Waterpower Resources of The Wilson River Basin Oregon

By DONALD W. NEAL

With a section on GEOLOGY

By DAVID L. GASKILL

WATERPOWER RESOURCES OF THE UNITED STATE

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1329-B

A discussion of possibilities for developing the potential power of the river

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1961

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C.

CONTENTS

ILLUSTRATIONS

[Plate 3 is in pocket]

TABLES

WATERPOWER RESOURCES OF THE UNITED STATES

WATERPOWER RESOURCES OF THE WILSON RIVER BASIN, OREGON

By DONALD W. NEAL

ABSTRACT

The Wilson River heads on the western slope of the Coast Range and flows into the Pacific Ocean near the town of Tillamook in Tillamook County, Oreg. Annual rainfall ranges from about 100 inches on the coast to 140 inches or more at the crest of the Coast Range. At the gaging station, located at river mile 3.2, mean discharge is 1,230 cfs. There are pronounced variations in rainfall and streamflow during the year. Five percent of the average annual streamflow occurs from June through September, and 64 percent from December through March. Variations within short periods are also pronounced owing to the short length of time required for rainfall to be realized as streamflow. Storage is therefore essential for any power development.

The Cedar Creek reservoir site is the only favorable storage site in the basin. The damsite is at mile 19.3 where a 239 foot dam would be required to provide adequate regulation. Power development would be accomplished by utilizing the head at the dam and developing the head downstream therefrom by diversion and conduit methods. Concentrating power development during the 5-month period, November through March, is considered the most logical plan of development. Since 77 percent of the average annual streamflow occurs during this period, less storage would be required than for a plan of development having a continuous power output. With such a plan it is estimated that about 20,000 kilowatts of firming power could be developed at the Cedar Creek damsite, and 29,000 kilowatts in the reach of river between the damsite and mile 4.5.

The most effective use of the Wilson River's potential power appears to be for firming purposes during the winter period, thereby utilizing the high winter runoff of this region. Integration with the Northwest Power Pool would result in a firm-power increase greater than from a similar project on a stream with high streamflow during spring and summer.

INTRODUCTION

PURPOSE AND SCOPE

The purpose of this report is to present an evaluation of the potential waterpower of the Wilson River basin. This is arrived at by considering the basic elements relating to waterpower development—namely, streamflow, topographic and geologic features, cli-

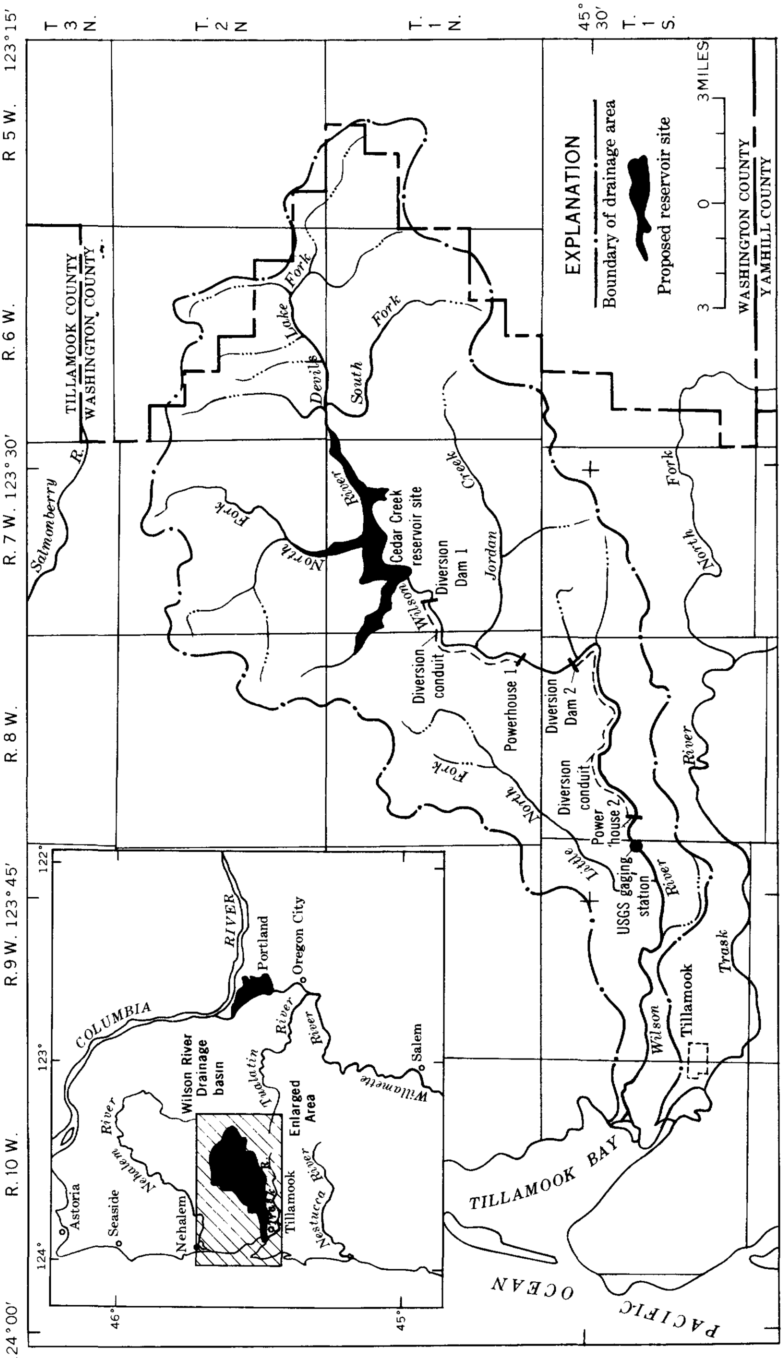

FIGURE 3.—Map of Wilson River basin, Oregon.

matic conditions, and other pertinent related data. As a means of estimating power a certain general scheme or illustrative plan of development is considered. Although actual development will most likely follow the general plan discussed, alternative plans may also prove worthy of consideration.

LOCATION OF AREA

The Wilson River is located in Washington and Tillamook Counties in western Oregon (fig. 3). It is formed by the junction of the Devils Lake Fork and South Fork in sec. 5, T. 1 N., R. 6 W., Willamette meridian, at an elevation of approximately 840 feet. It drains an area of 194 square miles on the west slope of the Coast Range and flows into the Pacific Ocean near Tillamook.

The Devils Lake Fork, which is the larger tributary, heads in sec. 8, T. 1 N., R. 5 W., at an approximate elevation of 1,680 feet, and flows in a westerly direction. In the 10 miles from its headwaters to the junction with the South Fork it has a fall of about 840 feet. The highest point within this drainage basin is 3,449 feet, on Larch Mountain, in sec. 16, T. 2 N., R. 6 W. The primary tributaries are Drift, Elliot, and Deo Creeks, but there are also several small unnamed tributaries.

The South Fork heads in sec. 13, T. 1 N., R. 6 W., at an approximate elevation of 2,080 feet and flows in a northwesterly direction. In 7 miles from the headwaters to its junction with the Devils Lake Fork it has a fall of about 1,240 feet. This fork has no named tributaries. The highest point within the South Fork basin is 3,535 feet, on the dividing ridge between the Wilson River and Trask River drainage basins, in sec. 28, T. 1 N., R. 6 W.

The Wilson River, from the junction of the South and Devils Lake Forks, flows southwesterly 33 miles to its mouth in Tillamook Bay. The total fall in these 33 miles is 840 feet, 660 feet of which is in the first 15 miles below the junction mentioned above. The highest point in the Wilson River basin is 3,550 feet, a mountain peak about 2 miles northeast of the Blue Lake guard station in sec. 2, T. 2 N., R. 7 W.

The Wilson River has more than 30 tributaries in the reach between the junction of its component forks and the ocean. Most important of these are the Little North Fork at mile 9.9 and the Big North Fork at mile 28.6.

PREVIOUS INVESTIGATIONS

A "Report on the Potential Water Power of Nehalem and Wilson River Basins, Oregon," was prepared by Benjamin E. Jones and Warren Oakey in March 1924 and is now in open file with the Geological Survey.

A report, "Water Power of the Coast Streams of Oregon," by R. O. Helland, was released to open file in 1953. It contains general information on the development possibilities of these streams and a short report on nine of the more important ones, including the Wilson River.

The Corps of Engineers prepared a report on the Wilson River in 1936, but it was not published. It was one of a series of reports that have become known as "308 Reports."

MAPS AND AERIAL PHOTOGRAPHS

The entire Wilson River basin is included in four 15-minute quadrangles mapped by the Geological Survey in 1955 as a revision of previous mapping by the Corps of Engineers. These, the Timber, Enright, Blaine, and Tillamook quadrangles, are published at a scale of 1: 62,500 and a contour interval of 80 feet.

A map entitled "Plan and Profile, Wilson River, Oregon, to Mile 29 and Tributaries" was published by the Geological Survey in 1957. This map is at a scale of 1:24,000 (1 inch=2,000 feet) with a 20-foot contour interval on land and a 5-foot interval on the river surface. Topography of the valley downstream from mile 18.8 is shown to 100 feet or more above the river surface, and upstream from mile 18.8 topography is complete to the 1,000-foot contour. A detailed map of the Cedar Creek damsite is included. This is at a scale of 1:4800 (1 inch=400 feet), with a 10-foot contour interval on land and a 1-foot interval on the river. The map set consists of 3 sheets, 2 showing the river and damsite and the third a diagrammatic profile of the river.

The Siuslaw National Forest map, 1946 edition, 1 inch=4 miles, includes the southern part of the Wilson River basin. This is not actually within the national forest, but the map extends beyond the forest boundaries.

