RED CEDAR RIVER
NORMAL PROBABILITY OF FLOW
AND GENERAL DATA

THESIS FOR THE DEGREE OF B. S.

Harold E. Sprague

J. Raymond Neff

1930

RED CEDAR RIVER NORMAL PROBABILITY OF FLOW
and
GENERAL DATA

A Thesis
submitted to the Faculty of the Michigan State College

by

Harold E. Sprague J. Raymond Neff

Candidates for the Degree

of Bachelor of Science

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PREFACE

The writers wish to take this opportunity to express their appreciation of the aid rendered them in their work by Associate Professors C.M.Cade and H.C.Wood and other members of the Civil Engineering department of the Michigan State College.

H.E.S.

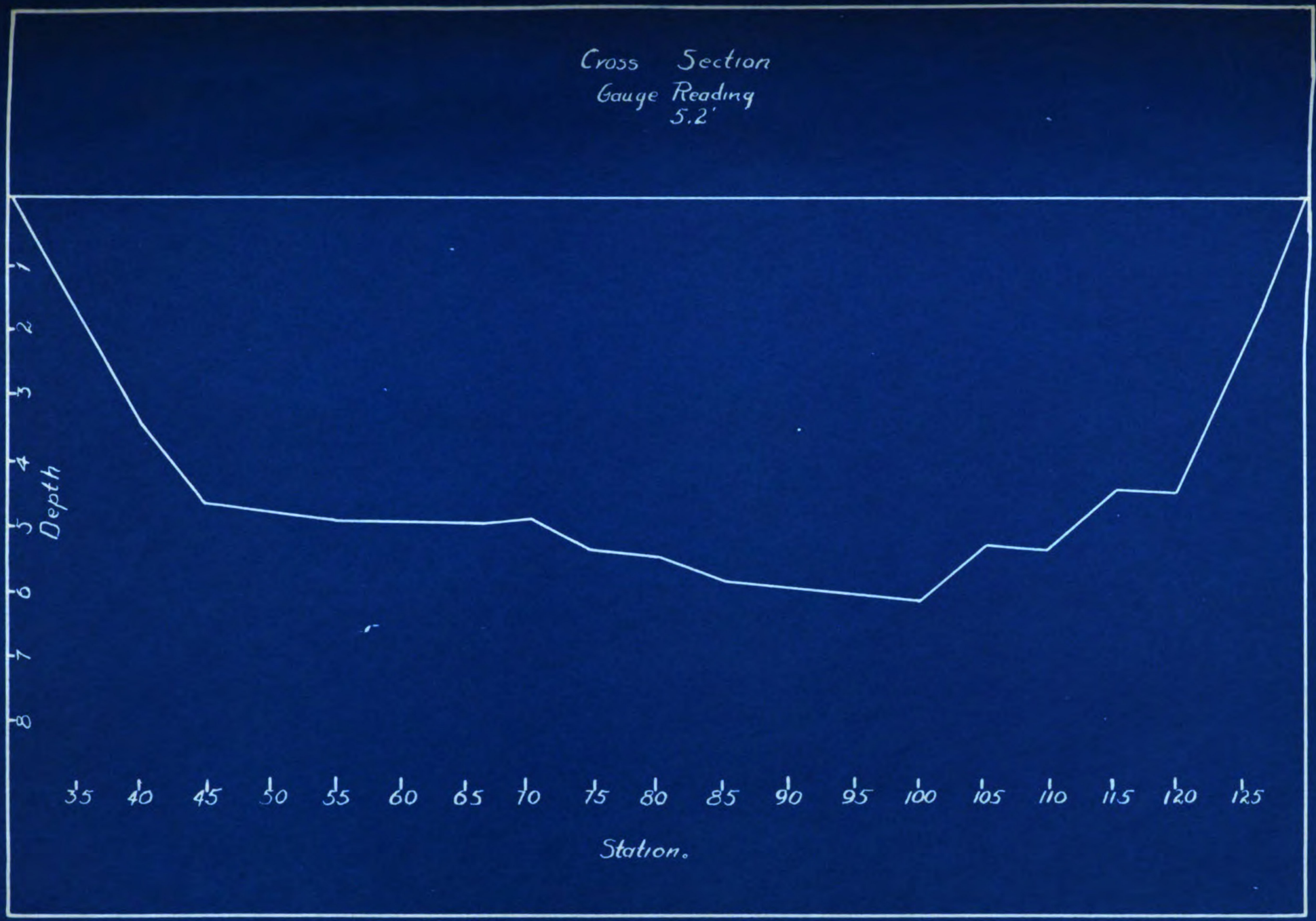
J.R.N.

OBJECT

The object of this thesis is to compute data necessary to determine equipment necessary to take care of maximum flood and conserve water for times of draught, using the theory of normal probability flow.

THE GAUGING STATION FOR ALL READINGS EXCEPT 1902 & 1903

The gauge is located at the railroad bridge of the College Spur of the Pere Marquette Railroad. The bridge has two spans of 65 feet each. The bed is of sand and gravel, fairly smooth and permanent. The channel is straight for a distance of about 1000 feet, upstream, and 800 feet dwon stream. About 300 feet upstream is a low dam, forming a pond, below which the stream does not ordinarily freeze over. The gauge is located on the down stream side of the center pier and is a steel plate, the face being white enamel with black figures in feet and tenths of feet. The gauging station is situated about four and one-half miles from the mouth of the stream. Sycamore Creek, and important tributary, enters in this section. The drainage area above the gauging station is 358 square miles and from the gauging station to the mouth of the stream 114 square miles, making a total above Grand River of 472 square miles. The flow is sluggish at low-stage and the station is subject to back-water from Grand River.


Cross Section
Gauge Reading
5.2'
Depth
1
2
3
4
5
6
7
8
35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125
Station.

RED CEDAR RIVER AT STATE COLLEGE, MICH.

This gauging station was established August 30, 1902. The gauge is located at the highway bridge just below the State College grounds. The bridge has a span of 75 feet between abutments. The bed is of sand and gravel, fairly smooth and permanent. The channel is straight for a distance of about 400 feet downstream. A short distance upstream is a low dam forming an ice pond, below which the stream does not ordinarily freeze over. In this stretch of the river is the railroad bridge of the college spur of the Pere Marquette Railroad, from which gaugings are made at high water or when the stream is frozen at the gauging station. Near this bridge low-water measurements are also made by wading. The gauge is of the usual wire type, and is attached to the down side guard rail of the bridge. The upstream corner of the right-hand wing wall of the bridge abutment is used as a bench mark, with an arbitrary elevation of 100 feet. The elevation of the datum plane of the gauge is 84.45 feet. The gauge is read twice each day by Clifford Walters. The gauging station is situated about four miles from the mouth of the stream. Sycamore Creek, an important tributary, enters in this section. The drainage area above the gauging station is 358 square miles, and from the gauging station to the mouth of the stream 114 square miles, making the total above Grand River 472 square miles. The flow is sluggish at low stage and the station is subject to back water from Grand River.

Great Lakes Drainage Grand River Basin

East Lansing (Station) Red Cedar River

Flood stage 8 feet Normal pool stage 6 feet

1903	January	February	March	April
1	4.3	8.65	9.7	3.7
2	4.03	8.27	9.63	3.78
3	4.32	7.88	9.62	4.35
4	5.02	7.50	9.62	4.35
5	5.48	6.92	9.25	5.87
6	5.38	6.40	9.17	6.6
7	5.13	6.05	9.0	7.48
8	4.78	5.30	9.42	6.87
9	4.25	4.93	9.35	5.91
10	4.23	5.00	8.97	5.22
11	4.13	5.38	8.85	5.07
12	3.98	6.35	8.68	7.67
13	3.83	7.33	8.15	8.85
14	3.8	7.62	7.60	9.55
15	3.78	7.18	6.87	10.07
16	3.7	5.85	6.45	10.02
17	3.75	5.47	6.15	9.55
18	2.73	5.23	5.92	8.80
19	3.63	4.80	5.6	7.95
20	3.55	4.25	5.45	7.12
21	3.50	4.22	5.1	6.18
22	3.48	4.10	4.75	5.45
23	3.40	4.03	4.5	4.92
24	3.43	3.98	4.6	4.7
25	3.35	3.92	4.5	5.1
26	3.38	3.9	4.42	5.35
27	3.55	4.37	4.28	5.02
28	4.6	8.16	4.40	4.60
29	7.68		4.22	4.2
30	9.13		4.05	3.82
31	9.23		3.85	

