APPENDIX IV

to

Report to the

International Joint Commission

UNITED STATES and CANADA

WATER RESOURCES

of the

Columbia River Basin

OKANOGAN - SIMILKAMEEN BASIN

Prepared by

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APPENDIX IV

OKANOGAN-SIMILKAMEEN BASIN

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APPENDIX IV

OKANOGAN-SIMILKAMEEN BASIN

I. DESCRIPTION

GEOGRAPHY

1. The Okanogan-Similkameen Basin, situated about 150 miles east of the Pacific Coast, drains an area of about 8,400 square miles: 6,000 square miles in south central British Columbia, and 2,400 square miles in north central Washington. It extends 180 miles from north to south and 85 miles from east to west. The basin is bounded on the north and west by the Fraser River basin, on the west by the Skagit River basin, on the southwest by the Methow River basin, and on the east by the Kettle and Sanpoil River basins. From its source, the Okanogan River flows south along the east side of the basin in a fairly narrow valley which is noted for its chain of lakes. It crosses the international boundary, near Osoyoos, about two-thirds of the distance from its headwaters to its junction with the Columbia River near Brewster, Washington. The major tributary of the Okanogan, the Similkameen, rises in Washington near the boundary, flows north into British Columbia, then east, then southeasterly to recross the boundary about 24 miles above its confluence with the Okanogan River near Oroville. A map of the basin is shown on Plate 1 and stream profiles on Plate 2.

TOPOGRAPHY

2. Mountains and mountain valleys are the principal land forms in the basin. In general, the Okanogan valley is U-shaped in cross section with mountains rising to elevations of 4,000 to 5,000 feet on either side. Occasional peaks reach elevations of about 8,000 feet. A notable feature at the north end of the valley is the low divide (el. 1,179) separating the Okanogan and Fraser River basins. Generally, flood plains occur only in narrow stretches along the river. In a few instances, however, the low ground slopes gently for a considerable distance from the river before a steep rise occurs. Benchlands 200 to 400 feet above the river are common. Beyond the benches the mountains rise steeply to rounded rolling tops.

3. The Similkameen valley is narrow with precipitous sides, except for the 22-mile portion extending south from Keremeos, which is comparatively flat and broad. Generally the mountains on the west and south sides of the valley rise to about 7,000 or 8,000 feet in elevation, and those on the north and east sides of the valley rise to about 5,000 or 6,000 feet in elevation.

STREAMS

4. The most northerly part of the drainage basin is the headwater of Deep Creek, which flows south for 21 miles into Okanagan Lake (el. 1,123). Numerous small creeks flow into Okanagan Lake. These include Mission Creek near Kelowna and Penticton Creek at Penticton, which drain from the east, and Trout Creek near Summerland, which drains from the west. Okanagan Lake, the source of the Okanogan River, is about 69 miles long and two miles wide. It is controlled by a low dam at its outlet at the south end. The Okanogan River flows south from Okanagan Lake for 43.7 miles to the international boundary, passing through Skaha and Vaseaux Lakes and entering Osoyoos Lake, which straddles the international boundary. After it leaves Osoyoos Lake, it then flows 73 miles to its confluence with the Columbia River near Brewster, Washington. The minor tributaries south of Okanagan Lake are Shingle, Ellis, and Shuttleworth Creeks near Penticton; Vaseaux and Inkaneep Creeks near Oliver, in British Columbia;

and Tonasket Creek near Oroville; Bonaparte Creek near Tonasket; and Salmon Creek, near Okanogan, in Washington.

5. The Similkameen River is the largest tributary of the Okanogan from the standpoint of both runoff and drainage area. Its headwaters are in the Cascade Mountains, in the vicinity of the international boundary. It is joined by the Pasayten River from the south and flows northerly for 50 miles to Princeton. There it is joined by its largest tributary, the Tulameen River. From Princeton it flows southeasterly for 88 miles to its confluence with the Okanogan River at Oroville, after crossing the boundary near Nighthawk. The largest tributaries downstream from Princeton are Allison, Hayes, Hedley, and Keremeos Creeks, which drain from the north, and the Ashnola River and Sinlahekin Creek which drain from the south.

6. A breakdown of the Okanogan-Similkameen drainage area to show the areas lying on each side of the boundary is contained in the following tabulation:

River	Drainage area in square miles		
	Canada	United States	Total
Similkameen River	2,880	700	3,580
Okanogan River, above Similkameen River	3,120	100	3,220
Okanogan River, below Similkameen River		1,600	1,600
TOTAL	6,000	2,400	8,400

GEOLOGY

7. The trough in which Okanogan River flows is one of several deep, north-south, parallel valleys developed in a complex of igneous and sedimentary rocks that are moderately to extensively metamorphosed. Extensive glaciation in the area between the Cascade Mountains and the Rocky Mountains has greatly modified the drainage and topography, and has largely obscured the bedrock geology.

8. Prior to the accumulation and advance of the several ice sheets during the Pleistocene glacial period, the Okanogan drainage area probably included adjacent areas north of the present source of the Okanogan River, including Shuswap Lake and Adams Lake. The coalescence of numerous valley glaciers emerging from the Rocky Mountain system on the east and the Cascade Mountains on the west produced an ice sheet which covered the Interior Plateau of British Columbia to an elevation of at least 6,000 feet. The flow of ice from the center of accumulation was generally northwest into Yukon and Alaska, and southward into the United States.

9. The movement of great amounts of debris during each ice advance, and the subsequent reworking by meltwater, caused marked changes in the drainage system of the area; and the present system, with only minor exceptions, is the result of processes which took place during the last ice advance and retreat. During melting of the glaciers, marginal streams between the ice and the valley walls produced terraces of the morainal material. Much of the valley floor south of Skaha Lake was covered with deep glacial drift, and at Okanagan Falls the river was forced over along the valley wall. Here it has cut a channel through rock which is some distance above the rock floor of the valley. The basin of Okanagan Lake escaped being filled with debris because it was already choked with ice

when extensive movements of drift were taking place. The lower end of the lake was dammed by the coalescing deltas and alluvial fans of Penticton, Ellis, and Shingle Creeks.

10. The lower Okanogan River valley in the United States has numerous terraces high on the valley sides. The most prominent of these is the Great Terrace of the Columbia, formed at a time when the Columbia River was dammed by ice.

11. The Similkameen River, which had flowed to the Okanogan at some point south of Conconully, was blocked from this outlet by glacial drift deposits. For a time, the escapement of this stream to the Okanogan was made over several low divides. The lowest of these, crossing Kruger Mountain Plateau, has since become the present course of the river.

SOILS

12. In Canada the arable lands are comprised of Brown Soils, Dark Brown Soils, Black Soils, and Groundwater Soils. The Brown Soils are the most arid in British Columbia, dominantly silt loam in texture, often gravelly or stoney, seriously erodable, low in organic matter, and deficient in some elements, yet fertile and highly productive under proper management. They once supported thin stands of bunchgrass, now indicated by subclimax growth of sage and wild brome, and are now used under irrigation for the production of tree fruits, including stone fruits. These soils are found on terraces and stream fans along the Similkameen River between the boundary and Hedley, and along the Okanogan River between the boundary and Summerland. The Dark Brown Soils, on the same formation as the Brown Soils, are used for tree fruits (except apricots and peaches). They are found around Hedley in the Similkameen valley and between Summerland and Oyama in the Okanogan valley. The Dark Brown Soils give way to the Black Soils at higher elevations where grass and areas of timber are found. The Black Soils are found in the Similkameen valley north and west of Hedley and in the Okanogan valley north of Oyama. These soils are grazed, dry-farmed for cereals, or used for forage crops under irrigation. The Groundwater Soils are medium-textured, with the groundwater table and drainage varying with river or stream elevations. The better drained lands are in orchard, and the balance is used for forage crops, gardens, and berries.

13. In the United States, soil textures range from sand to clay, and crop adaptability is restricted in some areas by very heavy or very light-textured soils. Depths range from less than two feet to more than 20 feet. Nearly all soils in the basin are mellow, friable, and free of harmful salt accumulations. They are light in color and low in organic matter, but unleached of basic mineral nutrients. Arable lands of the basin occupy relatively smooth areas of old flood plains, terraces, coulees, and fans. The low plains and terraces, some of which are subject to flooding, are broken by old channels and low ridges. The soils range from cobbly deposits to deep clayey alluviums. Only small areas are affected by alkali accumulations. Intermediate terraces are commonly irregular in surface relief; and, in places, are covered with rolling dunes. Here the soils are generally cobbly and gravelly except for scattered alluvial deposits of loamy sands above open substrata. The smooth and nearly flat portions of the higher lands contain the largest bodies of arable land. Soils of the high terraces and coulees are of light- to medium-textured materials over gravelly glacial outwash. They are well drained, are neutral to moderately alkaline, and have no salt concentrations.

CLIMATE

14. General. - The climate of the Okanogan-Similkameen Basin varies with elevation and location. The basin is subject to the

moderating influence of the prevailing westerly winds. During the winter months precipitation falls mainly in the form of snow, and differences in elevation throughout the basin cause an uneven distribution. Summer precipitation is light and results from storms which are characterized by heavy showers and occasional cloudbursts caused by the northward extension of low-pressure areas from the hot, southerly interior. Mean annual temperatures in the basin vary from 42° at Princeton to 50° at Oroville. The minimum and maximum observed temperature in the basin are -44° at Armstrong and 111° at Oliver and Oroville.

15. Precipitation varies widely throughout the basin, being greatest in the Cascade Mountain Range to the west and the Monashee Mountain Range to the north. It decreases to the south and east where much of the area is arid or semi-arid. As its headwaters are in the Cascades, the Similkameen Basin receives more precipitation than the Okanogan Basin.

16. The prevailing drift of air in the basin is from the southwest. The prevailing surface wind is up-valley from the southwest for all months of the year except July, when air movement from the northeast prevails.

17. The growing season in the basin varies with altitude and local conditions, as shown in Table 1.

18. Records. - Climatological records have been kept at 48 stations in the basin. Of these stations, ten existed for a period of a few months or years for which records are fragmentary, and 38 have records for five or more consecutive years. There are 26 active stations in the basin at the present time.

19. A summary of climatological data is presented in Table 1. Mean monthly and annual precipitation and temperature data for 11 representative stations in the basin are shown in Tables 2 and 3.

20. Storms. - Much of the moisture carried northeasterly in air masses from the Pacific Ocean is deposited on the intervening Olympic and Cascade Ranges. As a result of these depletions, rain storms in the basin are of high intensity and short duration, and occur over only small scattered areas. The principal storm centers in the basin are along the Cascade Range on the west and in the Monashee Mountains to the north and east. The basin is subject to general storms throughout the winter, with much of the precipitation occurring as snowfall, particularly at the higher elevations.

HYDROLOGY

21. General. - The Okanogan-Similkameen Basin has runoff characteristics similar in many respects to other tributaries in the upper portion of the Columbia River basin. There is one distinct high-water period in May and June, followed by a rapid recession during July and August. The flow during the fall and winter months remains well below average for the year, but an early spring may result in substantial rises during April. However, high water rarely occurs during the period September to March.

22. The average annual yield per square mile of the Okanogan-Similkameen Basin is relatively small in comparison with other tributaries of the Columbia River upstream from the Okanogan. This results from the position of the basin with relation to the Cascade Range and the prevailing westerly winds. The basin is thus situated in a rain shadow, and receives less precipitation than areas to the west and east. The Similkameen River, with a drainage area of 3,580 square miles at its mouth, has an average flow of about four times the Okanogan River at

TABLE 1

Summary of Climatological Data (Through 1950)

Station	Elevation	Precipitation In Inches: Years of Record	Precipitation In Inches: Mean Annual	Precipitation In Inches: Max. Annual	Precipitation In Inches: Min. Annual	Snowfall in Inches: Years of Record	Snowfall in Inches: Mean Annual	Temperature in °F.: Years of Record	Temperature in °F.: Mean Annual	Temperature in °F.: Extremes Max.	Temperature in °F.: Extremes Min.	Growing Season Days
Armstrong, B.C.	1,187	39	16.89	22.55	11.57	38	48.9	37	44	105	-44	194
Vernon	1,383	31	15.71	20.74	11.33	32	46.0	31	46	104	-31	206
Kelowna	1,200	36	12.38	18.09	8.28	37	32.4	37	46	102	-24	208
Penticton	1,121	43	11.35	17.40	6.28	40	21.4	43	48	105	-16	214
Oliver	995	27	9.79	16.40	5.01	28	20.4	27	49	111	-23	224
Princeton	2,289	12	14.24	21.06	7.90	44	47.1	12	42	107	-42	188
Hedley	1,700	44	11.52	21.31	5.76	40	30.1	43	46	106	-27	--
Hedley (Nickel Plate)	5,600	24	23.78	45.00	14.81	18	153.5	25	35	91	-38	--
Keremeos, B.C.	1,165	36	9.90	14.44	6.01	30	24.5	34	49	106	-22	222
Oroville, Wash.	1,060	36	10.77	18.50	5.43	20	16.8	36	50	111	-19	157
Conconully, Wash	2,285	50	14.54	25.88	6.84	33	48.4	50	45	109	-29	131

TABLE 2

Average Precipitation in Inches For The Period Of Record (Through 1950)

Station	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Armstrong, B. C.	1.81	1.16	0.88	0.90	1.23	1.82	1.20	1.10	1.33	1.73	1.64	2.09	16.89
Vernon	1.62	1.09	0.97	0.83	1.16	1.73	1.04	1.18	1.21	1.54	1.43	1.91	15.71
Kelowna	1.18	0.92	0.72	0.69	0.94	1.13	0.81	0.90	1.09	1.19	1.19	1.62	12.38
Penticton	0.98	0.81	0.66	0.78	1.12	1.35	0.86	0.84	0.94	0.93	0.96	1.12	11.35
Oliver	0.79	0.81	0.65	0.67	0.74	1.26	0.70	0.56	0.69	0.86	0.98	1.08	9.79
Princeton	1.31	1.47	0.64	0.75	1.13	1.47	1.01	0.80	0.83	1.19	1.79	1.85	14.24
Hedley	1.15	0.90	0.58	0.62	1.14	1.30	0.98	0.83	0.85	0.84	1.23	1.10	11.52
Hedley (Nickel Plate)	1.89	1.84	1.48	2.57	2.69	2.75	1.80	1.44	1.44	1.70	2.03	2.15	23.78
Keremeos, B.C.	0.85	0.66	0.54	0.64	0.90	1.09	0.67	0.80	0.83	0.85	1.04	1.03	9.90
Oroville, Wash.	1.00	0.83	0.63	0.79	0.80	1.31	0.64	0.59	0.82	0.88	1.25	1.23	10.77
Conconully, Wash.	1.35	1.17	1.03	1.01	1.39	1.62	0.82	0.69	0.92	1.08	1.70	1.76	14.54

TABLE 3

Average Temperatures In °F. For The Period Of Record (Through 1950)

Station	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Armstrong, B. C.	21	25	35	46	54	63	66	64	55	44	34	26	44
Vernon	22	27	37	48	56	63	69	66	57	46	35	29	46
Kelowna	25	29	38	47	55	62	67	65	57	47	37	30	46
Penticton	27	31	39	48	56	63	68	66	58	48	38	31	48
Oliver	25	31	41	51	59	66	73	70	61	49	37	30	49
Princeton	17	25	33	43	51	58	63	62	55	43	30	23	42
Hedley	22	28	38	47	55	61	68	67	58	47	35	26	46
Hedley (Nickel Plate	16	21	25	31	41	47	54	53	46	36	27	22	35
Keremeos, B. C.	24	30	41	51	59	64	71	70	61	50	36	28	49
Oroville, Wash.	26	30	42	52	59	66	73	70	61	50	38	30	50
Conconully, Wash.	21	26	36	46	53	60	67	66	57	46	33	25	45

their confluence. At this point the Okanogan River has a drainage area of 3,220 square miles, only slightly less than the Similkameen River. The higher runoff from the Similkameen Basin is due to the greater precipitation in the portion of the basin adjacent to the crest of the Cascade Range. Runoff per square mile from the Kettle River basin, bordering the Okanogan to the east, is about twice that of the Okanogan.

23. Most of the winter precipitation is retained on the watershed as snow, especially in the higher elevations. Consequently a large part of the annual runoff occurs during the snow-melt period, which usually begins about May 1 and ends by about June 15. High runoff continues, however, during June and July as a result of high groundwater levels and the saturated condition of the soil mantle after the spring snow-melt. Low-elevation precipitation and snow melt during the fall and winter often result in moderate rises in both the Okanogan and Similkameen Rivers, although very rarely do peak discharges during this period exceed the average annual discharge.

24. The Okanogan Basin upstream from the mouth of the Similkameen River is an area of very low rainfall and runoff. The discharge of the river is regulated to a great extent by the series of lakes through which it flows. The area and capacity of the lakes, being great in relation to the total flow of the stream, results in a relatively uniform discharge from this portion of the basin. Flood control is achieved also by artificial regulation of Okanagan Lake during the high-water period. During the irrigation season, water is released from Okanagan Lake for irrigation in the vicinity of Oliver, B.C.

25. The following tabulation illustrates the average distribution of runoff at gaging stations on the Similkameen River and on Okanogan River above its confluence with Similkameen River. The average runoff occurring during each month is expressed as a percentage of the total annual runoff.

Average monthly runoff, in percent of annual

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Similkameen R. nr. Nighthawk Wash. 1911-51	2.7	3.0	2.7	2.3	2.2	2.5	8.0	30.4	30.4	10.3	3.3	2.2
Okanogan R. at Okanagan Falls, B.C. 1916-52	6.8	6.7	7.0	6.6	5.7	7.0	7.9	12.3	13.6	11.2	8.4	6.8

26. Floods. - Floods in the lower Okanogan River originate primarily in the Similkameen Basin. Because of the great amount of storage provided by the series of lakes along the Okanogan River in Canada, and the regulation provided on Okanagan Lake by the dam at the outlet, floods in the Okanogan River in Canada are of small magnitude and relatively long duration. All past floods in the Okanogan-Similkameen Basin have been the result of snow melt alone or in combination with rainfall. Floods on the Similkameen River cause backwater in the Okanogan River above their confluence. This backwater may extend several miles upstream, and during five of the past 42 years it is known to have extended to Osoyoos Lake. During the flood of 1948 this effect reversed the flow of Okanogan River between its confluence with the Similkameen and Osoyoos Lake.

27. Floods in this basin, resulting primarily from snow melt, are of long duration and contain large quantities of water in comparison to floods resulting primarily from rainfall. Consequently the control of floods in this basin requires reservoirs of relatively large capacity. However, flash floods occur on many of the smaller tributaries.

Description

28. The three highest floods in the 39 years of record on the Okanogan River near Tonasket occurred during the three consecutive years of 1948, 1949, and 1950 followed in 1951 by the fifth highest. A list of annual peak discharges recorded at key gaging stations on the Okanogan and Similkameen Rivers is given in Table 4. The annual maximum stages of Okanagan and Osoyoos Lakes are shown in Table 5. Frequency curves of annual floods for the Similkameen River near Nighthawk, and the Okanogan River near Tonasket, are shown on Figure 1.

29. Runoff. - Records of Stream discharge have been maintained at gaging stations on the Okanogan River and tributaries at various points in Washington and British Columbia. The following tabulation gives pertinent data for the principal stream gaging stations in the basin:

Stream	Location	Drainage Area Sq. Miles	Period of Record	Average Annual Runoff Acre-feet
Okanogan River	Penticton, B.C.	2340	1921 to date	347,400
Okanogan River	Okanagan Falls, B.C.	2550	1915 " "	363,600
Okanogan River	Oroville, Wash.	3210	1942 " "	528,700
Okanogan River	Tonasket, Wash.	7270	1929 " "	2,037,000
Okanogan River	Okanogan, Wash.	7900	1911-1925	2,104,000
Similkameen River	Princeton, B.C.	690	1914-1917 1939-1942 1945 to date	635,000
Similkameen River	Keremeos, B.C.	2300	1914-1932	1,325,000
Similkameen River	Nighthawk, Wash.	3550	1911 to date	1,588,000
Tulameen River	Coalmont, B.C.	400	1914-1918 1947-1954	556,300
Tulameen River	Princeton, B.C.	680	1950 to date	657,000
Ashnola River	Ashnola, B.C.	500	1914-1918 1947 to date	252,900
Salmon Creek	Conconully, Wash.	121	1911-1922	22,600

30. Short periods of discharge record, or records for the irrigation season only are available for many additional streams in the basin.

31. Records of lake stages have been maintained by the Governments of Canada and United States at the following locations:

Lake	Location of Gage	Periods of Record
Okanagan	Kelowna, B.C.	1943 to date
Okanagan	Penticton, B.C.	1928 " "
Skaha	Okanagan Falls, B.C.	1943 " "
Osoyoos	Osoyoos, B.C.	1946-1949
Osoyoos	Oroville, Wash.	1928 to date

TABLE 4

Annual Peak Discharges in c.f.s.

Water Year	Similkameen River near Nighthawk, Wash. Dis-Charge	Date	Okanogan River near Tonasket, Wash. 1/ Dis-Charge	Date	Okanogan River at Okanagan Falls, B.C. Dis-Charge	Date
1911	16,500	June 15	16,100	June 16		
1912	12,800	May 22	13,700	May 22		
1913	18,300	June 4	18,800	June 5		
1914	13,000	May 17	14,300	May 18		
1915	5,920	May 30	7,220	May 26		
1916	20,600	June 19	22,200	June 20	1,300	July 2-9
1917	16,400	May 29	16,500	June 18	1,140	June 29-30
1918	17,200	June 14	16,200	June 15	1,100	June 10-23
1919	20,100	May 28	18,700	May 30	1,200	June 16-26
1920	10,400	June 22	11,000	June 19	1,100	July 10-11
1921	20,800	May 26	21,000	June 9	2/ 2,500	June 10,15-16
1922	21,400	June 5	20,600	June 7	950	May 19-23, June 2
1923	16,200	June 10	16,200	June 12	1,150	June 23-24
1924	18,300	May 17	17,800	May 20	558	Feb. 2
1925	18,300	May 21	19,200	May 22	1,160	May 20
1926	5,840	Apr. 30	-	-	707	Mar. 10
1927	17,300	June 9	-	-	740	May 22
1928	20,700	May 23	-	-	2/ 2,680	June 10
1929	8,500	May 23	8,500	June 10	1,060	Oct. 1
1930	8,500	June 8	8,310	June 9	402	May 14-16
1931	9,380	May 15	8,480	May 16	2/ 167	Oct. 30
1932	10,200	May 11	10,600	May 12	2/ 970	May 7
1933	20,000	June 17	20,200	June 18	2/ 1,300	May 30-31
1934	25,800	Apr. 26	26,600	Apr. 27	2/ 1,160	Apr. 24
1935	14,600	May 31	14,900	June 2	2/ 1,110	May 24
1936	11,400	May 15	11,800	May 16	2,340	May 15
1937	16,100	June 4	15,100	June 5	1,080	June 3
1938	21,400	May 27	21,400	May 28	1,270	May 28
1939	10,000	May 16	11,200	May 17	543	May 8
1940	7,550	May 25	7,540	May 26	292	Oct 1-2,6,12
1941	4,750	May 2, June 8	5,180	May 3	571	Sept. 26
1942	20,000	May 27	18,900	May 28	1,310	July 4
1943	13,400	May 27, June 10	13,500	June 11	913	Nov. 19
1944	9,740	June 2	10,200	June 3	802	June 4
1945	17,600	June 1	18,200	June 2	1,250	June 7
1946	15,900	May 28	16,900	May 29	1,360	May 13
1947	14,300	May 9	13,400	May 10	956	Oct. 25
1948	38,700	May 30	40,900	May 31	1,550	June 18
1949	26,900	May 15,17	27,200	May 17	1,510	Nov. 7
1950	29,700	June 17	29,600	June 18	1,310	June 15
1951	22,700	May 24	23,600	May 25	1,440	May 13

1/ At Okanogan, Wash. - through 1925

2/ Maximum observed discharge

TABLE 5

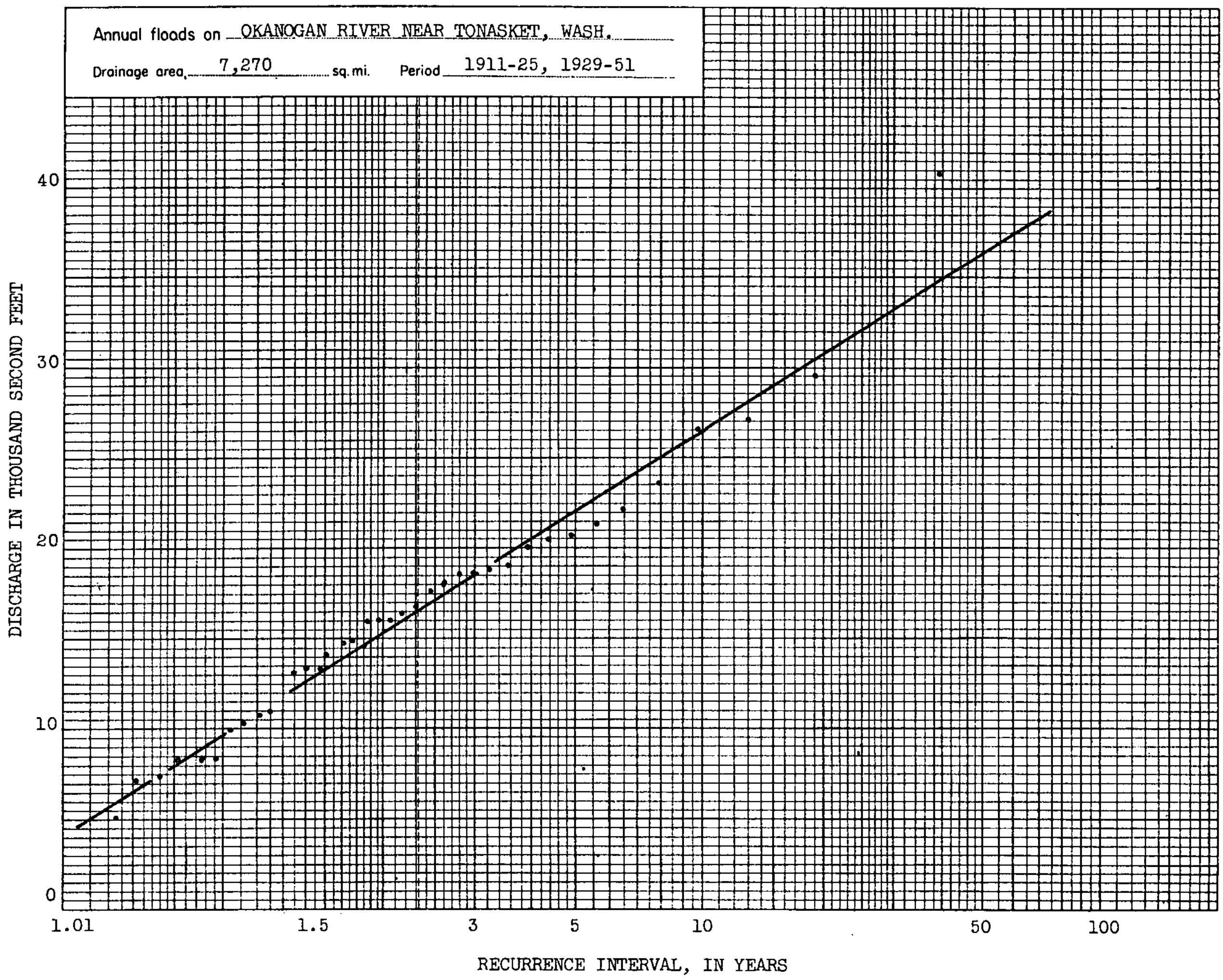
Annual Maximum Lake Stages

Water Year	Osoyoos Lake near Oroville, Wash. 1/ Maximum Elev. 2/	Date	Okanagan Lake at Penticton, B.C. Maximum Elev. 3/	Date
1928	913.62	July 28	1,125.79	June 8,9
1929	911.23	June 7	1,122.44	Oct. 1,2
1930	910.76	June 8	1,122.44	July 3,8,10
1931	909.89	May 17	1,122.59	July 6,11,18
1932	913.07	May 13	1,123.59	June 22,26,27
1933	913.50	June 18	1,123.74	July 5,6,7,12,14
1934	914.84	Apr. 28	1,123.93	May 26,31, June 2-10,12
1935	912.72	May 30,31	1,123.88	July 14,16,17
1936	912.71	June 20,22	1,124.13	June 24,25
1937	912.96	June 26	1,123.19	July 1-7
1938	913.90	May 29	1,122.79	June 26,28-30, July 1, 2,4,6,7,9-11,13
1939	912.87	May 2,3	1,122.99	June 28-30
1940	912.49	May 13,15,16	1,123.24	June 10-16,18,19
1941	913.41	Apr. 5,7,11,12	1,123.14	July 5,9-17
1942	914.15	May 29	1,125.49	June 25,26
1943	912.80	Apr. 25	1,123.09	Oct. 1,3
1944	913.05	June 7	1,122.78	June 26
1945	914.18	June 9	1,124.02	June 21,23-26
1946	914.02	May 14,15	1,125.17	July 1,2
1947	912.66	Nov. 1	1,122.84	Oct. 1
1948	916.74	May 31	1,126.16	June 24-26
1949	914.35	May 17	1,124.26	Oct. 1
1950	915.21	June 19	1,123.59	June 30, July 3
1951	914.09	May 14, 15	1,124.64	June 20

1/ Flood of May 29, 1894 reached an elevation of 918.8± 0.5' one mile below present lake outlet, from floodmark on old Okanogan Hotel building.

2/ Elevations are referred to datum of U.S.C. & G.S., 1929 adjustment. Factor for converting water surface elevations to datum of the 1947 International Joint Adjustment is -0.26 ft.

3/ Elevations are referred to G.S. of C. datum (Publication No. 24, 1951 edition, in which the 1957 IJA has been incorporated).



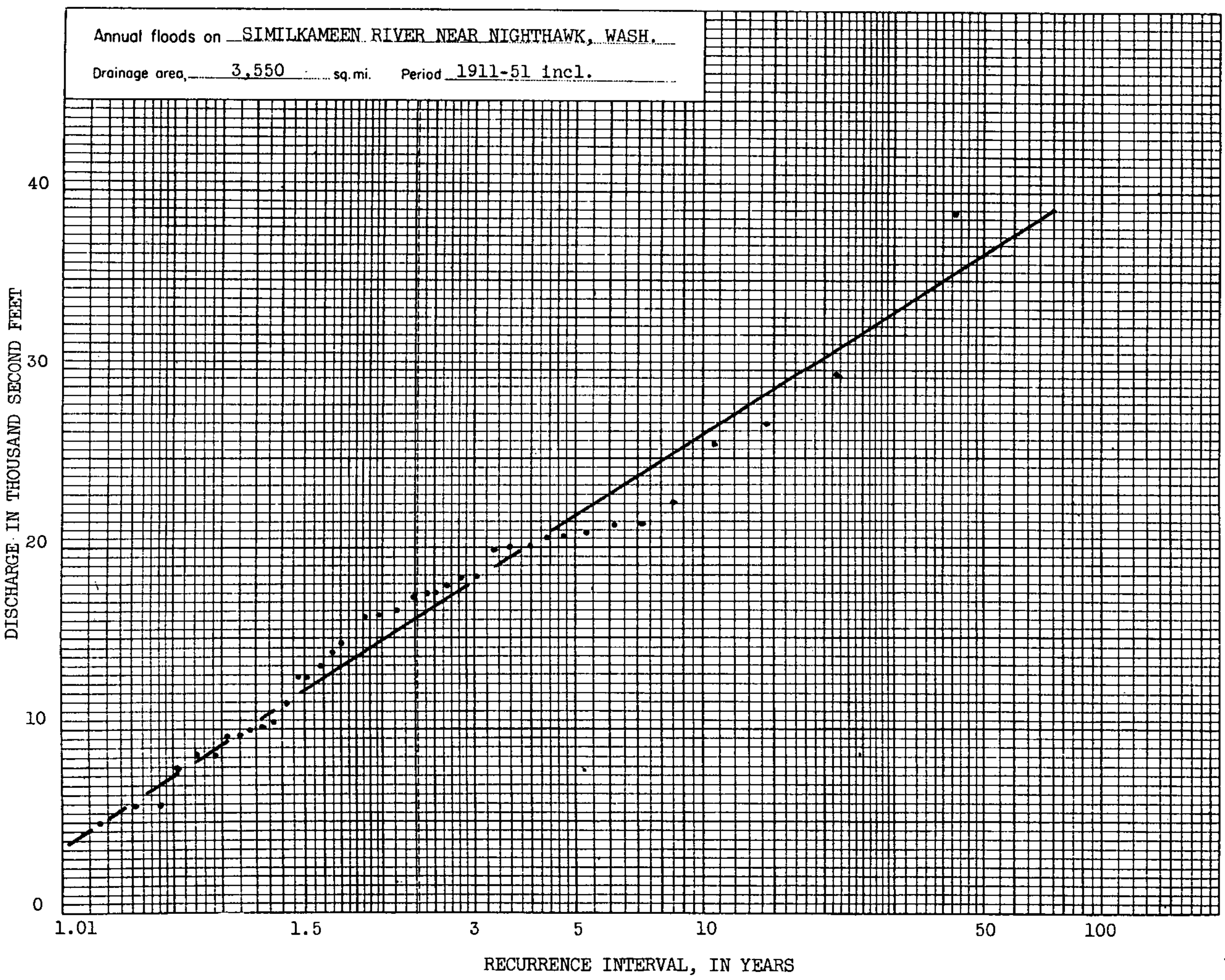


Figure 1.- Flood Frequency Curves.