The entire basin is covered by aerial photographs. Geological Survey photographs of the area, taken in 1953, are at an approximate scale of 1: 37,400. The Corps of Engineers and the Department of Agriculture have also obtained photographs which include the Wilson River basin.

ROADS AND TOWNS

The only town of any significance in the region is Tillamook, which is located about 3 miles southeast of the Wilson River mouth, but outside the Wilson River basin. Tillamook, nationally famous for its cheese production, had a population of 2,751 in 1940 and 3,685 in 1950. In 1958 the Oregon State Board of Census certified the population to be 4,250. Towns within the basin are small and unincorporated, consisting of only a few scattered buildings. The Wilson River voting precinct, which includes an area surrounding the river from its head to several miles below the mouth of Cedar Creek, listed a population of 276 in 1950.

The Wilson River Highway (State Route 6) joins with U.S. Highway 101 at Tillamook. It follows the Wilson River and its Devils Lake Fork east and slightly north over the Coast Range, ending at the Sunset Highway (U.S. Highway 26) west of Portland. This is the only paved road within the basin. Many unpaved forest access and logging roads are located along the larger tributary creeks and in the major logging and salvage areas.

A transmission line of the Bonneville Power Administration follows the highway in many places, connecting Tillamook and the surrounding area with the Northwest Power Pool. Relocation of sections of this line and road will be required in the event of any reservoir development on the river.

LAND DEVELOPMENT AND USE

Most of the land in the Wilson River basin is suitable only for forest growth, as the terrain is too steep for extensive agriculture. At one time this area was part of the huge Douglas-fir forest covering most of coastal Oregon. This resource was only beginning to be utilized when a series of fires in the 1920's and 1930's destroyed much of the timber over an area now known as the Tillamook Burn, which includes much of the Wilson River basin. Salvage operations in the burned-over area are nearly completed and there is little wood left that is suitable for use. Unfortunately much more effort has been expended on salvage than on reforestation, and the heavy brush which has grown up in the last 20 years makes reforestation difficult.

The valley bottom has 6 or 7 square miles of farmland, most of which is located near Tillamook, and which is used for grazing of dairy cattle. There are a few scattered farms farther up the river, but agriculture is not of great importance in the Wilson River basin.

In many areas of coastal Oregon the economy depends heavily on its recreational and scenic value. The Oregon coast attracts large number of tourists each year, and Tillamook receives an important share of its income from this source. The ocean beaches and adjacent areas of this region are a natural playground for many urban residents from Portland. The Wilson River Highway is an important access route.

The Tillamook Burn destroyed much of the timber upon which the economy of this region was based. One result of the fires was an increase in various species of wildlife. Destruction of the heavy forest allowed small trees and brush to flourish, resulting in a favor-

602795 O—61——2

able habitat for deer and other game animals. Hunters prefer the area because of greater visibility than in the dense forests characteristic of many coastal areas.

POWER VALUE OF OREGON COAST STREAMS

The potential power of each coast stream is small in comparison with the capabilities of the Columbia River and its tributaries, which now provide most of the power in the Pacific Northwest. However, streams which head in the Coast Range and enter the Pacific Ocean along the Oregon coast have power potentials, such that their development would be a desirable addition to existing power developments throughout the Pacific Northwest. The coast streams have their greatest streamflow during the period from November through March, which is the critical period for the Columbia River and most of its tributaries. The highest average monthly streamflow on the Columbia River is in June. During the period of record, 21 percent of the annual average has occurred during this month. From September through February average monthly streamflow ranges between 4 and 5 percent of the annual average. Part of the excess water in spring and early summer is stored or used for irrigation and production of secondary power, but only a small portion of this excess water can be

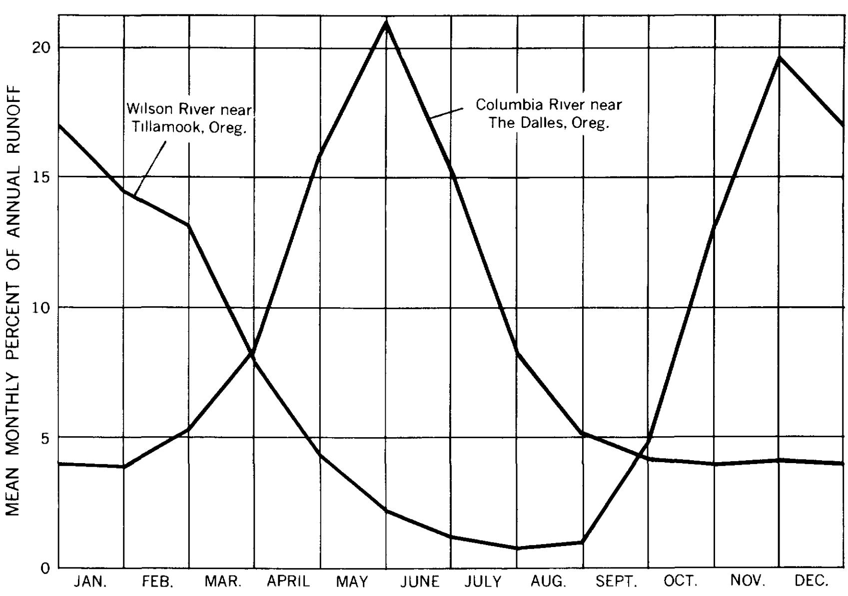

FIGURE 4.—Comparison of mean monthly streamflow in percent of annual runoff, Wilson and Columbia Rivers.

utilized. The superimposed graphs for mean monthly percent of annual flow of the Wilson and Columbia Rivers show that winter low flows begin to occur on the Columbia River in September. At this time the coast streams are still low and storage on the Columbia could be utilized until the heavy fall rains begin in the coastal region. A comparison of flow distribution for the Wilson and Columbia Rivers is shown in figure 4. Power development on the Wilson River and similar streams could be concentrated during the winter months. This would increase the prime power of the Northwest Power Pool more than if the projects were operated on a continuous annual basis.

CLIMATE

The Pacific Ocean exerts an important influence on the climate of coastal Oregon. It controls the major wind movements, stabilizes the temperature, and is the source of damp air that causes the fog and rain characteristic of this region.

Wind currents not affected by local storms proceed in definite patterns along the coast; they can be predicted quite accurately. In the afternoon of a warm or sunny day, the rocks, sand, and earth that have been absorbing heat all day, begin transferring this heat to the surrounding air. This warm air rises and the only air available to replace it is the cooler air over the ocean. This phenomenon is responsible for the late afternoon winds toward the shore. These winds are often felt as far inland as the valleys between the Coast and Cascade Ranges. If the ground cools enough below the water temperature, the effect is reversed, and early morning winds blow toward the ocean.

Precipitation between the ocean and the crest of the Coast Range is very heavy. Although precipitation is lighter between the Cascade and Coast Ranges, the pattern of annual precipitation is similar to that of regions along the coast.

Long-term averages show that 45 percent of the yearly rainfall at the Tillamook station falls during the 3-month period from December through February, 58 percent during the 4-month period from November through February, and 69 percent during the 5-month period from November through March.

Along the ocean, in this region, annual rainfall averages nearly 100 inches. The mean annual rainfall at Tillamook is 95 inches, and at Nehalem, 25 miles to the north, it is 109 inches. At the Glenora weather station, which is now discontinued but was located at the present settlement of Lees Camp on the Wilson River, the mean annual

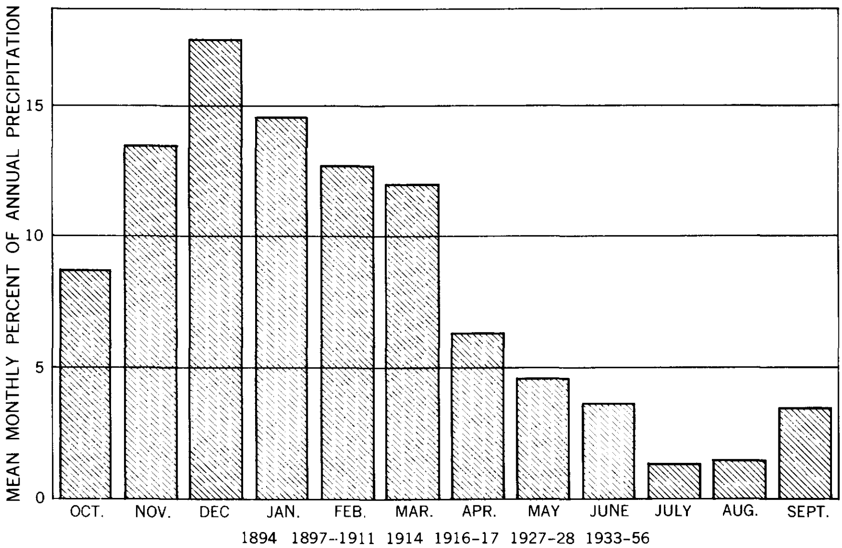

FIGURE 5.—Mean monthly distribution of precipitation at Tillamook, Oreg.

rainfall for the 24-year period 1892–1916 was 130 inches. Figure 5 shows the mean monthly distribution of precipitation in percent of annual precipitation.

Temperatures are generally mild in this region; snow is uncommon and freezing weather seldom lasts more than a few days at a time. Temperature records at stations in or near the Wilson River basin indicate that the average annual temperature is near 50°F. The difference between recorded maximum and minimum temperatures increases slightly in an eastward direction. At Tillamook the extremes are 0° and 101°F, at Glenora 3° and 106°F, and at Timber, just over the Coast Range summit, 0° and 107°F. Starting in 1948, Weather Bureau records show the number of days between the last occurrence of certain temperatures in the spring and their first occurrence in the fall. The mean values for the Tillamook Station for the years 1948 through 1957 gave results as follows: 164 days between the last 32°F temperature of spring and the first of fall, 224 days between the 28°F temperatures and 294 days between the 24°F temperatures. Since 1954, similar records have been kept at a permanent weather station for temperatures of 16° and 20°F, but such low temperatures have not occurred at Tillamook since the record was started. Precipitation and temperature data are summarized in table 1.