Great Lakes Drainage Grand River Basin

East Lansing (Station) Red Cedar River

Flood stage 8 feet Normal pool stage 6 feet

1905	May	June	July	August
1	3.7	2.32	2.78	2.42
2	3.6	2.4	3.47	2.38
3	3.55	2.37	4.27	2.40
4	3.55	2.37	3.70	2.7
5	3.95	2.3	3.3	3.42
6	3.72	2.27	2.95	3.82
7	3.52	2.25	2.82	3.48
8	3.36	2.15	2.65	3.18
9	3.25	2.32	2.55	2.88
10	3.1	2.35	2.47	2.62
11	3.92	2.45	2.40	2.68
12	2.82	2.35	2.35	2.50
13	2.75	2.3	2.22	2.40
14	2.7	2.55	2.18	2.32
15	2.67	2.4	2.08	2.00
16	2.65	2.42	1.98	2.22
17	2.57	2.5	1.88	2.1
18	2.45	2.7	2.35	2.18
19	2.62	2.62	3.6	2.18
20	2.75	2.9	3.58	2.3
21	2.55	3.27	3.40	2.95
22	2.62	3.45	3.62	2.08
23	2.72	4.85	3.97	1.88
24	3.1	5.70	3.7	2.38
25	3.15	5.45	3.32	2.92
26	3.12	5.02	3.02	3.15
27	3.12	4.5	2.82	3.35
28	3.15	3.87	2.7	4.9
29	2.87	3.35	2.8	6.08
30	2.65	3.00	2.68	6.82
31	2.55		2.52	7.12

Great Lakes Drainage Grand River Basin

East Lansing Station) Red Cedar River

Flood stage 8 feet Normal pool stage 6 feet

1903	September	October	November	December	
1	7.1	3.18	2.65	2.8	Highest stage for the year 10.07
2	6.8	3.2	2.25	2.9	
3	6.18	3.18	2.7	2.75	
4	5.45	3.28	2.68	2.72	
5	4.75	3.48	2.65	2.65	(date) Apr.15
6	4.1	3.3	2.6	2.68	
7	3.68	3.55	2.6	2.5	
8	3.48	4.48	2.7	2.75	
9	3.45	4.92	2.52	2.7	
10	3.35	4.52	2.62	2.68	Mean 4.15 ft.
11	3.32	4.1	2.6	2.65	
12	3.18	3.85	3.18	2.7	271 C.F.S.
13	3.1	3.62	3.85	2.65	
14	3.3	3.48	3.75	2.72	
15	4.25	3.35	3.55	2.65	
16	6.22	3.3	3.58	2.85	
17	7.15	3.3	4.02	2.95	
18	8.1	3.2	4.05	3.00	
19	7.82	3.15	3.75	2.9	
20	7.00	3.1	3.35	2.92	
21	6.32	3.05	3.5	2.9	
22	5.75	2.92	3.42	3.18	
23	5.08	2.9	3.25	3.2	
24	4.4	2.82	3.32	3.2	
25	3.9	2.72	3.28	3.25	
26	3.58	2.7	3.30	3.2	
27	3.52	2.78	3.12	3.2	
28	3.6	2.75	2.95	3.1	
29	3.4	2.72	2.95	3.22	
30	3.25	2.75	2.72	3.25	
31		2.7		3.22	

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1911	January	February	March	April
1	1.3	2.6	2.0	1.9
2	1.1	2.5	2.1	1.8
3	1.5	2.5	1.9	1.8
4	1.5	2.0	1.8	1.8
5	1.5	2.0	1.6	3.0
6	1.5	2.0	1.6	3.7
7	1.5	1.7	1.6	3.4
8	1.4	1.6	1.3	3.1
9	1.4	1.6	1.5	2.7
10	1.5	1.6	1.5	2.4
11	1.5	1.6	1.5	2.2
12	1.6	1.5	1.6	2.2
13	1.9	1.5	1.9	2.1
14	2.1	1.8	2.0	2.3
15	2.4	4.1	1.9	2.5
16	2.4	5.6	1.7	2.3
17	2.2	5.4	1.3	2.0
18	2.0	5.7	1.5	1.9
19	1.9	5.6	1.6	1.8
20	1.8	4.1	1.5	2.0
21	1.7	3.7	1.5	2.9
22	1.7	3.3	1.6	2.8
23	1.6	3.1	1.6	2.5
24	1.6	2.4	1.6	2.3
25	1.5	2.4	1.5	2.0
26	1.7	2.4	1.5	1.9
27	2.2	2.5	1.6	1.8
28	3.1	2.3	1.7	1.6
29	3.4		1.8	1.5
30	3.6		1.8	1.6
31	3.3		1.8	

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1911	May	June	July	August
1	1.7	1.0	0.9	0.7
2	1.9	1.0	0.9	0.8
3	1.8	1.0	0.8	0.9
4	1.7	1.1	0.8	1.0
5	1.6	1.9	0.8	1.0
6	1.5	2.6	0.8	1.0
7	1.4	2.3	1.0	0.9
8	1.4	2.0	0.9	0.8
9	1.4	1.8	0.8	0.8
10	1.4	1.5	0.8	0.9
11	1.3	1.4	0.7	0.9
12	1.2	1.7	0.8	0.9
13	1.2	1.6	0.8	0.9
14	1.1	1.5	0.8	0.9
15	1.1	1.4	0.8	0.8
16	1.1	1.3	0.8	0.9
17	1.2	1.3	0.8	0.9
18	1.1	1.2	0.8	0.9
19	1.1	1.1	0.8	0.9
20	1.2	1.1	0.9	0.9
21	1.1	1.2	1.0	0.9
22	1.2	1.2	0.9	0.8
23	1.2	1.2	0.9	1.1
24	1.2	1.0	0.9	1.1
25	1.2	1.0	0.8	0.8
26	1.1	0.9	0.9	0.7
27	1.0	0.9	0.9	0.7
28	0.9	1.0	0.8	1.5
29	0.9	1.0	0.8	1.1
30	1.9	1.0	0.8	0.8
31	1.0		0.9	0.7

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1911	September	October	November	December	
1	0.7	1.3	1.5	2.8	
2	0.7	1.8	1.5	2.5	
3	0.6	1.8	1.5	2.3	
4	0.6	2.0	1.5	1.9	
5	0.7	1.9	1.4	1.9	
6	0.7	1.7	1.4	1.8	
7	1.1	2.2	1.6	1.9	
8	1.1	2.1	2.0	1.9	
9	1.0	1.9	2.0	2.5	
10	0.8	1.7	1.8	3.7	
11	0.7	1.7	2.0	3.8	High. 5.7
12	0.7	1.6	2.3	3.5	Mean 1.7166
13	0.9	1.6	3.0	3.2	
14	0.9	1.5	3.0	2.8	159.4 C.F.S.
15	0.9	1.4	2.8	2.5	
16	0.9	1.4	2.4	2.3	
17	0.9	1.5	2.4	2.4	
18	0.9	1.9	4.3	2.2	
19	0.8	2.0	4.8	2.1	
20	0.9	1.8	4.2	2.0	
21	0.9	1.7	3.6	2.0	
22	0.9	1.7	3.1	2.1	
23	0.9	1.7	2.8	2.6	
24	0.9	1.7	2.7	2.8	
25	0.9	1.6	2.5	2.6	
26	0.8	1.5	2.3	2.3	
27	1.1	1.5	2.2	2.3	
28	1.4	1.5	2.5	1.8	
29	1.4	1.5	3.8	2.0	
30	1.4	1.4	3.6	2.1	
31		1.5		2.0	

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1912	January	February	March	April
1	2.0	1.8	1.9	10.2
2	2.1	1.8	1.9	11.0
3.	2.0	1.8	1.8	11.1
4	1.9	1.8	1.8	10.0
5	1.8	1.7	1.9	10.3
6	1.8	1.8	1.9	10.4
7	1.6	1.8	1.9	10.3
8	1.6	1.8	1.9	9.9
9	1.6	1.8	1.9	8.8
10	1.6	1.8	1.8	7.5
11	1.6	1.6	1.9	6.4
12	1.6	1.7	1.9	5.5
13	1.6	1.8	1.9	4.8
14	1.7	1.9	1.9	4.1
15	1.5	1.9	1.9	4.6
16	1.6	1.9	1.9	4.5
17	1.6	1.9	1.9	3.7
18	1.7	1.9	2.0	3.7
19	1.7	1.7	2.7	4.8
20	1.7	1.8	6.2	4.8
21	1.8	1.8	7.0	3.8
22	1.8	1.8	7.3	3.4
23	1.9	1.9	7.3	3.0
24	1.9	1.9	7.0	2.8
25	1.8	1.6	6.5	2.6
26	1.8	1.6	5.9	2.3
27	1.8	1.7	5.5	2.1
28	1.7	1.9	5.9	2.0
29	1.7	1.8	6.6	2.9
30	1.8		7.5	4.7
31	1.8		8.7	