Description

32. Records of monthly runoff by water years for the Okanogan River near Tonasket, the Similkameen River near Nighthawk, and the Okanogan River at Okanagan Falls, are given in average cubic feet per second and in acre-feet, respectively, in Tables 6 and 7, 8 and 9, and 10 and 11. Representative hydrographs of discharge for Similkameen and Okanogan Rivers are given in Figures 2 and 3.

33. Ground Water. - Because of what appears to be a relatively shallow soil mantle in the basin, no large bodies of ground water are believed to exist. Glacial deposits and terraces along stream channels are the principal sources of ground water, but their productive capacity has not been determined.

34. Water Rights. - The legal control of water in this basin is vested in the Province of British Columbia and the State of Washington, both of which have water laws covering the use of water. A summary of water rights granted by British Columbia for the use of water in the Similkameen River and tributaries is given in Table 12. Water rights for the Okanogan River and tributaries in British Columbia are summarized in Table 13. A summary of water rights in the United States portion of the basin is given in Table 14.

TABLE 6

Monthly and Annual Discharge, in c.f.s., of Okanogan River near Tonasket, Washington

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1929	-	-	-	-	-	-	-	3,890	5,530	1,330	406	270	-
1930	416	413	399	360	581	529	3,240	5,090	5,660	1,840	515	365	1,620
1931	442	588	443	439	600	525	770	5,630	2,730	908	231	335	1,140
1932	403	663	491	398	883	2,060	2,920	8,620	6,840	2,270	915	696	2,260
1933	887	1,870	1,850	1,500	1,040	916	1,980	7,200	13,300	5,940	1,810	1,090	3,280
1934	2,113	3,233	2,437	2,011	1,861	2,855	13,220	12,270	6,214	2,114	1,055	626	4,168
1935	950	2,203	1,755	1,388	2,889	1,896	2,011	9,283	10,710	4,727	1,881	1,251	3,409
1936	1,312	1,359	1,199	944	613	701	2,942	8,845	6,484	1,930	885	706	2,330
1937	842	895	828	504	532	704	1,258	6,485	11,950	3,382	958	731	2,424
1938	1,059	1,496	1,415	1,394	1,345	1,658	3,841	11,860	9,384	2,388	711	574	3,100
1939	736	784	821	927	611	849	2,946	7,356	5,535	2,321	696	516	2,015
1940	658	929	1,253	715	675	704	2,236	5,219	2,964	605	319	231	1,377
1941	710	712	739	700	687	957	3,054	3,790	3,720	1,553	662	1,492	1,565
1942	2,756	2,181	2.307	1,800	1,515	1,008	2,897	8,632	9,640	3,932	2,064	1,406	3,352
1943	1,352	1,576	1,598	1,115	1,317	1,101	3,766	6,467	10,170	5,423	1,270	575	2,980
1944	655	731	594	492	656	539	944	4,747	7,925	2,005	601	515	1,697
1945	764	893	1,026	1,193	1,262	1,121	1,339	8,148	11,250	2,796	1,030	707	2,629
1946	1,117	1,807	1,551	1,414	1,176	1,408	2,964	13,320	9,787	3,942	1,615	1,335	3,466
1947	1,455	1,445	1,326	1,144	951	1,023	2,941	9,161	5,761	1,742	824	757	2,386
1948	1,194	1,223	1,188	1,259	1,051	748	1,620	10,980	20,450	5,025	3,928	3,039	4,302
1949	2,788	2,556	2,171	1,865	1,805	1,768	3,689	15,530	8,336	2,659	1,349	1,197	3,824
1950	1,336	2,200	2,526	1,166	1,568	2,382	2,575	8,762	19,360	6,152	1,966	964	4,246
1951	1,384	1,812	2,342	1,984	2,380	2,027	4,583	15,700	11,600	4,596	1,708	1,659	4,323

TABLE 7

Monthly and Annual Runoff, in Acre-Feet, of Okanogan River near Tonasket, Washington

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1929	-	-	-	-	-	-	-	239,000	329,000	81,800	25,000	16,100	-
1930	25,600	24,600	24,500	22,100	32,300	32,500	193,000	313,000	337,000	113,000	31,700	21,700	1,170,000
1931	27,200	35,000	27,200	27,000	33,300	32,300	45,800	346,000	162,000	55,800	14,200	19,900	826,000
1932	24,800	39,500	30,200	24,500	50,800	127,000	174,000	530,000	407,000	140,000	56,300	41,400	1,650,000
1933	54,500	111,000	114,000	92,200	57,800	56,300	118,000	443,000	791,000	365,000	111,000	64,900	2,380,000
1934	129,900	192,400	149,900	123,600	103,300	175,600	786,800	754,400	369,800	130,000	64,880	37,260	3,018,000
1935	58,430	131,100	107,900	85,370	160,500	116,600	119,600	570,800	637,000	290,700	115,700	74,460	2,468,000
1936	80,670	80,850	73,710	58,040	35,260	43,080	175,100	543,900	385,800	118,700	54,390	41,980	1,691,000
1937	51,790	53,280	50,900	30,980	29,550	43,310	74,860	398,800	711,200	207,900	58,930	43,490	1,755,000
1938	65,090	89,000	86,980	25,730	74,720	101,900	228,500	729,200	558,400	146,900	43,720	34,160	2,244,000
1939	45,250	46,640	50,470	57,010	33,910	52,180	175,300	452,300	329,400	142,700	42,780	30,720	1,459,000
1940	40,440	55,250	77,050	43,980	38,850	43,270	133,100	320,900	176,400	37,200	19,600	13,750	999,800
1941	43,680	42,380	45,460	43,040	38,130	58,840	181,700	233,000	221,400	95,510	40,700	88,760	1,133,000
1942	169,500	129,800	141,800	110,700	84,140	61,980	172,400	530,700	573,600	241,800	126,900	83,680	2,427,000
1943	83,110	93,760	98,280	68,550	73,130	67,670	224,100	397,700	605,300	333,400	78,110	34,230	2,157,000
1944	40,280	43,470	36,550	30,230	37,760	33,120	56,190	291,900	471,600	123,300	36,940	30,620	1,232,000
1945	46,980	53,130	63,070	73,350	70,080	68,910	79,660	501,000	669,500	171,900	63,300	42,050	1,903,000
1946	68,700	107,500	95,350	86,960	65,300	86,600	176,400	818,900	582,300	242,400	99,290	79,460	2,509,000
1947	89,450	85,980	81,540	70,330	52,830	62,920	175,000	563,300	342,800	107,100	50,680	45,070	1,727,000
1948	73,410	72,790	73,050	77,430	60,430	45,990	96,420	675,000	1,217,000	309,000	241,500	180,800	3,123,000
1949	171,500	152,100	133,500	114,700	100,300	108,700	219,500	954,800	496,000	163,500	82,930	71,230	2,769,000
1950	82,160	130,900	155,300	71,720	87,050	146,500	153,200	538,800	1,152,000	378,200	120,900	57,330	3,074,000
1951	85,090	107,800	144,000	122,000	132,200	124,700	272,700	965,100	690,000	282,600	105,000	98,740	3,131,000

TABLE 8

Monthly and Annual Discharge, in c.f.s., of Similkameen River near Nighthawk, Washington

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1911	-	-	-	-	-	-	-	-	10,500	3,190	1,040	955	-
1912	662	554	518	523	509	425	1,040	7,450	6,130	2,350	964	707	1,820
1913	578	598	507	438	439	443	1,090	6,670	10,600	3,140	976	766	2,190
1914	883	802	568	671	520	595	2,370	8,540	7,140	2,310	671	512	2,140
1915	615	840	553	343	410	452	2,400	4,280	2,980	1,470	914	478	1,320
1916	632	825	461	404	629	1,110	2,160	8,800	13,700	6,880	1,780	884	3,190
1917	592	583	475	429	395	430	539	5,900	11,500	4,460	1,010	509	2,230
1918	441	690	799	1,790	746	661	2,260	8,920	10,100	2,640	1,080	511	2,580
1919	636	658	563	500	444	444	2,100	9,900	9,880	4,080	1,070	584	2,580
1920	453	817	649	602	838	578	619	4,450	7,640	4,600	949	688	1,900
1921	1,610	902	595	537	796	907	1,390	9,210	11,900	2,820	823	643	2,680
1922	911	1,230	1,160	752	663	520	737	6,270	10,800	1,830	726	540	2,180
1923	644	596	418	515	412	416	2,030	8,560	10,700	3,930	1,040	595	2,500
1924	521	462	430	369	871	678	1,110	10,100	4,700	1,420	547	412	1,810
1925	567	613	1,090	768	760	730	3,180	11,200	6,420	1,790	599	407	2,350
1926	348	382	526	402	369	518	2,870	3,160	1,430	555	276	252	925
1927	509	471	368	318	349	373	715	4,600	9,630	2,330	789	1,480	1,830
1928	2,210	1,690	1,440	1,440	1,110	1,050	2,130	12,200	5,200	2,230	645	388	2,660
1929	656	517	371	247	217	345	427	3,960	5,220	1,190	376	269	1,150
1930	330	306	285	215	442	466	3,470	5,230	5,620	1,740	533	391	1,590
1931	416	484	353	352	473	496	911	6,060	2,760	945	328	411	1,170
1932	395	532	387	344	774	1,370	2,290	7,960	6,090	1,650	568	374	1,900
1933	523	1,470	1,070	702	496	531	1,480	6,270	12,200	5,030	1,260	631	2,640
1934	1,595	2,599	1,661	1,302	1,141	2,206	13,510	11,070	5,377	1,516	645	441	3,588
1935	489	1,287	838	779	2,235	1,103	1,315	8,704	9,598	3,675	1,243	617	2,654
1936	498	490	462	405	265	409	2,724	8,003	5,287	1,158	385	323	1,703
1937	311	310	313	218	282	408	594	5,982	11,220	2,680	791	539	1,971
1938	665	963	702	643	535	670	2,536	11,400	8,385	2,108	599	457	2,481
1939	462	458	502	624	424	614	2,513	6,861	5,115	2,084	535	335	1,717
1940	367	575	911	393	440	525	2,060	5,065	2,795	665	295	219	1,194
1941	489	440	418	375	345	575	2,482	3,424	3,378	1,317	587	1,076	1,243
1942	2,180	1,516	1,441	765	661	544	2,396	7,937	8,125	2,489	892	468	2,459
1943	406	474	605	432	590	544	2,964	5,904	9,793	5,128	1,161	540	2,381
1944	473	470	393	327	319	373	922	4,786	6,659	1,815	690	479	1,475
1945	577	578	501	545	635	473	633	7,261	9,423	2,139	604	484	1,990
1946	678	1,152	666	554	491	539	1,954	12,250	8,447	2,987	834	529	2,603
1947	529	521	479	442	518	756	2,969	9,277	5,598	1,612	684	480	1,997
1948	762	837	682	514	466	446	1,131	11,130	17,130	3,668	2,625	1,608	3,413
1949	1,344	926	736	639	580	635	2,809	14,680	7,528	2,283	944	713	2,834
1950	762	1,737	1,898	749	735	735	1,013	7,626	17,980	5,323	1,418	618	3,383
1951	811	1,129	1,637	1,115	1,393	988	3,515	13,980	9,288	3,561	951	851	3,279

Note: Records May 1911 to September 1928 at site 4 miles above Oroville; records of Oroville-Tonasket Irrigation Canal included 1916-1928.

TABLE 9

Monthly and Annual Runoff, in Acre-Feet, of Similkameen River near Nighthawk, Washington

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1911	-	-	-	-	-	-	-	-	625,000	196,000	64,000	56,800	-
1912	40,700	33,000	31,900	32,200	29,300	26,100	61,900	458,000	365,000	144,000	59,300	42,100	1,320,000
1913	35,500	35,600	31,200	26,900	24,400	27,200	64,900	410,000	631,000	193,000	60,000	45,600	1,590,000
1914	54,300	47,700	34,900	41,300	28,900	36,600	141,000	525,000	425,000	142,000	41,300	30,500	1,550,000
1915	37,800	50,000	34,000	21,100	22,800	27,800	143,000	263,000	177,000	90,400	56,200	28,400	952,000
1916	38,900	49,100	28,300	24,800	36,200	68,200	129,000	541,000	815,000	423,000	109,000	52,600	2,320,000
1917	36,400	34,700	29,200	26,400	21,900	26,400	32,100	363,000	684,000	274,000	62,100	30,300	1,620,000
1918	27,100	41,100	49,100	110,000	41,400	40,600	134,000	548,000	601,000	162,000	66,400	30,400	1,850,000
1919	39,100	39,200	34,600	30,700	24,700	27,300	125,000	609,000	588,000	251,000	65,800	34,800	1,870,000
1920	27,900	48,600	39,900	37,000	48,200	35,500	36,800	274,000	455,000	283,000	58,400	40,900	1,390,000
1921	99,000	53,700	36,600	33,000	44,200	55,800	82,700	566,000	708,000	173,000	50,600	38,300	1,940,000
1922	56,000	73,200	71,300	46,200	36,800	32,000	43,900	386,000	643,000	113,000	44,600	32,100	1,580,000
1923	39,600	35,500	25,700	31,700	22,900	25,600	121,000	526,000	637,000	242,000	64,000	35,400	1,810,000
1924	32,000	27,500	26,400	22,700	50,100	41,700	66,000	621,000	280,000	87,300	33,600	24,500	1,310,000
1925	34,900	36,500	67,000	47,200	42,200	44,900	189,000	689,000	382,000	110,000	36,800	24,200	1,700,000
1926	21,400	22,700	32,300	24,700	20,500	31,900	171,000	194,000	85,100	34,100	17,000	15,000	670,000
1927	31,300	28,000	22,600	19,600	19,400	22,800	42,500	283,000	573,000	143,000	48,500	88,100	1,320,000
1928	136,000	101,000	88,500	88,500	63,800	64,600	127,000	750,000	309,000	137,000	39,700	23,100	1,930,000
1929	40,300	30,800	22,800	15,200	12,100	21,200	25,400	243,000	311,000	73,200	23,100	16,000	834,000
1930	20,300	18,200	17,500	13,200	24,500	28,700	206,000	322,000	334,000	107,000	32,800	23,300	1,150,000
1931	25,600	28,800	21,700	21,600	26,300	30,500	54,200	373,000	164,000	58,100	20,200	24,500	848,000
1932	24,300	31,700	23,800	21,200	44,500	84,200	136,000	489,000	362,000	101,000	34,900	22,300	1,370,000
1933	32,200	87,500	65,800	43,200	27,500	32,600	88,100	386,000	726,000	309,000	77,500	37,500	1,910,000
1934	98,080	154,700	102,100	80,050	63,350	135,600	804,200	680,700	319,900	93,240	39,650	26,210	2,598,000
1935	30,060	76,600	51,560	47,930	124,100	67,850	78,260	535,200	571,100	225,900	76,420	36,710	1,922,000
1936	30,620	29,180	28,410	24,920	15,230	25,130	162,100	492,100	314,600	71,210	23,690	19,190	1,236,000
1937	19,120	18,450	19,240	13,410	15,670	25,080	35,330	367,800	667,600	164,800	48,660	32,090	1,427,000
1938	40,860	57,290	43,130	39,550	29,740	41,220	150,900	700,900	498,900	129,600	36,860	27,210	1,796,000
1939	28,410	27,260	30,860	38,370	23,520	37,730	149,600	421,800	304,300	128,200	32,870	19,960	1,243,000
1940	22,570	34,240	56,030	24,160	25,280	32,270	122,600	311,400	166,300	40,920	18,160	13,020	867,000
1941	30,100	26,210	25,700	23,050	19,160	35,330	147,700	210,500	201,000	80,990	36,110	64,000	899,800
1942	134,000	90,190	88,600	47,060	36,690	33,430	142,600	488,100	483,500	153,000	54,860	27,870	1,780,000
1943	24,940	28,200	37,180	26,560	32,780	33,470	176,400	363,000	582,700	315,300	71,360	32,140	1,724,000
1944	29,080	27,960	24,170	20,120	18,320	22,960	54,880	294,300	396,300	111,600	42,430	28,490	1,071,000
1945	35,500	34,370	30,810	33,510	35,240	29,090	37,640	446,500	560,700	131,500	37,160	28,800	1,441,000
1946	41,690	68,570	40,930	34,050	27,290	33,120	116,200	753,500	502,600	183,700	51,250	31,510	1,884,000
1947	32,510	31,020	29,440	27,190	28,790	46,510	176,700	570,400	333,100	99,110	42,060	28,570	1,445,000
1948	46,830	49,820	41,940	31,600	26,810	27,400	67,320	684,500	1,019,000	225,500	161,400	95,660	2,478,000
1949	82,650	55,070	45,260	39,310	32,230	39,070	167,100	902,500	448,000	140,400	58,070	42,420	2,052,000
1950	46,880	103,400	116,700	46,070	40,790	45,180	60,260	468,900	1,070,000	327,300	87,220	36,780	2,449,000
1951	49,850	67,200	100,600	68,590	77,360	60,760	209,200	859,400	552,700	219,000	58,490	50,640	2,374,000

Note: Records May 1911 to September 1928 at site 4 miles above Oroville; records of Oroville-Tonasket Irrigation Canal included 1916-1928.

TABLE 10

Monthly and Annual Discharge, in c.f.s., of Okanagan River at Okanagan Falls, B. C.

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1915	-	-	-	485.0	433.0	426.0	497.0	850	966	857	737	570	-
1916	473.0	451.0	429.0	200.0	270.0	510.0	350.0	770	1,110	1,230	970	650	619
1917	410.0	285.0	265.0	227.0	213.0	223.0	206.0	449	1,050	1,010	671	495	459
1918	410.0	300.0	190.0	190.0	190.0	170.0	195.0	680	1,060	800	450	280	410
1919	205.0	190.0	190.0	170.0	170.0	155.0	195.0	550	1,190	1,050	570	300	410
1920	235.0	230.0	200.0	160.0	120.0	125.0	120.0	165	470	970	510	200	290
1921	178.0	152.0	132.0	130.0	126.0	132.0	193.0	955	2,360	1,540	407	228	545
1922	200.0	190.0	350.0	520.0	500.0	650.0	600.0	770	750	260	215	170	430
1923	250.0e	380.0e	500.0e	540.0e	500.0e	505.0	485.0	725	1,040	900	680	475	582
1924	500.0	484.0	409.0	430.0	522.0	471.0	349.0	385	170	125	110	122	340
1925	104.0	90.0	73.0	62.0	66.0	223.0	628.0	950	475	212	189	165	270
1926	155.0	125.0	138.0	170.0	361.0	628.0	391.0	262	177	127	93	68	224
1927	49.0	48.0	48.0	42.0	250.0	562.0	503.0	591	291	97	140	352	247
1928	734.0	820.0	967.0	1,130.0	1,080.0	1,090.0	1,120.0	1,940	2,580	2,320	1,610	1,080	1,370
1929	971.0	851.0	259.0	45.7	33.4	29.3	34.7	473	347	134	136	72	284
1930	33.8	24.8	9.1	7.7	8.0	10.1	57.0	289	209	110	99	61	77
1931	57.0	48.0	9.6	6.7	6.2	27.1	49.6	86	66	93	88	61	50
1932	47.7	68.0	9.8	38.4	357.0	639.0	677.0	883	846	624	479	458	427
1933	410.0	376.0	640.0	625.0	267.0	386.0	751.0	1,080	1,180	954	747	560	668
1934	562.0	661.0	706.0	719.0	744.0	724.0	946.0	933	818	725	421	343	691
1935	434.0	504.0	481.0	568.0	619.0	660.0	656.0	937	956	866	808	798	691
1936	807.0	792.0	567.0	374.0	251.0	246.0	377.0	790	876	819	647	541	592
1937	554.0	514.0	400.0	233.0	161.0	379.0	634.0	786	915	508	310	273	473
1938	279.0	385.0	599.0	666.0	634.0	598.0	642.0	1,020	751	318	178	197	522
1939	192.0	176.0	221.0	145.0	126.0	189.0	428.0	512	464	390	372	289	293
1940	233.0	209.0	214.0	156.0	65.0	145.0	172.0	200	221	184	154	163	177
1941	167.0	179.0	216.0	230.0	246.0	448.0	415.0	209	310	252	322	424	285
1942	533.0	613.0	756.0	781.0	657.0	215.0	346.0	468	1,070	1,250	1,070	962	727
1943	858.0	891.0	705.0	584.0	409.0	530.0	728.0	732	546	353	225	190	564
1944	164.0	161.0	148.0	138.0	142.0	127.0	121.0	216	735	424	176	147	225
1945	165.0	225.0	580.0	527.0	447.0	578.0	629.0	1,000	1,030	673	522	300	557
1946	466.0	586.0	795.0	611.0	538.0	768.0	806.0	1,240	1,180	1,000	918	890	819
1947	902.0	744.0	710.0	500.0	272.0	137.0	178.0	325	286	203	324	335	411
1948	259.0	274.0	421.0	625.0	326.0	168.0	435.0	904	1,370	1,350	1,400	1,390	745
1949	1,250.0	1,420.0	1,222.0	1,040.0	904.0	844.0	856.0	1,160	735	575	564	565	928
1950	522.0	406.0	389.0	369.0	476.0	835.0	785.0	982	1,170	728	614	478	647
1951	498.0	545.0	646.0	686.0	721.0	836.0	893.0	1,230	1,240	1,180	865	711	838
1952	748.0	765.0	769.0	676.0	777.0	560.0	791.0	1,200	916	806	714	725	788

e - Estimated

TABLE 11

Monthly and Annual Runoff, in Acre-Feet, of Okanagan River at Okanagan Falls, B. C.

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total Acre-Feet
1915	-	-	-	29,800	24,000	26,200	29,600	52,300	57,500	52,700	45,300	33,900	-
1916	29,100	26,800	26,400	12,300e	15,500e	31,400e	21,000	47,000	66,000	76,000	60,000	39,000	449,000
1917	25,000	17,000	16,000	14,000	12,000	14,000	12,000	28,000	63,000	62,000	41,000	29,000	333,000
1918	25,200	17,800	11,700	11,700	10,500	10,500	11,600	41,800	63,000	49,200	27,700	16,000	297,300
1919	12,600	11,300	11,700	10,500	9,400	9,500	11,600	33,800	70,800	64,600	35,000	17,900	298,700
1920	14,300	13,700	12,500	9,750	6,900	7,700	7,150	10,200	28,000	60,000	31,000	12,000	213,200
1921	11,000	9,050	8,100	8,000	7,000	8,100	11,500	58,700	140,000	94,600	25,000	13,600	394,650
1922	12,400	11,300	21,500	31,800	27,600	39,800	35,600	47,400	45,000	16,000	13,200	10,000	311,600
1923	15,400e	22,600e	30,700e	33,200e	27,800e	31,100	28,900	44,600	61,900	55,300	41,800	28,300	422,000
1924	30,700	28,800	25,100	26,400	30,000	29,000	20,800	23,700	10,100	7,690	6,760	7,260	246,000
1925	6,400	5,360	4,490	3,810	3,660	13,700	37,400	58,400	28,300	13,000	11,600	9,850	195,970
1926	9,530	7,440	8,480	10,500	20,000	38,600	23,300	16,100	10,500	7,810	5,720	4,050	162,000
1927	3,010	2,860	2,950	2,580	13,900	34,600	29,900	36,300	17,300	5,960	8,610	20,900	179,000
1928	45,100	48,800	59,500	69,500	62,100	67,000	66,600	119,000	154,000	143,000	99,000	64,300	998,000
1929	59,700	50,600	15,900	2,810	1,850	1,800	2,060	29,100	20,600	8,240	8,360	4,280	205,000
1930	2,080	1,480	560	474	444	621	3,390	17,800	12,400	6,760	6,090	3,630	55,700
1931	3,500	2,860	590	412	344	1,670	2,950	5,290	3,930	5,720	5,410	3,630	36,300
1932	2,930	4,050	603	2,360	20,500	39,300	40,300	54,300	50,300	38,400	29,500	27,300	310,000
1933	25,200	22,400	39,400	38,400	14,800	23,700	44,700	66,400	70,200	58,700	45,900	33,300	483,000
1934	34,600	39,300	43,400	44,200	41,300	44,500	56,300	57,400	48,700	44,600	25,900	20,400	501,000
1935	26,700	30,000	29,600	34,900	34,400	40,600	39,000	57,600	56,900	53,300	49,700	47,500	500,000
1936	49,600	47,100	34,800	23,000	14,400	15,100	22,400	48,600	52,100	50,300	39,800	32,200	429,000
1937	34,100	30,600	24,600	14,300	8,950	23,300	37,700	48,300	54,400	31,300	19,100	16,200	343,000
1938	17,200	22,900	36,800	40,900	35,300	36,800	38,200	62,800	44,700	19,600	10,900	11,700	378,000
1939	11,800	10,500	13,600	8,890	7,000	11,600	25,500	31,500	27,600	24,000	22,900	17,200	212,000
1940	14,300	12,400	13,100	9,560	3,710	8,940	10,200	12,300	13,100	11,300	9,460	9,720	128,000
1941	10,250	10,650	13,280	14,140	13,660	27,520	24,710	12,860	18,460	15,510	19,790	25,240	206,100
1942	32,750	36,480	46,480	48,020	36,490	13,230	20,590	28,760	63,850	76,760	65,580	57,230	526,200
1943	52,750	53,010	43,370	35,920	22,740	32,580	43,320	45,030	32,500	21,720	13,840	11,300	408,100
1944	10,080	9,560	9,090	8,460	8,160	7,800	7,220	13,300	43,740	26,080	10,850	8,770	163,100
1945	10,140	13,370	35,690	32,380	24,810	35,540	37,400	61,490	61,300	41,350	32,070	17,830	403,400
1946	28,670	34,890	48,910	37,540	29,900	47,230	47,990	76,480	70,160	61,480	56,460	52,970	592,700
1947	55,450	44,280	43,650	30,740	15,100	8,430	10,590	19,960	17,000	12,460	19,950	19,960	297,600
1948	15,910	16,290	25,870	38,420	18,760	10,330	25,870	55,560	81,560	83,170	85,960	82,950	540,600
1949	76,610	84,440	75,250	63,850	50,210	51,880	50,930	71,240	43,730	35,340	34,690	33,630	671,800
1950	32,110	24,190	23,950	22,690	26,450	51,370	46,710	60,410	69,440	44,740	37,780	28,430	468,300
1951	30,640	32,430	39,720	42,190	40,030	51,400	53,160	75,910	73,610	72,480	53,160	42,310	607,000
1952	46,000	45,510	47,250	41,570	44,710	34,420	47,080	74,040	54,500	49,580	43,880	43,160	571,700

e - Estimated
Flow regulated by control dam on outlet of Okanagan Lake.

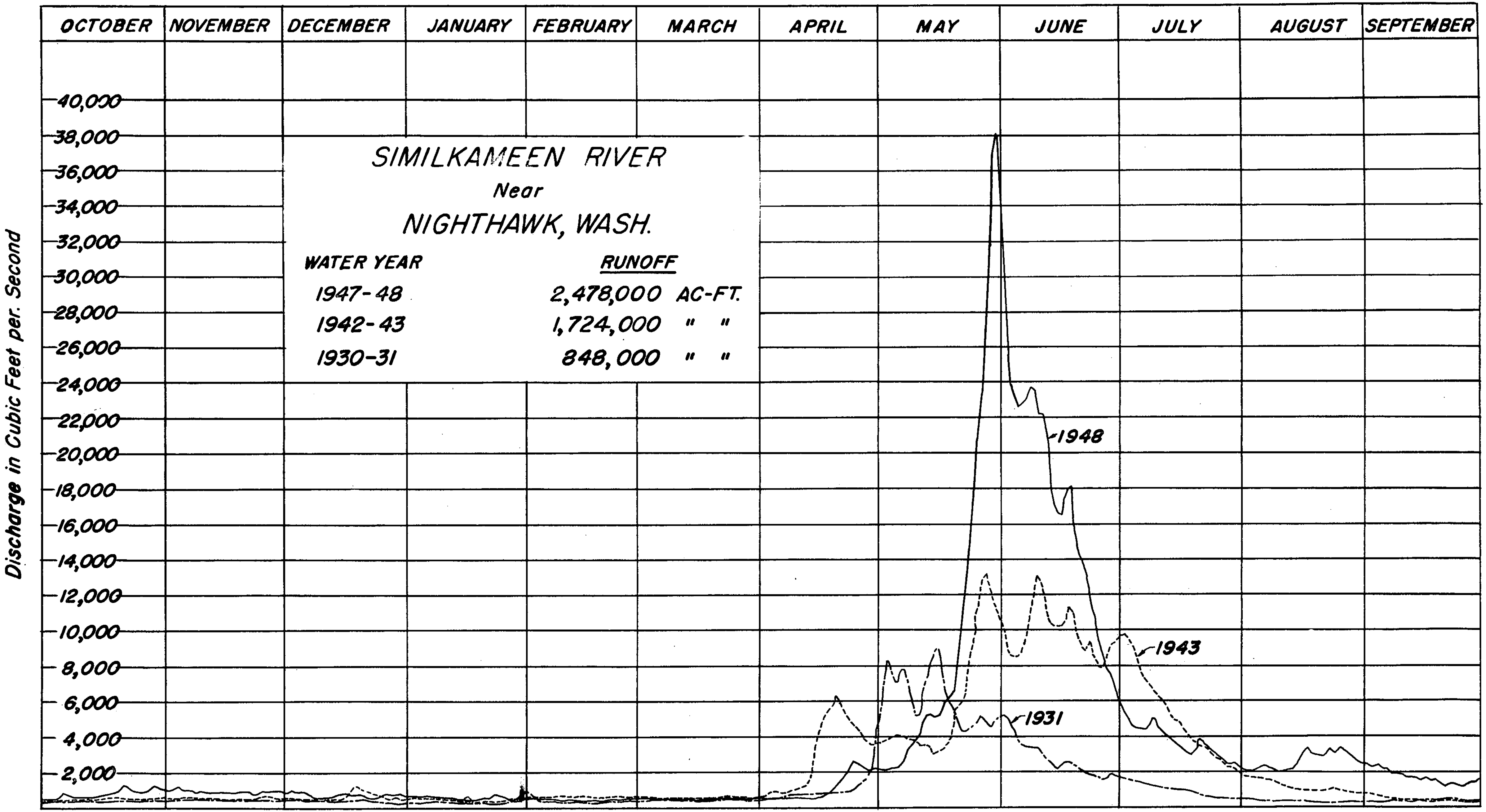

OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
Discharge in Cubic Feet per. Second
40,000
38,000
36,000
34,000
32,000
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
SIMILKAMEEN RIVER
Near
NIGHTHAWK, WASH.
WATER YEAR
RUNOFF
1947-48
2,478,000 AC-FT.
1942-43
1,724,000 " "
1930-31
848,000 " "
1948
1943
1931

Figure 2

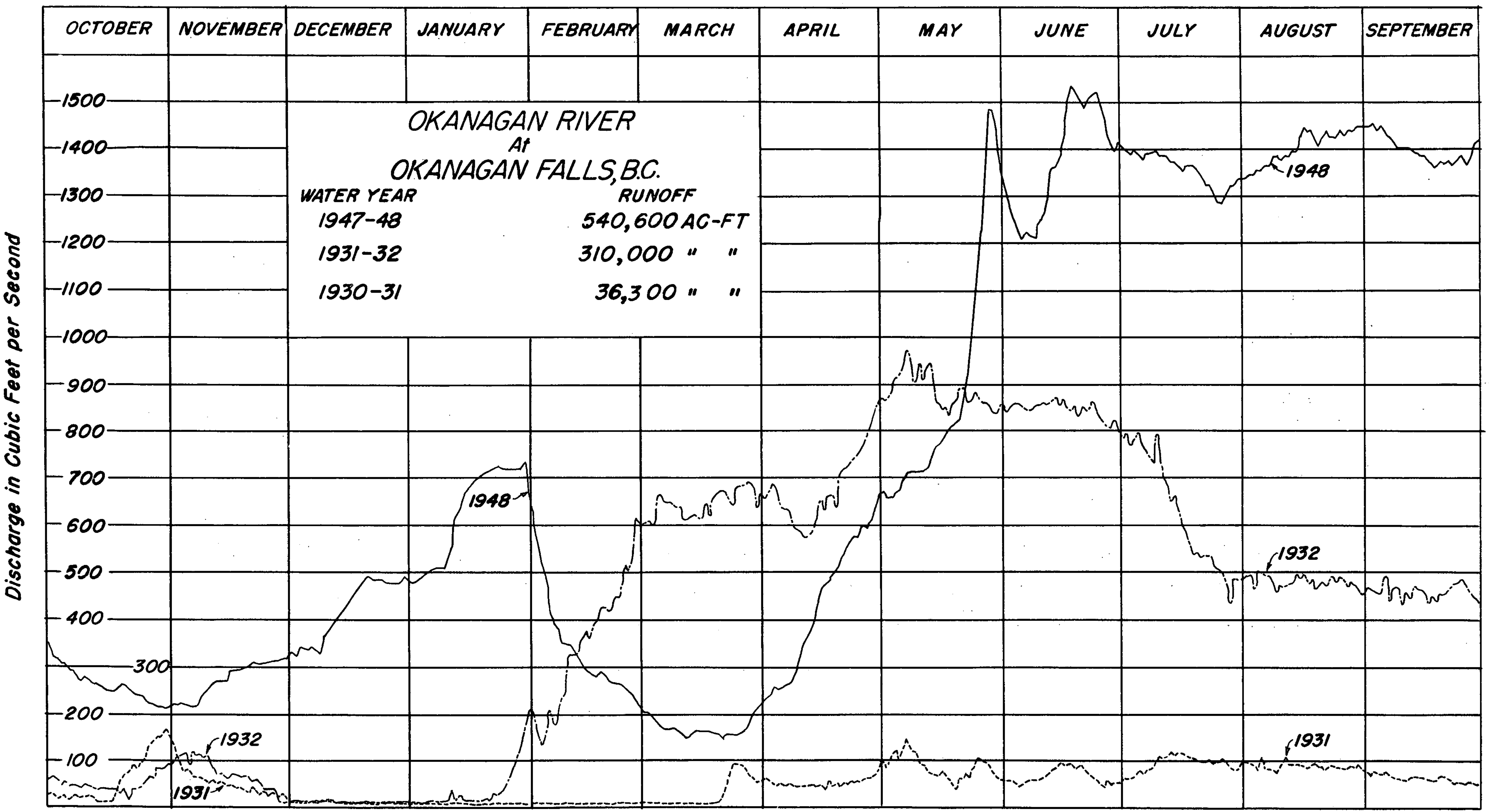

OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
Discharge in Cubic Feet per Second
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
OKANAGAN RIVER
At
OKANAGAN FALLS, B.C.
WATER YEAR
RUNOFF
1947-48
540,600 AC-FT
1931-32
310,000 " "
1930-31
36,300 " "
1948
1948
1932
1932
1931
1931

Figure 3

TABLE 12

Summary of Water Licenses on the Similkameen River and Tributaries

in British Columbia

Purpose	Amount in: Acre Feet	Amount in: Imperial Gallons per day	Amount in: Cubic Feet per Second	Equivalent Total Diversion in c.f.s.: At Point of use	Equivalent Total Diversion in c.f.s.: At Diversion Point (Including Losses)	Remarks
Irrigation						
Full Season	21,354.58		28.00	117.88	153.24	30% loss
Freshet	1,758.45			7.40	9.62	30% loss
Storage						Issued for Power purpose but used for Mining & Domestic
Irrigation	4,605					
Power	3,400					
Domestic		123,850		0.23	0.25	10% loss
Waterworks		2,275,000		4.23	4.65	10% loss
Industrial		29,957,000	1.25	56.89	62.58	10% loss
Mining		242,000	10.50	10.95	13.14	20% loss
Power			37.41	37.41	37.41	no loss
		Total Licensed Diversion		234.99	280.89	
		Total Used Diversion		144.78	174.58	

Note: Diversion losses estimated - subject to revision.

