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SECTION IV.—RIVERS AND FLOODS.

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RIVERS AND FLOODS, OCTOBER, 1917.

By ALFRED J. HENRY, Professor in Charge.

[Dated: River and Flood Division, Weather Bureau, Nov. 30, 1917.]

The rainfall of October, 1917, was light and infrequent except in the States from the lower Lakes Region eastward; even in those States flood stages were not reached until toward the end of the month, when two rainstorms within a week resulted in slight floods in the rivers of the Middle Atlantic and New England States. (Table 1.) The only other floods of the month were due to heavy rains which fell in Alabama during the closing days of September. Fortunately the rivers were at a low stage when the rains began, otherwise destructive floods would have resulted.

Property loss in watershed of Alabama River, October, 1917.

Tangible property, bridges, highways, etc.	Crops.	Suspension of business.	Money value of warnings.
$500	$10,000	$150	$6,000

Hydrographs for typical points on several principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

TABLE 1.—*Flood stages in Atlantic coast drainage during October, 1917.*

River.	Station.	Flood stage.	Above flood stages—dates.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Connecticut	White River Junction, Vt.	13	31	(†)	14.0	31
White	....do	15	.....	.....	13.5	31
Mohawk	Tribes Hill, N. Y.	16	31	(†)	20.2	31
Delaware (East Branch)	Fishs Eddy, N. Y.	10	31	(†)	12.0	31
Delaware (West Branch)	Hales Eddy, N. Y.	12	31	(†)	12.4	31
Lackawaxen	Honesdale, Pa.	8	29	29	8.0	29
Susquehanna	Bainbridge, N. Y.	11	30	(†)	13.2	31
Do	Wilkes-Barre, Pa.	20	.....	.....	18.1	31
Neuse	Smithfield, N. C.	13	.....	.....	11.9	31
Waccamaw	Conway, S. C.	7	.....	.....	6.7	4
Black	Kingstree, S. C.	12	.....	.....	10.9	6-7
Santee	Rimini, S. C.	12	1	3	12.7	2
Edisto	Edisto, S. C.	6	.....	.....	5.8	4

† Continued into November.

TABLE 2.—*Flood stages in various drainage areas other than the Atlantic coast drainage, during October, 1917.*

River.	Station.	Flood stage.	Above flood stages—dates.		Crest.	
			From—	To—	Stage.	Date.
East Gulf drainage:		*Feet.*			*Feet.*	
Alabama	Selma, Ala.	35	.....	.....	34.0	2
Chattahoochee	Alaga, Ala.	30	.....	.....	27.0	1
West Gulf drainage:						
Rio Grande	Rio Grande City, Tex.	15	(*)	2	21.7	1
Mississippi River (Ohio Basin):						
Allegheny	Olean, N. Y.	12	.....	.....	10.9	30
Do	Warren, Pa.	12	30	30	13.0	30
Great Lakes:						
Maumee	Fort Wayne, Ind.	15	30	(†)	15.5	31

* Continued from September. † Continued into November.

ANNUAL RISE OF THE COLUMBIA RIVER, 1917.

By E. M. KEYSER, Observer.

[Dated: Weather Bureau Office, Portland, Oreg., Oct. 4, 1917.]

The summer rise of the Columbia River in 1917 demonstrated conclusively that unusually heavy snow coverings at the beginning of the spring season are not necessarily precursors of unusually high water. Between January 1 and March 17 the river stages at Portland, Oreg., varied irregularly between 0.7 and 6.7 feet. On this latter date the stage was 1.8 feet and from this time on the river, except for short temporary falls, continued more or less regularly to rise till May 15, when the flood stage, 15 feet, was reached. On June 22 the crest of the rise, 23.8 feet, passed Portland. From June 22 the water subsided quite regularly and on July 22, just one month after the passage of the crest, fell below the flood stage. This stage of 23.8 feet, although 2.6 feet above the 39-year average crest stage, has been exceeded nine times during the period of record.

While it is recognized that the annual rise is due largely to the accumulated snows in the upper levels of the watershed, the snow records are not available for the whole period of river observations. However, in extensive portions of the basin, fairly reliable records are available for at least 9 years, showing the depth of snow remaining at the close of the winter month..

Bulletins issued by the Oregon section show that at the close of winter the snow covering at practically all stations was not only above the average but was the greatest of record. In Washington every station in March reported the average or more remaining, and at the close of April every station reported more than the average remaining. In Idaho all drainage basins showed plus departures for snow covering at the beginning of spring. Likewise the Canadian reports showed excessive amounts of snow held over at the end of winter. Below will be found quotations from the Section Report of Oregon for March, 1917, concerning the snowfall in all sections of the Columbia River Basin in the mountains preceding the annual rise:

SUMMARY OF SEASON'S SNOWFALL.