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

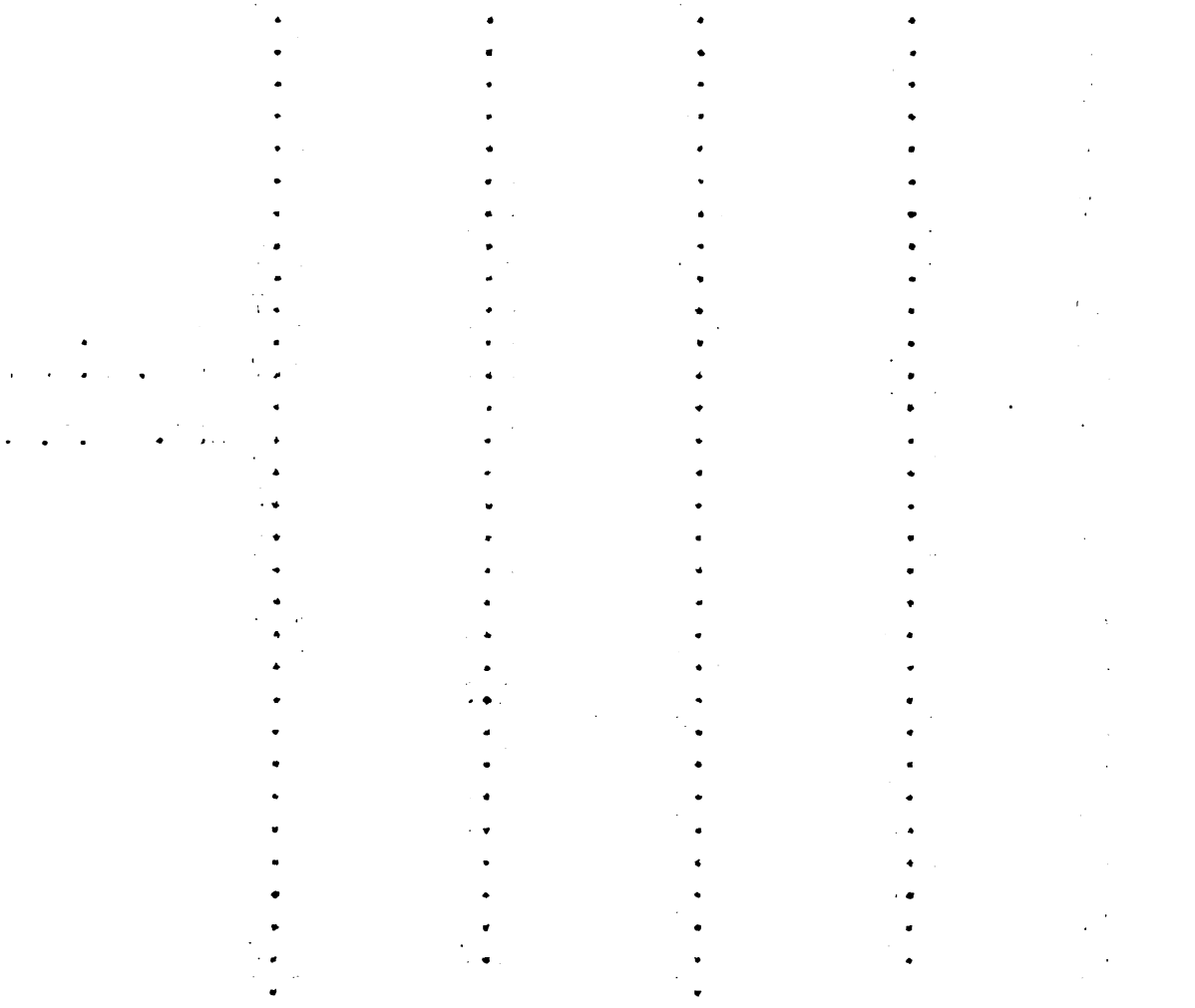
1912	May	June	July	August
1	4.8	2.9	1.1	1.6
2	3.8	2.1	1.2	1.6
3	3.2	2.1	1.1	1.6
4	2.8	2.4	1.1	1.4
5	2.4	2.8	1.1	1.4
6	2.2	2.6	1.1	1.4
7	2.0	2.2	1.1	1.4
8	2.0	1.9	2.1	1.2
9	1.9	1.8	1.5	1.3
10	1.8	1.6	1.4	1.3
11	1.8	1.5	1.3	1.4
12	3.9	1.5	1.2	1.5
13	5.7	1.5	1.3	1.5
14	6.3	1.4	1.2	1.4
15	5.4	1.4	1.3	1.3
16	4.8	1.5	1.2	1.3
17	5.7	1.5	1.2	1.2
18	6.0	1.4	1.2	1.1
19	4.8	1.3	1.1	1.2
20	3.8	1.3	1.2	1.5
21	3.8	1.3	1.2	1.7
22	5.4	1.3	1.2	1.5
23	5.0	1.3	1.3	1.4
24	4.0	1.2	1.6	1.4
25	3.2	1.2	2.9	1.3
26	2.5	1.2	2.4	1.1
27	2.8	1.2	2.0	1.0
28	2.8	1.2	1.7	1.2
29	2.7	1.2	1.6	1.2
30	3.1	1.2	1.6	1.3
31	3.0		1.7	1.2

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1912	September	October	November	December	
1	1.2	1.4	1.6	1.6	
2	1.0	1.5	2.4	1.7	
3	1.1	1.5	2.6	2.0	
4	1.2	1.5	2.5	2.2	
5	1.1	1.4	2.2	2.1	
6	1.1	1.3	2.1	2.4	
7	1.1	1.2	3.5	2.5	
8	1.2	1.2	4.4	2.3	
9	1.0	1.4	4.0	2.1	
10	1.1	1.4	3.4	1.7	
11	1.2	1.6	3.1	1.8	High 11.1
12	1.1	1.8	2.7	1.7	Mean. 2.2583
13	1.1	1.9	2.5	1.6	
14	1.0	1.6	2.9	1.6	234.6 C.F.S.
15	1.1	1.6	3.0	1.6	
16	1.1	1.5	2.8	1.5	
17	1.2	1.4	2.6	1.5	
18	1.3	1.4	2.5	1.6	
19	1.3	1.4	2.2	1.5	
20	1.3	1.4	2.2	1.4	
21	1.2	1.4	2.0	1.4	
22	1.2	1.4	1.9	1.5	
23	1.2	1.6	1.9	1.5	
24	1.3	1.4	1.9	1.3	
25	1.4	1.6	1.9	1.5	
26	1.2	1.6	1.9	1.3	
27	1.3	1.5	1.8	1.3	
28	1.3	1.4	1.8	1.5	
29	1.3	1.4	1.8	1.5	
30	1.4	1.4	1.7	1.5	
31		1.4		1.4	