The irrigation period assumed in compiling this table is 120 days.

TABLE 13

Summary of Water Licenses on the Okanogan River and Tributaries

In British Columbia, Excluding Similkameen River

Purpose	Amount in Acre Feet	Amount in Imperial Gallons per day	Amount in Cubic Feet per Second	Equivalent Total Diversion in c.f.s. At Point of use	Equivalent Total Diversion in c.f.s. At Diversion Point (Including Losses)	Remarks
Irrigation						
Full Season	243,351			1,024.20	1,331.46	30% loss
Freshet	3,311			13.92	18.10	30% loss
Storage						
Irrigation	107,476					
Waterworks	6,030					
Industrial	100					
Domestic		721,100		1.34	1.47	10% loss
Waterworks		15,190,408	1.25	29.46	32.41	10% loss
Industrial		1,397,000		2.59	2.85	10% loss
Mining		50,000		0.09	0.11	20% loss
Power			117.35	117.35	117.35	No loss
			Total Licensed Diversion	1,188.95	1,503.75	
			Total Used Diversion	708.32	913.90	

Note: Diversion losses estimated - subject to revision.

The irrigation period assumed in compiling this table is 120 days

TABLE 14

Summary of Water Rights and Current Permits
in the Okanogan River Basin in the United States

Purpose	Similkameen River incl. Palmer Lake	Okanogan River above Similkameen River incl. Osoyoos Lake	Okanogan River below Similkameen River
Irrigation:			
Unrestricted	13.8 cfs	4.63 cfs	142.69 cfs
April 1-15	63.8 cfs		
April 15-30	120.8 cfs		
May 1-31	137.8 cfs		
June 1-30	162.8 cfs		
July 1-31	199.8 cfs		
Aug. 1-31	178.8 cfs		
Sept. 1-30	141.8 cfs		
Oct. 1-15	63.8 cfs		
Power:			
	250 cfs (Primary)		
	750 cfs (Secondary)		
Municipal and Manufacturing:			1.5 cfs
Storage:			
	10,000 ac.ft. (undeveloped)	126 ac.ft. (mill pond)	

II. ECONOMIC DEVELOPMENT

POPULATION

35. The population of the Okanogan and Similkameen Basins in Canada increased from 35,000 in 1931 to 70,000 in 1951, and now constitutes six percent of the population of British Columbia. The rate of growth has been larger in the cities and towns than in the rural areas, and this has been accompanied by a shift in the distribution of labor force away from agriculture to a somewhat more diversified economy. The largest city in the area, Penticton, had a population of 10,584 in 1951; Kelowna with 8,517 was the second in size; and Vernon with 7,822 was third.

36. The British Columbia labor force for this area is employed in the following proportions: agriculture, 27 percent; manufacture and construction, 20 percent; other primary occupations, 6 percent; trade and finance, 10 percent; service industries, 15 percent; and others 22 percent.

37. The population of the Okanogan-Similkameen Basin in the United States, concentrated in narrow valleys with the remote areas virtually uninhabited, is divided between small town and individual farm living. The total population of the basin in 1950 was approximately 23,000. The largest town in the area is Omak, 1950 population 3,791. Okanogan with a population of 2,013 is the second in size, and Oroville ranks third with 1,500. The major trading center for Okanogan, Chelan, and Douglas Counties is Wenatchee, population 13,072, which lies some 96 miles south of Okanogan.

38. In the United States portion of the basin nearly 50 percent of the employed workers are engaged in agriculture, forestry and logging. Processing industries, chiefly sawmills, employ about 10 percent of the total employed labor force, and service industries account for the bulk of the remaining 40 percent.

RESOURCES AND INDUSTRIES

39. The economies of the Similkameen and Okanogan River valleys in Canada differ. That of the Similkameen is dependent upon mining operations, of which copper mining in the Princeton area and gold mining in the Hedley area are the most important. Agriculture, with tree fruit production predominating, is the basis of the economy of the Okanogan valley. The tourist industry is important and is growing in both areas.

40. Agriculture is the primary source of income in the United States portion of the Similkameen-Okanogan Basin, although logging and lumbering and the tourist industry are important phases of the economy.

AGRICULTURE

41. In the Okanogan-Similkameen Basin in Canada, agriculture plays a dominant role. In 1950 the agricultural income was valued at $15,774,000, of which tree fruits accounted for $13,868,000 and vegetables $1,906,000. Apples are the principal tree-fruit crop, and were valued at close to $11 million, while tomatoes and onions constituted nearly half of the value of the vegetable crops. By way of comparison, the total cash farm income for British Columbia was $101,709,000, and of this total tree fruits contributed $21,472,000 and vegetables $6,912,000. In other words, this area produces two-thirds of the provincial tree fruit and nearly one-quarter of the vegetable produce.

42. Dairying has become one of the most important mixed farming operations, and dairy products are now a major source of agricultural

income. To supplement their dairy revenue, a large number of small producers have turned to hog and poultry raising, and are acquiring an impressive quality of breeding stock. Sheep and cattle raising are also important activities, with the larger flocks using the mountain pastures for summer grazing.

43. Agricultural income in the United States portion of the basin is relatively high because of the high income produced by irrigated orchards. In 1949 the average gross income per farm of the specialized orchard variety in Okanogan County was $15,424, which is considerably higher than the average gross income of $1,565 for all farm types in Washington State. Apple production accounts for over one-half of the annual farm income, with livestock and livestock products accounting for a major share of the remaining farm income. Okanogan County is the leading beef-producing county in Washington, and also ranks high in the number of sheep raised. A very favorable condition for the livestock industry results from the presence of mountain meadows and range lands in the area, supplemented by the feed which can be grown locally on irrigated land.

44. The size of farms in Okanogan County, Washington, varies with the type of principal crop. In 1950, of the 2,022 farms in the county, 276 were less than 10 acres and, at the opposite extreme, only 260 were over 1,000 acres. A little less than one-third (606 in all) of the farms received their major income from fruit and nut production, and 487 depended primarily on livestock and livestock products. Nearly all of the orchards are operated by full-owners, although many of the livestock farms are managed by part-owners and tenants.

FORESTRY

45. Douglas-fir accounts for about 44 percent of the 1,628 million board feet of accessible merchantable timber in the Okanogan-Similkameen area of British Columbia. Yellow pine makes up approximately 23 percent, with the remaining 33 percent composed of lodge pole pine, western larch, spruce, silver fir and western red cedar.

46. It is unlikely that the lumber industry in this area can continue the rate of growth experienced in recent years. Existing forest resources are apparently sufficient to maintain current production, but any large increase would seriously deplete existing timber stands unless further merchantable timber becomes accessible.

47. In 1936 the Forest Service classified 67 percent, or 2.2 million acres, of Okanogan County in Washington as forest land and in 1945 the Forest Service estimated that there were 7,615 million board feet of saw-timber on unreserved land in Okanogan County.

48. Ponderosa pine covers two-thirds of the saw-timber lands in Okanogan and Chelan Counties; Douglas-fir, occurring near the upper limits of pine lands, occupies about one-ninth of the saw-timber area. Western larch, white fir, silver fir, white pine and lodgepole pine are mixed in among the Douglas-fir. Much of the Douglas-fir is of low quality and difficult to log because of its remote location.

49. The Forest Service, the Indian Service, and the State Government control most of the forest resources of Chelan and Okanogan Counties. Federal lands available for cutting in 1945 made up nearly 60 percent of the forest land; State lands covered about 7 percent; Indian lands accounted for around 9 percent; and private owners held approximately 19 percent of the forest land. Since 1936 heavy cutting depletion has reduced private ownership of ponderosa saw-timber by almost 9 percent.

50. Public agencies permit cutting only on a sustained-yield basis, and private owners are planning toward this as a means of permanent operations. Much of the national forest in the primitive area in northwestern Okanogan County is reserved from cutting.

51. Sawlog production in Okanogan County was estimated at 91,034,000 board feet in 1950. Although its importance has declined somewhat in recent years as logging operations moved to higher elevations, Ponderosa pine provided the bulk of timber logged. Logging of Douglas-fir is also becoming of major importance.

52. Logging operations are carried on by both sawmills and contract loggers. Most of the logs are hauled by trucks from the woods to the mills.

MINERALS AND MINING

53. The total production in 1951 of all minerals in the Okanogan-Similkameen area north of the international boundary was valued at 9.6 million dollars. The bulk of this mineral production was in copper and gold, primarily from operations in the Similkameen valley. The balance was distributed among silver, lead, zinc, coal, structural materials, and other miscellaneous minerals.

54. Coal production from the Princeton field is declining, and imported coal now supplies much of the local requirements. Quartz is mined at a small property near Oliver, and is shipped to Trail.

55. In the United States portion of the Okanogan River basin, mining is of minor importance. Small amounts of copper, silver and lead have been produced in the past, but there is little current production of any magnitude. Sand and aggregate are produced from several small pits for local use.

56. Known deposits of metallic minerals in the basin include gold, silver, copper, lead and zinc. Non-metallic deposits of dolomite, marl, gypsum, epsom salts and sodium sulfate occur in the basin also. In addition small occurrences of uranium, chromium, nickel, pyrite, talc, garnet and graphite have been located.

MANUFACTURING

57. Manufacturing in the Okanogan and Similkameen valleys in Canada is primarily concerned with processing the local products: wood, fruit, and vegetables. In 1949 the total estimated value of manufactured products in the region was $16,838,832. Fruit and vegetable preparation totaled $5,272,217; sawmills accounted for $4,408,557; wood boxes and baskets brought in $1,481,018; and butter and cheese processing was valued at $1,110,829. The balance of the total value was distributed widely, ranging from printing and publishing, bakery products, machine shops, planing mills, carbonated beverages, bookbinding, furniture, cement products, and miscellaneous other manufactured products.

58. The lumber industry in the region includes production of sawn lumber, shingles, laths, ties, hardwood squares, box shooks, as well as other lumber products. The average size of the sawmills in the area is small; this is because of the numerous mills, both portable and stationary, which operate on a seasonal basis. Actually, a few large mills account for the major proportion of total production. In 1949, 32 percent of the mills produced only 2 percent of the total cut, while 4.1 percent of the firms produced almost 48 percent of the total production. Including some production from the Shuswap Lake area, sawmill production in the region in 1950 amounted to 126 million board feet.

59. In 1949, some 203 firms operated in the area, employing 2,400 people with annual wages and salaries in excess of 4.3 million dollars. Kelowna was the leading producer in the two valleys, with an estimated total of 33 firms producing some 5 million dollars worth of goods.

60. In the United States portion of the Okanogan Basin, nearly all of the logging output is processed locally. In 1948, mills in Okanogan County cut 86.4 million board feet. The largest mill in the area is at Omak. A large portion of the sawmill output is remanufactured into box shooks, which are used in the region for packing local fruit. A considerable proportion of the lumber not used for boxes is remanufactured into sash and doors, screens, special mouldings, basket shooks, furniture parts, frames and other specialties. The eastern states provide the chief market for these mill products.

61. There are two dehydrated food plants in the United States portion of the Okanogan Basin: one in Omak and the other in Oroville. The primary raw material of these operations, which supply seasonal employment from August through December, is apples. A vinegar and pomace plant is located in Oroville. Surplus apples and apple peelings provide the raw material for this operation.

FISH

62. A number of lakes and streams in the Okanogan and Similkameen Basins are famous for sports fishing. This activity plays an important part in the economy of the area.

63. It has been estimated by the United States Fish and Wildlife Service that, of the total annual average catch of thirty million pounds of Columbia River salmon of all species, about 180,000 pounds are Okanogan River blueback salmon, valued at $90,000 gross. Very few of these fish are taken by Canadians and, for this reason, Canada has no commercial interest in the run in the Okanogan River.

RECREATION

64. Recreation facilities in the Canadian portion of the basin are plentiful and diversified. The Provincial Government operates Manning Park and Silver Star Park, as well as numerous camping and picnic sites. Tourist facilities are considered adequate.

65. The mountainous portions of the Okanogan Basin in the United States contain many streams and lakes, affording ample opportunity for fishing, hunting, camping, hiking, and picnicking and, to some extent, winter sports. These portions are contained largely in the Chelan National Forest. Construction and administration by the United States Forest Service of roads, trails, camps and picnic grounds, summer home sites, and other facilities are intended to keep pace with increased demands for such facilities. Conconully State Park, containing 12 acres, lies within the basin.

POWER

66. Electric power is available throughout most of the populated portion of the area in Canada. In the area north of the hamlet of Winfield, a few miles north of Kelowna, and in the Peachland and Westbank area, power is supplied by the British Columbia Power Commission from the Whatshan plant on Lower Arrow Lake. The Commission has carried out an extensive program of rural electrification, and has indicated that it has some 25,000 horsepower potentially available for further expansion.

67. In the area south of Winfield, power is supplied by the West Kootenay Power and Light Company from plants on the Kootenay River. The company has also indicated that it has additional power available for industry.

68. In the United States, the surrounding area is outstanding with respect to both developed and undeveloped hydro-electric power resources.

Grand Coulee Dam with an installed capacity (name-plate rating) of 1,944,000 kw. and Chief Joseph Dam with an installed capacity (name-plate rating) of about 1,024,000 kw.,Rock Island, Chelan Falls, and other smaller plants together account for most of these resources. The Okanogan County Public Utility District No. 1 distributes power to the Okanogan valley from a 3,200 kw. hydroelectric plant on the Similkameen River. A 115-kv. Bonneville Power Administration transmission line extends up the valley to Tonasket, and the Administration supplies the bulk of the power for distributors in the area. Approximately 78 percent of the farms in Okanogan County have electric service and 57 percent have telephones.

TRANSPORTATION AND COMMERCE

69. Transportation facilities in the Okanogan-Similkameen area are among the best in British Columbia. Many of the localities in the area are served by all principal methods of transportation. The water transportation in the region is confined to Okanagan Lake, and consists of a car-barge service between Penticton, Kelowna, and other points, and an automobile-ferry service between Kelowna and Westside. The average number of box cars moved by the car barges during the past 5 years was 12,000 per year.

70. Three railroads serve the area: the Canadian Pacific Railway, which serves all of the major points; the Canadian National Railway, which serves the northern part of the Okanogan valley as far south as Kelowna with a barge service to Penticton; and the Great Northern Railway, which serves southern points in the Similkameen valley.

71. An extensive system of roads exists in the area, which is utilized by truck-freight and bus lines. Highway No. 97 runs north from the international boundary through the northern part of the basin. The east-west Highway No. 3 facilitates the exchange of goods with the coastal region of the Province. There is a very extensive network of country roads, most of which are unimproved.

72. There are six airfields in the Canadian section of the basin. There is one scheduled airline service into the area using the airport facilities at Penticton. There are several non-scheduled charter airlines located in the area, operating principally out of Kelowna and Vernon.

73. The only commercial railroad service in the Okanogan-Similkameen region in the United States is furnished by a Great Northern Railway branch line extending north along the Columbia and Okanogan Rivers from Wenatchee to Canada.

74. The populated valleys are well served by paved highways; U. S. Highway 97, the Okanogan-Caribou Trail, parallels the Columbia and Okanogan Rivers north from Wenatchee to Canada. State Highway 10-A connects Omak and the Grand Coulee Dam area, and a paved highway joins Tonasket, on U. S. Highway 97, with Republic in Ferry County., In addition, county roads, many of which are hard-surfaced, extend through most of the inhabited areas of the basin.

75. Several interstate and intrastate truck lines serve the Okanogan valley. These lines provide overnight freight service from Portland, Seattle and Spokane to both valleys. Bus lines provide passenger service to the area.

76. There are fifteen airfields in Okanogan County, most of them being municipal fields of the towns in the area. In addition to these fields, the Forest Service has built landing strips in the more remote areas for fire-fighting purposes. There is no scheduled airline service into Okanogan County from outside areas.

PUBLIC LANDS AND RESERVATIONS

77. There about 2,880 square miles within the Similkameen drainage basin in British Columbia, of which some 618 square miles are privately owned. There are some 176 square miles within parks or park reserves Indian reserves total 28 square miles, and various miscellaneous reserves cover 17 square miles. This leaves approximately 2,041 square miles of vacant Crown land.

78. In the Okanogan drainage basin in British Columbia there are 3,120 square miles, of which approximately 729 square miles are privately owned. Forest reserves include 1,931 square miles, parks or park reserves cover 18 square miles, Indian reserves account for 165 square miles with another 12 square miles falling within miscellaneous reserves. There are approximately 265 square miles of vacant Crown land.

79. The Okanogan Basin in Washington is bounded on either side by National Forests. The western slope of the basin is contained in the Chelan National Forest, and much of the eastern part of the basin is included in the Colville National Forest.

80. The entire southeastern portion of Okanogan County north of the Columbia River and east of the Okanogan River is part of the Colville Indian Reservation. About 500,000 acres of the Reservation lie within the Okanogan Basin.

EXISTING AND AUTHORIZED DEVELOPMENT

81. The construction of an experimental control dam at the outlet of Okanagan Lake was completed in March 1915. The purpose of this dam was to maintain the level of Okanagan Lake as nearly as possible at, but not below, natural low-water level, and to assist in regulating the flow of the Okanogan River. The sill elevation was 97.0 (P.W.C. datum) and the top of dam elevation was 101.0 (P.W.C. datum). (Note: El. 100.0 Public Works of Canada datum equals 1120.70 feet above sea level, Geodetic Survey of Canada 1934 datum, and 1121.28 feet G.S.C. datum, Publication 24, 1951 edition).

82. Following complaints regarding the effect of this dam on the levels of Okanagan Lake, a further investigation brought forth the recommendations in the Brydone-Jack report of 1917:

"(a) That the water level in Okanagan Lake be maintained as nearly as possible between the elevations of 100.0 and 102.75 as referred to the datum of the Department of Public Works."

"(b) That the control dam at the outlet of Okanagan Lake be so maintained as to store the surplus water of June and July for discharge during the dry season from August to March, thus giving a fair flow in the Okanagan River."

83. A second control dam to replace the first or experimental dam was started in January and completed in October 1920. The sill elevation of this dam on the upstream side was 97.0 and the top elevation was 102.0.

84. The existing control range, between the low level of elevation 99.5 and a high level of 102.5 was agreed to following the flood of 1921 and in 1922 the control dam was raised to permit control up to 102.6.

85. The following tabulation shows the high and low water elevations and variation for the period of record for the years when high water was

above elevation 102.5, the point at which flood damage occurs:

	Year	High Water Elevation	Low Water Elevation	Variation in Feet
Pre-control years	1904	107.00	No Record	-
	1912	103.80	99.70	4.10
	1913	103.65	No Record	-
	1914	103.20	99.70	3.50
Experimental control dam	1921	103.60	100.70	2.90
Second control dam	1923	103.15	99.70	3.45
	1928	104.50	100.45	4.05
	1934	102.65	99.50	3.15
	1935	102.60	99.15	3.45
	1936	102.80	99.60	3.20
	1942	104.15	99.85	4.30
	1945	102.70	99.30	3.40
	1946	103.89	99.26	4.63
	1948	104.88	99.25	5.63
	1951	103.36	99.28	4.08
	1953	102.57	99.64	2.93

86. Following the flood year of 1942, the Joint Board of Engineers Okanagan Flood Control, was established to study the problems in Canada and to propose a plan for the control of flood damage along the Canadian section of the river. After a full investigation of the problem, the Joint Board of Engineers recommended reconstruction of the Okanagan Lake Control Dam to operate through a normal range from elevation 98.5 to 102.5 feet, a control dam at the outlet of Skaha Lake, and substantial river-channel improvements between Okanagan and Osoyoos Lakes.

87. The first portion of the Okanagan Flood Control Project, which includes dams at the outlets of Okanagan and Skaha Lakes and river channel improvements between the two lakes, is complete. Work is proceeding on the improvement of the river channel between Skaha Lake and the Oliver Intake Dam and will be completed in 1955. The reconstruction of the Oliver Intake Dam is complete. Work is proceeding on the remainder of the improvements, and the entire project will be complete in 1957.

88. In the Similkameen valley in Canada there are four irrigation districts and one water-users community. These supply water for 2,180 acres of land. In addition, there is a total of 4,345 acres being irrigated in numerous individual farms, making a total irrigated acreage in the Similkameen valley of 6,525 acres. The total licensed quantity

of water amounts to 29,765 acre-feet, and the total licensed acreage 10,740 acres. Of this amount the total licensed storage for irrigation existing at present amounts to 4,605 acre-feet, of which 3,755 acre-feet are developed.

89. In the Okanogan valley in Canada there are 29 irrigation districts and 17 water-users communities which together supply water for 40,900 acres of land. In addition there is a total of 17,400 acres being irrigated in numerous individual farms, making a total irrigated acreage in the Okanogan valley of 58,300 acres. The total licensed quantity of water amounts to 246,660 acre-feet and the total licensed acreage is 84,770 acres. Of this amount the total licensed storage for irrigation purpose is 107,480 acre-feet, of which 85,910 acre-feet are developed. The combined total acreage for the Okanogan-Similkameen Basin in Canada is 95,510 acres under license, of which 64,825 acres are being irrigated.

90. The one existing Federal project in the United States portion of the basin is the Okanogan Irrigation Project of the Bureau of Reclamation. Located in the central portion of the basin, the project lands totalling some 4,300 acres are on a series of benches between the river and the Okanogan Range. Water for the project is supplied by Salmon Creek, Duck Lake, and the Okanogan River. The reservoirs supplying storage for it are Salmon Lake with 10,500 acre-feet of active storage, and Conconully Reservoir on Salmon Creek with 13,000 acre-feet. Other reservoirs in the Okanogan Basin include Blue Lake on Sinlahekin Creek with 2,500 acre-feet, and Spectacle Lake in the Whitestone Coulee with 3,900 acre-feet.

91. In addition to the Okanogan Project, there are about 18,000 acres of privately developed irrigated lands in the United States portion of the Okanogan-Similkameen Basin. Nearly half of the irrigated acreage is included in the Oroville-Tonasket Irrigation District (formerly West Okanogan Valley Irrigation District) which, according to district officials, has a total area of 12,294 acres and an irrigable area of 8,682 acres. This district has a gravity supply from Similkameen River. The only other sizeable district is the Whitestone Irrigation District which includes some 1,500 acres irrigated from Toats Coulee Creek. Gravity water supplies from various tributaries and pumping from the Okanogan River supply the balance of the irrigated land.

92. Two soil conservation districts, embracing a total of 1,161,000 acres, have been established in the United States portion of the Okanogan Basin.

93. The only important existing hydro-electric power development in the United States portion of the basin is the plant of Okanogan County Public Utility District No. 1 (formerly Okanogan Valley Power Company) on the Similkameen River some five miles above Oroville. This run-of-river plant has an installed capacity of 3,200 kilowatts, and operates under a maximum head of 78 feet.

94. Zosel Dam, located about 1-1/2 miles downstream from Osoyoos Lake, constitutes an obstruction in the Okanogan River channel. It was constructed in 1927 to form a pool for storing sawlogs. Its effect on Osoyoos Lake levels, prior to 1948, varied according to the discharge of the Okanogan, the magnitude of the debris cone at the mouth of Tonasket Creek, the level of Osoyoos Lake, and the amount of backwater from the Similkameen. The discharge capacity of the dam was increased in 1948 in compliance with an order of the International Joint Commission, and its present effect on Osoyoos Lake levels is small (see para. 105).

WATER LAWS

95. Coordinated planning of water resource projects is influenced to some extent by the water laws applicable to the area in which the project is located or which is affected by the project. Except for navigation, which is under the jurisdiction of the governments of the United States and Canada, legal control of water is vested in the various states and provinces.

96. The proposed compact among states that include portions of the Columbia River basin, if concluded, may also have some effect upon projects discussed in this report.

97. In British Columbia, diversion of water is prohibited unless the user holds a provincial water license; common-law rights of riparian owners are not recognized. The province maintains strict control of all licenses, which require beneficial use and payment of annual rental fees.

98. In the state of Washington, the appropriative doctrine is followed. Priority of right is established by priority of beneficial use; in other words, first in time is first in right.

III. PROBLEMS

INTERNATIONAL

99. The development of this basin involves projects which affect both Canada and the United States. The specific problems outlined here are subjects of international interest.

100. Okanagan Flood Control Project. - Certain objections were raised to this project by United States interests on the grounds that the spawning areas in Canada of the blueback salmon run would be adversely affected by the work. This salmon run is the result of the successful transplanting of this species to the Okanogan River when access to their normal spawning grounds in the Upper Columbia was blocked by the construction of Grand Coulee Dam in the United States. The question was referred by the governments of the two countries in May 1951 to the International Joint Commission, and was reported on by the Board in July 1951. In February 1952 the Commission signed an order authorizing the carrying out of the project, with a recommendation that a study of the fish problem be made before carrying out the work below the Oliver Intake Dam, to ensure the least possible damage to the spawning beds.

101. A report was published in April 1954 by the technical staffs of the United States Fish and Wildlife Service, the Washington State Department of Fisheries, and the Department of Fisheries, Canada. This report indicated that, if the principal spawning beds, which lie approximately one mile below the Oliver Intake Dam and occupy a reach of approximately one mile of river, could be left undisturbed; and, if the thirteen drop structures could be modified so that the drop of three feet at each was taken in three steps instead of one single step, the blueback salmon run would be adequately safe-guarded. These modifications have been agreed to, and the project is proceeding on this basis.

102. Certain questions were also raised by United States interests regarding the effects of the operation of the flood-control project on the flow of water at the international boundary. As a result of these questions, the International Joint Commission requested the International Columbia River Engineering Board to carry out a study of these effects. A report covering this study was submitted to the Commission at its meeting in October 1952. The study was made for the period of April 1947 through June 1949, assuming that the proposed flood-control works in Canada were in operation and that Osoyoos Lake outlet conditions were as they existed in 1948 and 1949, following the channel improvements performed in March and April 1948. This study indicated that the operation of the flood-control project would have no major adverse effects on the flow of water at the international boundary.

103. Proposed Shankers Bend Dam. - In order to alleviate flood damage along the Okanogan River caused by flood flows of the Similkameen River, and also to obtain power and irrigation storage, a proposal has been made for the construction of a multiple-purpose dam at Shankers Bend on the Similkameen River in the United States, which would back water upstream to the vicinity of Cawston in British Columbia.

104. Irrigation Requirements on the Similkameen River. - The Cawston Project was the subject of a directive from the International Joint Commission in October 1947. An interim report on the Similkameen River was submitted to the Commission on April 7, 1949. The directive was concerned with the effects of the diversion of water in Canada for water-using purposes on the existing or vested rights of downstream users in the State of Washington, and also with the effects upon the natural flow of the Similkameen River of any proposed further diversions of the river in either country for irrigation or other purposes.

105. Osoyoos Lake Flood Problem. - Damage from flooding occurring around Osoyoos Lake and on the Okanogan River below Osoyoos Lake occasioned an application by the State of Washington to the International Joint Commission for an investigation into the effects of the Zosel Dam and of river bars on the levels of the water in the lake and river. These levels are sometimes increased by the backwater effects of the floods in the Similkameen River. The Commission held a public hearing in July 1943, and immediately thereafter appointed a special Board of Engineers to investigate and report on the problems together with recommendations for their solution. The Board submitted its report to the Commission in March 1946.

106. Following further public hearings, the Commission issued an order dated September 12, 1946, requiring revision of the Zosel Dam to provide greater spillway capacity and setting forth the manner of operation. At that time the Commission appointed an International Osoyoos Lake Board of Control to ensure the carrying out of the Commission's order.

107. By February 1948 the alterations to the dam were completed and by April of that year, channel-rectification work was completed. The channel-rectification work was largely nullified by succeeding floods.

NAVIGATION

108. The navigation needs of the Canadian portion of the basin are adequately served by the controlled elevations of Okanagan Lake provided for by the Okanagan Flood Control Project.

109. Although the Okanogan River in the United States is classified as a navigable stream for about 50 miles from its mouth, no commercial navigation has been practised on it since the completion of the railroad from Wenatchee to Oroville in 1914.

FLOOD CONTROL

110. Damaging floods of various magnitudes have occurred around Okanagan Lake and along the Okanogan River in Canada in 1894, 1921, 1923, 1928, 1934, 1935, 1936, 1942, 1945, 1946, 1948, 1951, and 1953. Serious damage has occurred in the cities of Kelowna and Penticton, and along the entire length of the river, but no estimates of the damages sustained in these floods are available. Local floods have also occurred at various times on the Similkameen River and other tributary streams.

111. In the United States, except for the narrow strips of bottom land adjacent to the river, most of the basin below Oroville is susceptible to flood damage only during extreme high flows. Severe floods occurred in 1894 and 1948, and lesser ones occurred in 1934 and 1949. The valley communities of Oroville, Tonasket, Omak, Okanogan, and Malott all are subject to flood damage. Above Oroville the lowlands adjacent to Osoyoos Lake are flooded frequently at high lake stages. Damaging floods of various magnitudes occurred in this area in the years 1894, 1928, 1934, 1938, 1942, 1945, 1948, 1949, 1950, and 1951. This area is damaged not only by direct flooding, but also by the attendant rise in ground-water levels.