TABLE 1.—*Summary of weather data for stations in or adjacent to the Wilson River basin*

Station	Elevation (feet)	Period of record	Average annual precipitation (inches)	Average annual temperature (°F)	Temperature range (°F)
Cherry Grove [1]	900	1936–56	54.1	50.7	0–107
Glenora	575	1892–1916	130.5	49.2	3–106
Lees Camp	575	1949–50	116.3		
Tillamook	26	1894, 1897–1911, 1914, 1916–17, 1927–28, 1933–56.	94.6	50.6	0–101
Timber [1]	975	1942, 1944–47, 1949–56.	62.1		

[1] East of Coast Range.

WATER SUPPLY

Streamflow records are available for the Wilson River, at mile 3.2, from 1931 to the present, and for the Little North Fork Wilson River, 800 feet above its mouth, for the water years 1914 and 1915. Table 2 summarizes this data and includes data from adjoining drainage basins and other parts of the state, which are used for comparison. This table shows that the unit discharge of the Wilson River is the highest of all the main streams listed. Storage within the basin is limited to ground water, as there are no natural lakes and no storage reservoirs. The drainage basin is small and rather steep, so streamflow is quickly affected by precipitation. River stage will rise in a matter of hours following any appreciable amount of rainfall.

The proposed damsite is located 0.3 miles below the mouth of Cedar Creek, at river mile 19.3, which is 16.1 miles upstream from the gaging station. The drainage area at this site is 100 square miles, or 62 percent of the area at the gaging station.

In order to obtain a comparison of the probable rainfall and resulting streamflow at the damsite with that at the gaging station, an isohyetal map with isohyetal lines at 10-inch intervals was constructed, using the rainfall data for stations within and near the Wilson River basin. The total volume of precipitation falling on the two areas was determined by measuring the areas within each 10-inch rainfall zone and multiplying by the inches of rainfall represented by the zone to give a volume of water. The results of these determinations showed that the total volume of rainfall falling on the drainage area at the damsite was 65 percent of that falling on the drainage area at the gaging station, whereas the drainage area ratio is 62 percent.

The number and distribution of the rainfall stations used in preparing the map would not permit the location of the isohyetal lines with any great degree of precision, but the results bear out the general condition that rainfall increases with altitude.

TABLE 2.—*Summary of streamflow data, Wilson River and adjoining streams*

Stream	Gaging station	Period of record	Drainage area (square miles)	Streamflow (cfs)			
				Average	Per square mile	Maximum	Minimum
Little North Fork Wilson River.	Near Tillamook, Oreg.	September 1913–September 1915 September 1916–October 1916	19.9	194	9.75	1,760	12
Wilson River	do	August 1931–September 1957	161	1,195	7.42	30,000	55
Trask River	do	July 1931–September 1950	143	976	6.83	20,000	58
Nehalem River	Near Foss, Oreg	October 1939–September 1950	667	2,573	3.85	36,900	77
Nestucca River	Near McMinville, Oreg.	October 1928–September 1944	12	44	3.67	1,480	1
Tualatin River [1]	At Farmington, Oreg.	October 1939–September 1950	568	1,254	2.21	17,400	23
Crooked River [2]	Near Post, Oreg	December 1908–September 1950	2,160	322	.15	6,190	4

[1] East of the Coast Range in Willamette Valley.
[2] East of Cascade Range.

The 65-percent factor has been applied to monthly streamflow records at the gaging station to obtain the estimated streamflow at the Cedar Creek damsite that is shown in table 3.

The duration curve (fig. 6) for the Cedar Creek damsite was prepared using data from the gaging station, adjusted with the same 65-percent factor as for monthly runoff.

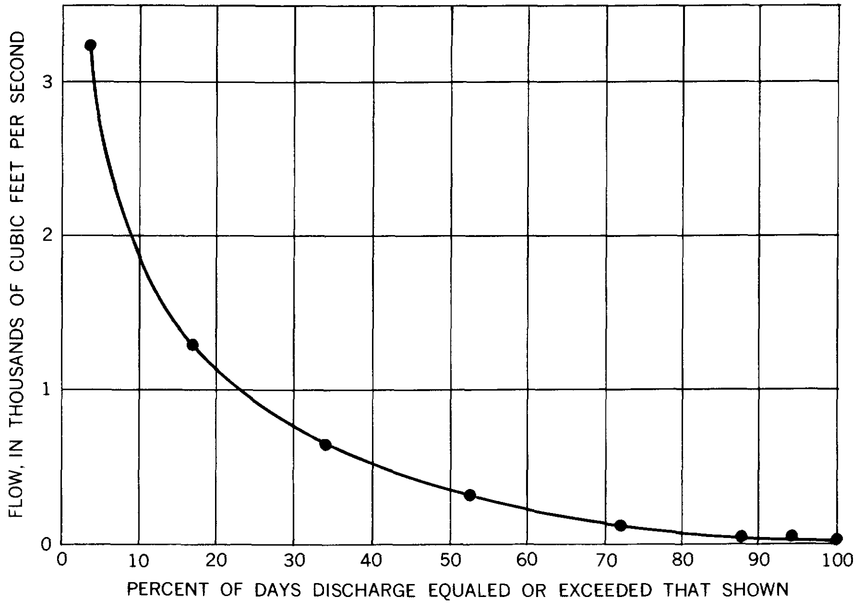

FIGURE 6.—Duration curve of estimated daily streamflow, Wilson River at Cedar Creek damsite, mile 19.3.

TABLE 3.—*Estimated monthly and annual runoff in acre-feet and annual runoff in inches, Wilson River at Cedar Creek powersite*

[Equivalent to 65 percent of runoff at gaging station at mile 3.2]

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual (Acre-feet)	Annual (Inches)
1932	32,200	87,200	89,800	110,000	82,700	132,800	70,300	17,100	7,230	4,880	3,980	2,940	641,100	120.27
1933	7,880	115,200	136,700	117,200	72,900	115,900	48,800	55,700	33,900	8,330	4,730	15,400	732,600	137.44
1934	47,700	44,500	319,800	149,000	26,000	70,600	35,400	29,800	7,410	5,230	3,930	4,780	744,100	139.59
1935	83,500	154,000	123,800	122,800	56,000	81,600	43,800	17,500	7,580	6,830	4,240	5,100	706,800	132.60
1936	8,630	30,800	57,900	181,200	76,000	66,800	24,500	37,300	18,200	10,700	5,680	4,640	522,900	98.10
1937	3,540	3,380	85,300	37,600	96,100	84,100	98,800	35,000	24,700	12,200	6,780	4,670	492,200	92.34
1938	17,200	140,200	160,100	85,900	57,400	90,800	56,000	17,600	7,100	4,450	3,130	2,880	642,800	120.59
1939	8,870	56,300	69,800	81,700	96,200	61,700	16,500	8,090	9,780	6,250	3,570	2,870	421,600	79.09
1940	10,900	16,400	122,300	61,100	123,600	74,300	35,900	34,900	7,020	4,320	3,160	2,990	496,900	93.22
1941	13,800	42,800	57,200	82,600	27,200	23,800	18,900	28,200	11,000	5,860	4,790	29,600	345,800	64.87
1942	31,300	55,900	124,900	40,600	64,300	37,800	21,800	24,700	22,400	11,100	5,660	3,690	444,100	83.31
1943	8,510	127,100	127,200	65,900	105,600	56,300	68,100	19,000	15,100	7,320	4,830	3,460	608,400	114.14
1944	19,500	30,400	66,700	61,700	51,700	42,900	45,100	16,100	13,900	5,340	3,430	3,900	360,700	67.67
1945	6,690	44,500	34,100	89,900	91,700	99,900	54,200	35,900	10,400	5,080	3,630	16,700	492,700	92.43
1946	8,250	119,500	124,300	120,400	99,000	79,700	43,200	14,100	10,200	11,900	4,800	3,760	639,100	119.90
1947	24,600	106,500	148,800	77,400	80,700	48,500	36,300	10,900	17,700	8,890	4,930	8,920	574,100	107.70
1948	89,300	88,300	65,900	97,600	97,200	64,200	59,600	55,500	12,100	6,130	4,360	6,550	646,700	121.32
1949	23,200	85,900	139,600	27,800	154,300	68,700	27,700	36,800	7,230	4,950	3,630	3,520	583,300	109.43
1950	18,200	90,400	99,900	122,300	126,800	131,800	69,300	26,400	9,230	5,030	4,290	3,610	707,300	132.69
1951	51,400	101,100	124,000	140,000	106,400	66,600	33,000	17,800	7,730	4,180	2,750	4,300	659,300	123.68
1952	77,700	70,000	108,800	68,000	91,900	60,600	36,400	17,900	8,240	5,060	3,330	2,600	550,500	103.27
1953	2,320	5,660	68,800	231,200	83,700	57,900	33,800	36,700	15,700	7,660	6,200	5,450	555,100	104.14
1954	24,000	75,500	147,500	136,600	128,000	48,600	57,700	10,800	18,200	10,600	5,570	6,160	669,200	125.54
1955	24,500	74,500	76,400	71,300	66,300	77,300	80,100	32,900	11,100	8,080	4,690	4,710	531,900	99.78
1956	63,600	152,400	174,900	139,100	42,300	145,600	47,900	12,700	10,400	5,060	4,170	3,390	801,500	150.36
1957	28,200	40,000	96,000	32,700	86,500	86,800	41,000	17,200	12,300	7,100	5,330	3,130	456,300	85.60

Averages for available records at the gaging station show that 51 percent of the streamflow from the Wilson River occurs during the 3-month period December through February, 64 percent during the 4-month period November through February, and 77 percent during the 5-month period November through March. The mean annual runoff for the Wilson River basin at the gaging station is 101 inches, and the mean annual precipitation estimated from the isohyetal map is 128 inches.