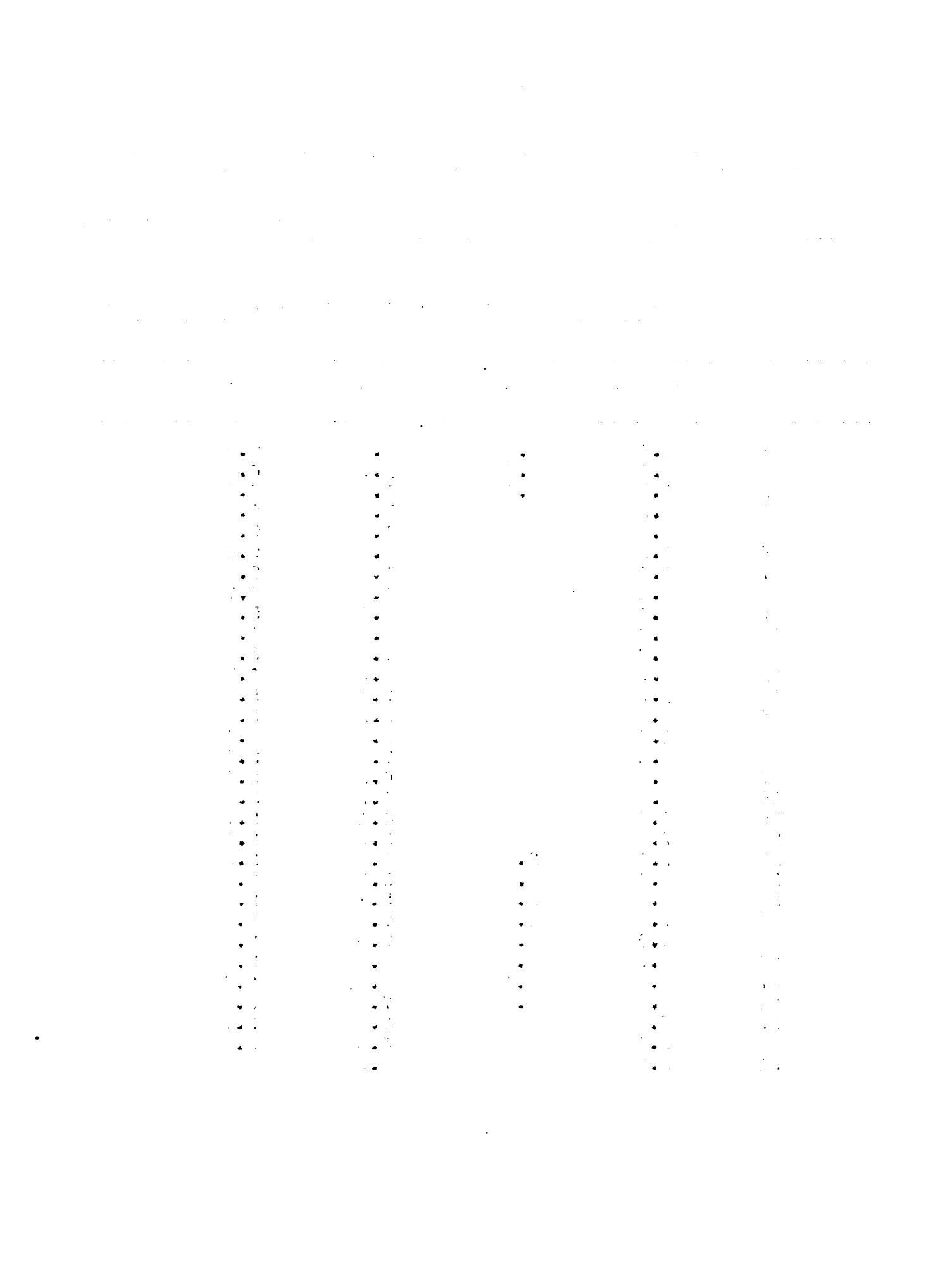


Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1913	January	February	March	April
1	1.4	3.5	1.8	7.5
2	1.4	3.5	1.9	6.6
3	1.5	3.4	1.6	6.4
4	1.5		1.8	8.3
5	1.5		1.8	9.8
6	1.5		1.8	9.6
7	1.6		1.8	8.3
8	1.6		1.8	6.7
9	1.6		1.8	5.6
10	2.0		5.4	4.6
11	1.9		7.5	5.3
12	1.9		8.5	6.1
13	1.9		9.4	5.9
14	1.8		8.2	5.0
15	1.8		8.0	4.4
16	2.2		7.2	3.8
17	5.3		6.3	3.4
18	8.3		4.9	3.1
19	8.6		4.1	2.7
20	7.3		3.9	2.4
21	7.4	2.5	4.0	2.3
22	8.0	2.2	5.5	2.1
23	8.0	2.1	5.7	2.0
24	7.1	2.0	7.2	2.1
25	6.8	2.1	9.5	2.0
26	5.9	2.0	9.5	2.0
27	5.5	2.1	8.9	2.6
28	5.3	1.9	7.5	3.5
29	5.3		6.6	3.7
30	5.4		6.8	3.2
31	5.2		7.5	



Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1915	May	June	July	August
1	2.7	2.4	1.3	1.1
2	2.2	2.1	1.2	1.1
3	2.0	1.9	1.2	1.1
4	1.9	1.7	1.1	1.0
5	1.8	1.5	1.1	1.0
6	1.8	1.5	1.2	1.1
7	1.7	1.4	1.2	1.1
8	1.6	1.4	1.2	1.0
9	1.6	1.3	1.1	1.2
10	1.5	1.3	1.1	2.0
11	1.4	1.3	1.1	1.6
12	1.3	1.3	1.1	1.4
13	1.3	1.3	1.0	1.2
14	1.5	1.1	1.1	1.2
15	1.7	1.1	1.0	1.1
16	3.0	1.0	1.0	1.1
17	4.0	1.0	1.0	1.6
18	4.3	1.0	1.1	1.3
19	3.6	1.0	1.1	1.4
20	2.9	1.0	1.0	1.2
21	2.4	1.3	1.0	1.2
22	2.3	1.3	1.0	1.3
23	2.9	1.2	1.0	1.4
24	2.8	1.2	1.0	1.4
25	2.3	1.1	1.0	1.3
26	2.2	1.1	1.1	1.4
27	2.2	1.1	1.1	1.2
28	2.4	1.2	1.0	1.0
29	2.4	1.2	1.1	1.1
30	2.2	1.1	1.1	1.1
31	2.4		1.1	1.1

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1913	September	October	November	December	
1	1.0	0.9	1.5	2.0	
2	1.0	0.9	1.5	2.6	
3	1.0	1.0	1.3	2.7	
4	1.0	0.9	1.3	2.8	
5	1.0	1.1	1.3	2.5	
6	1.0	1.0	1.2	2.2	
7	1.0	1.0	1.2	2.0	
8	1.0	1.0	1.2	2.0	High 9.5
9	0.9	1.2	1.4	2.0	Mean 2.33636
10	0.9	1.2	1.4	1.8	
11	0.9	1.1	1.4	1.8	248.2 C.F.S.
12	0.9	1.1	1.3	1.5	
13	0.9	1.1	1.3	1.7	
14	0.9	1.0	1.7	1.7	
15	0.9	1.0	1.6	1.7	
16	0.9	1.0	2.1	1.7	
17	1.2	1.3	2.0	1.7	
18	1.3	1.1	1.9	1.7	
19	1.3	1.3	1.9	1.5	
20	1.1	1.1	1.9	1.5	
21	1.0	1.1	2.4	1.5	
22	1.0	1.3	2.3	1.2	
23	0.9	1.5	2.3	1.1	
24	0.9	1.3	2.4	1.4	
25	0.9	1.2	2.3	1.5	
26	0.9	1.3	2.0	1.2	
27	0.9	1.1	1.9	1.2	
28	0.9	1.4	1.8	1.5	
29	0.8	1.4	1.8	1.1	
30	0.8	1.5	1.8	1.5	
31		1.5		1.4	

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1914	January	February	March	April
1	1.4	5.8	2.1	5.1
2	1.1	4.6	2.0	5.1
3	1.4	5.5	2.0	5.5
4	1.4	4.9	2.0	4.9
5	1.5	4.2	1.8	4.0
6	1.6	4.0	1.8	3.5
7	1.5		2.0	3.3
8	1.5		2.2	3.4
9	1.5		2.2	3.3
10	1.5		2.3	2.9
11	1.5		2.3	2.7
12	1.4		2.3	2.6
13	1.4		2.3	2.5
14	1.3		2.7	2.0
15	1.4		4.4	2.0
16	1.3		6.1	2.0
17	1.3		6.7	2.0
18	1.3		5.6	1.6
19	1.3		4.7	1.8
20	1.6		3.7	1.8
21	1.5		3.0	1.8
22	1.4		2.9	1.6
23	1.7		2.7	1.5
24	3.1		2.5	1.5
25	3.0		2.6	2.0
26	3.2		3.0	4.5
27	3.1		3.9	5.5
28	3.8	2.3	6.3	5.0
29	4.9		7.0	4.8
30	6.3		6.5	4.7
31	5.1		5.9	