112. In the United States, the Okanogan River falls only about two feet per mile, and flood damages result generally from inundation rather than from erosion. The major portion of the run-off occurs in the spring and summer, and the highest discharges may normally be expected in April, May, and June. As a result, major floods cause considerable damage in low-lying cultivated fields and orchards. Field crops are destroyed, and, in some instances, cannot be replanted because of the

lateness of the season. The flooding and resultant rise of the ground-water levels in low-lying orchards tends to kill the fruit trees or adversely affect the fruit crop.

113. Flooding around Osoyoos Lake has been caused to some extent by restrictions at its outlet, at Zosel Dam (see para. 94 and 105) and at the mouth of Tonasket Creek; it has also been caused by backwater from the Similkameen River during extreme high flows on the latter. The lake outlet has been restricted in the past by the deposition of silt and sand, possibly as a result of wave action. Enlargement of the outlet to correct this situation was undertaken in 1947, and again in 1952, by the Federal Government. The probabilities are that the need for this sort of corrective action will continue.

114. A natural obstruction exists in the Okanogon River channel about one mile below the outlet of Osoyoos Lake at the mouth of Tonasket Creek. This creek has a steep gradient; and, although it is dry during most of the year, during freshets it carries a large bedload of sand, gravel, and boulders, which it deposits in a debris cone in the Okanogan channel. This cone obstructs the flow of the Okanogan to varying degrees, depending upon the state of balance that exists between the eroding action of the river and the magnitude and frequency of the depositions by the creek. In March 1939, the main river channel was dammed so completely by this cone that the river broke through its right bank. The creek also causes damage during these freshets by overflowing its banks and depositing portions of its bedload in the adjacent orchards. The river channel at this point was dredged by the United States Government in 1947 and again in 1952. However, another freshet, carrying a very heavy bedload, has occurred since the last work, and the debris cone is approximately of the same magnitude as before.

115. The Similkameen River has, at various times, flooded low areas around Oroville. Occasionally, it has caused the Okanogan River to reverse its direction and flow north into Osoyoos Lake, thereby causing damage on both sides of the boundary.

116. Damages caused during the 1948 flood, in addition to a heavy crop damage, included the loss of several bridges, damages to highways, buildings, and utilities in rural areas, and damages to urban property in practically all of the communities in the valley. A detailed appraisal of damages from this flood was made in 1948 and 1949. At the same time, determinations were made of the high-water profiles of the 1894 and 1934 floods, and damages that would result from them were estimated on the basis of 1948 economic conditions. On the basis of these investigations, it was estimated that the following damages would be caused in the United States by future floods of equivalent magnitudes on Osoyoos Lake and Okanogan River and on Similkameen River below Shankers Bend:

Year	Discharge in c.f.s. (gage near Tonasket)	Damage (1948 prices and economic conditions)
1894	47,000	$4,465,000
1934	26,600	315,000
1948	40,900	1,516,000
Point of zero damage	11,200	0

When combined with the estimated discharge-frequency relationships of the river, the above data indicate that the total annual flood damage for the Okanogan-Similkameen Basin in the United States is about $171,000 (1948 prices and economic conditions).

POWER

117. As previously indicated, the supply of power available to the Canadian portion of the basin is adequate for current and anticipated needs, and no power problem exists in that area at present.

118. The power problem of the United States portion of the basin is not that of meeting needs of its local economy; but, instead, it is that of developing and utilizing the power-generating capabilities of its waters for the needs of the Pacific Northwest. Dams are in existence, are under construction, or are planned to develop a major portion of the head of the Columbia River from the mouth of the Okanogan to tidewater. The potential storage reservoirs in the Okanogan Basin could so regulate the flow that these dams would maintain a greater prime power to meet the mounting demand for power. This demand has exceeded the available supply since about 1947, and indications are that this condition will continue in this area.

IRRIGATION

119. Scant precipitation, abundant sunshine, and a relatively long growing season are characteristic of the climate of the Okanogan-Similkameen Basin, and demonstrate the need for irrigation for successful agriculture.

120. Because the total of the existing rights and permits on the Similkameen River exceeds the late summer flow, any further diversions of water, except during a freshet period, would appear to depend upon the provision of storage.

121. Much of the potentially irrigable land in the basin is on benches that are fairly high above the river; therefore it will be necessary to pump water to many of these areas which cannot be reached by gravity canals.

RECREATION

122. Recreation facilities in the basin appear to be adequate at present. It is probable that, in both countries, development of new storage facilities in the basin will take into consideration any accompanying recreational possibilities.

LEGAL CONSIDERATIONS

123. Projects in the Okanogan-Similkameen Basin involving the development of water resources are subject to applicable laws of the local and federal governments under which they are authorized and constructed. In Canada, such projects are subject principally to the water right laws of British Columbia, as the federal government is concerned principally with navigation and, in specific instances, to a lesser extent with flood control. In the United States such projects are subject to water right and other laws of the State of Washington, and, if they involve federal authorization or other participation, to a lesser extent with federal laws and regulations.

124. Projects in the Okanogan-Similkameen Basin involving the development of water resources will be subject to the laws of the province of British Columbia, the State of Washington, the Government of Canada and the Government of the United States. In addition, those projects involving waters crossing the boundary would be subject to certain

Articles of the Boundary Waters Treaty of 1909, and would require the approval of the International Joint Commission.

125. A few projects considered in this appendix -- principally in the Similkameen Basin in Canada -- involve encroachment on or use of Indian Reserve Lands, presenting legal difficulties.

IV. APPRAISAL OF WATER AND STORAGE REQUIREMENTS

POWER

126. Additional storage in the Similkameen Basin, up to the maximum which would provide for complete regulation of the Similkameen River, would increase the power output, both at-site and downstream. A preliminary study of downstream power produced by storage on the Similkameen River near Keremeos indicates that storage in excess of 600,000 acre-feet would produce decreasing amounts of downstream power per unit of storage, although storage up to the amount of the annual runoff would produce significant amounts.

127. The only hydro-electric power development in the basin at present is the small plant of the Okanogan County Public Utility District, located below the principal irrigation diversion in the basin -- that of the Oroville-Tonasket Irrigation District. Since this plant would doubtless be replaced or reconstructed if major storage were provided above it, no attempt has been made to compute storage requirements for meeting its primary or secondary rights or its hydraulic capacity.

128. However, in computing storage requirements for other uses, recognition of these rights would be made by requiring future developments to depend on storage after the spring flood. In this manner, the rights of the plant would be protected. In addition, irrigation releases from storage above the power plant, for those points of diversion below the plant, would be usable through the power plant.

IRRIGATION

129. The arable lands in the Similkameen valley in British Columbia and along the Similkameen and Okanogan valleys in the United States have been segregated into three classes according to the suitability for irrigation.

130. Lands designated in Class 1 are highly suitable for irrigation farming, being capable of producing sustained high yields of a wide variety of climatically adapted crops. The soils are deep and light-textured to medium-textured, with a mellow, open structure that allows easy penetration of roots, air, and water. They have free sub-drainage and good water-holding capacity. Surface layers are neutral and subsoils are mildly alkaline. These lands commonly occupy higher terrace and coulee areas, are smooth-lying with gentle slopes, and are nearly free of surface rock. Both soil and topographic conditions are such that no specific drainage requirements are anticipated to accompany irrigation development, no erosion problems are likely to arise, and land preparation costs will be low.

131. Class 2 lands are less desirable for irrigation farming than are the Class 1 lands because of deficiencies in soils or less favorable topography, or both. These lands are less productive, require more preparation for irrigation, and will be more costly to farm. Their water-holding capacity is lower, as indicated by light-textured or shallow soils. Surface layers generally are neutral and leached of carbonates, subsoils are calcareous and mildly alkaline, and the soluble salt content is low. Topographic limitations are uneven surfaces and short, moderately steep slopes. Surface rock in places may require removal.

132. Class 3 lands are inferior in productive capacity to Class 2 lands because of greater deficiencies in soil and less favourable topography or because of their occurrence in areas subject to high watertables.

133. The arable lands are well adapted to the production of a variety of irrigated crops, but economic considerations preclude use of the better lands for other than such relatively high income crops as

tree fruits. Adaptability of Class 1 lands to orchard crops is indicated by the satisfactory size and vigor of trees growing on irrigated portions of these lands. Profitable fruit production likewise is obtainable from orchards on Class 2 lands in non-frost areas, subject however to somewhat lower yields owing to shallower or lighter soils and to higher production costs because of greater water and fertilizer requirements and less favourable topography. Because of shallow, porous soils or seasonal high watertables, Class 3 lands are best adapted to forage crops, although where these lands are irrigated, apples are a major crop.

134. In the Okanogan valley in Canada the lands have been segregated into five classes, based on their arable and irrigable suitability, from Class 1, which is most superior, to Class 5, which is the least suitable for development.

135. Class 1 lands have deep, uniform, alluvial, glacio-lacustrine and glacial-till soils of medium to medium-heavy texture, including sandy loams, silt loams, and silty-clay loams. Topography is good and there are very few stones. Class 1 lands have desirable structure and other profile features and none or very slight deductions for alkali, topography, etc. This class represents the most desirable irrigation soils, capable of producing all irrigated crops in any given climatic regime.

136. Class 2 lands have less uniform soils of the same types as in Class 1, including well-drained, glacio-lacustrine clays. Most of the Class 2 lands will have similar crop adaptations to those of Class 1, but are rated down because they are less uniform, require stone clearing, or have some other limitation.

137. Class 3 lands have heavy clays with fair to good drainage, and include gravelly river channels and terraces with a comparatively stone-free soil. These lands have a more limited range of crop adaptation than the first two classes, or are more difficult to irrigate.

138. Class 4 lands have heavy clays, with alkali subsoil, have flat topography with slow or impeded drainage, and include all lands with depressional topography that are subject to flooding. These lands require drainage, and are placed in Class 4 until feasibility of drainage is determined. When drained, such lands may go to a higher class. Thin, gravelly, glacial river-terraces and channel-bottoms are placed in Class 4, also.

139. Class 5 lands have shallow soils and rough topography, and include all other lands of very limited use that may be irrigated for rough pasture. Such lands may not be worthy of any development under present conditions, yet may in time have limited use when land is at a premium.

140. In the Similkameen Basin in Canada, the estimate of irrigable lands on valley bottoms and terraces along the main stem and tributaries amounts to 45,468 acres, of which 10,740 acres are covered by existing licenses (see Plate 3). Some 9,491 acres are classed as orchard land, and the balance of 35,977 acres is better suited for the production of field crops. The area southward from the vicinity of Keremeos is one of the warmest and driest in Canada, and in this section the well-drained lands are suitable for the production of tree fruits. Such lands are scarce and are, therefore, highly valued. The poorly drained river bottoms, however, should be used for pasture and shallow-rooting crops.

141. Complete development of the irrigable land would require the diversion of about 172,400 acre-feet of water annually. Of this amount, licenses have been issued for the application of 29,777 acre-feet, requiring the diversion of about 38,700 acre-feet. The distribution of the lands and their water requirements are shown in Tables 15 and 16.

TABLE 15

Summary of Irrigable Acreage and Water Requirements
Similkameen Valley in Canada

Irrigable Acreage

	Class 1	Class 2	Class 3	Unclassified Irrigable & Arable	Total
Bench Land	3,909	10,315	6,718	-	20,942
Bottom Land	3,582	14,071	3,548	-	21,201
Additional Bench and Bottom Land	-	-	-	3,325	3,325
TOTAL	7,491	24,386	10,266	3,325	45,468

Water Requirements

	Acres	Water Duty Feet	Total Requirement Acre-Feet	Total Diversion Acre-Feet
Orchard	9,491	4.5	42,710	55,523
General Farming	32,652	2.5	81,630	106,119
Unclassified Land	3,325	2.5	8,312	10,805
TOTAL	45,468		132,652	172,447
Under License: Full Season	10,244		28,019	36,425
Freshet	497		1,758	2,285
Future Requirement	34,727		102,875	133,737

TABLE 16

Irrigable and Presently Irrigated Lands

Similkameen Basin in Canada

Unit	Acres							
	Now Licensed	Irrigated and Irrigable Land					Irrigated	Potential Irrigable
		Class 1	Class 2	Class 3	Additional Unclassified	Total		
Boundary to Ashnola site	6,546	4,745	12,698	2,404	-	19,847	3,772	16,075
Keremeos Creek above Olalla	118	-	-	-	1,035	1,035	118	917
Ashnola site to Bromley site	1,243	1,114	3,400	292	-	4,806	616	4,190
Bromley site to Copper Mountain	712	1,478	3,719	965	-	6,162	430	5,732
Wolfe Creek above damsite	93	-	378	78	-	456	93	363
Hayes Creek above damsite	428	-	1,062	1,922	-	2,984	321	2,663
Summers Creek above mouth	165	-	-	-	300	300	134	166
Allison Creek above mouth	658	154	1,294	2,820	450	4,718	538	4,180
Tulameen River below damsite	107	-	960	500	-	1,460	94	1,366
Tulameen River above damsite	-	-	-	120	-	120	-	120
Otter Creek	170	-	875	1,165	1,540	3,580	78	3,502
TOTAL	10,240	7,491	24,386	10,266	3,325	45,468	6,194	39,274

The amount of storage necessary for the Canadian portion of the basin, based on the seasonal distribution of water requirements shown in Paragraph 148, would amount to 67,000 acre-feet.

142. In Canada, the irrigated and irrigable lands in the Okanogan Basin lie on benches and flats adjoining Okanogan River and Okanagan Lake. Although definite irrigation projects have not been investigated for this report, it appears that any major expansion in agriculture will depend on irrigation, and that there is not enough water to irrigate all the land which could use it beneficially.

143. Soil surveys of the Okanogan valley in Canada conducted in 1953 revealed that there are a total of 141,339 acres of irrigable land, which would need 518,123 acre-feet of water applied to the land and would necessitate the diversion of approximately 674,000 acre-feet of water (see Plate 4). Of this amount, licenses have been issued for 246,660 acre-feet, requiring the diversion of about 321,000 acre-feet. The future water requirements would, therefore, require the diversion of an additional 353,000 acre-feet per annum. This information is shown in Tables 17 and 18.

144. In the United States portion of the Okanogan Basin, most of the better soils of the high terrace and coulee lands are now dry-farmed to grain. Vegetation on unfarmed areas affords some winter and spring grazing. Dry farming is less extensive on the intermediate terraces because of the sandy soils. Bitterbrush and cheat grass form a large part of the cover on the uncultivated lands. Where water is available from mountain streams, or where pumping facilities have been installed, tree fruits -- chiefly apples -- and alfalfa are grown under irrigation. About half of the low terraces and bottom lands are irrigated; tree fruits, alfalfa, berries, grain, corn, and garden crops are grown. Sagebrush flourishes on the best unfarmed lands.

145. The irrigated and potentially irrigable lands within the basin and in areas adjacent to Chief Joseph Reservoir occupy glacial and river terraces, coulees, river valley bottoms, and a mountain basin. They occur in narrow strips of a few hundred to several thousand acres on both sides of the rivers. Many of the land units are now producing, or are well adapted to the production of orchard crops under irrigation.

146. Of the 22,000 acres of irrigated land in the United States portion of the Okanogan Basin (see Plate 5) about 60 percent is used for the production of tree fruits, with the remaining 40 percent used principally for the production of hay and forage. Cropping patterns on presently irrigated lands will probably not change if supplemental water is provided. Additional irrigated areas are assumed to be about equally divided between orchards and general farming, with livestock production dominating in those areas where frost conditions preclude fruit raising.

147. A reconnaissance-type classification was made for all lands except those near the mouth of the Okanogan, for which a detailed classification was made. The results of these classifications are shown in Tables 19 and 20. Some lands are situated favourably to obtain water from Rufus Woods Lake, the reservoir created by Chief Joseph Dam on the Columbia River, and 5,750 acres are included in a plan of development utilizing that source.

148. Analysis of consumptive use, distribution losses, and operational waste, and depths and frequencies of irrigation applications necessary for types of land and crops expected to be grown, led to the establishment of weighted average farm delivery water requirements of 42 inches for sprinkler irrigation and 66 inches for surface irrigation. Estimated number of irrigations required per season are 8, 11, and 14 for land classes 1, 2, and 3, respectively. Distribution losses would reach an estimated 40 percent in unlined canals, would approach 10 percent

TABLE 17

Summary of Irrigable Acreage and Water Requirements, Okanogan Valley in Canada

Irrigable Acreage

Land Classes	Areas in Acres 1	2	3	4	5	Total
Brown Soils	776	1,848	4,913	11,634	12,282	31,453
Dark Brown Soils	1,477	3,752	15,262	19,049	7,285	46,825
Black Soils	2,832	6,148	5,542	9,204	3,114	26,840
Intermountain Podzol or Brown Wooded Soils	530	5,820	3,118	2,270	312	12,050
Ground Water Soils						
(a) Mineral Soils	1,503	3,119	5,835	8,503	3,484	22,444
(b) Bog Soils	-	-	213	1,260	254	1,727
TOTAL	7,118	20,687	34,883	51,920	26,731	141,339

Water Requirements

	Acres	Total Requirements Acre - Feet	Total Diversion Acre - Feet
Brown Soils	31,453	158,536	206,097
Dark Brown Soils	46,825	174,945	227,428
Black Soils	26,840	82,859	107,717
Intermountain Podzol or Brown Wooded Soils	12,050	30,496	39,645
Ground Water Soils			
(a) Mineral Soils	22,444)		
(b) Bog Soils	1,727)	71,287	92,673
TOTAL	141,339	518,123	673,560
Under License			
Full Season	82,999	243,351	316,356
Freshet	1,767	3,311	4,304
Future Requirements	56,573	271,451	352,900

TABLE 18

Irrigable and Presently Irrigated Lands, Okanogan Basin in Canada

Unit	Now Licensed	Acres Irrigable and Presently Irrigated Lands						Now Irrigated	Potential Irrigable Land
		Class 1	Class 2	Class 3	Class 4	Class 5	Sub Total		
Boundary to Penticton	20,790	628	788	5,335	15,874	13,990	36,615	11,502	25,113
Penticton to Peachland	11,283	781	1,729	4,172	4,766	2,972	14,420	8,262	6,158
Peachland to Oyama	36,113	1,881	5,037	16,349	19,515	6,024	48,806	27,326	21,480
Oyama to Vernon	15,705	3,416	5,767	7,251	9,835	3,219	29,488	10,625	18,863
Vernon to Deep Creek	875	412	7,365	1,777	1,931	525	12,010	588	11,422
TOTALS	84,766	7,118	20,686	34,884	51,921	26,730	141,339	38,303	83,036

TABLE 19

Summary of Irrigable Acreage and Water Requirements, Okanogan-Similkameen Basin, U.S.
(All pumping except Oroville-Tonasket which is a gravity diversion from Similkameen River)

Unit	Rounded Total Area Acres	Acres Needing		Irrigation Method	Diversion Ac.-Ft./Acre		Additional Diversions Ac.-Ft.		Static Pump Lift Feet	Peak Div. Rate c.f.s.	Pumping Power Requirement kw.
		Full Supply	Suppl. Supply		Full	Suppl.	Full	Suppl.			
West Malott		140		Surface	6.0	-	840	-	75	4	33
" "	1,790		1,650	"	-	3.0	-	4,950	75		
East Malott		400		"	6.0	-	2,400	-	100	11	126
" "	750		350	"	-	3.0	-	1,050	100		
Tarheel Flat		420		"	6.0	-	2,520	-	475	11	620
" "	1,320		900	"	-	3.0	-	2,700	475		
Jackass Butte	1,020	1,020		Sprinkler	3.5	-	3,570	-	500	15	1,345
East Omak		670		Surface	6.0	-	4,020	-	75	18	159
" "	1,260		590	"	-	3.0	-	1,770	75		
Okanogan Project 1/	2,370	2,370 2/		"	6.0	-	14,220	-	440	62	3,280
Spring Coulee 3/		130		"	6.0	-	780 3/	-	-	-	-
" "	290		160	"	-	3.0	-	480 3/	-	-	-
Omak-Riverside		150		"	6.0	-	900	-	50	4	24
" "	830		680	"	-	3.0	-	2,040	50		
Scattered Areas		1,310		Sprinkler	3.5	-	4,580	-	350	20	1,190
" "	1,770		460	"	-	2.0	-	920	350		
Horse Springs		2,390		Surface	7.0	-	16,730	-	420	69	3,500
Whitestone Coulee	2,390		0	"	-	-	-	-	-	-	-
Oroville-Tonasket Irrigation District	8,680 6/		8,680 4/	"	-	2.0	-	17,360	-	-	-
TOTALS	22,470	9,000	13,470		-	-	49,780	30,790	-	214 5/	10,277

1/ Principal source of supply for this project is Salmon Creek.
2/ Larger acreage has been combined into 2,370 acres by exchange of water supplies.
3/ Groundwater supply. Not included in total.
4/ Supplemental late-season water.
5/ Exclusive of Oroville-Tonasket Irrigation District.
6/ Total district area 12,294 acres.

TABLE 20

Irrigable Lands, and Lands Requiring Supplemental Water

Okanogan Basin in United States 1/

Unit	Irrigated Subtotal 2/	Irrigable Acres Class 1	Class 2	Class 3	Subtotal	Total
East Canal Div. - Chief Joseph Irrigation Project						
Monse Bench	-	-	-	750	750	750
Brewster Flat	-	-	-	3,130	3,130	3,130
Monse Gravity	-	188	27	55	270	270
North Gravity	-	542	516	542	1,600	1,600
Sub-Total - Columbia River	-	730	543	4,477	5,750	5,750
Okanogan River and Tributaries						
West Mallott	1,647	27	68	46	141	1,788
East Mallott	347	21	296	85	402	749
Tarheel Flat	904	83	331	0	414	1,318
Spring Coulee	157	0	134	0	134	291
Jackass Butte	0	472	550	0	1,022	1,022
East Omak	585	118	410	146	674	1,259
Johnson Creek - Okanogan Project	3/	3/	3/	3/	2,370 3/	2,370 3/
Omak - Riverside	674	0	70	82	152	826
Horse Springs - Whitestone Coulee	0	709	1,678	0	2,387	2,387
Oroville - Tonasket Irrigation District	8,680	0	0	0	0	8,680
Scattered Areas	459	386	927	0	1,313	1,772
Sub-Total - Okanogan River & Tributaries	13,453	1,816	4,464	359	9,009	22,462

1/ Including lands in Okanogan Basin that will receive irrigation water from Columbia River via diversion from Chief Joseph Dam.
2/ Under existing system but requiring supplemental water.
3/ Equivalent new land area; combining about 510 acres new lands on Johnson Creek with existing irrigated areas on Johnson Creek and on the Okanogan Project.

in lined canals, but would be negligible in pipelines for sprinkler operation. Assumed seasonal distribution of irrigation diversion requirements follows:

Month	Percent of Seasonal Total
April	10
May	16
June	21
July	22) Late season
August	21) sub-total 53%
September	10)

Peak month would be July when 22 percent of the season requirement is deliverable. The estimated peak demands per acre are 0.026 c.f.s. for surface and 0.015 c.f.s. for sprinkler irrigation.

149. Assuming lined canals, diversion requirements are estimated at 72 inches, or 6 feet per acre for gravity distribution. However, in the case of the Horse Springs-Whitestone Coulee area, a diversion requirement of 84 inches, or 7 feet, is assumed. For pressure-system distribution, the diversion requirement is assumed the same as delivery requirement -- 42 inches, or 3.5 feet.

150. Table 19 shows by areas and potential service-units the irrigable lands and presently irrigated lands needing supplemental water that may use water from the Similkameen and Okanogan Rivers. The table also shows diversion requirements, methods of irrigation, pump lifts, and pumping-power requirements. This listing includes a total of 9,000 acres of new lands and 13,470 acres of presently irrigated lands needing supplemental water. These lands would require a total diversion of some 81,000 acre-feet of additional water annually, 31,000 acre-feet for supplemental supply and 50,000 acre-feet for development of new land. Obviously the supplemental supply requirement, 31,000 acre-feet, would have to come from storage. Likewise, on the basis of the diversion requirements shown above, at least one-half of the seasonal requirements for new areas would come from storage. Disregarding use of return flow, the storage requirements in the U.S. would be as follows:

Supplemental Supply	31,000 acre-feet
New land (½ season total)	25,000 acre-feet
	56,000 acre-feet

151. An estimate was made to determine the storage required to provide adequate water for existing and future irrigation needs during a year similar to 1926, the lowest of the 40 years of record on the Similkameen River. The study indicated that all of the lands classed as irrigable in the Similkameen valley in Canada and in the Okanogan-Similkameen Basin in the United States could be irrigated with the provision of 123,000 acre-feet of storage. With a total future estimated diversion requirement in excess of 674,000 acre-feet per season for complete development of available irrigable lands in the Okanogan valley in Canada, and successive low-year water supplies of 56,000 and 36,000 acre-feet available in 1930 and 1931, respectively; it is obvious that no water will be available for use elsewhere in the basin from the Okanogan River in Canada. Therefore, it has been assumed that all future development in the Similkameen Basin and in the Okanogan Basin in the United States will be dependent on Similkameen storage.

152. The foregoing storage requirement did not take into account the possibility that return flow from upstream development would be available for re-diversion, which would lessen the actual storage requirement somewhat. Furthermore, no attempt was made to correlate available water supply with the various areas of irrigable land in Canada. The figure for storage requirement is a maximum figure, which can be used for comparative purposes, but which should not be used for project formulation.

FLOOD CONTROL

153. Storage in Okanagan and Skaha Lakes, together with the projected channel improvements in Okanogan River in Canada, is believed to provide adequate protection against floods in the Okanogan valley in Canada.

154. Flood damage along the Okanogan River in the United States is due primarily to floods originating in the Similkameen River, and consequently could be alleviated by flood-control storage in that basin. Storage capacity required for power could also be very effectively utilized for flood control in this basin, and studies of storage requirements assume that the same reservoir space could be utilized for both purposes. A reservoir capacity of about 900,000 acre-feet at Shankers Bend would have substantially controlled the greatest flood of record, that of 1948. Capacity of about 600,000 acre-feet at the same site would prevent about 87 percent of the average annual flood damages downstream. Flood-control storage in the Okanogan-Similkameen Basin would also provide a small amount of flood control in the lower Columbia River basin.

V. PLAN OF DEVELOPMENT

INVESTIGATIONS AND OFFICE STUDIES

155. The collection and analysis of the physical data required for the determination of a plan of development of the Okanogan-Similkameen Basin entailed a considerable amount of effort because of the lack of necessary basic data. The basin is sparsely settled, and with the possible exception of minerals, the natural resources had not been extensively explored. The agricultural potential at the start of these investigations was only partially known. The Canadian portion of the Similkameen Basin was known to be favorably situated with respect to the development of storage, but no potential sites had been investigated. Stream-gaging stations had been operated for many years at several points in both countries, providing a good measure of the water supply of the basin.

156. Preliminary dam-and reservoir-site investigations were made on the Similkameen River and major tributaries in Canada by the Department of Lands and Forests, Water Rights Branch, and the Department of Northern Affairs and National Resources, Engineering and Water Resources Division. Results of these investigations were available for use in connection with the studies of the Engineering Board. Topographic maps of the Similkameen River in Canada from the international boundary to Princeton were prepared and published by the Department of Mines and Technical Surveys, Surveys and Mapping Branch.

157. In the United States, the Corps of Engineers carried out preliminary investigations of the dam site at Shankers Bend on the Similkameen River. A preliminary design of a dam and power plant, cost estimates, and economic studies, are given in the "Review Report on the Columbia River and Tributaries" of 1948 (H.D. 531-81-2 Vol. III). That agency also investigated the flood damage problem and made preliminary designs for flood protection works on the Okanogan River. Dam-site surveys for three locations on the Similkameen River, in the United States, were made by the Geological Survey, Department of Interior.

158. At the start of the Columbia River investigations very little was known about the irrigation potentialities and the over-all water requirements of this area in Canada. A reconnaissance soil survey of part of the Similkameen and Okanogan River basins was followed by preliminary land-use surveys in the remainder of the Similkameen, which revealed the location and extent of the main irrigable areas, their agricultural suitability and water requirements (see Table 16). Engineering investigations have not been made in either valley in Canada, and, therefore, the method of irrigation and costs of required works and economic feasibility are not known.

159. Irrigation possibilities in the United States portion of the basin were determined by a basin-wide reconnaissance investigation that included the following: land classification for irrigability and preliminary engineering surveys in the field; and preliminary water supply, cost estimate, and economic studies in the office. All lands up to 500 feet in elevation above the Similkameen and Okanogan Rivers were included. Results of the investigation are contained in a report by the Bureau of Reclamation entitled "Okanogan River Basin, Washington, Reconnaissance Report", dated September 1951.

160. The principal conclusion drawn from the investigation was that reclamation of the dry, arable lands and provision of supplemental water to presently irrigated areas within the basin should be premised on diversions from the Chief Joseph pool with respect to divisions and units adjacent to the pool, downstream along Columbia River, and upstream in Okanogan valley to the vicinity of the railroad bridge across the Okanogan River located about five miles north of Monse. A detailed report on the Chief Joseph Irrigation Project, which includes units in

the Okanogan Basin, has been prepared by the Bureau of Reclamation. Additional irrigation development upstream in Okanogan valley should be accomplished by future construction of storage facilities and by diversion from the Okanogan and Similkameen Rivers.

161. Office studies in connection with the preparation of this appendix were made by the staffs of agencies represented on the Engineering Board and Committee, and pertinent material is preserved in the files of those agencies. Such studies include the determination of storage requirements for flood control, power, and irrigation; preliminary designs and cost estimates for various features of projects included in the plan of development; determination of potential benefits; and similar items.

IMPROVEMENT ELEMENTS

162. Many alternatives are available in planning the development of the water resources of the Okanogan-Similkameen Basin. The storage capacity required for flood control, irrigation and power may be provided by reservoirs in several locations. Dams of different heights are possible at some sites, which would provide greatly different reservoir capacities and would result in additional alternatives. Similarly, the available water supply in some areas is insufficient to develop completely the available land suitable to irrigation, and alternative plans might be devised for utilizing the available water supply most efficiently. The principal elements of the possible improvements are storage sites, irrigation units, local flood-protection works, and power developments. These elements are described and discussed in detail in the ensuing paragraphs.

163. Storage Sites. - The storage requirements in the Similkameen Basin are described in paragraphs 126, 141, 150, and 154. Requirements for different uses are not additive, because they do not occur at the same time. The maximum demand for flood-storage capacity occurs before the spring freshet, generally in May or June, after the critical power period has ended and when the power reservoirs would normally be drawn down. Similarly, the principal demand for irrigation storage occurs after the spring freshet, by which time the reservoirs would normally be filled. However, in the case of joint power and irrigation reservoirs, the two uses tend to conflict with each other. The following paragraphs describe the various storage sites that were studied.

164. SHANKERS BEND. The site is on the Similkameen River, 7.3 miles upstream from the junction with Okanogan River.

(a) High Dam. - The site is suitable for either a concrete or an earth-and-rockfill dam (see Plate 6). For purposes of this report, the latter type has been assumed and cost estimates were made on this basis. Solid rock is exposed or near the surface in the foundation as well as on the abutments. The maximum height of the dam would be about 260 feet, and its length about 1,200 feet. The maximum normal pool level would be at elevation 1,289 feet, which is about the upper limit that can be attained without flooding the town of Loomis, Washington, and the irrigation developments near Cawston, British Columbia. This would provide a maximum gross head of 244 feet and usable power storage of 1,310,000 acre-feet, with 86-foot draw-down. As explained in the previous paragraph, the power storage space can be made available for flood control on a forecast basis with no great loss of system power benefits. Irrigation needs in both countries would be met. A concrete-lined tunnel would be constructed through the left abutment with control gates to release water for irrigation. The spillway would be constructed in rock on the right abutment. The power plant would have an installed capacity of about 84,000 kw., and would be served by means of a tunnel through a low ridge, which forms the right wall of the canyon. The total reservoir area would be about 18,000 acres, of which about one-half would be in Canada. Of the portion in Canada, about 5,600 acres are Indian Reserve land, as shown on

Plate 7. The Indians have occupied these lands for generations, and would not readily move elsewhere. They are primarily stockmen. While much of their producing area is river bottom land on which hay crops are grown without irrigation, some of it is on irrigated benches. Adjoining these is a large area of range land. Of the Indian lands which would be inundated, a substantial amount would be comprised of these hay lands and irrigated benches. Since adjacent land in the Similkameen valley is already occupied and devoted to fruit farming, the resettlement of Indians on such land would produce other resettlement problems without providing a completely satisfactory solution to the Indian resettlement problem. In addition to the resettlement of the dispossessed Indian population, the principal flowage items are: acquisition of private lands and improvements; relocation of 27 miles of Great Northern Railway, 24 miles of roads, and communication and power lines; and compensation for lost business and taxes.

