands.

b. Channel improvement in order to increase carrying capac ity. This would consist of the removal of trees, brush, islands or other obstructions, with the proper straightening and widening where engineering investigation would indicate the same to be economically feasible.

c. Levee construction, where it can be determined that such construction would not materially raise the flood plane.

d. Zoning of lands adjacent to the river and its tributaries to prevent the construction of and to provide for the evacuation of homes, summer resorts or establishments of any other nature where it is apparent that such lands will be continually subject to floods of even moderate intensity, and that no method of flood control will eliminate the hazard.

e. Retirement of certain agricultural or other lands in order to provide bypass channels which would relieve the burden of carrying capacity of the main channels to such an extent that the net result would be an economic saving.

As has been stated before, it is impossible to submit a complete list of these projects, or to submit even an approximate estimate of the cost of those which suggest themselves by their obviousness. However the following are suggested as those which would accomplish the most benefit. Detailed investigation will undoubtedly reveal many more of a similar nature.

Project No. 1. At the bend in the Russian River immediately above the State Highway and Railroad bridges at Healdsburg. Bank protection is needed to prevent scouring during the flood stages. The action here has been progressive, extending over many years and has reached the stage where it is imperative that something be done.

Project No. 2. Levee construction at the mouth of Mark West Creek near Trenton. During flood stages the runoff of Mark West Creek at this point, which includes the runoff of the Lagunas and Santa Rosa Creek, reaches its maximum before the peak flood stage of the river reaches this point. After the flow of Mark West Creek has been partially discharged into the River, the direction of flow reverses and backwater of the river forces the water back

onto the lands which have been drained. It is proposed to build a levee approximately three quarters of a mile long with control gates which would allow the flow of Mark West Creek to be discharged before the peak flow of the river arrived. The gates would then be closed to prevent backwater from going up the Mark West Creek channel. This levee would also serve a very useful incidental purpose as a highway which would be passable at all times.

Project No. 3. Dry Creek. It is possible by channel enlargement, clearing of obstructions, straightening, widening and the construction of levees to confine the entire flow of Dry Creek to its original channel. This area has suffered continually for many years from floods due to the fact that the main channel is filling up with gravel willows have been allowed to grow and many other obstructions exist. Material removed from the channel would be suitable for levee construction provided the right type of design is selected.

Project No. 4. Improvement of channel conditions of the Russian River gorge east of Healdsburg. Any increase in carrying capacity which could be effected here by removal of obstructions, straightening and widening would result in a material relief to the Alexander Valley area.

Project No. 5. Bank protection and channel improvement from Sulphur Creek to Asti. This is an area which is subject to periodic inundation which is not particularly harmful if the processes of erosion could be controlled.

Project No. 6. Zoning of lands in the recreational region, especially between Forestville and Monte Rio. Many summer homes and resorts have "been and are being built too low to be safe from floods which must be normally expected to occur in spite of any relief measures that can be taken.

Project No. 7. Bank protection and channel improvement in the vicinity of Hopland.

Project No. 8. Bank protection and channel improvement from the junction of the Main and East Forks of the Russian River to Morrison Creek.

Detailed plans, and estimates of cost of these widely separated projects would require many months of investigation and study.