The major portion of the annual precipitation occurs as rainfall. This is evidenced by the fact that mean monthly percent of annual values for precipitation and streamflow are quite similar, as shown in table 4. The highest percentages of both occur in December. The minimum percentage of precipitation occurs in July and the lowest monthly runoff occurs in August.

TABLE 4.—*Mean monthly percentages of annual rainfall at Tillamook, Oreg., and streamflow at Wilson River gaging station*

Month	Rainfall at Tillamook, Oreg.[1]	Runoff, Wilson River near Tillamook, Oreg., 1931–57	Month	Rainfall at Tillamook, Oreg.[1]	Runoff, Wilson River near Tillamook, Oreg., 1931–57
October	7.79	4.89	May	5.53	4.44
November	14.45	13.03	June	3.38	2.24
December	16.28	19.63	July	1.42	1.22
January	14.42	16.98	August	1.58	.77
February	12.39	14.58	September	4.47	1.06
March	11.49	13.15			
April	6.80	8.01	Total	100.00	100.00

[1] Weather Bureau long-term means.

GEOLOGY

By DAVID L. GASKILL

REGIONAL GEOLOGY

The Wilson River drains a maturely dissected mountainous country on the western slope of the Oregon Coast Range. Nearly all of this area is rough, noncultivable forest land that has in large part been cut over and ravaged by forest fires.

The bedrock exposures in the upper Wilson River basin have been assigned to the Tillamook volcanic series of Eocene age (Warren and others, 1945). These rocks are composed of basic lava flows interbedded with tuff, breccia, and tuffaceous sediments, and are among the oldest rocks exposed in the core of the Coast Range geanticline in northwestern Oregon. According to Baldwin (1947), part of the Tillamook volcanic series interfingers to the south in the Spirit Mountain quadrangle with Umpqua-Tyee sediments of middle Eocene age, and to the southwest in the Nestucca Bay quadrangle with upper

Eocene sedimentary beds. Warren and others (1945) have mapped middle Eocene sedimentary beds as a separate unit in contact with the Tillamook volcanic series in the valley of the North Yamhill River, 16 to 20 miles southeast of the confluence of Cedar Creek and the Wilson River. It would thus appear that the Tillamook volcanic series contains rocks of both middle and late Eocene age and may in part be equivalent to the Siletz River volcanic series to the south (Baldwin, 1947).

CEDAR CREEK POWERSITE

DAMSITE

BEDROCK

The damsite for the Cedar Creek powersite is located at mile 19.3 on the Wilson River, 0.3 mile below Cedar Creek.

Bedrock in the damsite area is represented by basic lava flows and sills, with some thick beds of intercalated tuffaceous shale and arkosic sandstone. These rocks are cut in places by feeder dikes intruded along fault and fracture planes.

Samples of igneous flow and sill rock examined under the binocular microscope appear to have a texture and composition near that of diabase. The thick, dense, diabasic flows are generally greenish olive gray in color, locally porphyritic, and exhibit few vesicular or amygdaloidal zones. The dikes appear to be less altered than the flow rock and range in texture and composition from andesite and dolerite to basalt and diabase. Lithologically, the sedimentary rocks range from dark greenish-black or bluish-gray indurated, slaty argillite—almost indistinguishable in hand specimens from the basic flow rock—to light-colored claystone, argillaceous siltstone, and siliceous sandstone. The sedimentary rocks are largely noncalcareous, tuffaceous, and micaceous; they contain a large amount of carbonaceous plant material and exhibit occasional mudcrack, ripple-mark, and concretionary structures.

STRUCTURE

The bedrock sequence is strongly fractured and offset by a system of high-angle normal faults. The faults strike in a general north, northwest, or northeast direction; locally they show evidence of lateral movement. Some of the flow layers exhibit poorly developed columnar cooling joints, and most of the bedrock exposures are broken by tectonic joint sets that carry through both the igneous and sedimentary intervals. Jointing is particularly well displayed in and along the riverbed near locality 3 (pl. 3), where the dominant northeast-trending joints, 3 to 8 inches apart, have been deeply channeled by the river. A wide shear zone is displayed along the highway cut

602795 O—61——3

at locality 4 (index map, pl. 3) and numerous small faults, having a displacement of one or more feet, are exposed near localities 1 and 3. Wide gouge and shatter zones were observed along some of the faults and intrusive dikes in the area. In places the flow rocks are highly decomposed where they have been crosscut by veins and subjected to strong hydrothermal alteration. Dikes 15 feet or more in width have alteration zones as wide as 1 foot along their margins.

The attitude of the layered rocks varies from a northerly dip west of the north-trending fault that crosses the river 2,400 feet downstream from the mouth of Cedar Creek to a northeasterly, upstream dip east of this fault. A number of lineaments suggestive of faulting were plotted from aerial photographs and are shown on plate 3.

FOUNDATION ROCK

East of the fault described above, the foundation rocks dip upstream about 20° NE. The foundation rock at section *A–A′* is represented by two thick diabase flows separated by about 4 feet of indurated shale and sandstone. The base of the lower flow is not exposed, but the flow appears to be over 100 feet thick as shown by its downstream outcrop. The flow rock above the 4-foot sedimentary layer is largely concealed; it may be composed of more than one flow with a total thickness of about 90 to 100 feet. These foundation rocks also form the lower 100 feet of the south abutment face up to about the 650-foot contour along section *A–A′*. The lower flow exhibits rough polygonal fractures and a system of flat-lying and near-vertical joints. The best developed of the vertical joints strike north but are widely spaced—30 to 40 feet apart. These fractures are tight and appear to have exerted little control on the development of potholes and rills in the river channel.

The river is flowing on bedrock at section *A–A′*, and is degrading its channel some 20 feet or more below a surface of unconsolidated river terrace deposits on the north bank. Both up and downstream from the damsite area the river has cut narrow gorges in bedrock, as much as 30 feet below bedrock benches covered with stratified terrace deposits. Below the mouth of Cedar Creek and in the vicinity of section *A–A′* the foundation rocks are largely concealed by thin, active alluvial deposits in the riverbed. Both the older terrace and younger river-bar deposits are largely composed of coarse gravel, cobbles, and boulders. The river drops 17 feet in the interval from the mouth of Cedar Creek to a point 1 mile downstream.

SOUTH ABUTMENT

Abutment slopes have been defrosted, but bedrock is largely covered by a thin soil mantle and dense ground thickets of brush and fern

FIGURE 7.—Photograph of north abutment, Cedar Creek damsite, showing gully formed along a fault 2,400 feet downstream from mouth of Cedar Creek.

FIGURE 8.—South abutment face at Cedar Creek damsite, as seen from the north abutment ridge.

(figs. 7, 8). Insofar as could be determined, the bedrock exposures on the south abutment conform to the northeast dip of the foundation rock exposed in the river channel. At least two thin intervals of sedimentary rock are intercalated between the massive igneous flows that compose the mass of the south abutment. The upper sedimentary interval is largely shale, which has a minimum thickness of 30 feet at locality 2 (pl. 3). No sedimentary bedrock float was found above this upper interval on the south abutment face. The trend of the small faults shown on the south abutment ridge near locality 1, together with the apparent northeast-striking lineaments discernable on aerial photographs south of the river, indicate that this ridge and probably the south abutment face are weakened by many transverse fractures.

NORTH ABUTMENT

The north abutment is broken by one or more large high-angle north-trending faults that are apparently downthrown to the east by many hundreds of feet. Section *A–A′* is cut by at least two or more faults downthrown to the southeast, at an oblique angle to the north-trending fault previously mentioned.

Sedimentary sections up to 70 feet thick are exposed in the prominent gully formed along that fault (fig. 7). The geologic map (pl. 3) also illustrates a number of sedimentary intervals 1 to 30 feet thick, separated in places by thin sills, on the upper part of the north abutment. These sedimentary beds are locally baked and in places are rather well indurated; they are represented by thick yellowish-gray to light-olive-gray siltstone and shale, which alternate with medium thick beds, 1 to 3 feet thick, of greenish-olive-gray arkosic sandy siltstone and silty sandstone. Outcrops of massive flow rock near the base of the north abutment exhibit a few slickensides and secondary mineral coatings along irregular fracture planes. The north-trending fault zone east of section *A–A′*, on the north abutment ridge, probably extends across the river to the south and may transect the south abutment. Limited bedrock exposures and faulting in the lower part of the north abutment present a very incomplete picture of possibly complex geologic conditions along section *A–A′*.

STRIPPING ESTIMATES

About 10 feet or more of coarse, unconsolidated river terrace deposits overlie tough, relatively fresh appearing foundation rock along section *A–A′* in the Wilson River valley. The steep abutment slopes are largely covered by a thin soil-slope-wash mantle a foot or less thick, with some talus accumulation at the base of each abutment. Bedrock exposures along section *A–A′* do not appear to be deeply weathered; however, washouts and logging road exposures south of section *A–A′*, along the top and sides of the south abutment ridge, reveal a soil horizon, about 1 foot thick, which grades downward into a deeply weathered boulder regolith, in places more than 10 feet thick; several of these log road cuts disclose highly decomposed, hydrothermally altered flow rock transected by many small veins and stringers.

Stripping requirements are largely problematical; they will depend on the degree of bedrock fracturing, alteration, depth of weathering, and in part on the volume and composition of intercalated sedimentary rocks.