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1914	May	June	July	August
1	4.7	1.6	2.5	1.5
2	5.3	1.5	2.3	1.4
3	2.8	1.4	2.3	1.4
4	2.5	1.4	1.9	1.3
5	2.8	2.3	1.6	1.3
6	2.4	2.8	1.5	1.3
7	3.3	2.3	1.5	1.3
8	3.5	2.0	1.5	1.3
9	2.7	1.7	1.5	1.3
10	2.4	1.5	1.3	1.5
11	2.2	1.5	1.2	1.3
12	5.3	1.5	1.2	1.3
13	8.8	1.7	1.2	1.3
14	9.7	1.2	2.3	1.5
15	9.0	1.7	2.5	1.5
16	7.8	1.5	4.0	1.5
17	6.2	1.5	3.5	1.6
18	4.8	1.0	3.0	1.5
19	3.7	1.0	2.5	1.5
20	3.0	1.0	2.0	1.5
21	2.5	1.2	2.0	1.6
22	2.2	1.3	1.9	1.5
23	2.0	2.9	1.8	1.4
24	1.9	3.2	1.5	1.2
25	1.8	1.5	1.5	1.2
26	1.2	1.2	1.5	1.3
27	1.7	1.6	1.3	1.2
28	2.0	2.7	1.5	1.4
29	1.8	3.7	1.5	1.4
30	1.9	3.5	1.3	1.4
31	1.8		1.3	1.0

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (station)

Flood stage 8 feet Normal pool stage _____ Feet

1914	September	October	November	December	
1	1.7	1.3	1.4	1.2	
2	2.3	1.3	1.3	1.5	
3	3.0	1.4	1.4	1.5	
4	2.9	1.4	1.5	1.5	
5	2.3	1.2	1.4	1.6	
6	2.2	1.2	1.4	1.6	
7	1.9	1.2	1.5	1.6	
8	1.8	1.2	1.4	1.6	
9	1.6	1.2	1.4	1.5	
10	1.6	1.3	1.4	1.6	High 9.7
11	1.5	1.3	1.4	1.6	Mean 2.21
12	1.6	1.3	1.5	1.4	
13	1.5	1.5	1.3	1.4	226.6 C.F.S.
14	1.2	1.5	1.5	1.4	
15	1.0	1.5	1.4	1.3	
16	1.2	1.5	1.2	1.3	
17	1.1	2.0	1.3	1.2	
18	1.1	2.7	1.3	1.2	
19	1.0	2.7	1.4	1.2	
20	1.3	2.7	1.3		
21	1.0	2.0	1.3		
22	1.0	1.7	1.3		
23	1.2	1.5	1.3		
24	1.2	1.6	1.3		
25	1.0	1.5	1.5		
26	1.2	1.4	1.5		
27	1.4	1.4	1.5		
28	1.2	1.4	1.3		
29	1.2	1.4	1.5		
30	1.2	1.4	1.1		
31		1.4			

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1915	January	February	March	April
1			3.0	1.6
2			2.8	1.6
3			2.8	1.6
4			2.3	1.6
5			2.3	1.7
6	1.5	3.0	2.0	1.7
7	1.5	3.8	2.1	1.8
8		3.5	2.0	1.8
9		3.5	1.9	1.8
10		3.5	2.2	1.8
11		3.5	2.3	2.4
12		4.0	3.2	3.0
13		5.6	2.9	3.2
14		7.2	2.7	2.8
15		9.4	2.7	2.4
16		10.0	2.7	2.2
17	1.9	9.5	2.9	2.0
18	2.0	8.9	2.9	1.9
19	2.9	7.5	2.9	1.8
20	2.4	6.3	2.2	1.7
21	2.0	5.3	2.1	1.5
22	2.0	4.4	2.3	1.5
23		4.5	2.0	1.5
24		6.4	2.0	1.5
25		7.0	2.0	1.5
26		6.0	2.0	1.5
27		5.4	1.9	1.5
28		3.9	1.8	1.5
29			1.7	1.3
30			1.7	1.3
31			1.7	

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage feet

1915	May	June	July	August
1	1.0	1.6	1.3	1.7
2	1.4	1.6	1.4	1.5
3	1.0	1.6	1.9	2.0
4	1.2	1.6	1.8	2.0
5	1.4	1.5	1.7	2.2
6	1.5	1.3	1.5	2.4
7	1.5	1.4	1.5	2.5
8	1.8	1.4	1.7	2.1
9	1.9	1.5	4.0	1.7
10	2.0	1.5	3.8	1.5
11	1.8	1.5	2.9	1.5
12	1.6	1.4	2.3	1.6
13	1.5	1.4	1.8	2.5
14	1.5	1.4	1.6	4.0
15	1.3	1.4	1.6	4.4
16	1.4	1.4	1.5	3.9
17	1.6	1.6	1.5	4.6
18	1.8	2.3	1.4	5.4
19	1.6	3.4	1.4	4.4
20	1.6	3.4	1.4	3.1
21	1.6	3.1	1.5	2.5
22	1.7	3.3	1.3	3.7
23	1.7	2.0	1.3	4.4
24	1.6	2.0	1.2	3.8
25	1.6	1.8	1.2	3.1
26	1.6	1.6	1.2	2.5
27	1.8	1.5	1.2	2.3
28	1.8	1.3	1.3	2.0
29	1.6	1.3	1.3	1.8
30	1.6	1.3	1.5	1.7
31	1.7		1.5	1.7

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1915	September	October	November	December	
1	1.6	3.0	1.4	2.0	
2	1.6	2.5	1.6	2.0	
3	1.6	2.5	1.6	1.9	
4	1.6	2.5	1.5	1.8	
5	1.5	2.5	1.5	1.6	
6	2.0	2.5	1.5	1.6	
7	4.1	2.2	1.4	1.6	
8	5.0	2.2	1.4	1.6	High 10.0
9	5.7	2.0	1.4	1.6	Mean 2.46363
10	5.3	2.0	1.4	1.5	
11	5.5	2.0	1.4	1.5	264.6 C.F.S.
12	6.0	2.0	1.5	1.5	
13	6.9	1.7	1.5	1.5	
14	7.5	1.8	1.4	1.5	
15	7.7	1.8	1.5	1.5	
16	6.6	1.9	1.5	1.4	
17	5.0	1.8	1.5	1.6	
18	4.0	1.9	1.5	1.4	
19	3.2	2.0	1.7	1.4	
20	3.0	2.0	2.2	1.4	
21	3.5	2.0	2.4	1.4	
22	3.5	2.0	2.2	1.4	
23	3.3	1.8	2.2	1.4	
24	3.2	1.7	1.9	1.4	
25	3.0	1.8	1.9	1.5	
26	2.4	1.8	2.0	1.5	
27	3.8	1.7	2.0	1.4	
28	3.6	1.7	1.9	1.4	
29	3.6	1.8	2.0	1.4	
30	3.4	1.6	2.0	1.4	
31		1.5		1.5	

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1916	January	February	March	April
1	1.5	7.6	3.0	7.4
2	3.5	6.5	2.9	7.4
3	6.0	5.6	2.9	7.3
4	6.4	5.0	1.6	6.4
5	5.7		2.2	5.6
6	5.0		2.2	5.0
7	4.5		1.9	4.4
8	4.0		2.0	4.0
9	4.0		2.0	3.4
10	4.0		3.0	3.1
11	3.5		3.0	2.8
12	3.5		2.8	2.8
13	3.1	3.4	3.7	2.8
14	2.8	3.2	4.2	3.0
15	1.6	3.2	4.0	4.5
16	1.6	3.2	4.0	4.6
17	1.5	3.5	4.0	4.0
18	1.5	3.5	4.0	3.5
19	1.5	2.6	2.6	3.0
20	Frozen	2.4	4.0	3.7
21	3.0	2.6	2.3	3.5
22	8.5	2.6	2.2	4.0
23	8.5	4.0	2.8	3.5
24	6.9	4.2	2.8	3.5
25	4.8	4.0	2.8	3.5
26	4.9	3.0	7.5	3.8
27	5.0	3.9	11.5	3.0
28	5.0	3.0	11.4	3.0
29	5.9	3.0	10.0	2.7
30	5.7		9.6	2.4
31	6.0		8.5	