ESTIMATE BY STATE ENGINEER OF AMOUNT OF DAMAGE IN SONOMA COUNTY DUE TO FLOOD OF DECEMBER, 1937

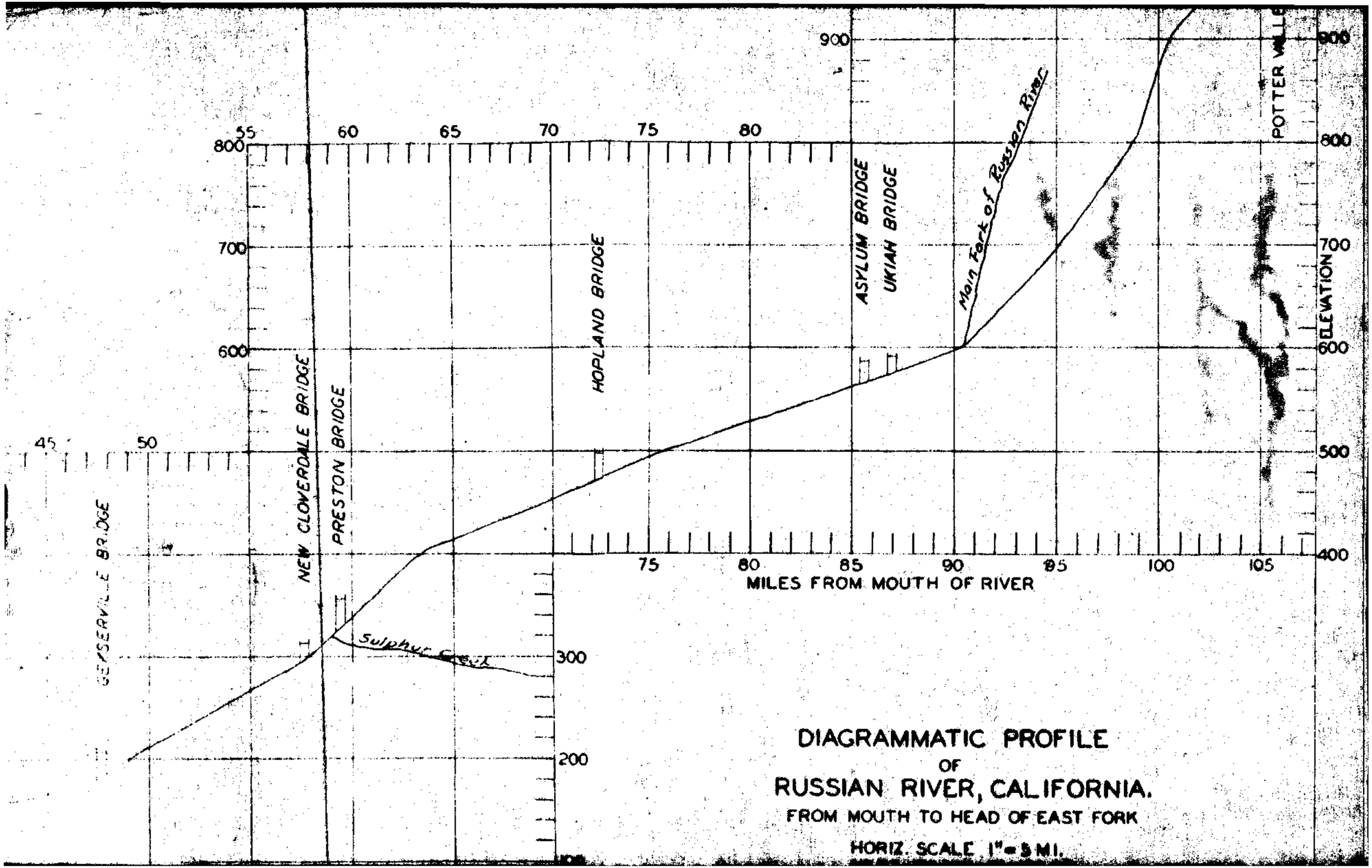
Sonoma County		
Railway Systems		
Northwestern Pacific Railway Co.		
Bridges and culverts	117	
Roadbed and right of way	2,031	
Petaluma & Santa Rosa Railway - unsegregated	1,500	3,648
State Highways		
Unsegregated	5,000	5,000
County Roads		
Bridges and Culverts	22,100	
Roadbed	23,750	45,850
Other roads and streets		
City of Healdsburg - bridge	200	
Farm roads	3,600	
- bridges	1,200	5,000
Telephone and Telegraph Systems		
No damages reported	0	0
Gas and Electric Systems		
Pacific Gas and Electric Co.		
Power and Telephone lines substations	4,400	4,400
Irrigation and domestic water supplies		
City of Healdsburg	300	
Farm canals and ditches filled up	3,600	3,900
Urban improvements, hones and businesses		
City of Healdsburg and vicinity		
Houses	49,500	
Household effects	45,000	94,500
Industries in rural areas		
Theater	35,000	35,000
Summer camps, homes, and resort equipment		
Cottages and tent platforms	57,000	
- furnishings	68,000	
- grounds	14,000	
Dance Halls	48,400	
Boats	23,400	
Boat Houses	21,200	
Landing stages, platforms and rafts	12,000	
Summer dam material	24,000	268,000
Farm Buildings, fences, and equipment		
Ranch houses and household effects	120,000	
Outhouses - barns - hop kilns and yards	61,200	
Tools, machinery and equipment	7,000	
Fences - 53,000 rods	159,000	347,200