At the end of March, 1917, the amount of snow within the Columbia River drainage area was much greater than at the same time a year ago. The total fall during the winter of 1916–17 was considerably less than the amount last season, but owing to cold weather in February and March, 1917, very little had melted, while last year those months were mild, and the snow at low levels had nearly all disappeared by the 1st of April. Should the temperatures during May be normal, or above the normal, unusually high water is almost certain to occur in the lower portion of the Columbia River next June. Much depends upon the manner in which the snow melts. When the spring months are cool, and the season is backward, we should expect higher water with the same amount of snow than when the season is early; therefore, as this year's season is backward and there is an unusual amount of snow in the mountains, caution should be exercised not to cultivate bottom lands that were overflowed last year, as present conditions indicate that we will have even higher water than that of 1916. * * *

Washington.—The snowfall of the past winter in the elevated regions, while above the normal, was not nearly so much as in the season of 1915–16. In December it averaged somewhat above normal; in January and February it was deficient at the lower levels of the eastern slope of the Cascades, but plentiful at the higher elevations. In March, especially during the last two weeks, the snowfall was phenomenal for the season, and the absence of warm winds and rain during February and March caused an accumulation of snow, so that the depth on March 31 was greater than in 1916, and almost unprecedented. There will doubtless be an abundance of water in the streams during the summer season.—*G. N. Salisbury, Meteorologist.*

Idaho.—The winter was the coldest of record, temperatures having been below normal for six consecutive months. The total snowfall was somewhat less than that of the preceding season, but previous records for heavy snowfall were exceeded in December and probably in March, and the snowfall in November, January, and February was above normal. Almost no melting has occurred in the mountains, hence the present snow supply is the greatest known at the close of March, being much greater even than that of the same date a year ago. Much ground that is ordinarily bare at this date is covered with from 1 to 2½ feet of snow. The snow was rather loose most of the winter, having fallen while the temperature was low, but most of it is now fairly solid. Many slides have occurred in the southern counties. A good flow of water may be expected during the season, and unusually high water is likely to occur with the first warm weather.—*Edward L. Wells, Meteorologist.*

Montana.—The snowfall for the season ending March 31 was one of the heaviest, if not the heaviest on record, over all the watersheds west of the Divide. The October snowfall was much greater than normal, the November and December amounts were in excess of the normal, the January snowfall was practically normal, and the amounts that fell during February and March were much greater than normal. Owing to the uniformly cold weather that has prevailed throughout the winter there has been less run-off than usual and the snow is not packed as hard as it would have been had there been thawing weather. At the end of March there had been very little thawing except in the lower valleys, and it is probably true that there is more snow in the mountains than there has been for the past 20 years. The density of the snow is less than it was a year ago, but due to the greater depths the resulting water will be greater. A heavy flow of water is early expected in all streams, and with a normal rainfall during the coming season an abundant water supply for all purposes is assured.—*F. L. Disterdick, Acting Section Director.*

Wyoming.—Snow layer at the close of March in the Snake River drainage of Wyoming was the deepest of record. Five stations had an average depth of 50 inches; last year the same stations averaged 27 inches, two years ago 11 inches, and in 1912 45 inches. A sample of snow taken at Alta 36 inches deep, the least reported, showed 28 per cent moisture. At Bechler River the snow was 7 feet deep, which is the greatest reported, although it is believed adjacent regions carry from 10 to 11 feet, solidly packed. There has been no appreciable melting of the snow up to the persent time.—*J. C. Alter, Meteorologist.*

British Columbia.—The snowfall again this year has been very heavy, particularly at Glacier; the season has been abnormally cold, and the climatic conditions at the close of March in the B. C. Columbia River district were nearly a month later than the average. Abnormally high temperatures now may cause floods this spring. At Rossland the snow on the mountains was 6 to 8 feet, with streams abnormally low, and should present mild weather continue the water will rise rapidly; at Cranbrook the streams are normal and the snow about 7 feet deep, but do not expect very high water; at Grand Forks, snow on the mountains still very deep, and on account of the extremely late season the streams are expected to reach higher levels than usual; at Golden, snowfall below average, but the streams are icebound and with late breaking up abnormal water may be expected; at Revelstoke snowfall has been exceptionally heavy and is over 12 feet, and spring has hardly started. A sudden hot spell or warm rains would cause very high water.—*F. Napier Denison, Supt. Dominion Meteorological Service.*

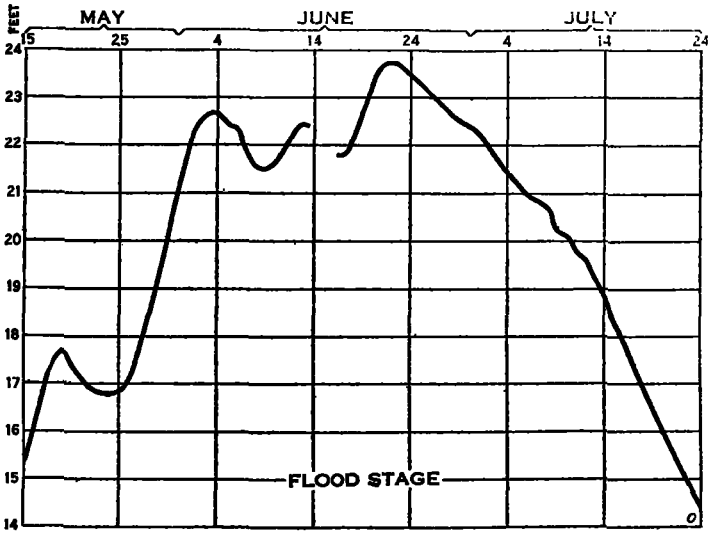

FIG. 1.—Hydrogram of the annual rise in the Columbia River in 1917, as shown at Portland, Oreg., by the flood stages between May 15 and July 22, 1917.