APPURTENANT WORKS

An overflow spillway would probably be the most feasible type for a dam at this site. The foundation rock is tough and resistant to water erosion but would probably require protection from plucking along joint planes. A water-diversion tunnel under the south abutment ridge will probably encounter fault and shear zones, and possibly areas of highly altered, decomposed rock—all of which might afford avenues of strong ground-water influx. Tunnels will probably require some support, even in relatively fresh flow rock, and will probably require lining throughout their length. The tunnel route shown on plate 3 would be about 1,000 feet long at the 700-foot contour; it appears to be the best situated topographically. However, this tunnel route closely parallels a possible fault lineament, which may prove this to be an undesirable location.

CONSTRUCTION MATERIALS

Large quantities of alluvial gravel, cobbles, and small boulders are present in river terrace and bar deposits in the vicinity of the damsite, particularly near the mouth of Cedar Creek. Most of this material is volcanic in origin and might prove to be a source of construction material, although much of it may be too deeply weathered or altered for use as concrete aggregate.

The thick basic flows, sills, and large dikes of the area would be a source of riprap and rock-fill material, and may prove to be an excellent source of coarse concrete aggregate if found to be physically sound. Because of their toughness, strength, surface texture, and low chemical reactivity with cement, these basic rocks commonly constitute one of the best sources of concrete aggregate (Mielenz, 1948, p. 7–8, and Dirmeyer, 1950, p. 147). No investigation was made of the suitability of these deposits for construction purposes.

RESERVOIR AREA

The reservoir area is assumed to be water tight. Ground-water levels are high, runoff is rapid, and there is relatively little opportunity for ground storage of rainfall in this region. Ground-water storage is sufficient to furnish many of the shorter tributaries with a continuous, though greatly diminished, flow of water during the dry summer and early fall seasons.

FEASIBILITY OF THE CEDAR CREEK DAMSITE

The damsite appears to be geologically suitable for a large rock-fill or possibly a concrete, gravity-type structure with an overflow spillway. More detailed exploration to determine the extent of bedrock fracturing, alteration, and engineering properties of the bedrock will be necessary prior to final damsite evaluation.

The massive foundation rocks at section *A–A′* have a structurally favorable upstream dip and are probably competent to sustain any type of construction with moderate stripping and foundation preparation. However, these rocks are rather well jointed and may be cut by faults concealed beneath the unconsolidated river deposits. The development of flat-lying joints in particular may present design problems should they extend to any great depth.

Abutment exposures are largely represented by dense lava flows that possess a tough, interlocking internal texture and have a favorable upstream dip corresponding to that of the foundation rock. Unfortunately, much of the bedrock structure is obscured by faulting and overburden, and the general geology of the damsite area strongly suggests that the abutment rocks may be seriously weakened by faulting and deep bedrock alteration. Intercalated shaly beds may have important effect upon the stability of abutment slopes, particularly on the south abutment face, where the bedrock layers have a moderate component dip of about 9° toward the river. Leakage at the damsite should prove negligible along flow contacts, but some leakage might be anticipated along northeast-trending fault zones. A small seep emerges on the north abutment about 300 feet above the river, in the fault gully west of section *A–A′*. This is probably a large spring during the wet season. No other seeps were noted in the area of section *A–A′*. No evidence of recent shifting along faults was observed, and it is probable that the faults in the area are not active. A seismic probability map (Coast and Geodetic Survey, 1950) shows this region as one where moderate to strong earthquake damage might be expected at long intervals. Earthquake-resistant design should be considered for large construction projects in this area.

FACTORS AFFECTING HYDRAULIC STRUCTURES

Problems due to ice would be minimized because of the moderate climate. However, temperatures as low as 0°F have been recorded at Tillamook, and while the duration of such temperatures would normally be for short periods of time as compared to inland regions, ice conditions and related problems would have to be considered in the design and operation of hydraulic structures.

Since little farming is done within the basin, heavy natural vegetation holds the soil with a good root system and silt deposits behind dams should not be a serious problem.

The heavy rainfall and the topographic characteristics of the basin are conducive to rapid runoff and high flood stages, against which adequate spillway capacity must be provided. Since the reservoir would normally be full or nearly full when maximum runoff might be expected, the reservoir could not be counted on to store much of the flood water. The greatest monthly runoff shown in table 3 was 319,800 acre-feet, or an average discharge of 5,321 cfs, occurring in December 1934. The highest instantaneous flood peak recorded at the gaging station is 30,000 cfs. With a factor of 65 percent, the corresponding flood peak at the Cedar Creek damsite would be 19,500 cfs. For design purposes an estimated flood peak somewhat greater than this should be allowed for.

PRIOR WATER RIGHTS

The State Engineer's Office regulates water rights in Oregon. Abstracts in that office show that 14.10 cfs have been allotted. Of these allotments, 53 percent are for irrigation, 46 percent for domestic use, and 1 percent for the combined mining, livestock, restaurant, and logging needs. The maximum and minimum unregulated flows at the gage near Tillamook are 30,000 and 55 cfs, respectively. It does not seem probable that the water rights allotted along the Wilson River would interfere with its value for power purposes.

POWERSITES

The Cedar Creek powersite appears to be the only feasible site for development of the storage required to regulate the flow of the river. The primary power development on the Wilson River would be at this site, with possible additional developments downstream by diversion and conduit methods.

There appear to be no significant opportunities for the development of power on the Wilson River tributaries. The South Fork and Devils Lake Fork drain small areas; because of the steep gradients, there are no favorable storage sites on these streams. The North Fork and Cedar Creek would be partly included in the Cedar Creek reservoir. Little North Fork, whose mouth is located at mile 2.2 of the main river, has a very high unit area runoff, and the 2-year

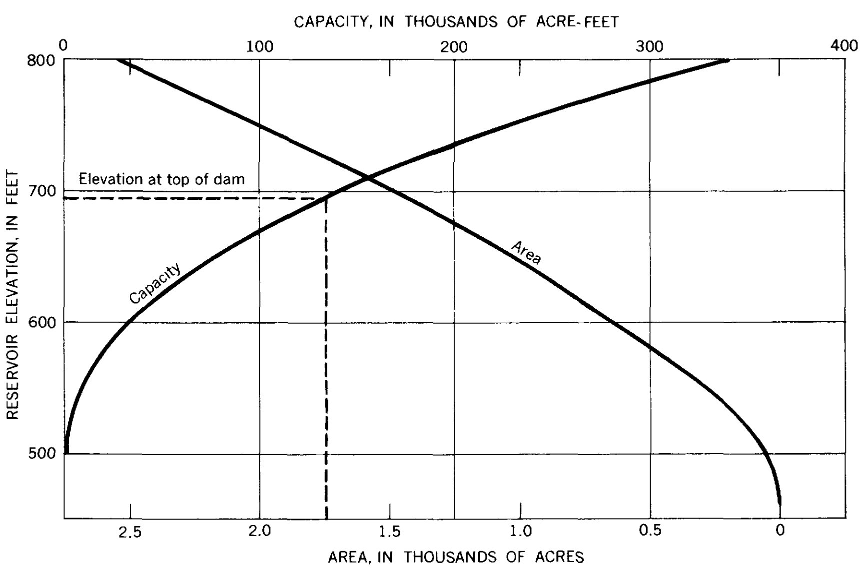

FIGURE 9.—Area-capacity curves, Cedar Creek reservoir site.

TABLE 5.—*Area and capacity, Cedar Creek reservoir site*

Elevation (feet)	Reservoir area (acres)	Capacity (acre-feet)	Extent upriver from damsite (miles)
457	0	0	0
460	2	4	.1
480	18	211	.6
500	57	965	1.2
520	130	2,840	1.6
540	224	6,380	2.1
560	366	12,300	2.6
580	510	21,000	3.1
600	673	32,900	3.6
620	818	47,800	4.0
640	1,010	66,100	4.6
660	1,130	87,500	4.9
680	1,290	112,000	5.3
700	1,490	139,000	5.6
720	1,680	171,000	6.0
740	1,860	207,000	6.3
760	2,050	246,000	6.7
780	2,290	289,000	7.0
800	2,560	338,000	7.2
900	3,860	658,000	8.4

average discharge at the gaging station near its mouth is 194 cfs. This stream has some power potential; but when compared to the reaches of the main river below the Cedar Creek damsite, it is quite small and will not be considered in power computations in this report.

The Cedar Creek damsite is located at river mile 19.3, sec. 17, T. 1 N., R. 7 W., a short distance downstream from the mouth of Cedar Creek. The river elevation at the damsite is 457 feet, and topography at the site would allow a dam up to the 1,000-foot elevation. Area and capacity values for the Cedar Creek reservoir site are shown in table 5 and graphically in figure 9.

There are no developed powersites within the Wilson River basin.

PLAN OF DEVELOPMENT

In the following illustrative plan of development, a minimum continuous flow of 150 cfs would be released at the dam to provide a favorable habitat for fish as well as improved recreation opportunities. The monthly flow has been less than this during 89 of the 312 months, or 29 percent of the period for which records are available. The average streamflows for July (117 cfs), August (74 cfs), and September (102 cfs) are lower than the recommended continuous minimum release. It does not seem desirable to consider a conservation release of less than 150 cfs, since operation of the powerplant will probably be concentrated in 4 or 5 months of the year. If average flow during the driest month of record was used as a basis for minimum flow allowed while the reservoir was filling, a situation of near drought could occur 7 or 8 months a year instead of 1 or 2 months for unregulated flow. When the possibility exists that minimum releases would occur 7 or 8 months of each year, the criteria for setting this minimum flow should not be the flow occurring at a critical period shown in the streamflow record. For these reasons the 150 cfs minimum, which might appear too high at first glance, has been proposed. Regulation of the stream would increase the summer recreational values of fishing and boating by increasing and stabilizing normal low flows and eliminating extreme low flows. This minimum flow would not be wasted from a power standpoint at the Cedar Creek damsite and will be included in estimates of power in the latter part of this report.