Sonoma County. Cont'd.		
Livestock		
Sheep – 85	425	
Cows – 16	1,800	
Poultry – 700	700	
Miscellaneous	1,000	3,925
Growing crops and produce in storage		
Vineyards - 50 acres	10,000	
Prunes - 100 acres	12,500	
Field Crops - 200 acres	3,000	
Hay - 1200 tons	30,000	
Dry feed - 10 tons	400	
Hops - 160 tons	6,400	
Feed in silos	8,700	
Dried prunes	20,000	91,000
Channel erosion and debris removal		
Erosion - 950 acres	110,000	
Debris - 5000 acres	10,000	
Sloughing of banks & trees in resort areas	40,000	160,000
Flood protection works		
Levees	27,000	
Bulkheads	147,000	174,000
Increased operating expense and interruption of business		
Pacific Gas and Electric Co.	200	
Northwestern Pacific Railroad	10,000	10,200
Total damage in Sonoma County		1,251,623

ESTIMATE BY STATE ENGINEER OF AMOUNT OF DAMAGE IN MENDOCINO COUNTY
DUE TO FLOOD OF DECEMBER, 1937

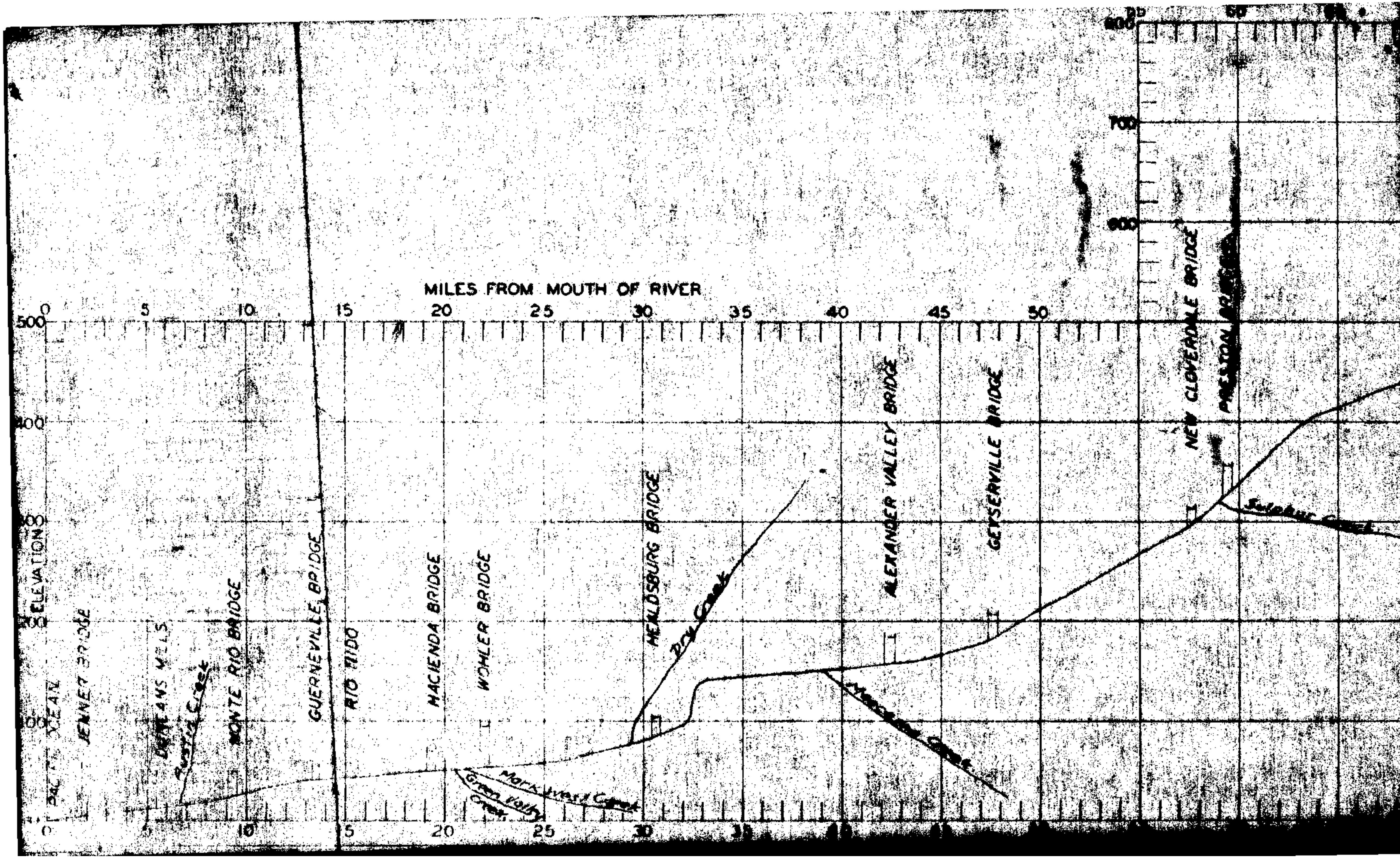
Mendocino County		
Railway Systems		
Northwestern Pacific Railway		
Bridges and culverts	2,875	
Roadbed and right of way	62,671	65,546
State Highway		
Unsegregated	55,000	55,000
County Roads		