The 1917 rise of the trunk stream is shown graphically for Portland in figure 1 during the time the water was above the flood stage. The accompanying Table 1 shows for each station on the Columbia River the following data: Flood stage, dates of reaching and falling below flood stage, and date and height of crest stage. An examination of this table reveals the fact that the flood stage was not reached at more than half of the river stations. It was not reached in the Snake River at all, although the highest water at these stations passed fully three weeks before the crest in the trunk stream. At three of the seven stations on the trunk stream the flood stage was not reached—viz, Umatilla, Celilo, and Cascade Locks.

TABLE 1.—*High water during annual rise of the Columbia River, 1917 (tributaries and stations arranged downstream).*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Kootenai:	*Feet.*			*Feet.*	
Bonners Ferry, Idaho	26.0	June 19	June 19	26.0	June 19.
Pend Oreille:					
Newport, Wash	16.0	May 28	July 13	21.6	June 25.
Clearwater:					
Kamiah, Idaho	14.0	June 16	June 21	15.4	June 17.
Snake:					
Welser, Idaho	14.0	.....	.....	11.9	May 28-29.
Lewiston, Idaho	22.0	.....	.....	18.2	May 30.
Santiam:					
Jefferson, Oreg	10.0	.....	.....	7.8	Apr. 8.
Yamhill:					
McMinnville, Oreg	35.0	.....	.....	22.3	Mar. 25.
Clackamas:					
Cazadero, Oreg	12.0	.....	.....	6.6	June 9.
Willamette:					
Eugene, Oreg	10.0	Apr. 8	Apr. 8	10.5	Apr. 8.
Albany, Oreg	20.0	Mar. 25	Apr. 27	13.4	Apr. 9.
Salem, Oreg	20.0	.....	.....	12.5	Mar. 30.
Oregon City, Oreg	10.0	.....	.....	9.4	Mar. 30.
Portland, Oreg	15.0	May 15	July 22	23.8	June 22.
Columbia:					
Marcus, Wash	24.0	May 26	July 28	30.0	June 23-25.
Wenatchee, Wash	40.0	June 18	June 29	40.4	June 20,21,24
Umatilla, Oreg	25.0	.....	.....	23.7	June 19.
Celilo, Oreg	30.0	.....	.....	20.8	June 19.
The Dalles, Oreg	40.0	June 20	June 21	40.4	June 20.
Cascade Locks, Oreg	40.0	.....	.....	32.5	June 20.
Vancouver, Wash	15.0	May 15	July 23	24.5	June 22.

Notwithstanding the presence of the immense reservoir of snow at the water heads and its potentiality to give perhaps a record flood, the height of 23.8 feet has been exceeded twice in the last nine years—viz, 1913 and 1916. This great volume of melted snow was carried out to sea with a large portion of the public being scarcely aware that the annual rise was in progress.

In seeking an explanation for this rather unexpected outcome from the great snow mass, the reason is found, perhaps entirely, in the extreme low temperatures prevailing over the watersheds of the Columbia system during the spring and early summer. The backward spring in the Pacific Northwest permitted a moderate rate of melting. The river reached flood stage at Portland six days before the 39-year average date and continued above the flood stage 69 days, or 26 days longer than the average flood-stage duration. Had the melting of this vast snow covering been rapid and the water been carried off in the average period of 43 days or less, it can readily be surmised that immense damage and general public inconvenience would have resulted.

Regarding these low temperatures, an examination of the records over the entire watershed show that with a few isolated exceptions there were no plus departures shown during the first six months of 1917. Not until July, after the passage of the crest into the ocean, did the monthly mean temperatures reach and pass above the

normal. In January there were places as much as 10 degrees below normal, in February and March as much as 9 degrees below, in April and May as much as 6 degrees, and in June 3 degrees below the seasonal average. (See Chart IV—Departure of the Mean Temperatures from the Normal, in January–June, 1917, issues of this REVIEW.)

The bureau issued special bulletins to approximately 400 persons or firms showing the stages of the river at the most important stations and containing warnings one, two, and three days in advance. The warnings were of very great practical value.

So far as can be ascertained, losses due to this year's high water were as follows:

Loss due to annual rise in Columbia River.

Tangible property, bridges, highways, etc.	Crops.		Suspension of business.	Removing and protecting goods.
	Matured.	Prospective.		
$15,000	$20,000	$100,000	$25,000	$6,000