In evaluating the potential power, an analysis was made to determine the minimum storage capacity that would be required to obtain the optimum utilization of the water supply. From an inspection of the water-supply records, 5 tentative operational plans or controlled water release schedules were selected for analysis. These are as follows:

Schedule A: 32,000 acre-feet each month for entire year, or 384,000 acre-feet per year.
B: 38,000 acre-feet each month for entire year, or 456,000 acre-feet per year.
C: 80,000 acre-feet per month from November through March and 9,000 acre-feet per month from April through October, or 463,000 acre-feet per year.
D: 85,000 acre-feet per month from November through March and 9,000 acre-feet per month from April through October, or 488,000 acre-feet per year.
E: 95,000 acre-feet per month from November through February and 9,000 acre-feet per month from March through October, or 452,000 acre-feet per year.

The purpose of the method used is to estimate recurrence interval, or probable time elapsing between these water-supply deficiencies, for varying amounts of storage below the amount required for complete control during the period of record. For any period in the future equal to the period of record, the most accurate statement that can be made is that the future period would conform to the record available. Therefore, the computation of recurrence intervals of deficient flow is based on the probability that the ranked yearly values of minimum storage required, for a period in the future equal to the period of record, will be similar to those for the period of streamflow record available. This does not assume that the same combination of present and previous storage demands would occur, but that the ranked values would be similar. To show the basic information for estimating recurrence intervals, table 6 was prepared, listing active storage re-

TABLE 6.—*Schedule C: Active storage required in acre-feet for periods of deficient natural streamflow*

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Maximum
1932									1,770	5,890	10,910	16,970	16,970
1933	18,090				7,100					670	4,940		18,090
1934		35,500			54,000	63,400	37,000	16,200	17,790	21,560	26,630	30,850	63,400
1935					24,000	22,400			1,420	3,590	8,350	12,250	24,000
1936	12,620	61,820	83,920		3,400	16,600	1,100				3,320	7,680	83,920
1937	13,140	89,760	84,460	126,860	110,760	106,660	16,860				2,220	6,550	126,860
1938					22,600	11,800			1,900	6,450	12,320	18,440	22,600
1939	18,570	42,270	52,470	50,770	34,570	52,870	45,370	46,280	45,500	48,250	53,680	59,810	59,810
1940	57,910	121,510	79,210	98,110	54,510	60,210	33,310	7,410	9,390	14,070	19,910	25,920	121,510
1941	21,120	58,320	81,120	78,520	131,320	187,520	177,620	158,420	156,420	159,560	163,770	143,170	187,520
1942	120,870	144,970	100,070	139,470	155,170	197,370	184,570	168,870	155,470	153,370	156,710	162,020	197,370
1943	162,510	115,410	68,210	82,310	56,710	80,410	21,310	11,310	5,210	6,890	11,060	16,600	162,510
1944	6,100	55,700	69,000	87,300	115,600	152,700	116,600	109,500	104,600	108,260	113,830	118,930	152,700
1945	121,240	156,740	202,640	192,740	181,040	161,140	115,940	89,040	87,640	91,560	96,930	89,230	202,640
1946	89,980	50,480	6,180			300					4,200	9,440	89,980
1947				2,600	1,900	33,400	6,100	4,200		110	4,180	4,260	33,400
1948			14,100			15,800				2,870	7,510	9,960	15,800
1949				52,200		11,300			1,770	5,820	11,190	16,670	52,200
1950	7,470									3,970	8,680	14,070	14,070
1951						13,400			1,270	6,090	12,340	17,040	17,040
1952		10,000		12,000	100	19,500			760	4,700	10,370	16,770	19,500
1953	23,450	97,790	108,990			22,100				1,340	4,140	7,690	108,990
1954		4,500				31,400					3,430	6,270	31,400
1955		5,500	9,100	17,800	31,500	34,200				920	5,230	9,520	34,200
1956					37,700					3,940	8,770	14,380	37,700
1957		40,000	24,000	71,300	64,800	58,000	26,000	17,800	14,500	16,400	20,070	25,940	71,300

quired. This shows active storage required to maintain scheduled water releases for periods of deficient natural flow. Entries for each month in table 6 represent the active storage required at the beginning of deficient natural flow periods so that water deficiencies will not occur through the month in which entry was made. Table 6 was prepared for use with release schedules A, B, C, D, and E, but only the table for schedule C is shown in this report.

The largest amount of storage shown by these tables for each water year, plus 11,000 acre-feet of dead storage to maintain 100 feet of head, was entered on a data sheet and ranked in descending magnitude. The recurrence intervals of deficiencies for each item were computed by the formula $RI=\frac{n+1}{m}$, when n=years of record and m=rank. A graph of recurrence interval versus storage was then prepared for each water release schedule as shown in figure 10.

The data in table 6 is nonrandom. The arrangement of yearly runoff record used in preparing table 6 is in a fixed chronological order and cannot be chosen at random. Arranging runoff data at random would neglect critical storage requirements caused by several years of low flow occurring together in the low-flow portion of a cycle. Also, any runoff record is biased, because runoff at the first

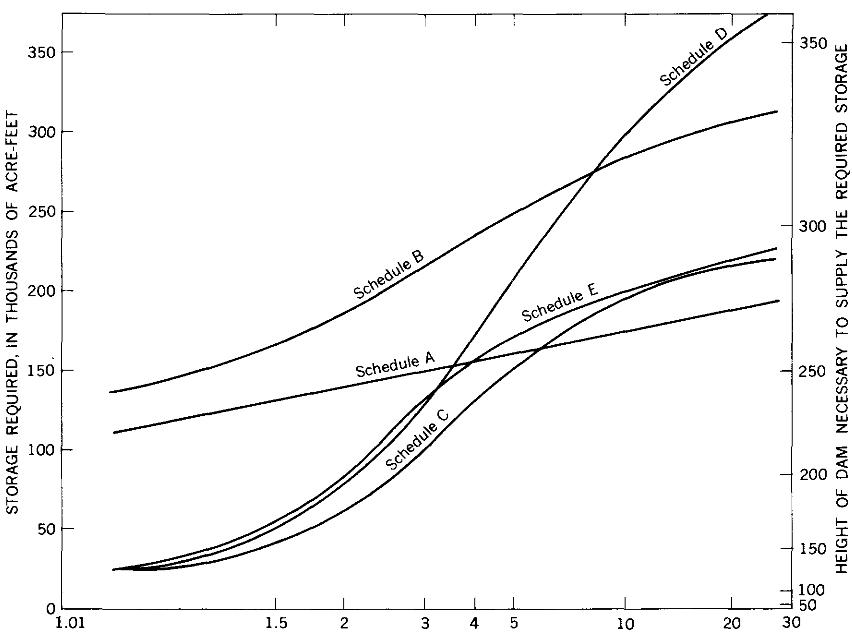

FIGURE 10.— Recurrence interval of streamflow deficiency for selected release schedules.

of a month depends on river stages that occurred during the latter part of the previous month.

Before comparing the curves shown on figure 10, it should be noted that the total amount of water utilized for power varies among the several schedules and the amount of power capable of being produced is directly proportional to this water volume. The amount of water utilized for power with each release schedule is listed with the description of the schedules.

Figure 10 indicates that schedules A and B, which release water continuously throughout the year, produce curves with less slope than the other three schedules. This indicates less reduction in storage required than is shown by a curve having a steeper slope for an equivalent reduction in recurrence interval of deficient flow. Schedules B and C have nearly equivalent yearly volumes of water utilized for power production, but curve C is well below curve B throughout. This indicates that less storage is required with schedule C to produce an amount of power equivalent to schedule B for any recurrence interval of deficient flow. In addition, power from schedule C would be concentrated for peaking purposes during the period of highest demand. For these reasons schedule B will not be considered further. Schedule A conforms approximately to schedule C for recurrence intervals greater than 4 or 5 years, but the yearly volume of water utilized for the production of power is considerably less in schedule A. Schedule D requires much more storage than schedule C for recurrence intervals greater than 3 or 4 years. This is due to the accumulation of the 25,000 acre-feet per year difference in the deficiency period June 1938 to September 1947. This 25,000 acre-feet increase in water utilized for power production from schedule C to D does not appear great enough to justify the additional amount of storage required to realize it. Curve E is above curve C throughout the length of the curves, indicating that greater storage is required for equivalent recurrence intervals of deficient flow in schedule E than in schedule C. Schedule E also has less water available for the production of power than schedule C.