Bridges and culverts	266,500	
Roadbed	223,700	490,200
Other roads and streets		
City of Ukiah - 2 bridges	1,200	
National Forest - trails	1,700	
- bridges	1,100	4,000
Telephone and Telegraph Systems No damages reported	0	0
Gas and Electric Systems		
Pacific Gas and Electric Co. - Reservoirs	750	750
Irrigation and domestic water supplies		
City of Ukiah	300	300
Urban improvements, homes and businesses		
City of Ukiah - parks	300	300
Industries in rural areas		
No damages reported	0	0
Summer camps, homes and resort equipment		
National forest camp grounds	400	
65 cabins, 16 small houses	100,000	
Cold Creek Fish Hatchery	30,000	
Snow Mountain Egg Collecting Station	500	
Dimmick State Park	9,000	
State Parks - unsegregated	1,500	141,400
Farm Buildings, fences and equipment		
3 Residences, 4 barns	20,000	
Fences, hop poles, trays, wood, food, misc.	50,000	70,000
Livestock		
Cows -25-	2,000	
Horses - 5-	750	
Sheep -100-	750	
Poultry-500-	500	4,000
Growing Crops and Produce in storage		
Grain - 50 acres	5,000	
Hops - 50 acres	10,000	
Trees - 2000 acres	10,000	25,000