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1916	May	June	July	August
1	2.0	4.4	3.6	1.2
2	2.0	3.4	4.7	1.2
3	2.3	3.0	4.0	1.2
4	2.8	2.5	2.5	1.2
5	2.6	2.1	1.9	1.2
6	2.9	2.0	2.0	1.0
7	2.5	2.0	2.0	1.3
8	2.5	3.4	1.5	1.3
9	2.4	3.1	1.5	1.3
10	2.5	3.5	1.5	1.3
11	2.5	3.8	1.5	1.2
12	2.8	3.2	1.5	1.2
13	2.0	3.0	1.4	1.2
14	2.0	3.0	1.6	1.1
15	4.0	2.5	1.5	1.1
16	8.5	3.5	1.3	1.2
17	9.3	3.0	1.5	1.1
18	8.0	3.5	1.5	1.1
19	6.4	3.6	1.5	1.1
20	5.5	3.5	1.6	1.1
21	3.8	3.3	1.5	1.0
22	3.1	2.2	1.7	1.0
23	3.0	2.0	1.2	1.0
24	4.2	2.4	1.4	1.0
25	3.5	3.8	1.3	1.0
26	3.5	4.0	1.5	1.0
27	2.5	3.6	1.1	1.0
28	2.3	2.2	1.3	1.0
29	2.9	2.2	1.0	1.0
30	4.6	2.2	1.0	1.0
31	5.0		1.2	0.9

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet. Normal pool stage _____ feet

1916	September	October	November	December	
1	0.9	1.4	1.4	1.2	
2	0.9	1.1	1.2	1.2	
3	0.9	1.0	1.4	1.3	
4	0.9	1.0	1.2	1.3	
5	1.0	1.0	1.2	1.3	
6	1.0	1.2	1.3	1.3	
7	1.0	1.2	1.3	1.3	
8	0.8	1.0	1.3	1.3	High 11.5
9	0.8	1.1	1.3	1.3	Mean 2.6166
10	0.8	1.1	1.3	1.5	
11	0.8	1.1	1.3	1.3	290.6 C.F.S.
12	1.0	1.0	1.3	1.3	
13	1.0	1.3	1.3	1.4	
14	1.0	1.4	1.2	1.4	
15	1.0	1.4	1.2	1.3	
16	1.0	1.1	1.2	1.3	
17	0.9	1.1	1.3	1.3	
18	0.9	1.1	1.2	1.5	
19	0.8	1.1	1.4	1.5	
20	0.8	1.1	1.2	1.4	
21	0.8	1.3	1.2	1.4	
22	1.0	1.4	1.2	1.4	
23	1.0	1.3	1.3	1.5	
24	0.9	1.3	1.4	1.5	
25	0.8	1.3	1.4	1.4	
26	0.7	1.2	1.3	1.4	
27	1.0	1.4	1.2	1.5	
28	1.5	1.3	1.2	1.5	
29	1.5	1.3	1.2	1.5	
30	1.3	1.3	1.3	1.5	
31		1.3		1.5	

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage ____ feet

1917	January	February	March	April
1	1.2	1.8	3.0	3.5
2	1.3	2.0	3.0	4.2
3	1.4	1.9	2.8	4.8
4	1.4	1.8	2.5	4.1
5	1.5	1.9	2.3	4.4
6	1.8	1.8	2.3	5.3
7	2.0	1.9	2.2	9.4
8	2.0	1.6	2.4	8.7
9	1.8	1.5	2.0	7.1
10	1.8	1.9	2.1	5.6
11	1.8	1.9	2.6	4.5
12	1.8	1.9	4.4	3.5
13	1.8	1.9	4.8	3.2
14	1.7	2.0	4.5	2.8
15	1.7	1.9	4.3	2.6
16	1.8	1.6	3.9	2.5
17	1.8	1.7	3.4	2.3
18	1.7	1.8	3.1	2.2
19	1.7	1.8	3.0	4.8
20	1.7	1.9	2.3	6.6
21	1.7	1.6	2.9	7.1
22	1.5	1.4	3.2	6.7
23	1.4	1.4	3.1	5.4
24	1.5	2.0	4.4	5.2
25	1.6	2.0	5.4	4.5
26	1.6	2.5	4.6	4.4
27	1.4	2.9	4.5	4.7
28	1.4	3.0	4.7	4.0
29	1.8		4.8	3.4
30	1.8		4.9	3.1
31	2.0		5.0	

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1917	May	June	July	August
1	3.2	4.3	4.5	1.3
2	3.5	3.5	4.5	1.2
3	3.3	3.0	4.1	1.1
4	2.8	3.5	3.1	1.0
5	2.5	3.0	2.3	1.0
6	2.5	3.2	2.0	1.0
7	2.5	6.9	2.3	1.0
8	2.5	8.0	3.0	1.2
9	2.4	6.8	2.6	1.2
10	2.2	4.6	2.1	1.4
11	2.0	3.4	1.8	1.4
12	1.9	2.8	1.6	1.1
13	1.8	2.4	2.1	1.0
14	1.8	3.5	2.3	1.0
15	1.5	2.3	2.1	1.0
16	1.5	2.1	1.9	1.0
17	1.5	1.8	1.8	0.9
18	1.5	1.7	4.1	0.9
19	1.6	1.7	3.9	0.8
20	1.4	1.7	3.1	0.8
21	1.2	1.6	2.4	0.9
22	1.8	1.5	2.0	0.9
23	3.0	1.4	1.7	0.9
24	3.8	3.8	1.7	1.3
25	3.3	3.3	1.5	1.4
26	3.7	2.7	1.5	1.3
27	3.1	2.2	1.5	1.3
28	6.5	2.3	1.5	1.0
29	7.3	3.7	1.3	0.9
30	6.1	5.1	1.3	0.9
31	4.9		1.3	0.8

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1917	September	October	November	December	
1	1.0	0.8	2.1	1.5	
2	1.2	0.8	2.0	1.4	
3	1.0	1.4	1.9	1.5	
4	1.0	1.3	1.7	1.5	
5	1.7	1.0	1.6	1.5	
6	2.8	1.3	1.5	1.5	
7	2.5	1.1	1.5	1.5	
8	2.4	1.0	1.5	1.5	
9	1.9	1.0	1.5	1.5	
10	1.6	1.2	1.4	1.5	High 9.4
11	1.4	1.0	1.4	1.5	Mean 2.25
12	1.4	1.0	1.4	1.5	
13	1.2	1.2	1.4	1.5	233.0 C.F.S.
14	1.3	1.1	1.4	1.5	
15	1.2	1.0	1.4	1.5	
16	1.4	1.3	1.4	1.5	
17	1.1	1.2	1.4	1.5	
18	1.3	1.3	1.4	1.4	
19	1.1	1.6	1.4	1.5	
20	1.1	1.6	1.5	1.5	
21	1.0	1.5	1.5	1.9	
22	1.0	1.6	1.5	2.0	
23	1.0	1.5	1.5	2.3	
24	0.9	2.0	1.5	2.1	
25	0.9	2.1	1.5	2.1	
26	1.0	1.9	1.5	2.1	
27	1.0	2.3	1.5	1.7	
28	1.0	2.5	1.5	1.7	
29	1.0	2.2	1.5	1.6	
30	0.9	2.4	1.5	1.6	
31	1.1	2.4		1.6	

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1918	January	February	March	April
1	1.6	1.4	8.8	2.8
2	1.6	1.3	7.7	3.8
3	1.6	1.4	7.5	4.7
4	1.5	1.4	7.1	4.3
5	1.5	1.4	7.6	3.4
6	1.5	1.4	7.4	2.9
7	1.5	1.4	7.0	2.8
8	1.5	1.3	6.4	2.4
9	1.5	1.4	5.5	2.4
10	1.5	1.7	4.9	2.3
11	1.5	1.8	4.2	2.1
12	1.5	2.3	5.1	2.1
13	1.5	5.5	8.1	2.0
14	1.5	7.8	9.5	2.0
15	1.5	9.9	12.0	1.8
16	1.4	11.0	11.6	1.8
17	1.6	10.7	10.3	1.9
18	1.5	9.8	9.2	2.9
19	1.5	9.6	8.0	2.9
20	1.5	9.5	6.5	2.9
21	1.5	9.3	5.7	2.8
22	1.6	9.7	5.0	2.8
23	1.6	8.6	4.8	2.6
24	1.4	7.5	4.2	2.5
25	1.4	7.3	3.8	2.3
26	1.4	7.4	3.5	2.0
27	1.4	9.0	3.1	2.0
28	1.4	9.6	2.8	2.1
29	1.4		2.6	2.3
30	1.4		2.6	2.4
31	1.4		2.6	