The foregoing comparisons show that schedule C would provide the fullest use of the available water for a given storage capacity and recurrence interval of flow deficiencies. Schedule C appears to be very close to the optimum power schedule, because the 25,000 acre-feet per year increase from schedule C to schedule D—5.4 percent—results in a 78 percent increase in storage required for the 27-year recurrence interval. Schedule C will therefore be used to illustrate development of the Cedar Creek site and as a basis for the estimate of power. The information contained in schedule C in table 6 is shown graphically on figure 11. The numbers at the high points for

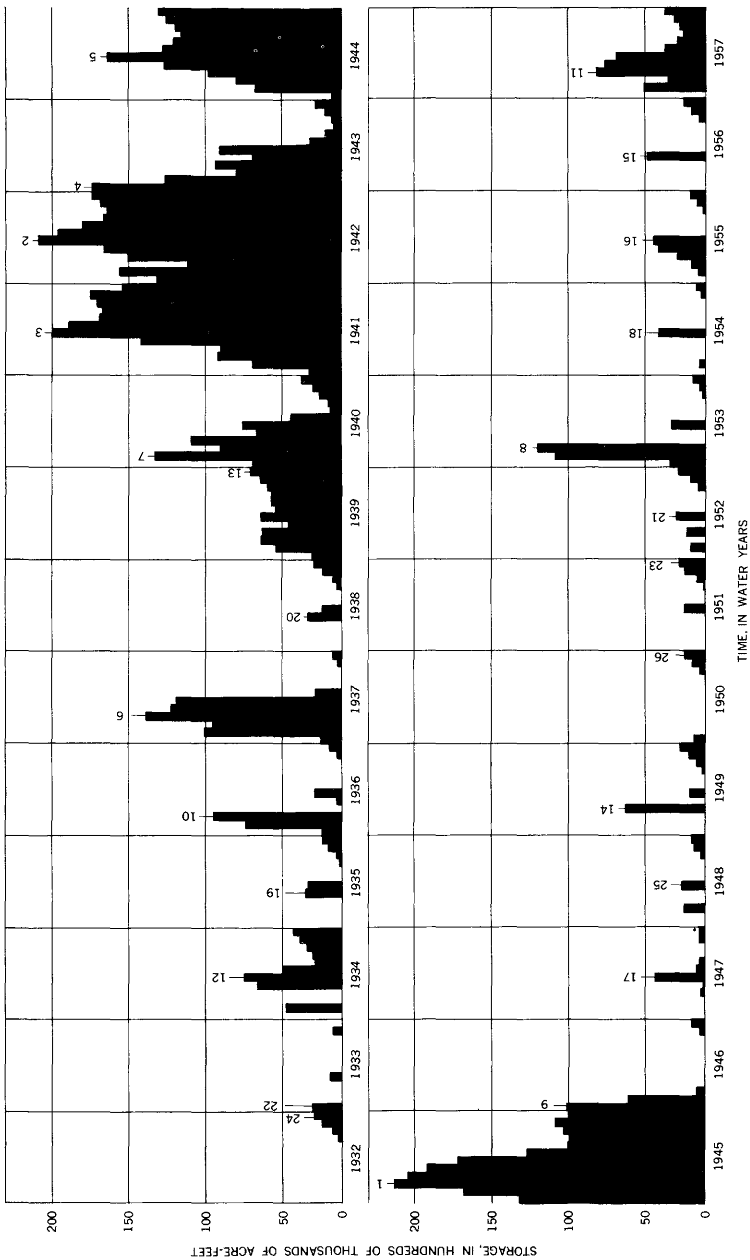

FIGURE 11.—Monthly storage required during periods of deficient natural flow (schedule C).

each water year are ranking numbers used in the computation of recurrence interval.

Relocation costs would be extremely high, so the amount of roadway and transmission line flooded by the resulting reservoir would be a major factor in the height of dam proposed. A deficient flow recurrence interval of four years was selected by examination from schedule C of figure 10, as the one best suited for illustrating potential power. A recurrence interval of 4 years would require storage of 134,000 acre-feet, and a corresponding dam height of 239 feet. A dam of this height would have a crest length of about 1,000 feet. The highway flooded would be 5.5 miles and a relocated route around the reservoir would be somewhat longer. The transmission line flooded would amount to about 4½ miles.

The reservoir content that would have existed during the period of streamflow record, for the plan of water use outlined above, is shown in figure 12. The graph was prepared on the assumptions that maximum gross storage is 134,000 acre-feet, that 11,000 acre-feet of dead storage will be kept to retain a minimum head of about 100 feet, and that evaporation and other losses are negligible. On these assumptions, figure 12 shows that streamflow would have been unable to meet the proposed schedule during 7 months of the 312 months of record available. These deficiencies occurred in 5 different water

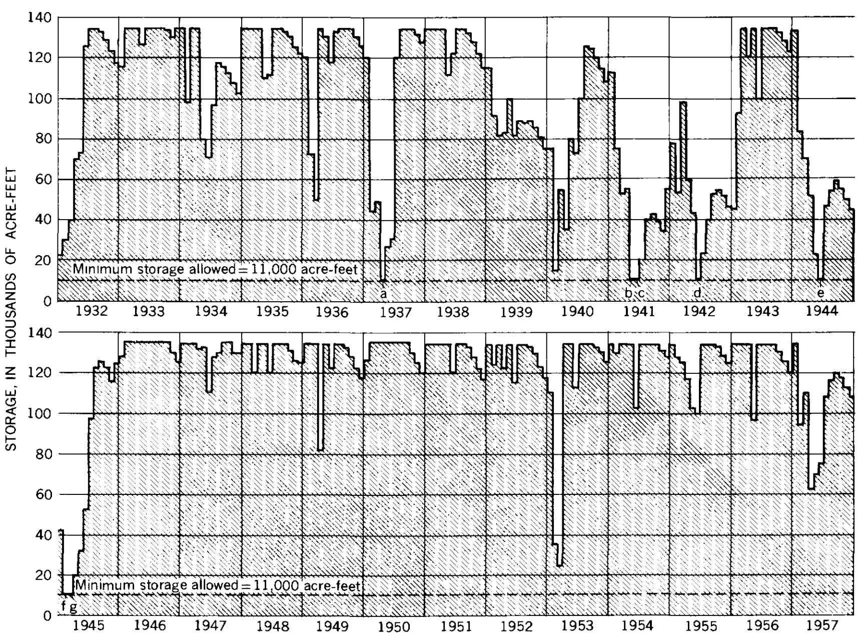

FIGURE 12.—Storage available, 1932–57, if proposed plan of development had been used.

years and the deficiency would not have exceeded 13 percent of the scheduled release during 4 of these 7 months. The reservoir would have been full during 107 months of this interval or 34 percent of the time. The area enclosed by the graph shown on figure 12 was planimetered, and the average volume in the reservoir was found to be 110,000 acre-feet for a corresponding average head of 222 feet. This head has been used in computing the potential power at the Cedar Creek powersite.

Below the Cedar Creek powersite at mile 19.3, the river is susceptible of development to the vicinity of mile 5. Development along this reach of the stream would depend on the Cedar Creek reservoir for regulation and is considered as a future source of power if the Cedar Creek powersite is developed. This reach of the river drops 390 feet from the Cedar Creek powersite to mile 5.0 at an elevation of 67 feet. There are no favorable storage sites along this section of the river. Power development would therefore have to be by diversion-dam and conduit methods or run-of-river dams.

For illustrative purposes two diversion-dam and conduit systems are considered for the development of this section of the river. A diversion dam approximately 40 feet high would be located at river mile 18.0, with the conduit intake at an elevation of 410 feet. The conduit would follow the right bank to a powerhouse at river mile 13.8 elevation 282 feet. The second diversion dam, approximately 45 feet high, would be located at river mile 12.0. The conduit intake would be at an elevation of 235 feet, and the conduit would follow the right bank to a powerhouse at river mile 4.5, elevation 60 feet. A schematic diagram of the Wilson River and developments proposed herein is shown in figure 13.

Neither of the ponds created behind these diversion dams would interfere with any existing roads. It would interfere with the transmission line to the extent that 5 towers would have to be moved as a result of pond 1. Two towers would require moving as a result of pond 2. The location of the line need not be changed for pond 2, however, as the towers could be moved a short distance out of the pondage area and longer unsupported portions of the line used over the water.

Riverflow at diversion dam 1 from November through March is assumed equal to the 80,000 acre-feet per month released from the Cedar Creek powersite 1.3 miles upstream. This assumption is very close, as there are no tributaries in this reach and the upper level of the pond is only 0.1 mile from the Cedar Creek powersite. A conservation release of 9,000 acre-feet per month would be allowed to remain in the stream channel, leaving 71,000 acre-feet per month, or an equivalent continuous flow of 1,180 cfs, to pass through the conduit

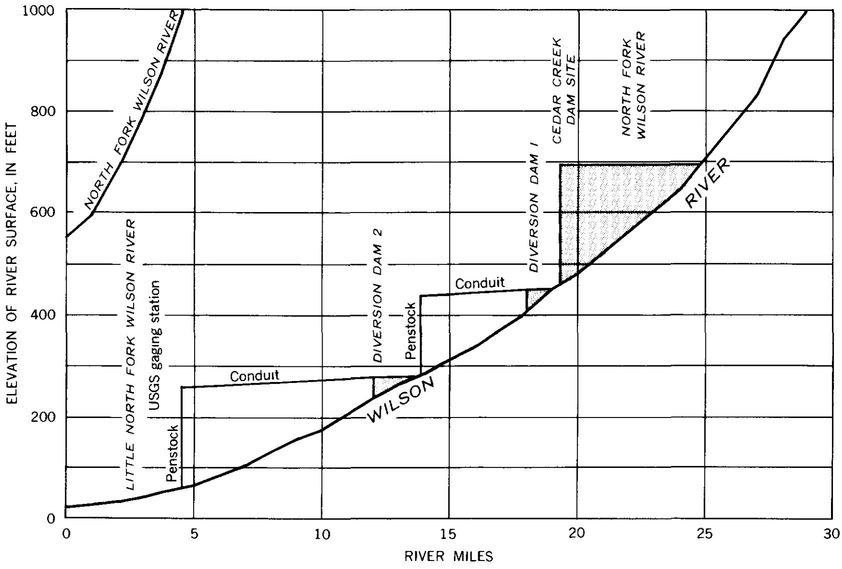

FIGURE 13.—Profile of Wilson River to mile 29 and North Fork Wilson River to mile 4.5, showing power development schemes.

during the November–March operational season. The powerhouse at river mile 13.8 could not be operated when only minimum flow was being released at the Cedar Creek powersite, as this would satisfy only the conservation release requirement at the diversion dam. Any power produced from the diversion-conduit system during the April–October period is secondary power and therefore not listed in power totals for the stream.