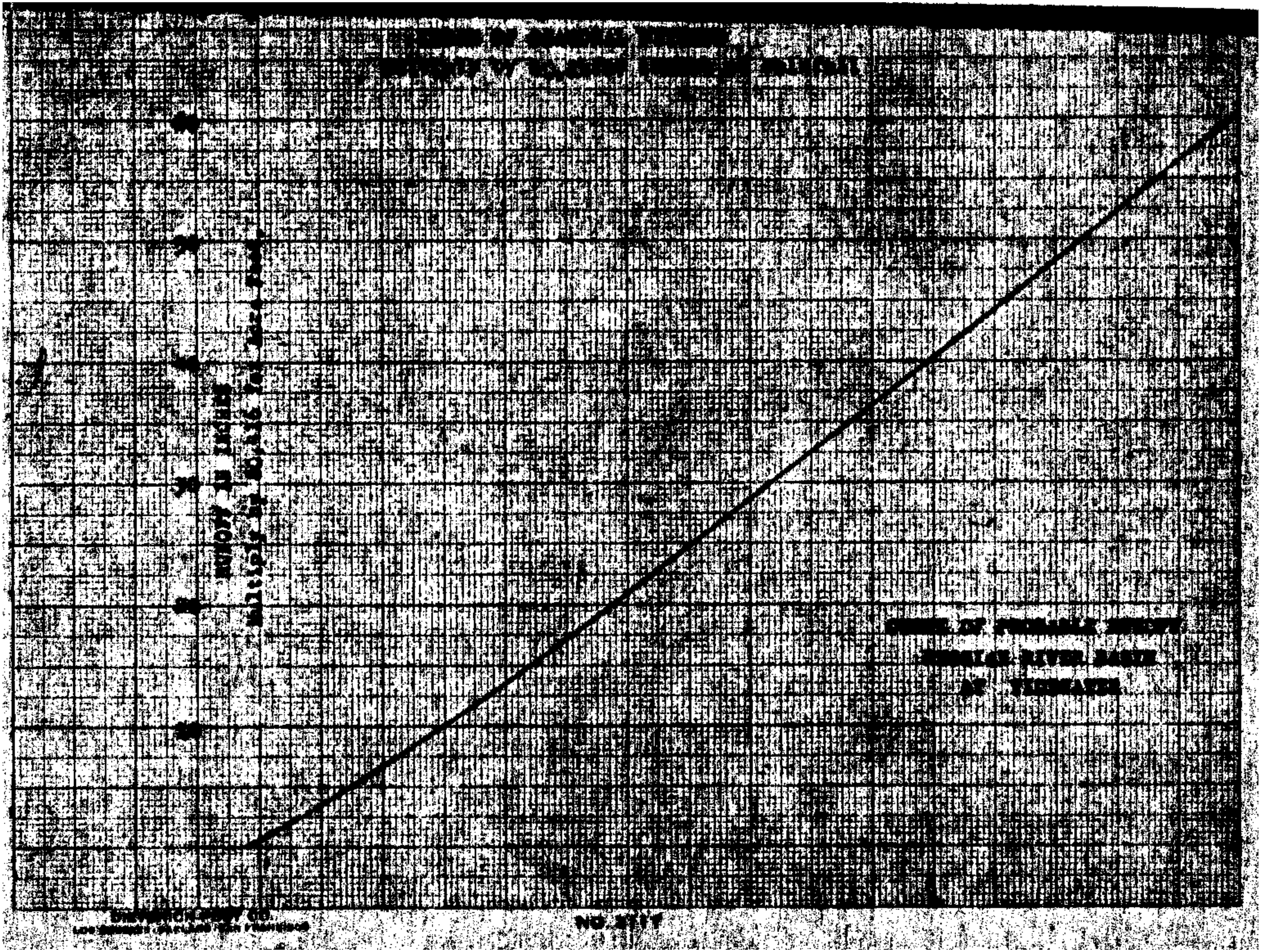
Mendocino County. Contd.		
Channel erosion and debris removal		
Eroded - 200 acres	60,000	
Debris - 3,000 acres	25,000	85,000
Flood protection works		
River bank repairs	50,000	50,000
Increased operating expenses and interruption of business	100	
Pacific Gas and Electric Co.	10,000	10,100
Northwestern Pacific Railway		
Total damage in Mendocino County		1,001,596