(b) Low Dam. - The same site was also considered for possible development with a low concrete gravity dam with a maximum normal pool elevation of 1,175 feet, as determined by the elevation at the international boundary (see Plate 8). The reservoir would be wholly contained within the United States, and would have a live storage capacity of about 162,000 acre-feet. This capacity would be usable not only for flood control during the spring run-off, but would also serve for irrigation and for power production. The dam would have a crest elevation of 1,190 feet, a crest length of about 800 feet, and a maximum height of about 160 feet. Irrigation releases would be made through a gated sluice in the dam. The power plant would have an installed capacity of about 11,000 kw., and would be served by a tunnel approximately 1,800 feet long.

165. PALMER LAKE. This site is on Palmer Creek, in the lower reaches of Sinlahekin drainage, at a point below where backwater from the Similakameen raises the natural level of Palmer Lake during each high-water period. No data are available on site conditions, although it is probable that a low earthfill dam, with floodgates, would be required to provide the necessary storage. An increase in water depth over minimum natural lake levels of about 15 feet would provide 30,000 acre-feet of storage. A diversion canal from Similkameen River, heading near the international boundary, would be required as run-off from Sinlahekin Creek and floodwater from Similkameen River are probably insufficient to fill the storage each year.

166. NIGHTHAWK. This site is on Similkameen River, with alternative axis locations designated as Mile 12.0, Mile 14.4, and Mile 15.8, on U. S. Geological Survey River Survey map. It is an alternate to the Palmer Lake site, and, except for flooding of additional lands, including Indian lands, is probably preferable to the Palmer Lake site because it is on the main stem of the river and would require no diversion canal. Some branch railway and secondary highway grade raising or relocation would be required if this site were to be utilized. Low-water elevation of Similkameen River at the international boundary is about elevation 1175, and storage in the amount of 50,000 acre-feet or less would not affect the water level at the boundary. Following is a summary of preliminary information on storage at Nighthawk (Mile 15.8) site:

Dam Required (Approximate)

Height Above Streambed	Length	W.S. El.	Total Capacity
30 ft.	900 ft.	1155	31,900 a.f.
35 ft.	1100 ft.	1160	52,600 a.f.
45 ft.	1300 ft.	1170	106,000 a.f.

167. ASHNOLA. The site is on the Similkameen River, six miles upstream from Keremeos and one mile below the mouth of the Ashnola River (see Plate 9). Both banks are mainly gravel, although rock outcrops on

the right bank about 120 feet above river level and on the left bank about 240 feet above river level. Four test holes were drilled across the valley bottom without encountering bedrock within 150 feet of the ground surface. An earthfill-type dam was considered most suitable for this site. A dam 80 feet high with a crest length of 550 feet could be built, utilizing a knoll on the left bank of the river. A saddle dam 50 feet high with a 1,000-foot crest length would have to be constructed between this knoll and the north side of the Similkameen valley. These dams would impound 62,000 acre-feet of water.

168. BROMLEY. The site is on the Similkameen River, 13 miles downstream from Princeton and two miles downstream from Wolfe Creek. The left bank is rock from water level up to 200 feet above river level; above this point, the bank is covered with overburden to 300 feet above river level, where rock again outcrops. The rock bluff on the right bank is covered with gravel up to 120 feet above river level. Test borings through this gravel have disclosed that bedrock is at least 200 feet below the ground surface, so an earthfill-type of structure was considered.

(a) High Dam. - The maximum height of a high dam is limited by the elevation of Princeton. The dam would be 240 feet high with a crest length of 1,400 feet, and would provide about 400,000 acre-feet of storage. The rock outcrop on the left side of the river would provide foundations for powerhouse, spillway, and, possibly, diversion and bypass tunnels (see Plate 10).

(b) Low Dam. - A dam 100 feet above river level would have a crest 600 feet long and would require a smaller structure in a saddle in the left bank. This saddle dam would be 60 feet high, with a crest length of about 150 feet. About 50,000 acre-feet of storage could be provided here.

169. SIMILKAMEEN NO. 3. This site is on the Similkameen River, about ten miles upstream from Princeton and one mile downstream from Copper Mountain, where the river flows through a narrow, rock canyon about a mile long. A dam 250 feet high would have a crest length of about 310 feet, creating about 18,000 acre-feet of storage. Bedrock is apparent in the river channel near the site.

170. SIMILKAMEEN NO. 4. This site is on the Similkameen River about 30 miles above Princeton and one mile below the confluence with the Pasayten, where the Similkameen flows through a narrow, rock canyon about 600 feet long. A dam 167 feet high would have a crest length of 220 feet, and would create about 25,000 acre-feet of storage. The maximum head for power production could be increased by utilizing the falls in the river below the damsite. Bedrock is apparent in the river channel near the site.

171. SIMILKAMEEN NO. 5B. This site is on the Similkameen River immediately above the Pasayten River. An earth fill dam to elevation 3450 would impound 55,000 acre-feet of water. The right abutment would be tied into a high promontory which divides the Similkameen and Pasayten valleys. Rock outcrops were found on the Pasayten side of the shoulder, and it is thought that the main body of this formation is rock. The valley floor is a glacial fill with no evidence of bedrock. The left abutment would be tied into what is now a deep rock cut on the highway. Unwatering would be accomplished through an eleven-foot, horseshoe-shaped, lined tunnel nine hundred feet in length through the left abutment. This tunnel would subsequently be adapted for emergency spilling by the installation of a roller or stoney gate eleven feet square and for normal releases by a 48-inch high-pressure gate valve.

172. SIMILKAMEEN NO. 6. This site is on the Similkameen River about four and one-half miles upstream from the mouth of the Pasayten River, at an elevation of 3,460 feet. Storage volume for a dam 215 feet

high, estimated from aerial photographs, indicates a capacity of 73,000 acre-feet. It is believed that bedrock is close to the ground surface at this site, but no subsurface investigations have been undertaken.

173. ASHNOLA RIVER NO. 1. The site is on the Ashnola River, about 19 miles above its confluence with the Similkameen River, and just above Etches Creek. A dam 220 feet high with a crest length of 800 feet would create a storage capacity of 47,500 acre-feet. Although there has been no subsurface investigation, foundation conditions are believed to be good (see Plate 11).

174. ASHNOLA RIVER NO. 2. The site is on the Ashnola River, about 25 miles above its mouth and about a mile below McBride Creek. A dam 140 feet high would have a crest length of 710 feet and would impound 22,100 acre-feet of storage. No subsurface investigations have been undertaken.

175. ASHNOLA RIVER NO. 3. The site is on the Ashnola River, about 28 miles above the mouth of the river and 1-1/2 miles below Wall Creek. The left bank consists of basalt covered by slide material, and the right bank is an alluvial fan. Foundation conditions are believed to be poor. A maximum of about 30,000 acre-feet could be impounded at this site.

176. TULAMEEN. The site is on the Tulameen River, about five miles above Tulameen and a half mile below Lawless Creek. A dam 200 feet high would have a crest length of 330 feet and a storage capacity of 12,000 acre-feet. There have been no subsurface investigations, but rock is apparent on both banks and in the stream bed.

177. MISCELLANEOUS SMALL SITES. Several small sites were investigated on tributaries of the Similkameen River. At Surprise Meadows, on Keremeos Creek near Olalla, a dam 26 feet high with a crest length of 717 feet would provide about 3,000 acre-feet of storage. At a site on Hayes Creek, it is estimated that a dam 70 feet high and 560 feet long at the crest would provide about 4,000 acre-feet of storage. There are also lakes on Wolfe Creek and on Summers Creek that could be used to develop small amounts of storage.

178. Table 21 gives the preliminary pertinent data for the more significant storage sites in the Similkameen Basin. Of the nine possible sites and alternatives in Canada, only the following four are considered to be possibilities for development at this time:

Bromley - for power and storage

Similkameen No. 5B - for storage

Similkameen No. 6 - for storage

Ashnola River No. 1 - for storage

179. <u>Irrigation</u>. - The irrigated and presently irrigable lands, as shown on Plates 3, 4, and 5, have been grouped into units for the purposes of identification in this report. Tabulations by land classes and units of presently irrigated and irrigable land in Canada and tabulations of presently irrigated lands in need of supplemental water and irrigable lands in the United States are shown in Tables 16, 18, and 20.

180. CHIEF JOSEPH PROJECT, EAST CANAL DIVISION, BREWSTER FLAT, MONSE GRAVITY, NORTH GRAVITY, AND MONSE BENCH UNITS (5,750 acres). Lands of these units lie on terraces and benches bordering the Okanogan River near its junction with the Columbia River. These units constitute the major portion of a division of a potential project to receive water from the Columbia River. They are included in the plan of development for the Okanogan Basin because they are actually in that basin.

TABLE 21

Summary of Damsite Data - Similkameen Basin

Site	Storage in Acre Feet		Costs			Total Cost	Forebay (full pool)	Tailwater	Installed Capacity
	Total	Usable	Storage Facilities Only	Flowage	Power		Elevation	Elevation	Kw.
Shankers Bend High Dam	1,700,000	1,310,000	$13,240,000	$16,522,000	$12,927,000	$42,689,000	1289	1044	84,000
Shankers Bend Low Dam	168,000	162,000	6,540,000	10,767,000	1,778,000	19,085,000	1175	1046	11,000
Nighthawk	106,000	106,000	not determined	not determined	0	not determined	1170	1125	0
Ashnola	62,000	62,000	2,423,000	2,454,000	0	4,877,000	1510	1420	0
Bromley	405,000	273,000	7,024,000	5,777,000	1,519,000	14,320,000	2070	1833	12,000
Similkameen #3	18,000	18,000	5,406,000	not determined	507,000	not determined	2720	2483	3,700
Similkameen #4 1/	25,000	25,000	1,205,000	448,000	779,000	2,432,00	3370	3215	1,900
Similkameen #5B 1/	55,000	55,000	2,597,000	799,000	2/	3,396,000	3450	3300	2/
Similkameen #6	73,000	73,000	4,850,000	1,000,000	2/	5,850,000	3660	3460	2/
Ashnola River #1	48,000	48,000	5,028,000	nominal	2/	5,028,000	3725	3470	2/
Ashnola River #2	22,000	22,000	1,473,000	nominal	0	1,473,000	3850	3720	0
Tulameen	12,000	12,000	1,746,000	nominal	0	1,746,000	2800	about 2600	0

1/ Similkameen #4 and #5B are alternatives.

2/ Sites Similkameen #5B and #6 and Ashnola River #1 could be adapted for power development.

181. WEST AND EAST MALLOT TERRACES (1,790 acres and 750 acres respectively). Lands of these units are on the terraces bordering Okanogan River, between Monse and Okanogan, and they are the lowest that are proposed to be served from the Okanogan River. Most of the area in these units is presently irrigated, but in need of a supplemental supply, which would be obtained by pumping from Okanogan River. Principal irrigated crops are apples and alfalfa. Dry-land crops are principally grains, and remaining areas are grazed or left idle. The irrigable lands are principally Class 2.

182. TARHEEL FLAT (1,320 acres). This unit, most of which is now devoted to irrigated orchards, lies on a terrace between Malott and Okanogan. Present supply comes from creeks in most years, with some pumping from the river in dry years. A supplemental supply for the lands now short of water and a full supply for irrigable lands, most of which are Class 2, could be pumped from Okanogan River.

183. SPRING COULEE (290 acres). The Spring Coulee unit, located on a bench near Okanogan, comprises about one-half irrigated and one-half irrigable land, the latter being principally Class 2. The present supply is from wells, and the additional supply would likewise come from groundwater.

184. JACKASS BUTTE (1,022 acres). This unit is on a terrace on the east side of the Okanogan River, southeast of Omak, and comprises two major bodies of irrigable land, about evenly divided into Classes 1 and 2. Existing use is for grain or grazing, with some areas idle. Water supply would be pumped from Okanogan River. The area is best adapted for general farming.

185. EAST OMAK (1,260 acres). Lands of this unit occupy bottom lands and adjacent terraces on the east side of the Okanogan River, between Omak and Riverside. The lands are about evenly divided at present into irrigated and dry-farmed areas, with some idle lands. The dry and idle lands are principally Class 2, and occur in small elongated bodies separated by irrigated lands. The new lands would be adaptable to orchards or general farming. Water supply would be pumped from Okanogan River.

186. JOHNSON CREEK UNIT (1,030 acres). Lands of the Johnson Creek unit are above the Okanogan Project along Johnson Creek. The unit consists of about equal areas of irrigated and irrigable lands, but the existing water supply is inadequate. Of the irrigable lands about one-third are Class 1 and the remainder Class 2. The several bodies of irrigable land occupy creek bottoms and adjoining terraces. This unit is best adapted to general farming. Although tree fruits could be raised thereon, frost would be a hazard.

187. THE OKANOGAN PROJECT. This project, developed early in the century, occupies high glacial and river terraces west of Okanogan River between Omak and Riverside. A 1946 survey placed 4,090 acres in arable land Classes 1, 2, and 3. Apples are the principal crop, followed by alfalfa and pasture grasses. Water supplies for this project are inadequate in very dry years. Supplemental supplies for the Okanogan Project would be pumped from Okanogan River. Johnson Creek lands would be served by a diversion from Conconully Reservoir, with exchange water being provided from the Okanogan by pumping.

188. OMAK - RIVERSIDE (830 acres). Lands of this unit are along the west side of the Okanogan River between Omak and a point about six miles north of Riverside. Most of this unit is presently irrigated, with the irrigable areas about evenly divided into Class 1 and Class 2 lands. Water supply would be pumped from the Okanogan River. Present and anticipated crops include tree fruits and alfalfa.

189. HORSE SPRINGS - WHITESTONE COULEE (2,390 acres). All lands in this unit are dry at the present time, the principal farming uses being for grazing and raising of grain. These lands are in Horse Springs Coulee and the coulee to the north of Whitestone Mountain. Their general location is a few miles west of Tonasket. Development of these lands was undertaken at one time by the Whitestone Irrigation and Power Company, but the water supply proved to be inadequate and the venture failed. Water supply for these lands, which are best suited for general farming, would be pumped from Palmer Lake (or Similkameen River) storage.

190. OROVILLE-TONASKET IRRIGATION DISTRICT (supplemental water for 8,680 irrigable acres). This district is the largest organized irrigation development in the basin and is irrigated from Similkameen River by a gravity distribution system. The district lands are on both sides of the Okanogan River and extend from the international boundary to a point several miles below Tonasket. Apples are the principal crop grown, although some of all crops common to the area are raised. Most of the better land in the district is being irrigated at present, but late-season water shortages occur almost every year. Although the district's water right is junior to a power right on the Similkameen River, the practice of subordinating this latter right has been common in the past, in order to prevent crop failures. Late-season storage water would be provided for this development, with the water supply coming from Similkameen River storage by existing canal facilities. Some rehabilitation of the distribution system is required.

191. SCATTERED SMALL AREAS (1,770 acres). Numerous small and isolated bodies of irrigable lands are scattered in coulees, and others are on high terraces around Palmer Lake. About one-fourth of these areas is now irrigated, principally in alfalfa; and the remainder is dry-farmed, grazed, or idle. About one-fourth of the irrigable lands is Class 1 and the balance Class 2. These areas would best be adapted to general farming, but their isolated locations and small size may limit or preclude development. Water supplies would be pumped from various sources.

192. BOUNDARY TO ASHNOLA DAMSITE. The irrigable land in this section is along both banks of the Similkameen River, Keremeos Creek, and Blind Creek, extending continuously along the river, varying in width from a few feet up to a maximum of two miles near Keremeos and Cawston. Most of the land is fairly flat, being either in the river bottom or on low benches, and has a light cover of bush and scattered trees. The elevations vary from 1175 feet on the Similkameen River at the boundary to 2,500 feet at the upper extremity of Blind Creek. The river level at Ashnola damsite is 1,420 feet. Of the total of 19,847 acres of irrigable land in the area 6,546 acres are under license for irrigation. Approximately half the total area is Indian Reserve.

193. ASHNOLA DAMSITE TO BROMLEY DAMSITE. The irrigable land in this section of the Okanogan-Similkameen Basin lies in the narrow, steep walled valley of the Similkameen River. It is on the river flats or benches ranging in elevation from 1,400 feet to 2,200 feet, varying in width from a few feet to about a half mile. The cover of coniferous and deciduous trees is relatively light. Of the 4,806 acres of irrigable land 1,243 acres are under license for irrigation. About one-third of this section of the lower parts of the valley is Indian Reserve.

194. BROMLEY DAMSITE TO COPPER MOUNTAIN. The irrigable land in this section lies along the Similkameen River on the river flats and on benches and rolling hills ranging in elevation from 1,900 to 3,000 feet above sea level. The forest cover is very light. Of the 6,162 acres of potentially irrigable land in the Similkameen Valley between Bromley damsite and Copper Mountain, at present 712 acres are under license for irrigation.

195. WOLFE CREEK. Just above the damsite at Wolfe Lake there are about 150 acres of irrigable land, above which there is a rock canyon about six miles long. Above this the Wolfe Creek valley again widens out and there are about 306 acres of irrigable land in an open park-like country at elevations ranging from 2,300 to 3,000 feet above sea level. Licenses have been issued for irrigation on 93 acres of land in Wolfe Creek valley above the canyon.

196. HAYES CREEK. Along Hayes Creek from the damsite about 12 miles upstream from its confluence with the Similkameen River to elevation 3,000 which is about 14 miles above the damsite, there are 2,984 acres of irrigable land. The valley is quite narrow, about one-third of a mile wide, with fairly steep, wooded sides. At the upper end, the valley is wooded with a few open meadows. At present, licenses have been issued for irrigation on 428 acres on Hayes Creek above the damsite, including tributaries above 3,000 feet elevation.

197. OTTER CREEK. In the 20 miles of Otter Creek from the Tulameen River to creek elevation 3,000 feet there are about 3,580 acres of potentially irrigable land. The valley is about one-quarter of a mile wide, fairly flat and quite open, with steep wooded sides, narrowing about 12 miles upstream from Otter Lake. Licenses have been issued for the irrigation of 170 acres.

198. TULAMEEN RIVER. From Princeton to the damsite on Tulameen River, about 20 miles above Princeton, there are 1,460 acres of irrigable land. This stretch of the valley is very narrow with steep sides, with no licensed irrigation being carried on at present. Licenses have been issued for irrigating 107 acres on the tributaries of the Tulameen, excluding Otter Creek (see above).

199. OTHER AREAS. Of the other areas of irrigable and arable land in the Similkameen Basin in Canada there are 1,035 acres on Keremeos Creek above Olalla of which 118 acres are licensed for irrigation, 300 acres on Summers Creek above its mouth of which 165 acres are licensed for irrigation, 4,718 acres on Allison Creek above its mouth of which 658 acres are licensed for irrigation and Tulameen River above the damsite where there are 120 acres of arable land, none of which is licensed for irrigation.

200. OKANOGAN BASIN. Between the international boundary and Penticton there about 36,615 acres of irrigable lands lying mainly in the valley bottoms, but including benches about 500 feet above river level and also including about 5,000 acres in Park Rill and Shingle Creek valleys. Around the south end of Okanagan Lake, along the west side of the lake as far north as Peachland, and including the valley of Trout Creek, there are about 14,420 acres of irrigable lands. This land around Okanagan Lake is a narrow belt, extending from the lake shore to about 1,000 feet in elevation above the lake on a series of benches. In the area extending from Westbank, on the west side of Okanagan Lake, through Kelowna and Winfield to Oyama, there are about 48,806 acres of irrigable lands, mostly within 500 feet of the elevation of Okanagan Lake. From Oyama north to Larkin, including the area at the north end of Okanagan Lake and the Coldstream Creek area, there are 29,488 acres of irrigable land. From Larkin north, and including Armstrong and the Deep Creek valley, there are 12,010 acres of irrigable land. The irrigable lands along Deep Creek extend to the east over a low summit (2,500 feet elevation) into the Shuswap River valley, to the west through a low pass (1,900 feet elevation) into the Salmon River valley, and to the north to the area around Salmon Arm of Shuswap Lake. The above total of 141,339 acres includes both irrigated and irrigable lands (see Table 18). Any substantial increase in presently irrigated areas, in particular the Deep Creek area north of Armstrong, would require water additional to that presently available in the Okanogan Basin in Canada.

Plan of Development

201. A reconnaissance survey has indicated that a gravity diversion from the Shuswap River near Enderby is physically possible through the low divide between Fortune Creek and Deep Creek to carry irrigation water to Okanagan Lake. Review of water records indicates there is ample unused water in the Shuswap River to fill any deficiency in the Okanogan valley. The low-water elevation at the point of diversion on Shuswap River is 1,140 feet above sea level, and maximum high water was 1157.36 feet in 1894. A control structure about 25 feet high across the river channel and a low dyke across the flood plain would raise the water level at the diversion point to elevation 1155 feet. The town of Enderby and the highway would not be affected but about two miles of the C.P.R. branch line from Sicamous to the Okanogan valley would have to be raised to provide the necessary freeboard. The channel of Fortune Creek would have to be enlarged and a connecting channel constructed through the low divide (elevation 1175) to Deep Creek. The maximum depth of the connecting channel below the summit would be about 40 feet and the length two miles. The connecting channel would require a capacity of about 1,000 cubic feet per second for maximum demand, and the channel of Deep Creek (near Armstrong) would have to be straightened and enlarged to that capacity for a distance of about ten miles to the north end of Okanagan Lake. Servicing for irrigation would be by means of pumps, either from the diversion channel or from Okanagan Lake. Because most of the arable lands requiring water are on benches up to 500 feet in elevation above Okanagan Lake, pumping heads would be high and irrigation expensive.

202. Local Flood Protection Works. - Preliminary plans which appeared to have the best possibilities for justification for providing local flood protection in the United States were studied for three communities -- Okanogan, Omak, and Riverside. Principal elements of the protection works would be levees, floodwalls, and riprap. The lengths of the various projects studied were as follows:

Project	Length of walls and/or levees
Okanogan (right bank)	9,000 feet
Omak (both banks)	13,800 feet
Riverside (right bank)	1,900 feet

None of the plans investigated was found justified.

203. The most practical solution of the flood problem on Tonasket Creek (see para. 114) would be to increase the capacity of the channel, in its existing alignment, from a point near where it enters the delta to a point near its mouth; and to change the alignment at the lower end so that the outlet discharge would take place in an old oxbow of the Okanogan River. The oxbow would provide a natural sedimentation basin for the debris from the creek. Principal features of this work would be a widening of the existing channel in the delta area, construction of levees on the banks with the excavated material, and protection of the banks with riprap as required by local current velocities. Because of valuable lands required for rights of way, local opposition precludes further consideration of this improvement at the present time.

PROPOSED PLANS

204. Introduction. - Alternative plans for further development of the water resources of the Okanogan-Similkameen Basin are described in the following paragraphs. In presenting these alternative plans, the Board wishes to emphasize that other possibilities for storage of flood flows exist in the upper reaches of the Similkameen Basin, but on the basis of data available from limited investigations, the following proposals appear to be the most feasible and desirable.

205. The important influence of economic factors on any further development of the water resources of the basin is fully recognized by the Board. These factors will very largely govern the rate of development. Some elements of the proposed plans are not economically justified under present conditions, and may not be justified for many years. Elements for which there is little prospect of early construction have been investigated only to the extent necessary to determine the engineering feasibility and physical characteristics of the project. Preliminary damsite investigations were sufficient to indicate the general foundation conditions and suggest the type of structure suitable for the site. Irrigation projects in the United States were investigated sufficiently to determine the land types, availability of water supply, and engineering feasibility of irrigation. In Canada, investigations were made to determine land types, irrigability, and availability of water supply.

206. Preliminary designs and cost estimates were made for the storage projects, in order to provide a comparison between alternative projects. Although such cost estimates serve the immediate purposes of the Board in determining a proposed plan of development and in making comparisons between projects, they may be unrealistic for an individual project (except for Shankers Bend) and are therefore not considered suitable for economic analyses. The investigations and office work required to provide a preliminary design and reliable cost estimate for each element of the proposed plan were not considered justified for this report.

207. One element of the proposed plan -- a high dam at Shankers Bend on the Similkameen River -- is presently of interest to the United States because of power and flood-control aspects, and, consequently, has been investigated in greater detail.

208. The proposed alternative plans, although not recommended nor necessarily desirable for immediate construction, provide a framework on which further development may be based as economic factors dictate.

209. Plan A. - This plan consists of essentially complete development of the irrigable land in the basin through numerous small projects, indicated as land units in paragraphs 180-200, and of a high dam on Similkameen River at Shankers Bend. In Canada, 39,274 acres of new land in the Similkameen Basin and 83,036 acres of new land in the Okanogan Basin would ultimately be developed; and in the United States, 9,000 acres of new land would be developed in addition to the provision for supplemental water for 13,000 acres of land presently irrigated. The power plant at Shankers Bend would have installed generating capacity of 84,000 kw. The reservoir would have an active storage capacity of 1,310,000 acre-feet partly in Canada and partly in the United States, covering an area of 18,000 acres of which nearly one-half is in Canada. Since this storage is more than sufficient to meet downstream water requirements, the irrigation requirements upstream on the Similkameen River could be almost completely satisfied by the normal stream flow, supplemented by a total of about 67,000 acre-feet of storage where needed. In the Okanogan Basin in Canada, the amount of water needed for complete development of all the irrigable land exceeds the water supply in most years, so a necessary part of Plan A is the importation of water from the Shuswap Basin through the low divide at the northerly end of Okanagan Lake.

210. Plan B. - This plan is an alternative to Plan A and, although it includes less storage than that with Shankers Bend high dam, there is sufficient storage to meet all irrigation requirements, to provide substantial flood protection, and to develop appreciable amounts of power. The storage dams included are: Low Shankers Bend, Ashnola, Bromley, Similkameen No. 3, Similkameen No. 4, and Ashnola River sites Nos. 1 and 2, which would create about 610,000 acre-feet of usable storage. Irrigation development would be identical with that under Plan A, with ample water for the Similkameen and the Okanogan in the United States supplied

by the storage projects. The capacities of the above reservoirs are shown on Table 21. Provision for full development of the Okanogan Basin in Canada would require additional water as outlined in Plan A.

211. As a possible alternative to irrigation storage in Plan A or Plan B for use in the United States, supplemental supplies for presently irrigated lands and late-season supplies for new lands could be obtained in Palmer Lake or at the Nighthawk (mile 15.8) site on Similkameen River.

212. From an overall engineering standpoint, the Board is of the opinion that Plan A is the preferable scheme of developing the water resources of the basin. The existence of a damsite at Shankers Bend favorable to the construction of a high dam, and a potential reservoir site containing few residents and relatively little economic activity at this time, indicate the probability of a favorable benefit-cost ratio for this project. Plan B, on the other hand, requires seven smaller reservoirs, at considerably greater cost, to provide 610,000 acre-feet of storage compared to 1,310,000 acre-feet in Plan A. Power benefits under Plan A would probably be greater than those of Plan B.

213. The location of the reservoir that would be created by Shankers Bend high dam with respect to the international boundary and the existence of the Indian reservation in the reservoir site in British Columbia, present substantial obstacles to the development of this project. If these obstacles should prove insurmountable, or their solution unduly delay development of the Similkameen Basin, Plan B offers a potential, though less desirable solution. Discussion of the benefits and accomplishments of each plan follow under separate headings.

BENEFITS AND ACCOMPLISHMENTS

214. Navigation. - Any storage on the Similkameen River that would cause an increase in downstream flow during periods of low flow and reduce the downstream flow in periods of high flow would have a slight beneficial effect on navigation downstream on the lower Columbia. However, it is very doubtful if the creation of reservoirs in the Similkameen Basin would cause the introduction of navigation to replace any of the existing transportation facilities in the basin. The only navigation in the basin occurs on Okanagan Lake, which is not affected by either Plan A or Plan B.

215. Flood Control and Drainage. - The high dam at Shankers Bend would provide the greatest amount of flood control for the Okanogan and Columbia Rivers, and eliminate such backwater in Osoyoos Lake as is caused by the Similkameen River. The usable flood control storage of 1,310,000 acre-feet would eliminate practically all damages in the Okanogan valley below the boundary; and, under the present stage of development in the Columbia Basin, would have reduced peak flows of the 1948 flood at The Dalles by approximately 35,000 cubic feet per second. The alternative plan of seven smaller dams, with a total storage capacity of about 610,000 acre-feet, could probably prevent about 80 percent of the average annual flood damage in the United States portion of the Okanogan valley, but its effect on the lower Columbia would be relatively minor.

216. Power. - The high dam at Shankers Bend could produce 24,000 kw. of prime power at the site in uncoordinated operation. However, if its operation were coordinated with existing and certain proposed projects of the Columbia River system, the resulting increase in system power could be of the order of 100,000 kilowatts. In the case of the alternative plan, the increase in system power that would result from a low dam at Shankers Bend could be about 19,000 kilowatts. The power capabilities of the other sites of Plan B have not been computed, but they are believed to be substantial.

217. Irrigation. - Both Plan A and Plan B include essentially complete development of the irrigable land in the Okanogan-Similkameen Basin. Although economic factors do not favor the early development of much of this land, the Board is of the opinion that the ultimate plan of development of the resources of the basin must include such irrigation, and that the required water supplies should be reserved for such use.

218. Storage provided under Plan A will meet all water rights and water requirements for irrigation as well as meeting other needs in the Similkameen Basin and in the Okanogan Basin below the Shankers Bend site, thus releasing the natural flow in Canada for complete utilization during low-flow periods. The water supply needed for complete development of the Okanogan Basin in Canada would, however, require importation of water from outside the basin.

219. Plan B will provide adequate water for all irrigation requirements described above as well as for other existing rights during the low water season. In addition, storage at various sites in the Similkameen Basin in Canada will facilitate the application of water to lands adjacent to the reservoirs and in the valley areas below.

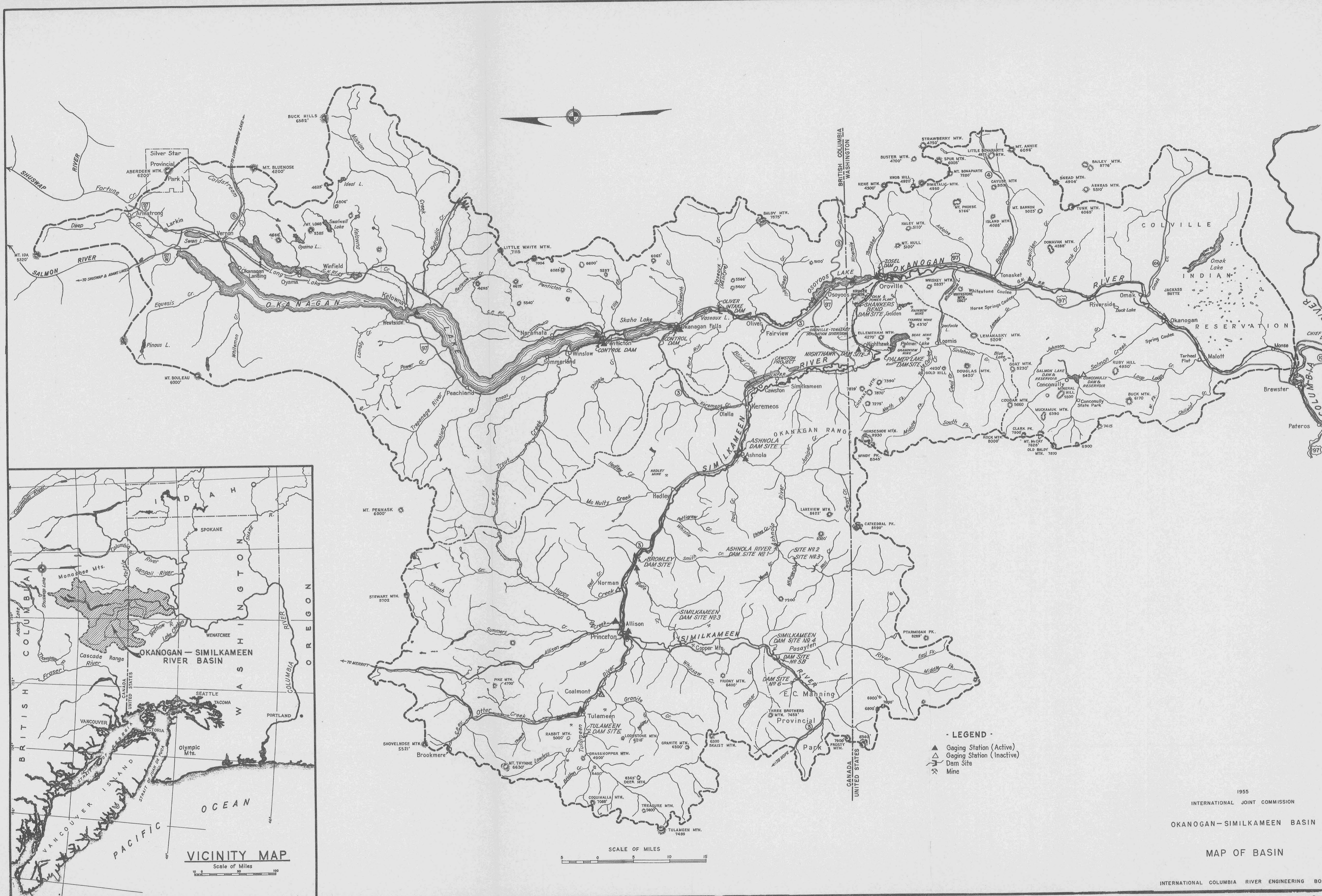
220. Preliminary Cost Estimates of Storage Facilities.