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1918	May	June	July	August
1	2.4	1.8	1.3	1.0
2	2.4	1.7	1.3	1.0
3	2.4	1.4	1.3	1.0
4	2.3	1.4	1.2	1.0
5	2.1	1.4	1.1	1.0
6	1.9	1.4	1.0	1.0
7	1.9	1.4	1.1	0.9
8	1.8	1.4	1.1	0.9
9	1.7	1.5	1.0	0.9
10	1.9	1.3	1.0	0.9
11	2.1	1.4	1.0	0.9
12	2.8	1.4	1.2	1.0
13	2.8	1.4	1.1	1.0
14	3.8	1.5	1.0	1.0
15	3.5	1.3	1.0	1.0
16	3.1	1.3	0.9	0.9
17	2.7	1.3	0.9	1.0
18	2.4	1.2	1.0	1.0
19	1.8	1.2	1.0	1.0
20	1.8	1.2	1.0	0.9
21	1.6	1.2	0.9	1.0
22	1.7	1.3	1.0	1.1
23	1.5	1.2	1.0	1.1
24	1.5	1.0	0.9	1.1
25	1.6	1.1	0.9	0.9
26	1.5	1.0	0.9	0.9
27	1.5	1.0	1.5	0.9
28	1.6	1.0	1.0	0.9
29	1.6	0.9	1.0	1.0
30	1.8	1.0	1.0	1.0
31	1.8		1.0	1.0

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1918	September	October	November	December	
1	1.0	1.1	1.2	1.6	
2	1.0	0.9	1.3	1.5	
3	1.0	0.7	1.2	1.5	
4	1.1	0.6	1.2	1.4	
5	1.2	0.6	1.0	1.4	
6	1.0	1.3	1.4	1.4	
7	1.0	1.4	1.1	1.3	
8	0.9	1.3	1.3	1.6	
9	0.9	1.1	2.0	1.6	High 12.0
10	1.0	1.2	1.9	1.9	Mean 2.35
11	1.0	1.1	1.9	2.3	
12	1.1	1.1	1.9	2.7	250.0 C.F.S.
13	1.2	1.1	1.9	2.8	
14	1.1	1.0	1.7	3.5	
15	1.1	0.8	1.7	4.4	
16	1.0	1.0	1.7	4.5	
17	1.0	0.9	1.5	4.3	
18	1.2	1.1	1.8	3.7	
19	1.3	1.4	2.3	3.1	
20	1.3	1.5	2.6	3.1	
21	1.2	1.1	2.3	3.1	
22	0.8	0.9	2.3	3.7	
23	1.2	1.1	1.9	5.2	
24	1.0	1.4	1.7	4.8	
25	1.0	1.2	1.7	4.3	
26	0.9	1.3	1.6	3.2	
27	0.9	1.5	1.6	3.1	
28	1.1	1.2	1.5	3.0	
29	1.1	1.4	1.6	3.1	
30	1.1	1.4	1.6	3.2	
31		1.4		3.8	

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1919	January	February	March	April
1	3.5	2.1	3.8	2.2
2	3.9	1.7	3.1	2.1
3	4.9	1.8	3.1	2.1
4	3.9	2.0	3.2	2.3
5	3.8	1.8	2.9	2.7
6	3.8	1.6	2.8	2.8
7	2.9	1.7	2.6	2.4
8	3.0	1.5	2.3	4.1
9	3.0	1.5	2.2	4.2
10	2.9	1.4	2.1	4.5
11	2.8	1.5	2.0	5.0
12	2.2	1.5	1.8	5.2
13	2.5	1.6	2.9	4.3
14	2.6	1.8	3.9	4.0
15	2.6	1.7	4.5	3.7
16	2.6	1.7	7.8	6.9
17	2.9	1.4	10.0	8.4
18	2.1	1.5	9.8	9.4
19	2.2	1.4	9.3	8.5
20	2.4	1.2	8.9	7.0
21	2.4	1.4	7.7	6.2
22	2.2	1.5	6.8	4.6
23	2.4	3.0	5.3	5.5
24	3.3	2.7	3.8	3.8
25	3.1	2.8	3.4	4.0
26	2.9	2.6	3.5	3.7
27	2.7	2.6	3.4	3.1
28	2.7	2.5	3.2	3.6
29	2.4		3.2	3.1
30	2.5		2.8	2.8
31	2.5		2.7	

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1919	May	June	July	August
1	3.2	1.5	2.1	1.0
2	3.5	1.3	1.7	1.0
3	4.0	1.2	1.5	0.9
4	6.6	1.0	1.3	0.9
5	8.8	1.0	1.2	2.3
6	9.1	1.2	1.4	2.9
7	8.5	1.2	1.3	2.9
8	6.7	1.2	1.3	2.8
9	5.4	1.1	1.2	2.5
10	4.7	1.1	1.3	2.4
11	3.8	1.1	1.3	2.4
12	3.8	1.0	1.3	1.4
13	3.5	0.9	1.3	1.3
14	2.7	1.4	1.3	1.3
15	2.7	1.2	1.4	1.2
16	3.2	1.2	1.4	1.2
17	3.5	2.0	1.3	1.4
18	2.9	1.4	1.2	1.3
19	2.6	1.6	1.1	1.2
20	2.3	1.5	1.1	1.1
21	2.4	1.3	1.2	1.1
22	2.4	1.6	1.3	1.1
23	2.5	1.5	1.3	1.1
24	2.2	1.5	1.3	1.0
25	2.2	2.5	1.3	1.0
26	2.0	4.6	1.4	0.8
27	2.0	4.7	1.2	0.7
28	1.8	3.6	0.8	0.7
29	1.8	2.8	0.9	1.0
30	1.6	2.3	1.1	1.2
31	1.5		1.2	1.2

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage ____ feet

1919	September	October	November	December
1	1.0	1.4		
2	1.0	1.3		
3	0.9	1.3		
4	1.0	1.2		
5	1.0	1.2		
6	1.0	1.0		
7	1.0	1.0		
8	1.0	1.3		
9	1.0	1.3		
10	1.0	1.2		
11	1.0	1.4		
12	1.2	1.4		
13	0.9	1.2		
14	1.0	1.2		
15	1.0	1.3		
16	0.7	1.3		
17	0.9	1.4		
18	0.9	1.2		
19	0.9	1.2		
20	1.0	1.2		
21	1.1	1.2		
22	1.0	1.4		
23	1.4	1.4		
24	1.4	1.0		
25	1.3	1.1		
26	1.2	1.4		
27	1.3	1.2		
28	1.2	1.5		
29	1.1	1.5		
30	1.2	1.5		
31		1.7		

High 10.0
Mean 2.38

254.2 C.F.S.

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1925	May	June	July	August
1	1.3	1.0	.9	1.8
2	1.3	1.0	.9	1.4
3	1.3	1.0	.85	1.4
4	1.3	1.0	.85	1.3
5	1.25	1.0	.85	1.3
6	1.25	1.0	.85	1.2
7	1.25	1.0	.85	1.2
8	1.25	1.0	.85	1.2
9	1.25	1.0	.85	1.25
10	1.25	1.0	.85	1.2
11	1.2	1.0	.8	1.2
12	1.2	1.0	.8	1.3
13	1.2	1.0	.8	1.25
14	1.2	1.0	.8	1.25
15	1.2	1.0	.8	1.2
16	1.2	1.0	.8	1.2
17	1.1	1.0	.8	1.2
18	1.15	1.0	.8	1.2
19	1.15	1.0	.8	1.2
20	1.15	.95	.8	1.2
21	1.15	.95	.8	1.2
22	1.15	.95	.8	1.15
23	1.1	.95	.8	1.15
24	1.1	.95	.8	1.15
25	1.1	.95	.8	1.15
26	1.1	.95	.8	1.15
27	1.0	.95	.8	1.1
28	1.0	.9	.8	1.1
29	1.0	.9	.8	1.0
30	1.0	.9	.8	1.1
31	1.0		.8	1.1