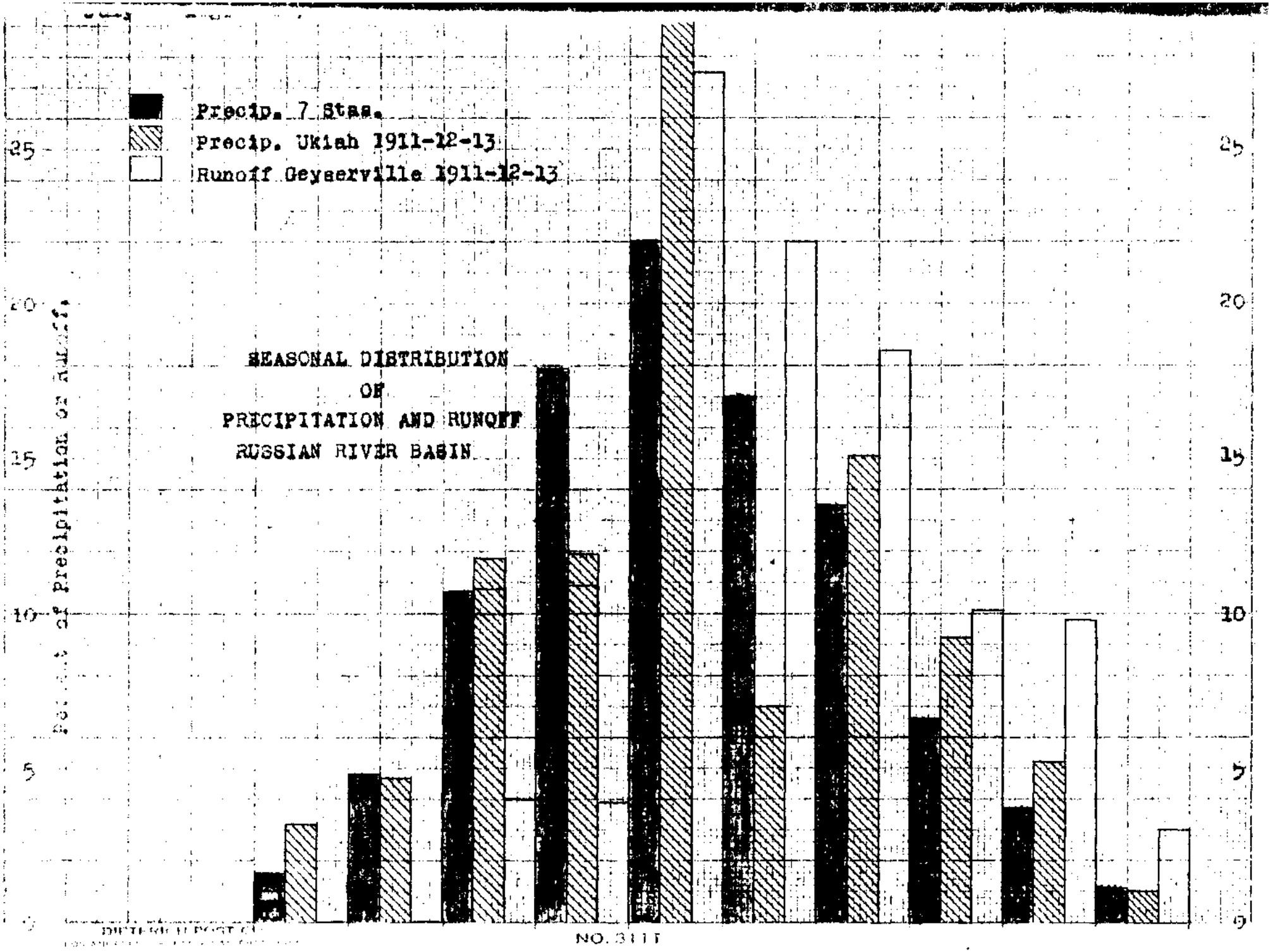


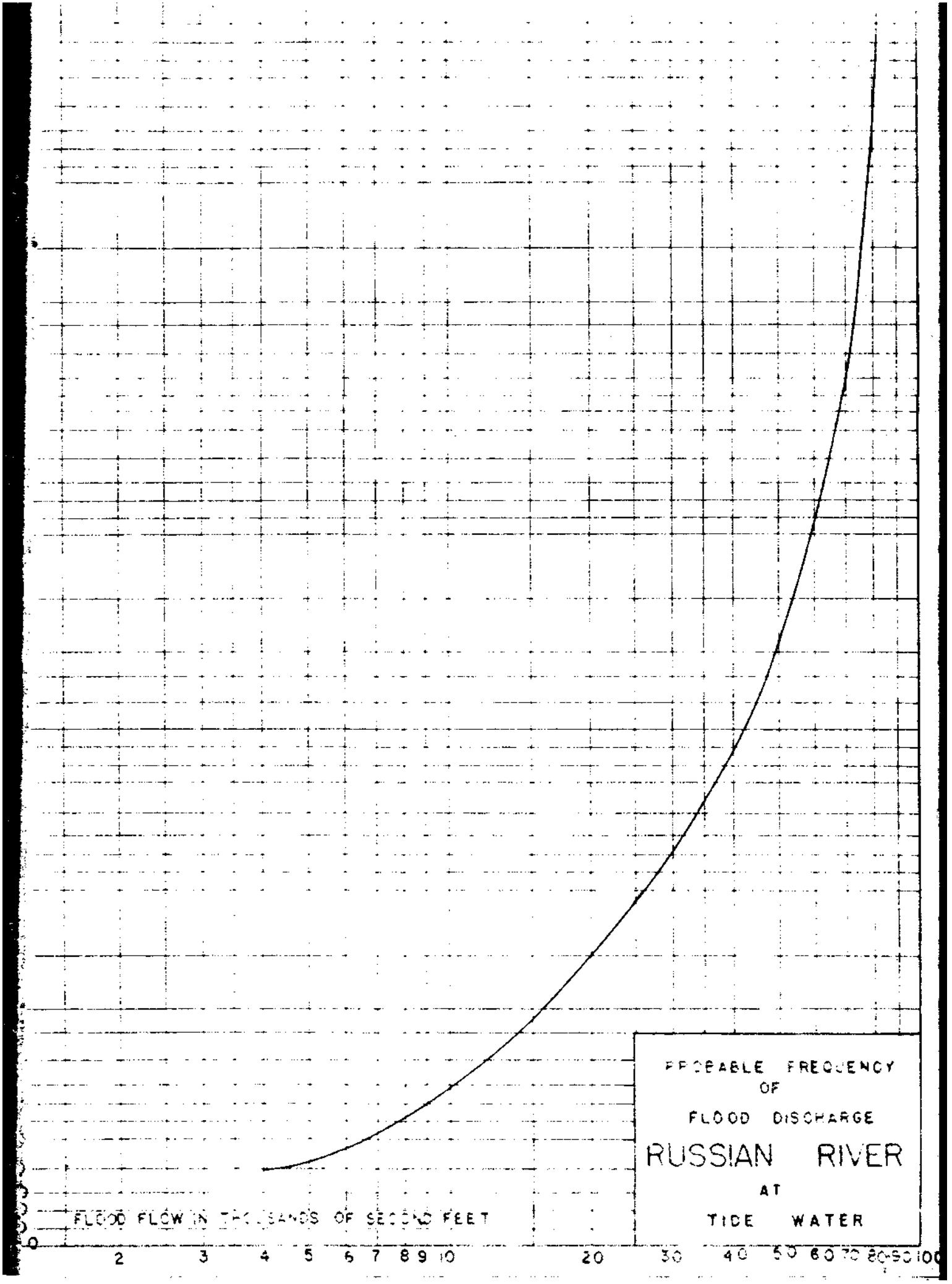
DIAGRAMMATIC PROFILE
OF
RUSSIAN RIVER, CALIFORNIA.
FROM MOUTH TO HEAD OF EAST FORK

HORIZ. SCALE 1" = 5 MI.


MILES FROM MOUTH OF RIVER
0
5
10
15
20
25
30
35
40
45
50
55
60
ELEVATION
500
400
300
200
100
700
800
600
JENNER BRIDGE
Austin Creek
MONTE RIO BRIDGE
GUERNEVILLE BRIDGE
RIO NIDO
HACIENDA BRIDGE
WOHLER BRIDGE
Green Valley Creek
Mark West Creek
HEALDSBURG BRIDGE
Dry Creek
ALEXANDER VALLEY BRIDGE
GEYSERVILLE BRIDGE
NEW CLOVERDALE BRIDGE
PRESTON BRIDGE
Sulphur Creek




Precip. 7 Stas.
Precip. Ukiah 1911-12-13
Runoff Geyserville 1911-12-13
SEASONAL DISTRIBUTION
OF
PRECIPITATION AND RUNOFF
RUSSIAN RIVER BASIN
25
20
15
10
5
0
NO. 3111


PROBABLE FREQUENCY
OF
FLOOD DISCHARGE
RUSSIAN RIVER
AT
TIDE WATER
FLOOD FLOW IN THOUSANDS OF SECOND FEET
0
2
3
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100