	Estimated Cost (1954 prices)		Usable Storage Acre-feet
Plan A			
Shankers Bend High Dam	$42,689,000	1/	1,310,000
Plan B			
Shankers Bend Low Dam	19,085,000	1/	162,000
Ashnola	4,877,000		62,000
Bromley	14,320,000	1/	273,000
Similkameen No. 3	5,913,000	1/	18,000
Similkameen No. 4	2,432,000	1/	25,000
Ashnola River No. 1 & No. 2	6,501,000		70,000
Total Plan B	$53,128,000		610,000

1/ Cost of power facilities included.

VI. SUMMARY

221. On the basis of data available from limited investigations, two possible comprehensive plans for providing flood control and implementing irrigation and power production have been determined for developing the water resources of the Okanogan-Similkameen Basin. Plan A includes the construction of a high dam and reservoir at Shankers Bend, which would provide ample storage capacity for irrigation and flood control, and would be capable of increasing the power output of the Columbia River power system by a substantial amount. Plan B, which includes a number of smaller reservoirs, would not be capable of providing as much storage capacity or producing as much power as Plan A, but could be developed to provide substantial local flood-control benefits and to provide adequately for the irrigation needs in the Okanogan-Similkameen Basin. The latter plan would cost more, and would produce less benefits than Plan A, but its reservoirs would not flood as much pasture and potential crop-land. Both plans require the importation of water from outside of the basin for irrigation in the Okanogan Basin in Canada. A major portion of the lands required for the Shankers Bend reservoir in Canada and the Ashnola reservoir are Indian Reserve lands, and this fact may present insurmountable difficulties in the use of these sites. Palmer Lake or Nighthawk sites could provide storage for future irrigation development in the United States.



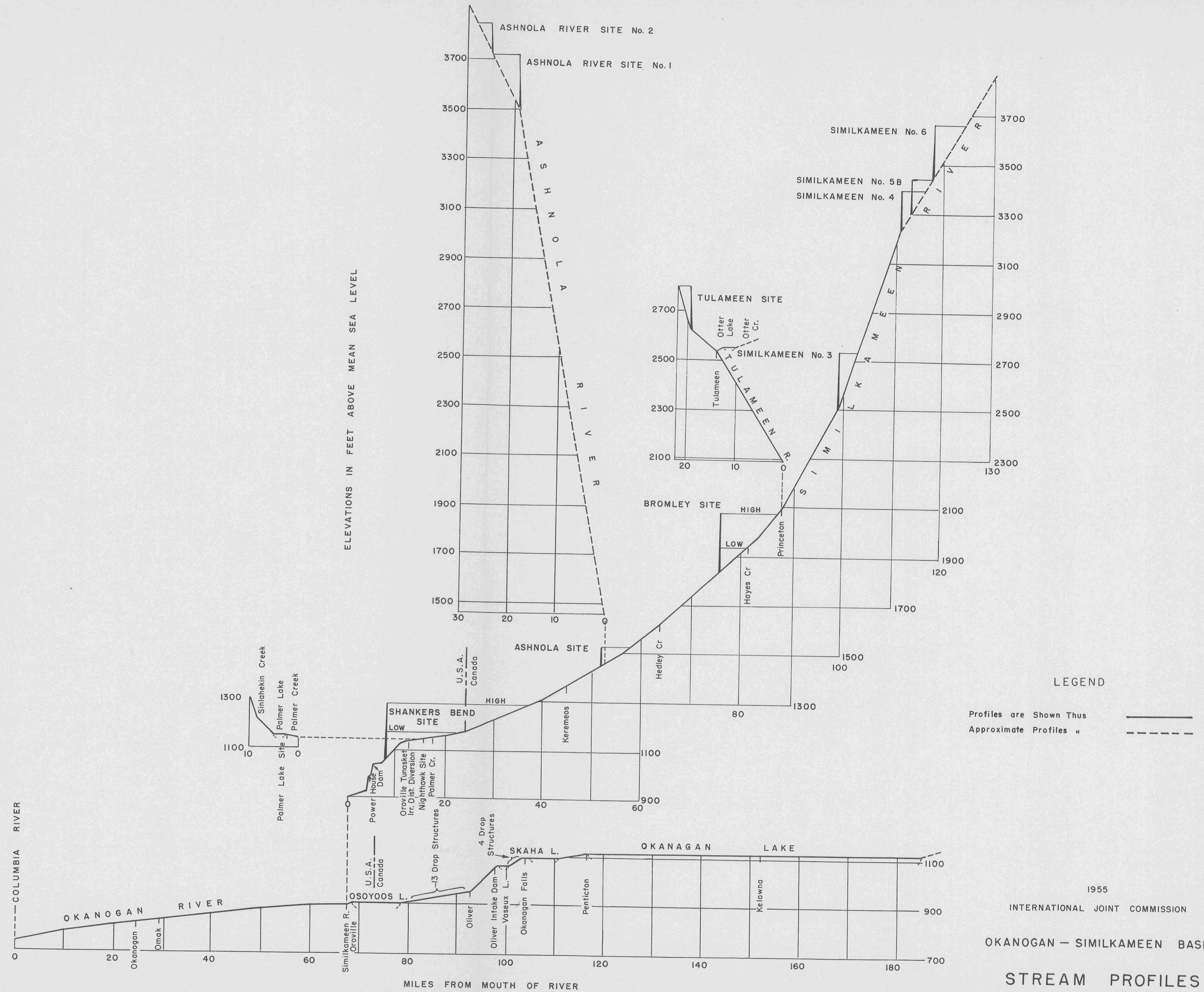
1955
INTERNATIONAL JOINT COMMISSION

OKANOGAN—SIMILKAMEEN BASIN

MAP OF BASIN

INTERNATIONAL COLUMBIA RIVER ENGINEERING BOARD

PLATE 1



1955

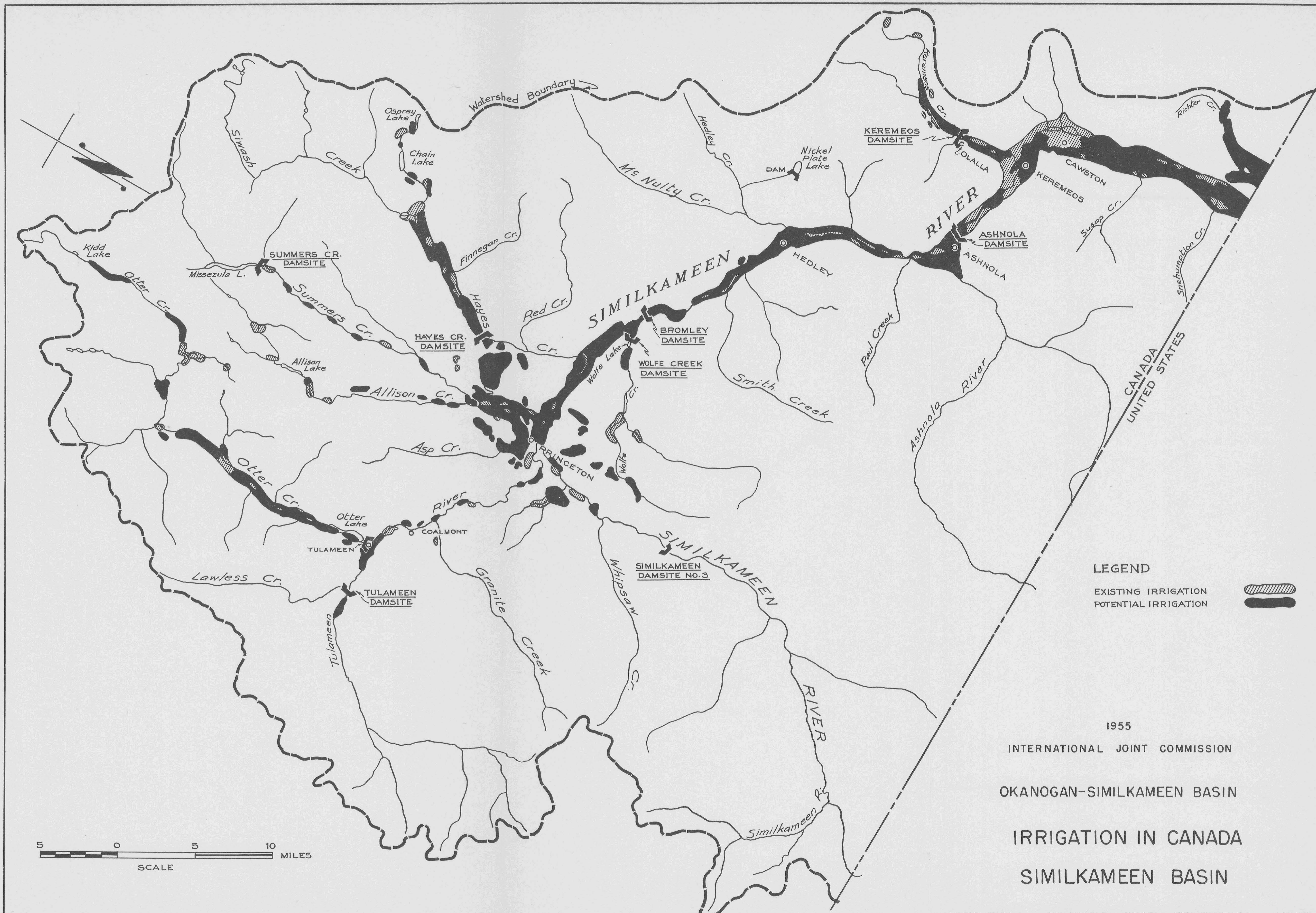
INTERNATIONAL JOINT COMMISSION

OKANOGAN — SIMILKAMEEN BASIN

STREAM PROFILES

INTERNATIONAL COLUMBIA RIVER ENGINEERING BOARD

PLATE 2



1955

INTERNATIONAL JOINT COMMISSION

OKANOGAN-SIMILKAMEEN BASIN

IRRIGATION IN CANADA
SIMILKAMEEN BASIN

INTERNATIONAL COLUMBIA RIVER ENGINEERING BOARD

PLATE 3

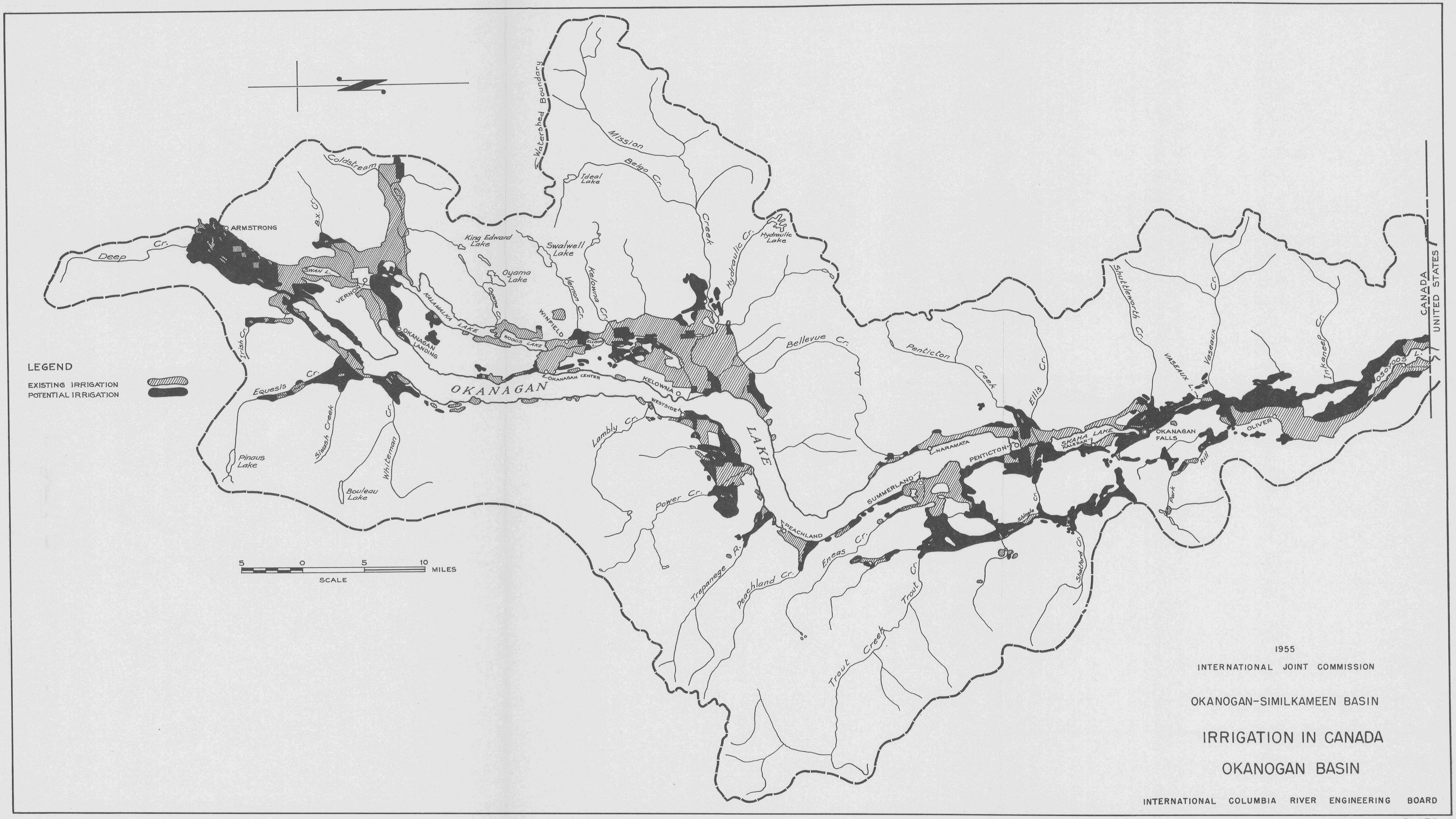
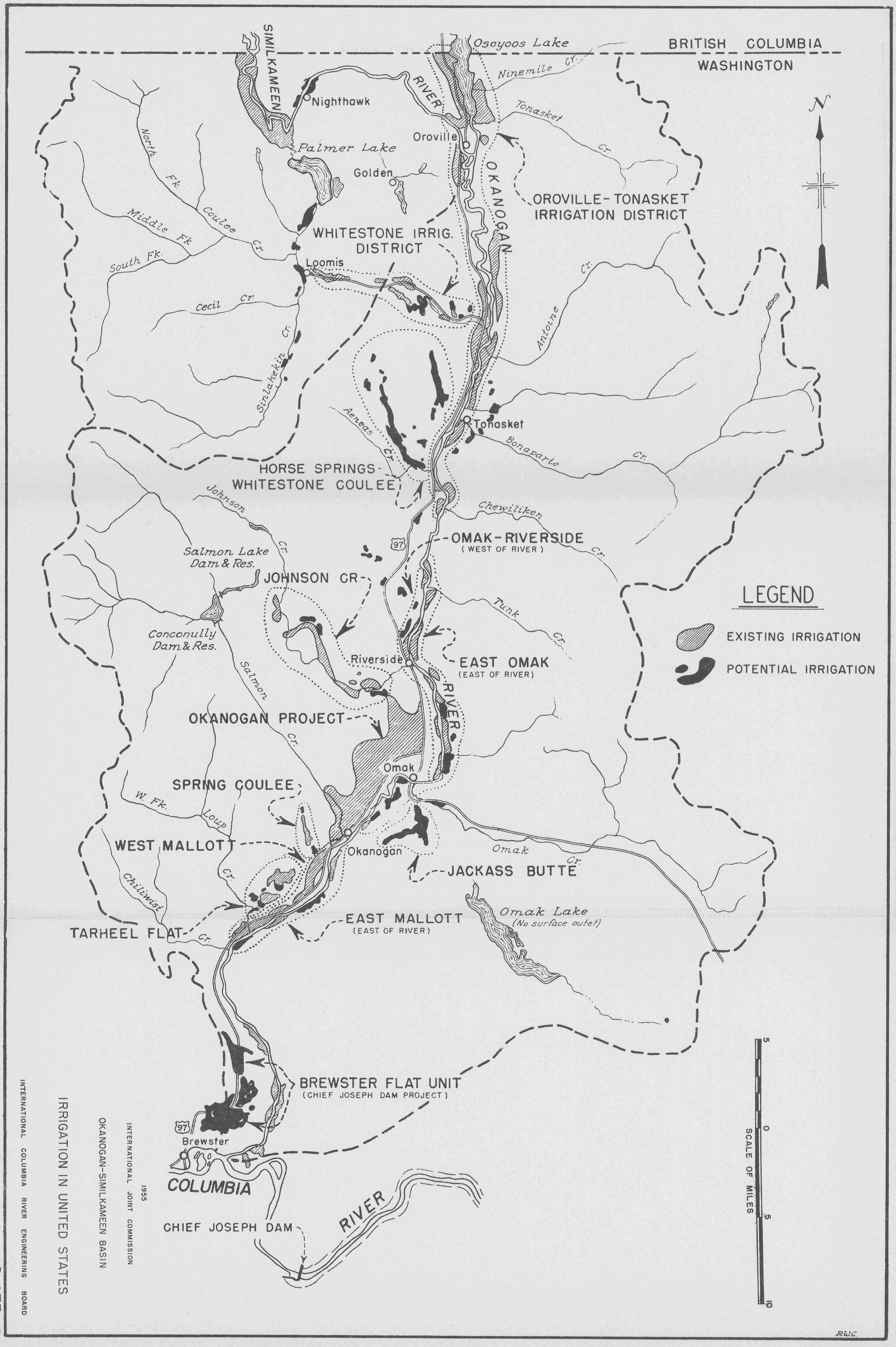

LEGEND
EXISTING IRRIGATION
POTENTIAL IRRIGATION
5 0 5 10 MILES
SCALE
ARMSTRONG
Deep Cr.
Coldstream
B.X. Cr.
SWAN L.
VERNON
KALAMALKA LAKE
WOODS LAKE
OKANAGAN LANDING
Irish Cr.
Equesis Cr.
Siwash Creek
Whiteman Cr.
Pinaus Lake
Bouleau Lake
OKANAGAN
LAKE
OKANAGAN CENTER
WINFIELD
King Edward Lake
Oyama Lake
Swalwell Lake
Vernon Cr.
Kelowna Cr.
Watershed Boundary
Ideal Lake
Mission
Belgo Cr.
Creek
Hydraulic Cr.
Hydraulic Lake
KELOWNA
WESTSIDE
Lambly Cr.
Bellevue Cr.
Power Cr.
Trepanege R.
PEACHLAND
Peachland Cr.
Eneas Cr.
Trout Cr.
Trout Creek
SUMMERLAND
NARAMATA
Penticton Creek
Ellis Cr.
PENTICTON
SKAHA LAKE
Shingle Cr.
Shatford Cr.
Shuttleworth Cr.
VASEAUX L.
Vaseaux Cr.
OKANAGAN FALLS
Park Rill
OLIVER
Inkaneep Cr.
OSOYOOS L.
CANADA
UNITED STATES
1955
INTERNATIONAL JOINT COMMISSION
OKANOGAN-SIMILKAMEEN BASIN
IRRIGATION IN CANADA
OKANOGAN BASIN
INTERNATIONAL COLUMBIA RIVER ENGINEERING BOARD