Riverflow at diversion dam 2 from November through March is also assumed equal to the 80,000 acre-feet per month released from the Cedar Creek site 7.3 miles upstream. Although there would be some inflow in this section of the river it would be unregulated and has not been considered in this report. A conservation release of 9,000 acre-feet per month will be allowed to remain in the stream channel, leaving 1,180 cfs for power production during the November–March operational season. The powerhouse site at river mile 4.5 would not be operated during the April–October period.

Characteristics of the conduit were computed for three conduit slopes assuming maximum flow of 1,180 cfs and a 0.016 coefficient of roughness in the Manning formula. This information and the resulting effective head on each powerhouse is shown in table 7. The 0.0005 slope, resulting in an effective head of 157 feet on the powerhouse at mile 13.8 and 200 feet on the powerhouse at mile 4.5 is used for power computations in this report.

TABLE 7.—*Conduit characteristics and effective head for powerhouses at mile 13.8 and mile 4.5*

	Slope	Conduit diameter (feet)	Conduit area (square feet)	Velocity (feet per second)	Rate of head loss between intake and penstock (feet per mile)	Effective head on powerhouse at—	
						Mile 13.8 (feet)	Mile 4.5 (feet)
1	0.001	14.68	170	6.88	5.28	146	180
2	.0005	16.72	220	5.25	2.64	157	200
3	.0001	22.60	400	2.92	.53	166	216

ESTIMATE OF POWER

Power computations are based on the formula $P=EQH$ which becomes $P=0.068\ QH$ when P=power in kilowatts, E=80 percent efficiency, Q=discharge in cfs, and H=head in feet. The 20-percent loss includes entrance and exit turbulence, penstock friction, and machinery losses, but it does not include head loss in a conduit. Table 8 contains power and energy values for the illustrative plan of development.

TABLE 8.—*Potential power and energy of the Wilson River*

Power site and period of power production	Head (feet)	Flow (cfs)	Power (kilowatts)	Energy (kilowatt hours)
Cedar Creek site November–March	222	1,330	20,100	72,800,000
Cedar Creek site April–October	222	150	2,260	11,600,000
Powerhouse at mile 13.8	157	1,180	12,600	45,700,000
Powerhouse at mile 4.5	200	1,180	16,000	58,000,000
Total power and energy			50,960	188,100,000

The Cedar Creek powersite could produce 20,100 kilowatts throughout the November–March period and 2,260 kilowatts throughout the April–October period, for a yearly energy output of 84,400,000 kilowatt-hours.

The diversion sites could produce 28,600 kilowatts, yielding a maximum of 103,700,000 kilowatt-hours during the November–March period. Combining these diversion projects with the Cedar Creek powersite, a maximum yearly energy total of 188,100,000 kilowatt-hours of energy could be produced. Most of this could be used as firming energy by the Northwest Power Pool, as 176,500,000 kilowatt-hours would be produced in the critical November–March period. Transmission and line costs would be minimized, owing to the location of the project in western Oregon near the concentration of industry and population.

DIVERSION TO TUALATIN RIVER BASIN

The Tualatin basin, especially in the areas being developed as Portland suburbs, is approaching a point where it must seek additional water. The Wilson River is a possible source for this water, and there are several sites in its headwaters where diversion to the Tualatin might be made. Two of these sites are discussed. Diversion of Wilson River water to the Tualatin basin would have an adverse effect upon waterpower development possibilities on the Wilson River proportionate to the amount of water diverted.

A dam might be constructed at the Larch Mountain damsite on Devils Lake Fork of Wilson River, in sec. 34, T. 2 N., R. 6 W. The damsite is about 1 mile upstream from the point where the recent river survey was discontinued. The water surface altitude there is about 1,100 feet, and a dam that would raise it to 1,280 feet would have a crest length of possibly 700 feet. Water would back about 2 miles up Devils Lake Fork and about ½ mile up Drift Creek. The 1,280-foot contour crossing on Drift Creek is only 1 mile airline from the 1,280-foot contour on the Tualatin basin side of the divide, in a tributary to Gales Creek.

The second site is on Wilson River at McNamers Camp, just downstream from the mouths of South Fork and Elk Creek in sec. 6, T. 1 N., R. 6 W. The river-surface altitude there is about 800 feet. A dam to raise the water to the 1,040-foot contour would be about 900 feet long and would require a low auxiliary dike across a saddle in sec. 31, T. 2 N., R. 6 W. Water raised to the 1,040-foot contour would back 2½ miles up the Wilson River from which point the corresponding contour on the Gales Creek tributary is only 2¾ miles by tunnel route.

Drainage area at the Larch Mountain damsite is 19.5 square miles and at the McNamers Camp damsite 50 square miles. Runoff in the area is estimated to average more than 7.5 cfs per square mile. This indicates that up to 145 cfs average could be diverted by gravity through the 1-mile tunnel at altitude 1,280 feet, and that up to 375 cfs average could be diverted through the 2¾-mile tunnel at altitude 1,040 feet.

The additional water at the McNamers Camp site may make it preferable even after considering the extra diversion costs. There would be an additional advantage in the larger McNamers Camp reservoir site. For these reasons the following discussion concerns the McNamers Camp site only.

The diversion described for the McNamers Camp site does not lend itself to waterpower production, nor does it afford any regulation of the stream, because the tunnel was considered to be at the top of the reservoir. To utilize this storage, the tunnel would have to be at a lower altitude and somewhat longer. If the upper 100 feet of the reservoir were used for regulation, the diversion altitude would be 940 feet and the tunnel length about 5 miles. The reservoir site would store 39,000 acre-feet, of which 31,000 acre-feet would be above altitude 940 feet.

During water years 1938 through 1952, the 31,000 acre-feet of active storage could have assured 100 cfs continuous diversion to the Tualatin River basin, after allowing a discharge of at least 25 cfs (Q95) to pass on down the Wilson River and after allowing a continuous 10 cfs to cover evaporation and other losses. Or, if desired, a minimum dry-season (April–October) diversion of 80 cfs and a minimum winter (November–March) diversion of 380 cfs could have been obtained in combination. Had the reservoir been operated with an aim to obtaining the highest maximum dependable flow during the 5-month period November–March, the minimum assured discharge would have been 400 cfs. As in the continuous regulation computations, 25 cfs could have been discharged down the Wilson River continuously except during March 1941, when the downriver discharge would have averaged 20 cfs.

Once in the Tualatin basin, a large part of the water diverted in winter could be stored until the dry season by constructing a reservoir on Gales Creek. The Timber 15-minute quadrangle shows that a dam 160 feet high in sec. 23, T. 2 N., R. 5 W., would create a reservoir in the valley around Glenwood whose surface area would be about 700 acres. Present maps are not adequate for measuring the capacity of the Glenwood site, but it would be much larger than that of the McNamers Camp site on the Wilson River where a dam of corresponding height (160 feet) would have a surface area of only 200 acres.

The diverted water would have a power potential that might justify development. Water diverted from the McNamers Camp reservoir at altitude 940 feet as described could be carried along the right bank of Gales Creek a distance of approximately 3½ miles from the tunnel outlet to a point in sec. 21, T. 2 N., R. 5 W. It could be dropped there to the backwater limit of the Glenwood re-regulating reservoir site which, for the purposes of this report, is considered to be at altitude 560 feet. If 40 feet of head is lost in the tunnel and the conduit, the effective head remaining would be 340 feet. This site would have a power potential of 2,300 kilowatts per 100 cfs diverted.

If water is to be diverted from the Wilson River, the possibility of developing pumped-storage waterpower at the same time should be investigated. Water could be pumped from the upper 100 feet of the McNamers Camp reservior site to the 1,600-foot contour and carried along the left bank of Devils Lake Fork and along the right bank of Gales Creek. It could be dropped 1,000 feet in a mile-long penstock to Gales Creek, in sec. 15, T. 2 N., R. 5 W. The pumping head would range between 560 and 660 feet.

Using a head of 1,000 feet this site would have a power potential of 6,800 kilowatts per 100 cfs pumped. The power head in the Wilson River scheme just described would be enough greater than the pumping head to make at least one kilowatt available for every kilowatt used for pumping. This is an attractive feature of the site. Whether it would be economical to develop a pumped-storage diversion at this site has not been considered. The economic feasibility of pumped-storage additions to power systems is well established, however, and this one should be investigated. The increasingly evident need for additional water supplies in the Tualatin River basin makes the study especially desirable.

REFERENCES CITED

Baldwin, E. M., 1947, Geology of the Dallas and Valsetz quadrangles, Oregon: Oregon State Dept. Geology and Mineral Industry Bull. 35.

Byerly, Perry, 1952, Pacific Coast earthquakes, *in* Condon Lectures: Eugene, Oreg., Oregon State System of Higher Education.

Dimeyer, R. D., Jr., 1950, Geology and irrigation engineering: Colorado School Mines Quart., v. 45, no. 1B, Applied Geology.

Helland, R. O., 1953, Water power of the coast streams of Oregon: U.S. Geol. Survey open-file rept.

Jones, B. E., and Oakey, Warren, 1924. Report on the potential water power of Nehalem and Wilson River basins, Oregon: U.S. Geol. Survey open-file rept.

Mielenz, R. C., 1948, Petrography and engineering properties of igneous rocks: Denver, Colo., U.S. Bur. Reclamation Eng. Mon. 1.

U.S. Coast and Geodetic Survey, 1950, Seismic probability map of the United States, with explanatory note.

Warren, W. C., and others, 1945, Geology of northwest Oregon west of Willamette River and north of latitude 45°15′: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 42.

U. S. GOVERNMENT PRINTING OFFICE : 1961 O - 602795