PLATE 4



INTERNATIONAL COLUMBIA RIVER ENGINEERING BOARD

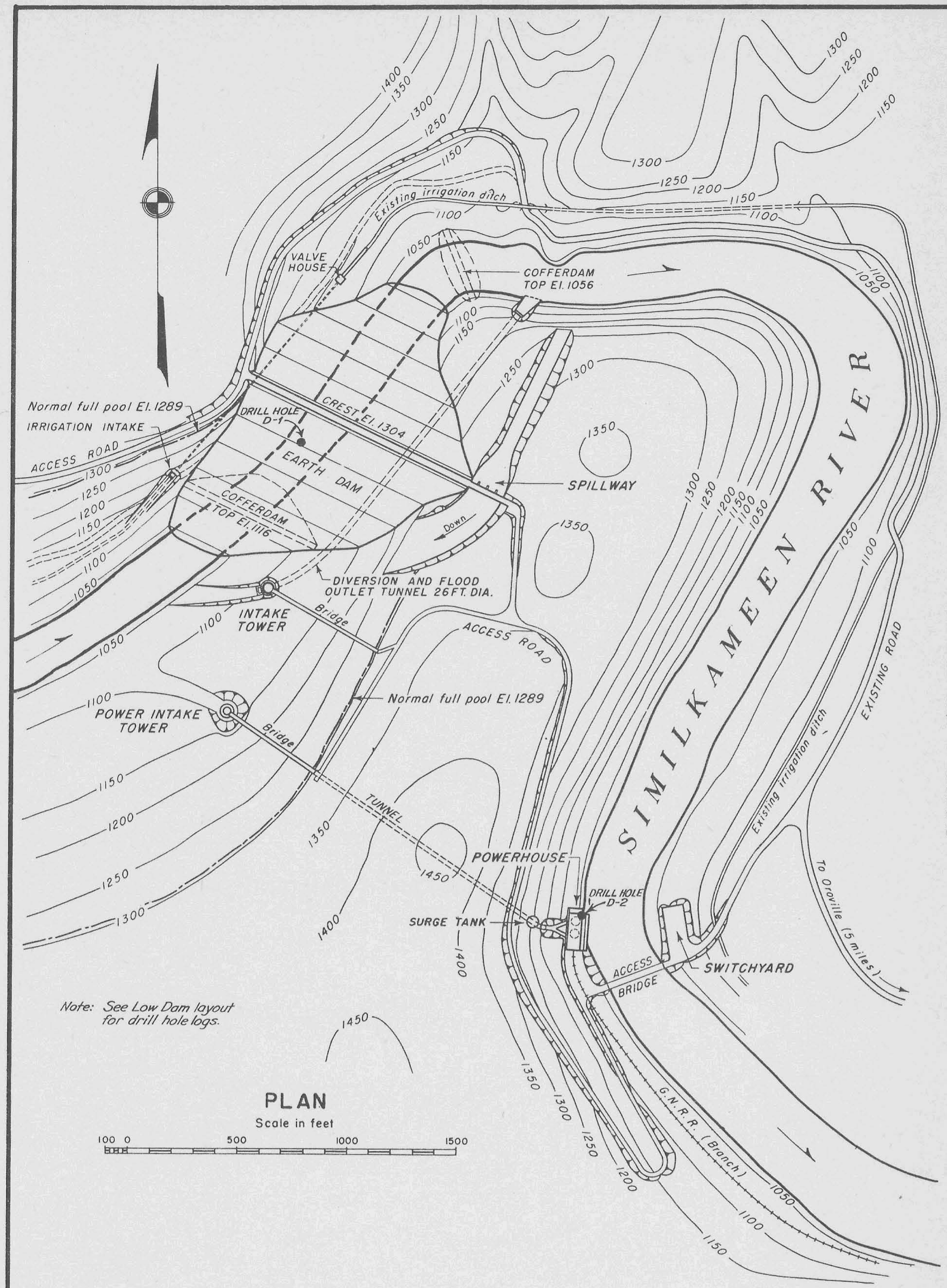
IRRIGATION IN UNITED STATES

OKANOGAN-SIMILKAMEEN BASIN

INTERNATIONAL JOINT COMMISSION

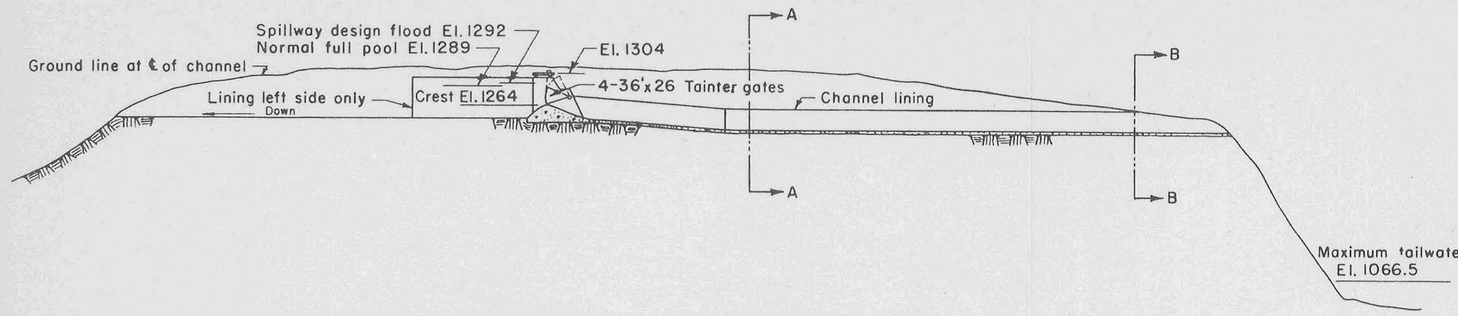
1955

PLATE 5



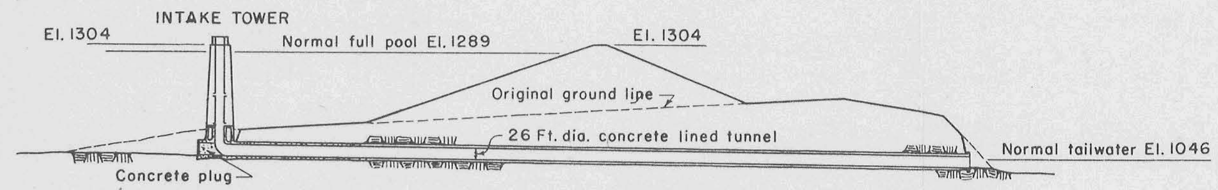
PLAN

Scale in feet



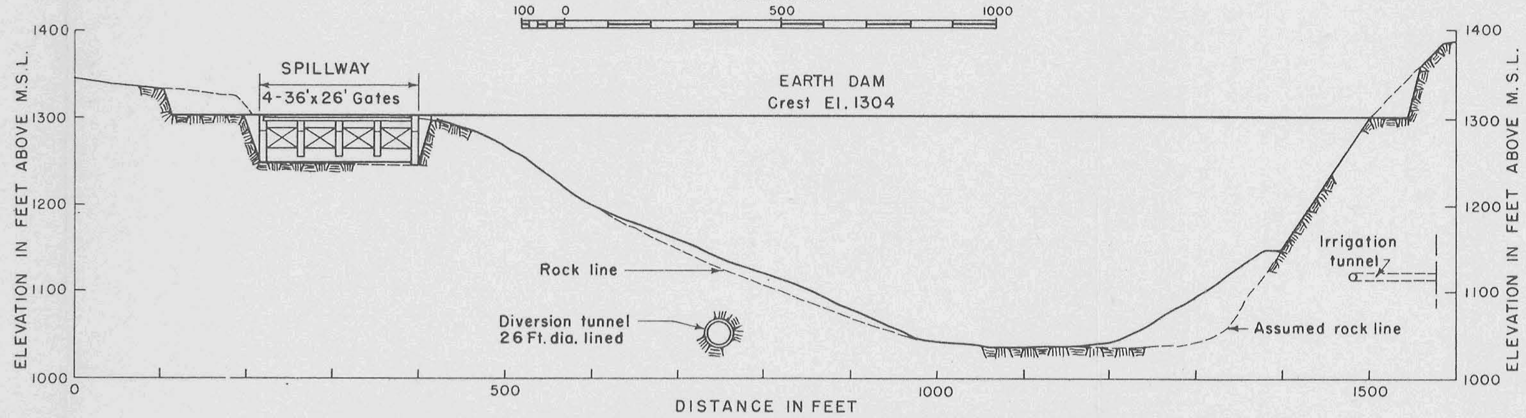
SECTION THROUGH SPILLWAY AND CHANNEL

Scale in feet

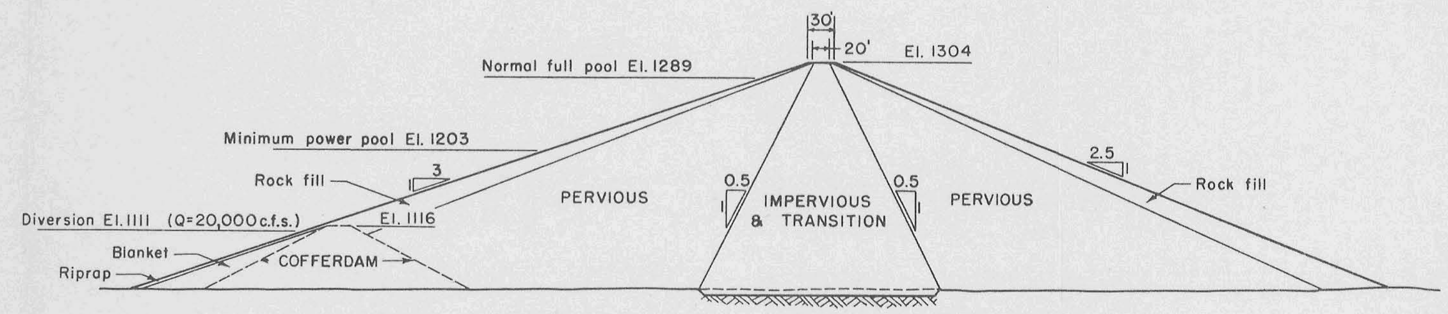


DIVERSION TUNNEL & FLOOD CONTROL OUTLET WORKS

Scale in feet

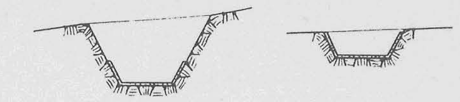


DOWNSTREAM ELEVATION OF EARTH DAM AND SPILLWAY

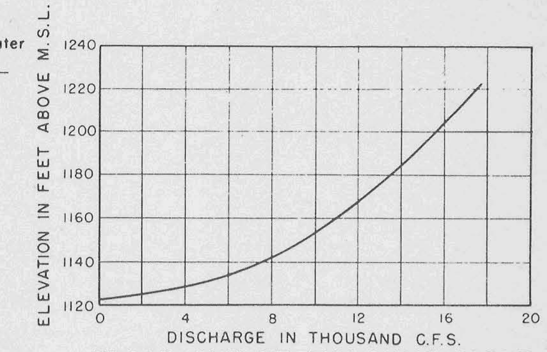


SECTION THROUGH EARTH DAM

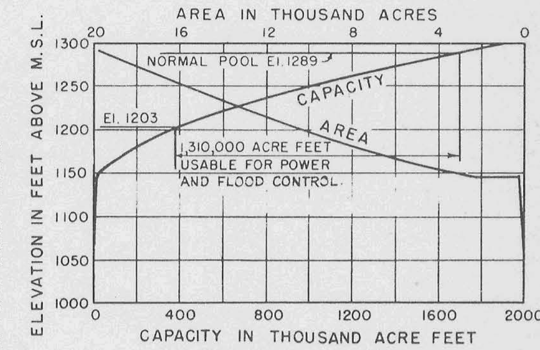
Scale in feet



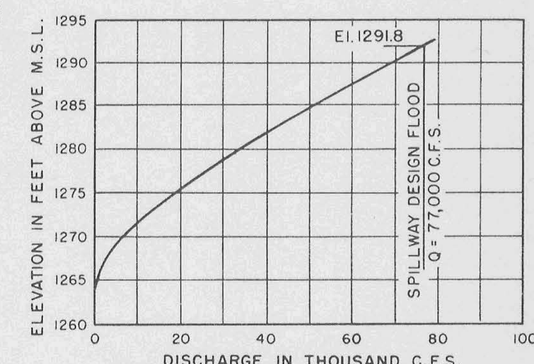
SECTION A-A SECTION B-B



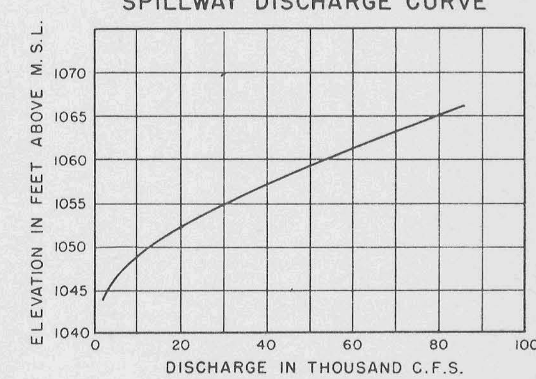
FLOOD OUTLET DISCHARGE CURVE



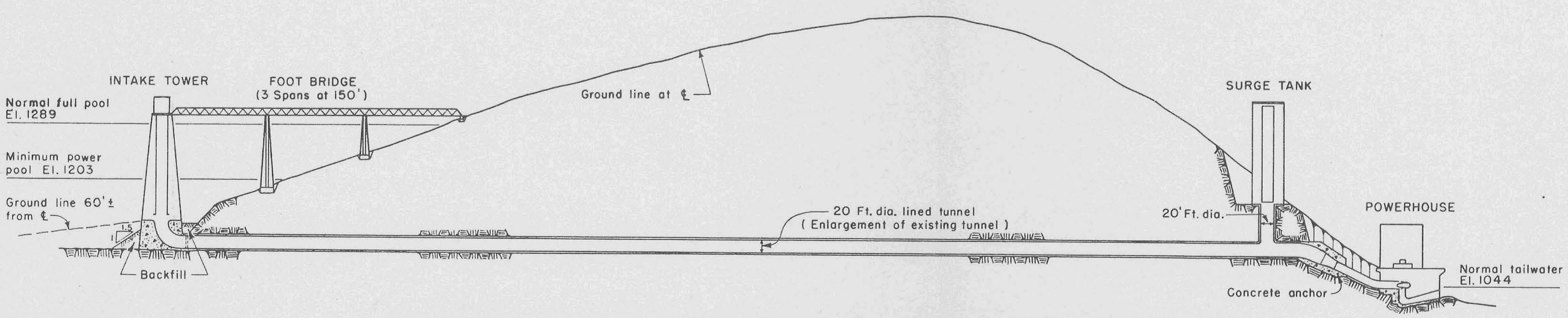
AREA & CAPACITY CURVE



SPILLWAY DISCHARGE CURVE

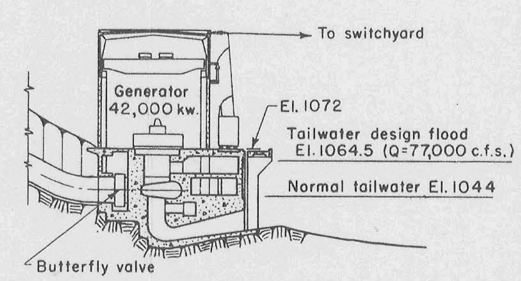


TAILWATER RATING CURVE AT POWERHOUSE



SECTION THROUGH POWER TUNNEL AND POWERHOUSE-DEVELOPED

Scale in feet



SECTION THROUGH POWERHOUSE

Scale in feet

1955

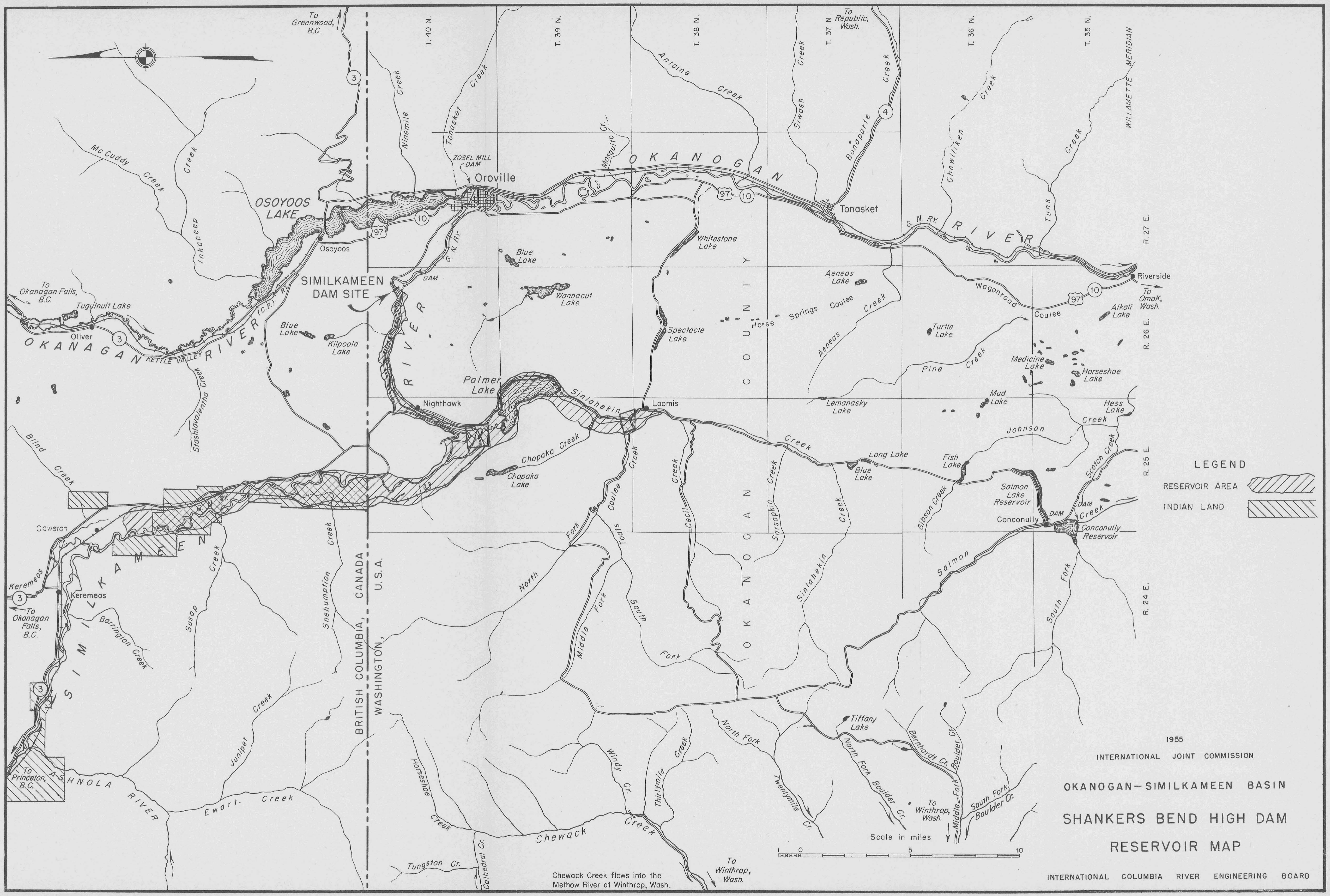
INTERNATIONAL JOINT COMMISSION

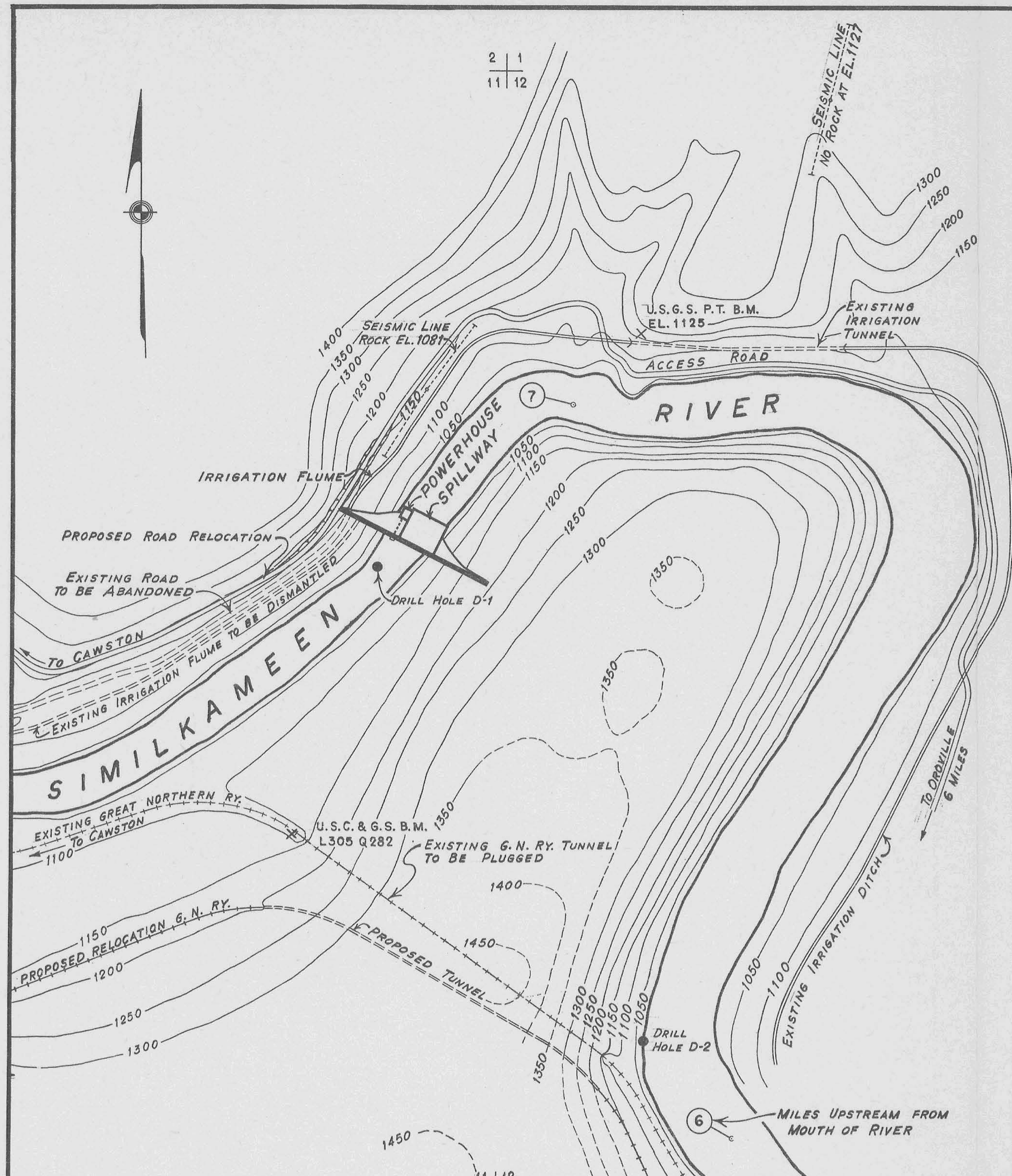
OKANOGAN-SIMILKAMEEN BASIN

SHANKERS BEND HIGH DAM

PLAN AND SECTIONS

INTERNATIONAL COLUMBIA RIVER ENGINEERING BOARD


1955
INTERNATIONAL JOINT COMMISSION
OKANOGAN–SIMILKAMEEN BASIN
SHANKERS BEND HIGH DAM
RESERVOIR MAP
INTERNATIONAL COLUMBIA RIVER ENGINEERING BOARD
LEGEND
RESERVOIR AREA
INDIAN LAND
Scale in miles
1 0 5 10
SIMILKAMEEN DAM SITE
OSOYOOS LAKE
Osoyoos
Oroville
ZOSEL MILL DAM
Tonasket
Riverside
Loomis
Nighthawk
Palmer Lake
Conconully
Conconully Reservoir
Salmon Lake Reservoir
Cawston
Keremeos
Oliver
OKANAGAN RIVER
OKANOGAN RIVER
SIMILKAMEEN RIVER
ASHNOLA RIVER
OKANOGAN COUNTY
BRITISH COLUMBIA, CANADA
WASHINGTON, U.S.A.
KETTLE VALLEY RY.
G. N. RY.
To Greenwood, B.C.
To Republic, Wash.
To Okanagan Falls, B.C.
To Princeton, B.C.
To Omak, Wash.
To Winthrop, Wash.
Chewack Creek flows into the Methow River at Winthrop, Wash.
T. 40 N.
T. 39 N.
T. 38 N.
T. 37 N.
T. 36 N.
T. 35 N.
R. 27 E.
R. 26 E.
R. 25 E.
R. 24 E.
WILLAMETTE MERIDIAN
Whitestone Lake
Spectacle Lake
Blue Lake
Wannacut Lake
Kilpoola Lake
Chopaka Lake
Aeneas Lake
Turtle Lake
Medicine Lake
Horseshoe Lake
Mud Lake
Lemanasky Lake
Long Lake
Fish Lake
Hess Lake
Alkali Lake
Tiffany Lake
Tugulnuit Lake
Sinlahekin Creek
Chopaka Creek
Wagonroad Coulee
Horse Springs Coulee
Salmon Creek
Chewack Creek
Tungston Cr.
Cathedral Cr.
Horseshoe Creek
Ewart Creek
Juniper Creek
Susap Creek
Barrington Creek
Snehumption Creek
Blind Creek
McCuddy Creek
Inkaneep Creek
Ninemile Creek
Tonasket Creek
Antoine Creek
Siwash Creek
Bonaparte Creek
Chewiliken Creek
Tunk Creek
Pine Creek
Aeneas Creek
Johnson Creek
Scotch Creek
Gibson Creek
Toats Coulee Creek
Cecil Creek
Sarsapkin Creek
Windy Cr.
Thirtymile Creek
Twentymile Cr.
North Fork Boulder Cr.
Middle Fork Boulder Cr.
South Fork Boulder Cr.
Bernhardt Cr.
Mosquito Cr.
DAM

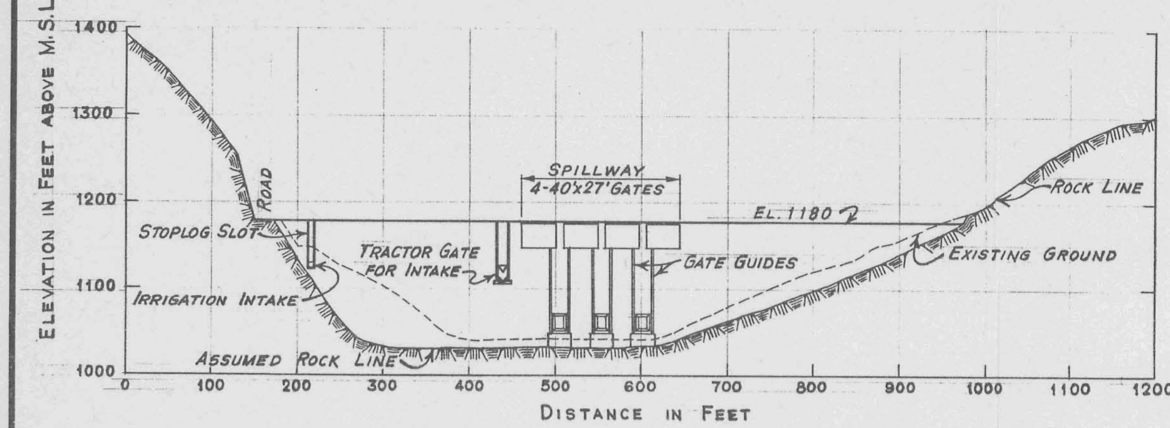


PLAN

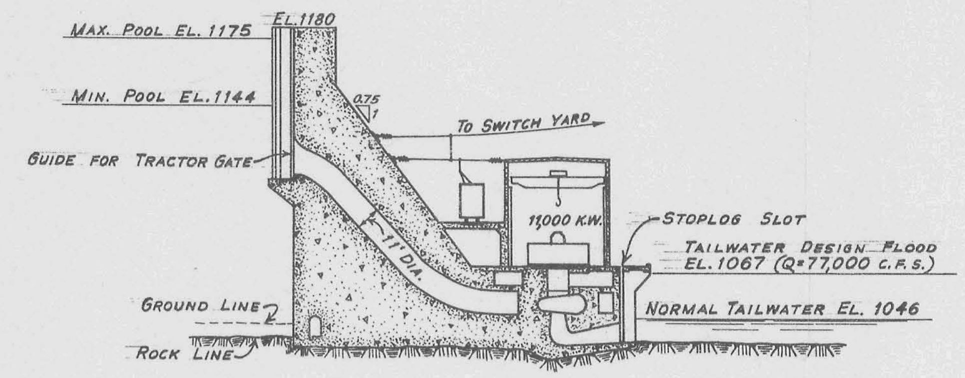
SCALE IN FEET

100 0 500 1000 1500

U. S. G. S. RIVER SURVEY DATUM



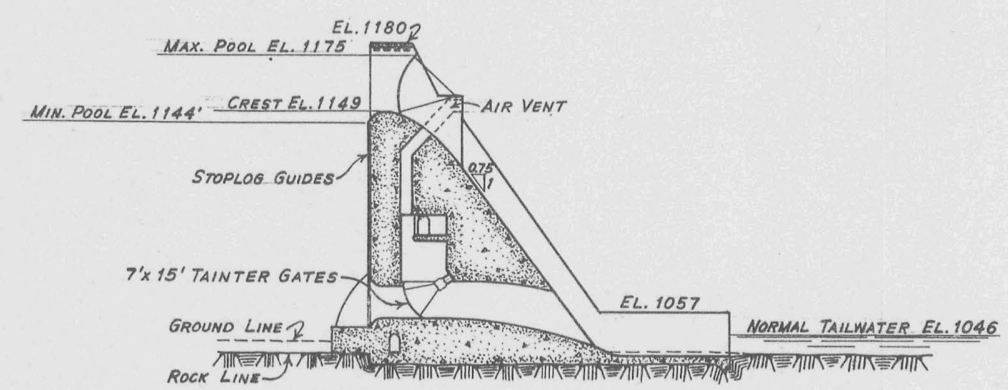
UPSTREAM ELEVATION OF DAM



SECTION THROUGH POWERHOUSE

SCALE IN FEET

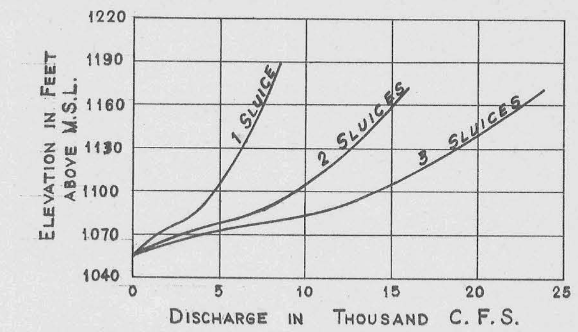
50 0 50 100



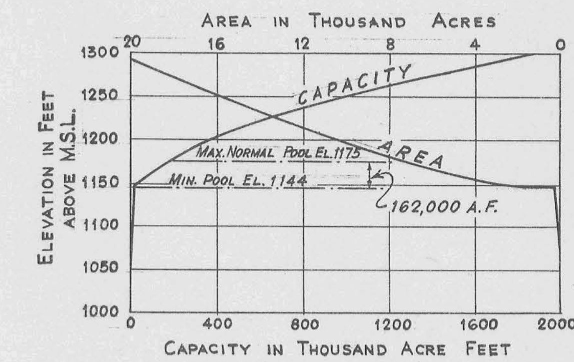
SECTION THROUGH SPILLWAY

SCALE IN FEET

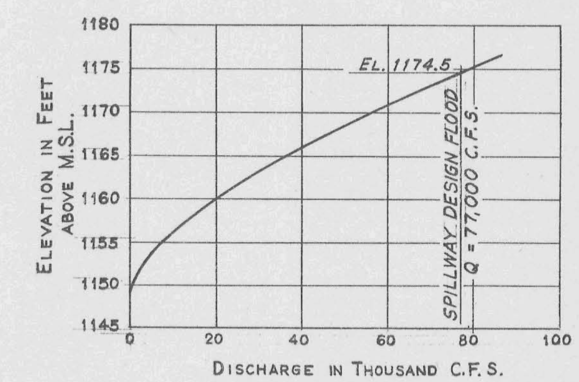
50 0 50 100



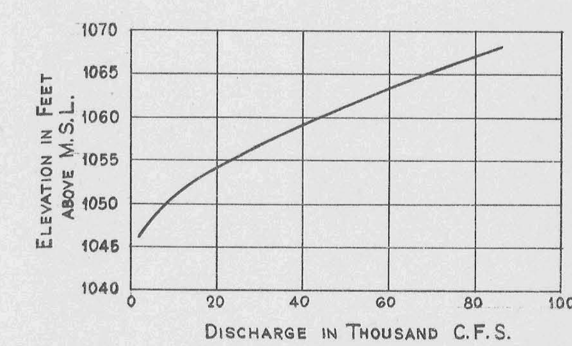
FLOOD OUTLET DISCHARGE CURVE



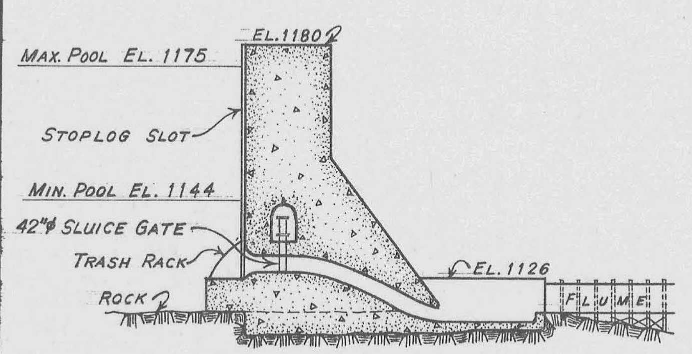
AREA & CAPACITY CURVES



SPILLWAY DISCHARGE CURVE



TAILWATER RATING CURVE



SECTION THROUGH IRRIGATION INTAKE

SCALE IN FEET

10 0 50

D-1

DEPTH	ELEVATION	LEGEND	FIELD CLASSIFICATION
0.0	1043.5		RIVER SAND & GRAVEL
6.0	1037.5		ARGILLITE
			6" SANDSTONE
			ARGILLITE
55.6	987.9		

BOTTOM OF HOLE

D-2

DEPTH	ELEVATION	LEGEND	FIELD CLASSIFICATION
0.0	1058.4		SAND & ANGULAR FRAGMENTS
8.6	1049.8		ARGILLITE
10.7	1047.7		QUARTZITE
14.7	1043.7		ARGILLITE
61.0	997.4		

BOTTOM OF HOLE

LOGS OF DRILL HOLES D-1 & D-2

1955

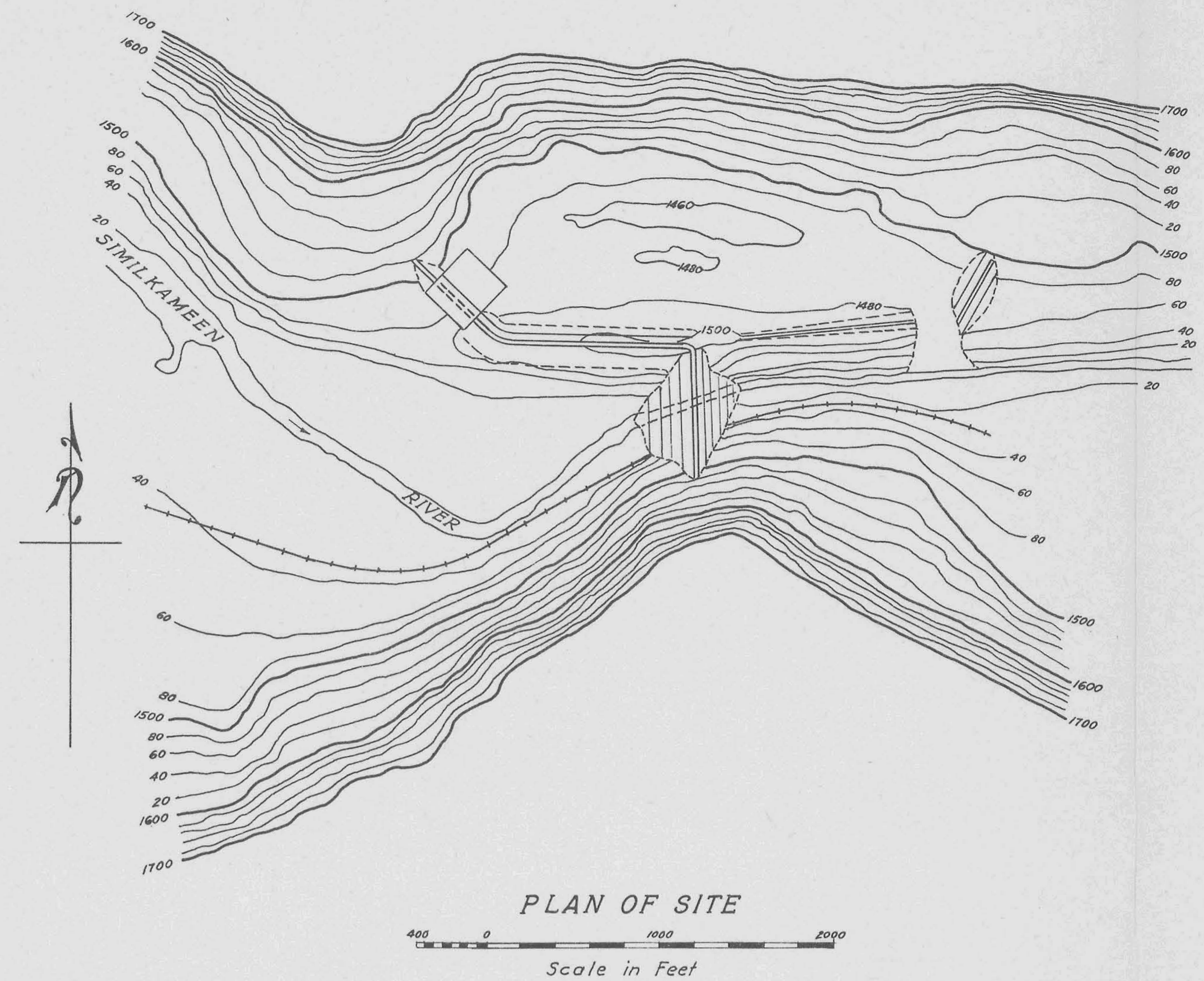
INTERNATIONAL JOINT COMMISSION

OKANOGAN–SIMILKAMEEN BASIN

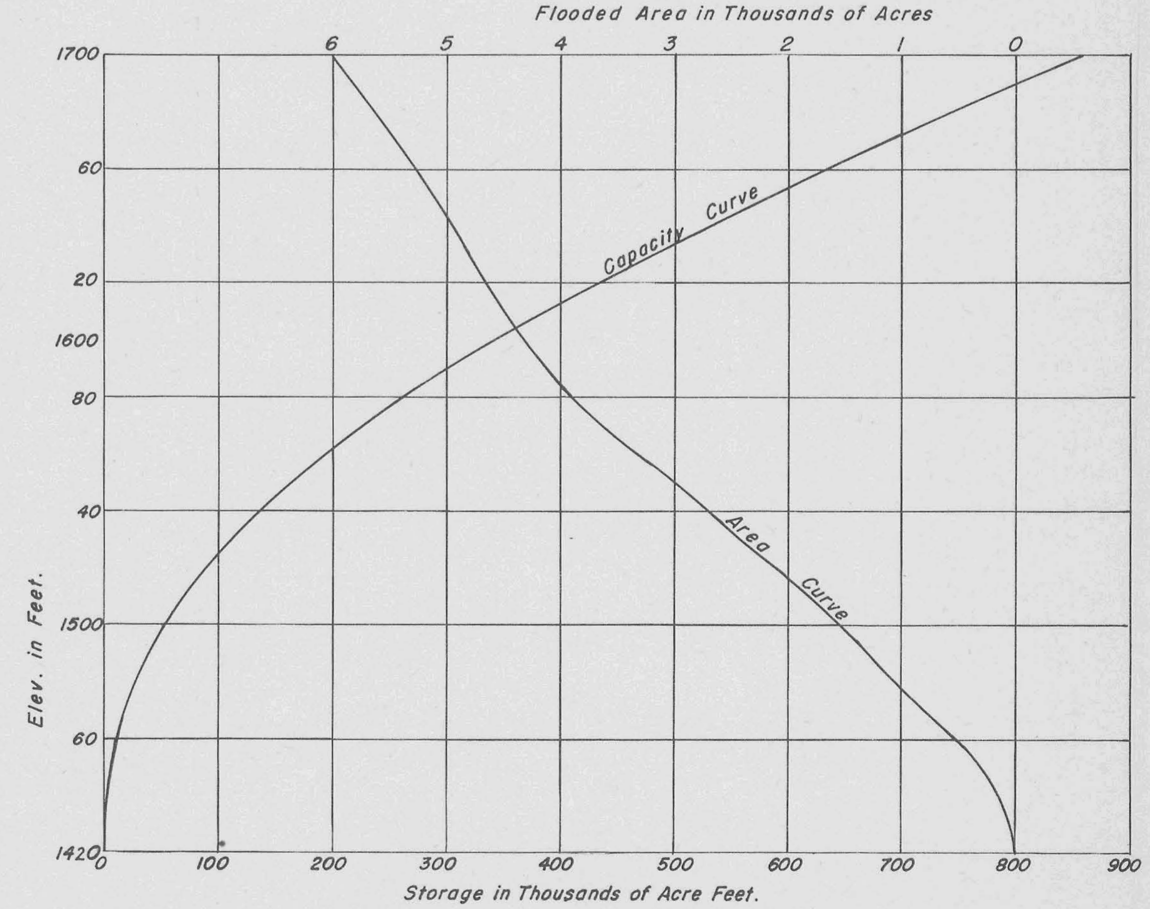
SHANKERS BEND LOW DAM

PLAN AND SECTIONS

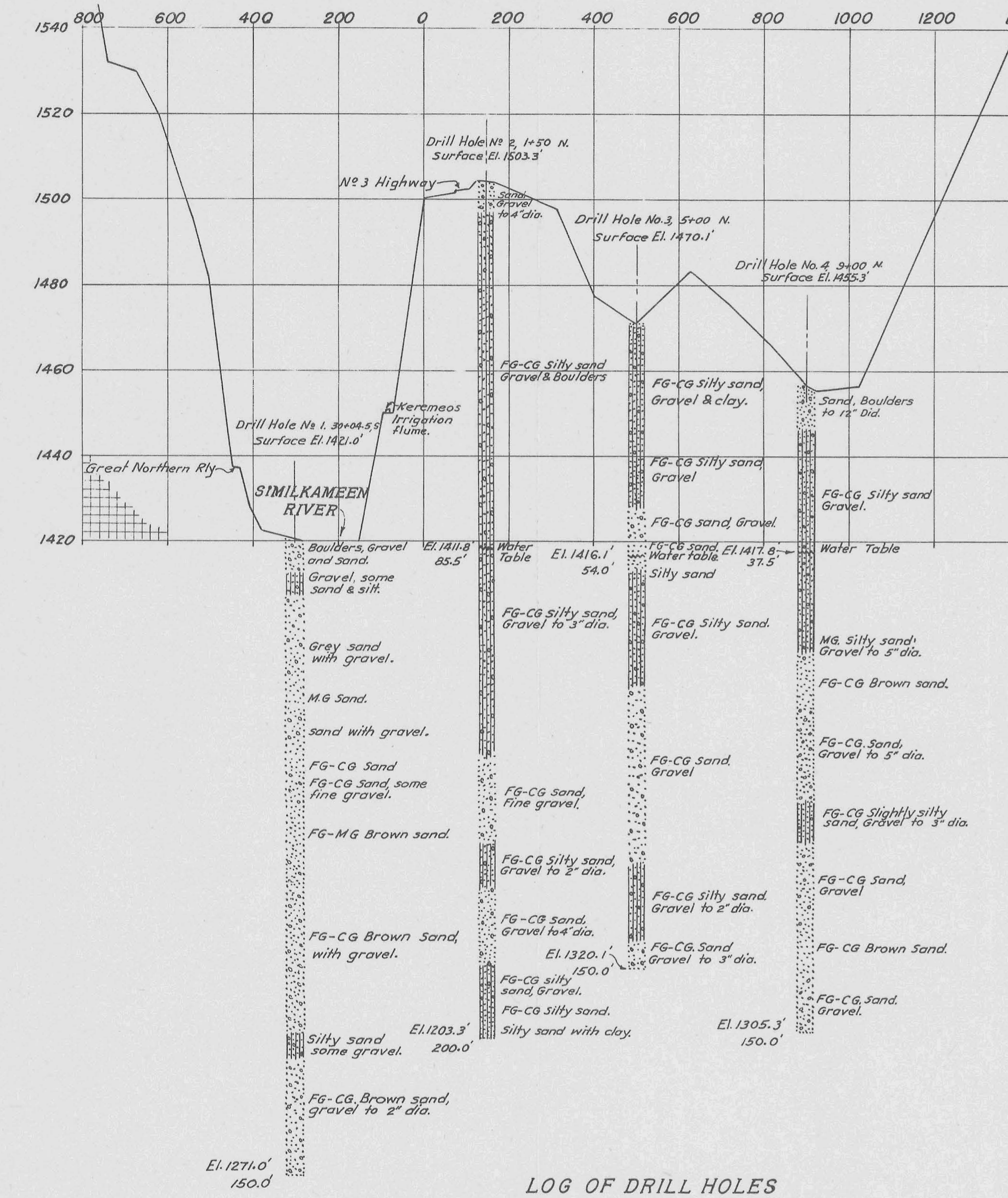
INTERNATIONAL COLUMBIA RIVER ENGINEERING BOARD



PLAN OF SITE



AREA & CAPACITY CURVES.



LOG OF DRILL HOLES
and
PROFILE OF SECTION

NOTE

F.G. Indicates fine grain.
M.G. " medium "
C.G. " coarse "

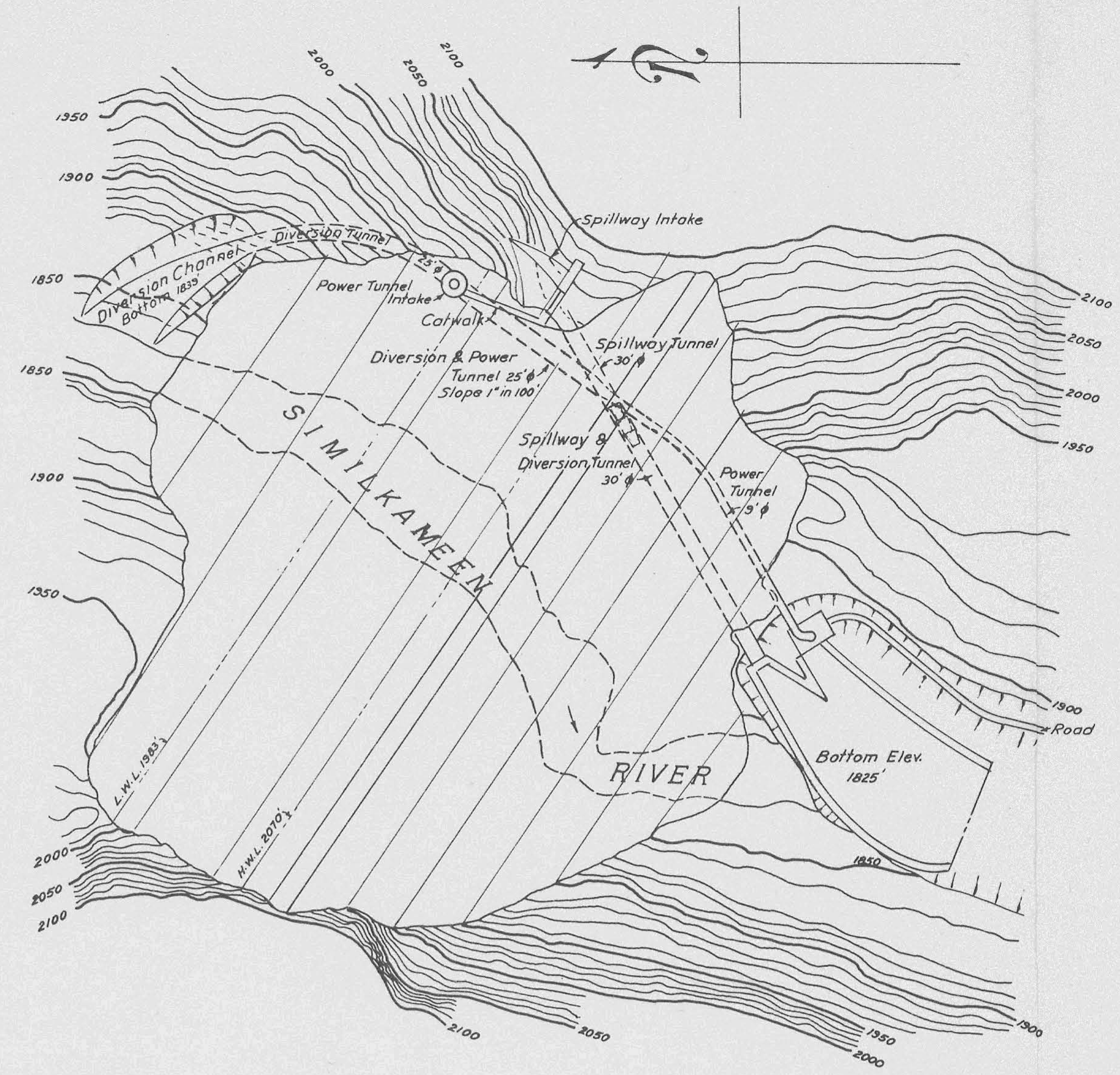
1955

INTERNATIONAL JOINT COMMISSION

OKANOGAN—SIMILKAMEEN BASIN

ASHNOLA SITE
PLAN AND SECTIONS

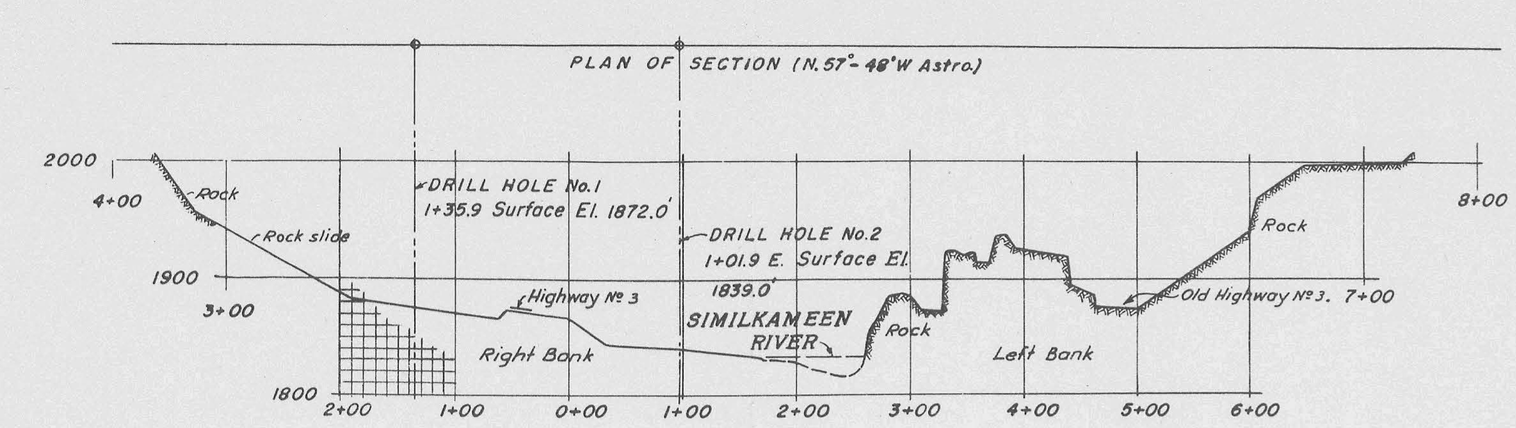
INTERNATIONAL COLUMBIA RIVER ENGINEERING BOARD



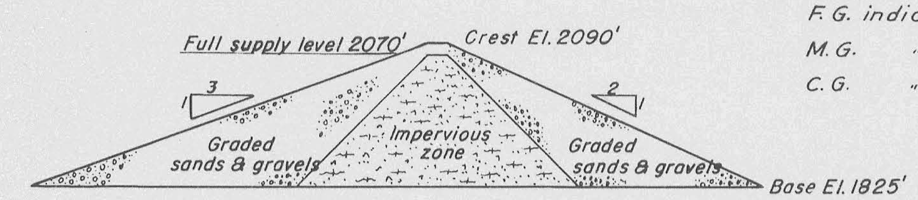
PLAN OF SITE

Scale in Feet

100 0 500 1000



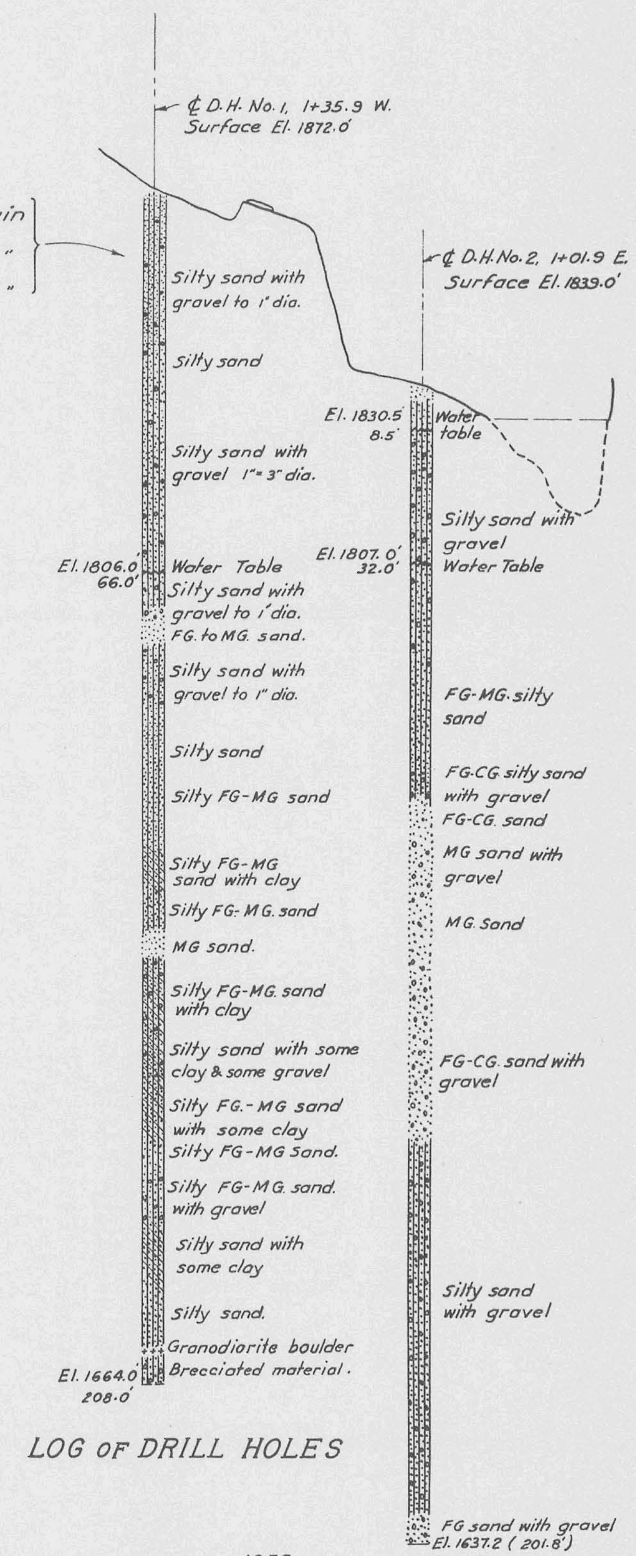
PROFILE OF SECTION



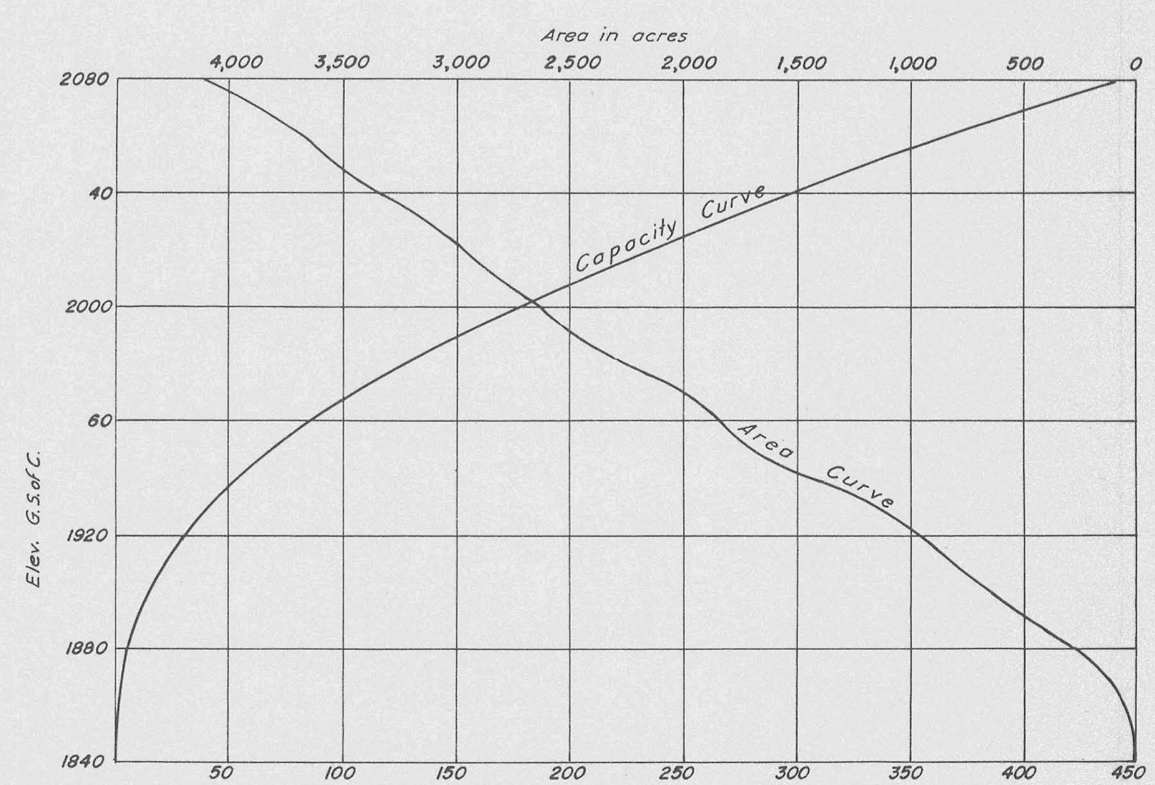
CROSS SECTION OF DAM

NOTE

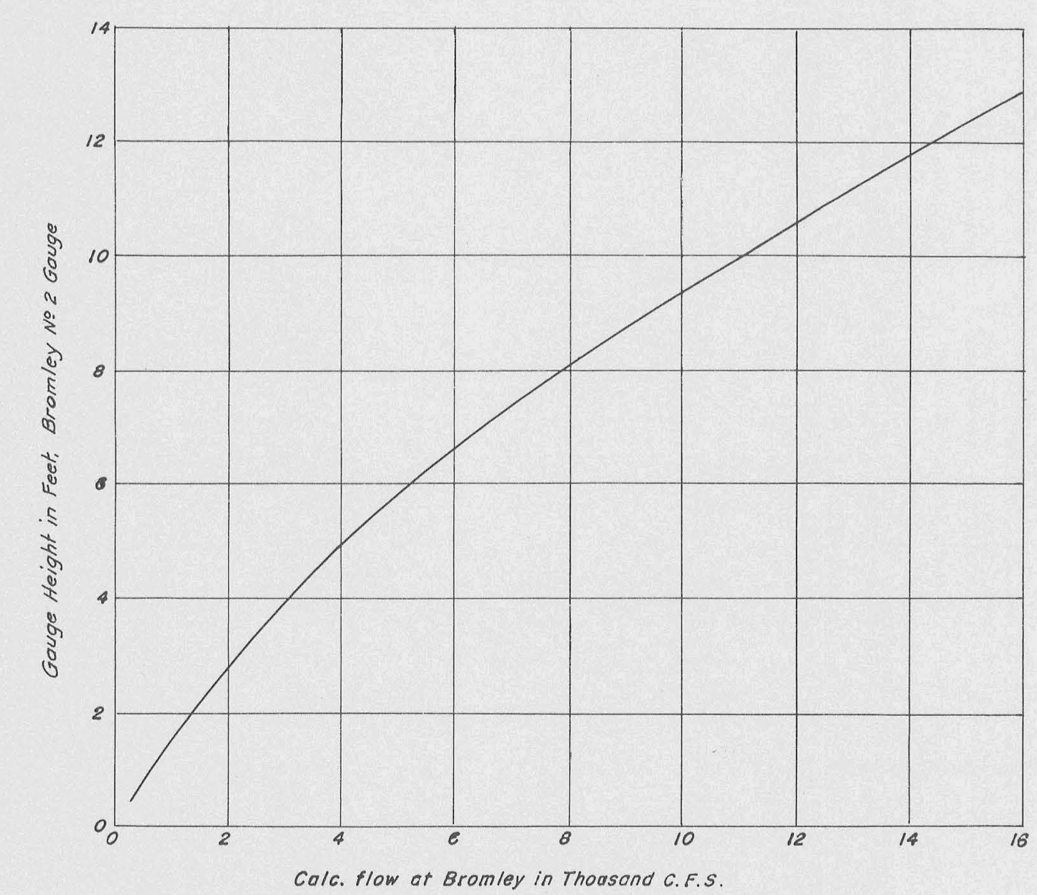
F. G. indicates Fine Grain
M. G. " Medium "
C. G. " Coarse "



LOG OF DRILL HOLES



AREA & CAPACITY CURVE (BROMLEY)



TAILWATER CURVE

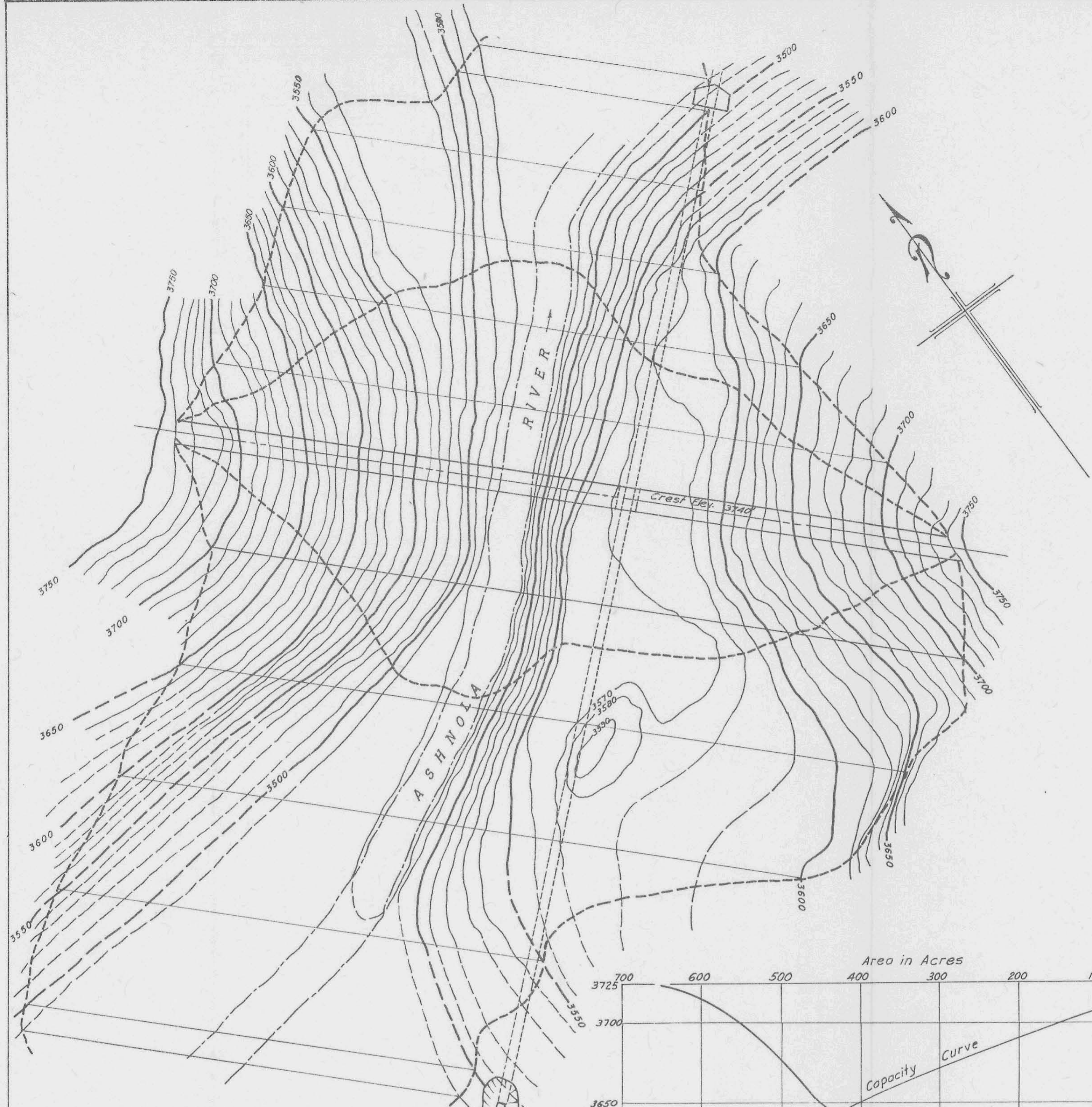
1955

INTERNATIONAL JOINT COMMISSION

OKANOGAN— SIMILKAMEEN BASIN

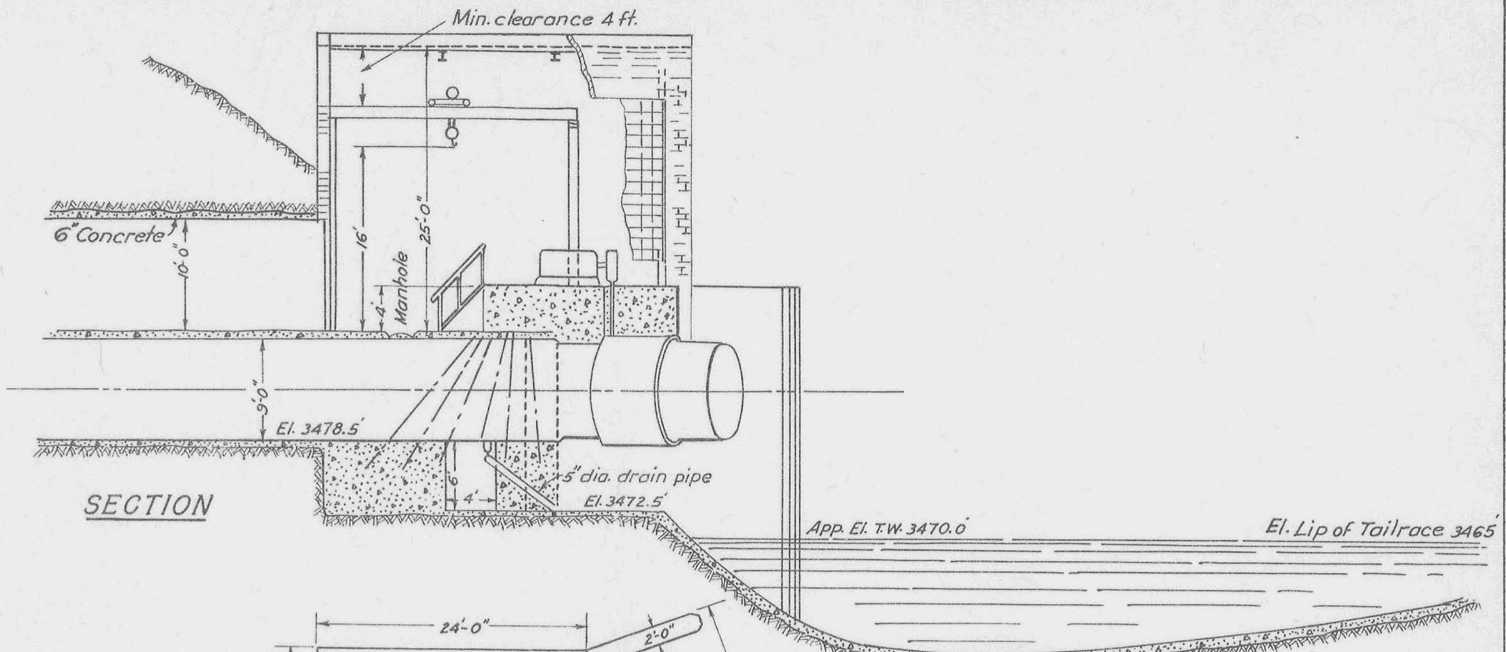
BROMLEY SITE
PLAN AND SECTIONS

INTERNATIONAL COLUMBIA RIVER ENGINEERING BOARD

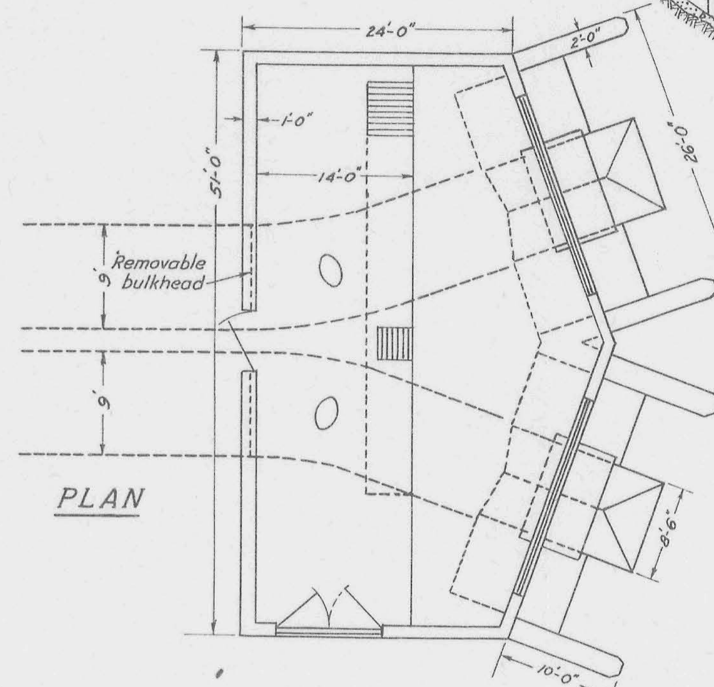


PLAN OF SITE

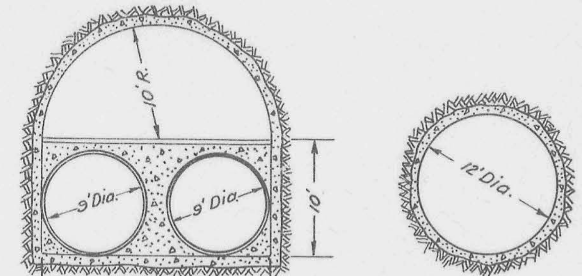
Scale in Feet



SECTION



PLAN

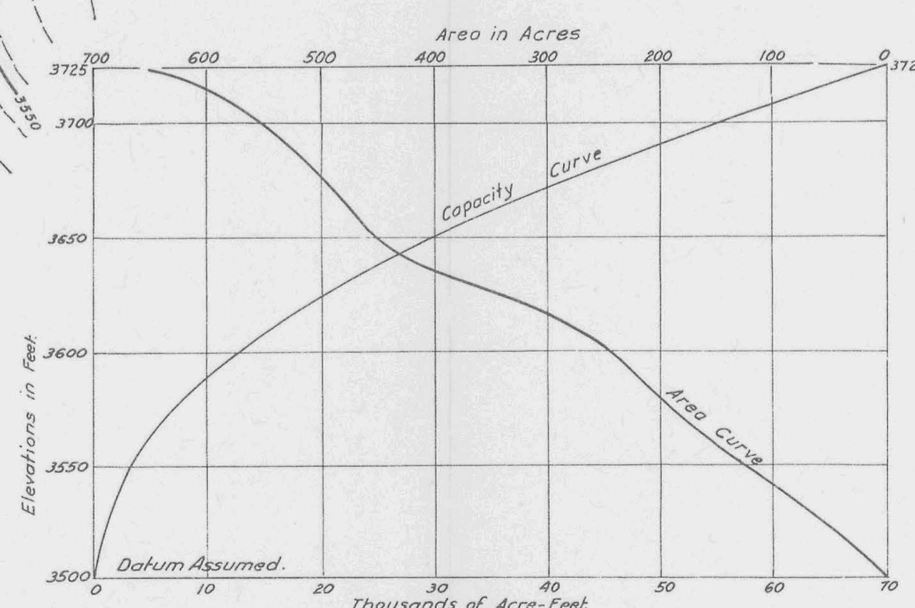


TUNNEL SECTION AT A-A

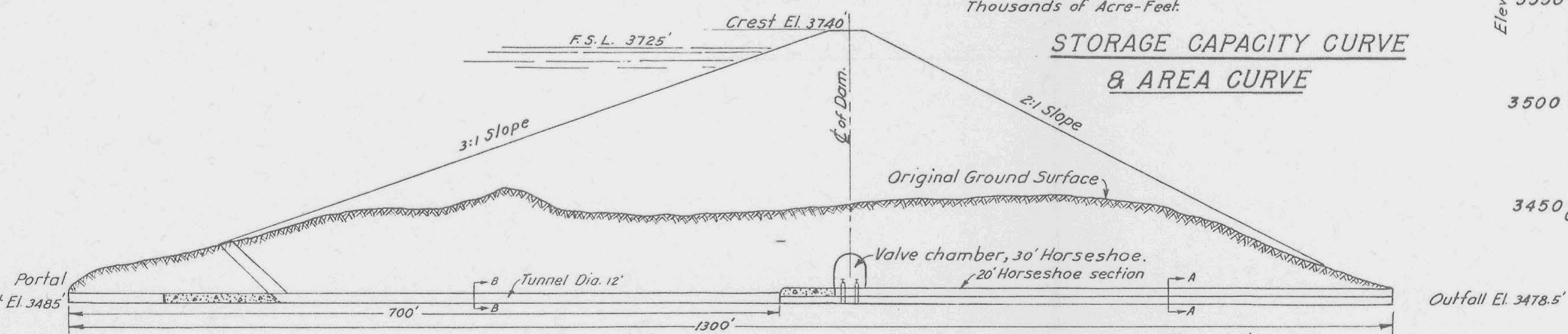
TUNNEL SECTION AT B-B

PROPOSED VALVE HOUSE

Scale in Feet

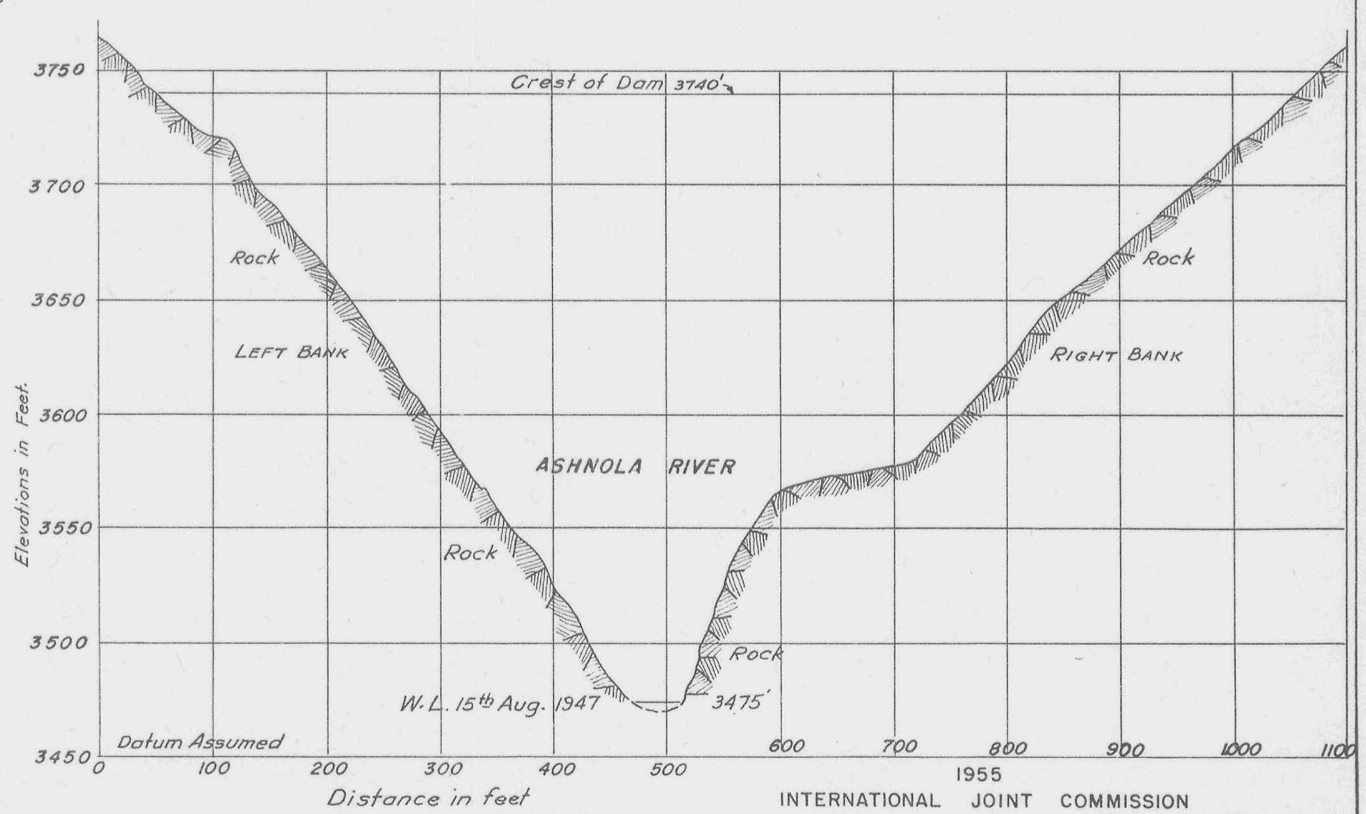


STORAGE CAPACITY CURVE & AREA CURVE



PROFILE ON ℄ OF TUNNEL

Scale in Feet.



CROSS SECTION

1955

INTERNATIONAL JOINT COMMISSION

OKANOGAN — SIMILKAMEEN BASIN

ASHNOLA RIVER SITE No. I
PLAN AND SECTIONS

INTERNATIONAL COLUMBIA RIVER ENGINEERING BOARD