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1925	September	October	November	December	
1	1.1	1.0	1.9	1.7	Highest stage
2	1.05	1.2	1.80	1.7	for the year
3	1.05	2.3	1.7	1.7	11.35
4	1.05	3.3	1.65	1.7	
5	1.0	4.5	1.6	2.5	Date _____
6	1.0	3.9	1.6	2.9	
7	.95	3.1	1.6	2.9	
8	.95	2.5	1.6	2.5	Mean 2.35
9	.9	2.1	1.6	2.35	
10	1.0	2.0	1.6	2.0	
11	1.3	2.0	1.7	1.9	
12	1.3	1.9	1.9	1.9	
13	1.2	1.9	3.4	1.9	
14	1.2	1.85	3.6	1.70	
15	1.2	1.85	3.8	1.5	
16	1.2	1.8	4.0	1.5	
17	1.15	1.8	3.6	1.45	
18	1.15	1.8	3.6	1.45	
19	1.15	1.8	4.5	1.4	
20	1.0	1.7	4.9	1.4	
21	1.0	1.7	4.75	1.35	
22	1.0	1.6	4.2	1.27	
23	1.0	1.7	3.35	1.2	
24	1.0	1.80	2.9	1.15	
25	1.0	1.9	2.5	1.15	
26	1.0	2.0	2.3	1.1	
27	1.0	2.5	2.1	1.1	
28	1.0	2.6	2.0	1.1	
29	1.0	2.4	1.85	1.1	
30	1.0	2.1	1.7	1.1	
31		2.0		1.1	

Great Lakes Drainage Grand River Basin

Red Cedar River East Lansing (Station)

Flood stage 8 feet Normal pool stage _____ feet

1926	January	February	March	April
1	1.2	2.2	6.6	7.7
2	1.2	2.3	6.1	7.6
3	1.3	2.2	5.14	7.4
4	1.3	2.1	4.27	7.15
5	1.4	2.0	3.65	7.0
6	1.8	2.0	3.32	7.2
7	1.6	1.8	3.3	7.3
8	1.4	1.6	3.25	7.45
9	1.4	1.6	3.32	8.0
10	1.3	1.6	3.41	8.2
11	1.3	1.5	3.46	7.65
12	1.2	1.5	3.55	6.85
13	1.1	1.5	3.6	5.83
14	1.1	1.5	3.45	5.04
15	1.1	1.5	3.05	4.4
16	1.1	1.5	2.35	3.76
17	1.4	1.8	2.25	3.50
18	2.3	1.85	2.2	3.23
19	4.3	1.85	5.85	3.01
20	5.2	1.9	9.95	2.75
21	5.4	1.9	11.35	2.5
22	4.6	2.0	9.9	2.4
23	4.0	2.05	9.45	3.35
24	3.8	2.1	9.08	2.55
25	3.5	4.0	8.45	2.85
26	3.2	6.2	7.85	2.92
27	2.5	6.55	7.80	2.9
28	1.8	6.6	7.80	2.85
29	1.8		7.75	2.8
30	1.9		7.74	2.7
31	2.1		7.70	

RATING TABLE FOR RED CEDAR RIVER AT MICHIGAN STATE COLLEGE

Discharge in Cubic Feet per Second

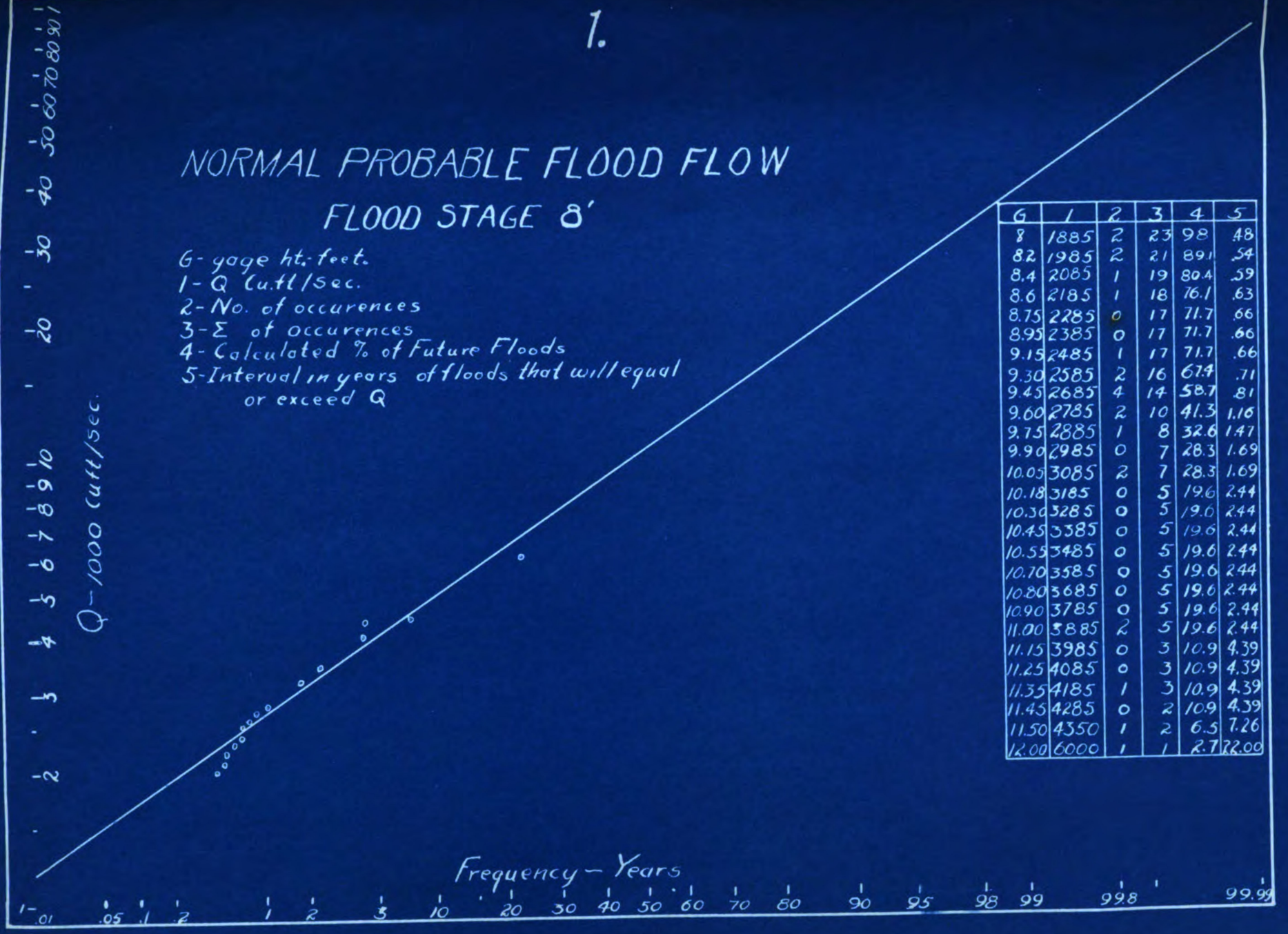
Guage Height	Dis-charge	Guage Height	Dis-charge	Guage Height	Dis-charge
0.50	35	1.75	163	3.00	357
0.55	37	1.80	169	3.05	366
0.60	40	1.85	175	3.10	375
0.65	45	1.90	183	3.15	384
0.70	50	1.95	191	3.20	395
0.75	55	2.00	205	3.25	404
0.80	59	2.05	205	3.30	414
0.85	63	2.10	208	3.35	422
0.90	67	2.15	216	3.40	432
0.95	70	2.20	225	3.45	441
1.00	77	2.25	233	3.50	450
1.05	80	2.30	241	3.55	460
1.10	83	2.35	250	3.60	470
1.15	88	2.40	257	3.65	480
1.20	95	2.45	263	3.70	490
1.25	105	2.50	270	3.75	500
1.30	110	2.55	278	3.80	509
1.35	115	2.60	287	3.85	518
1.40	120	2.65	296	3.90	527
1.45	125	2.70	305	3.95	536
1.50	132	2.75	314	4.00	545
1.55	138	2.80	322	4.05	555
1.60	144	2.85	331	4.10	565
1.65	150	2.90	340	4.15	575
1.70	157	2.95	348	4.20	585
4.25	596	5.50	906	6.75	1326
4.30	607	5.55	920	6.80	1345
4.35	618	5.60	935	6.85	1365
4.40	629	5.65	950	6.90	1385
4.45	640	5.70	965	6.95	1405
4.50	650	5.75	981	7.00	1425
4.55	661	5.80	997	7.05	1446
4.60	672	5.85	1013	7.10	1468
4.65	684	5.90	1029	7.15	1490

Guage Height	Dis-charge	Guage Height	Dis-charge	Guage Height	Dis-charge
4.70	696	5.95	1045	7.20	1509
4.75	708	6.00	1060	7.25	1551
4.80	720	6.05	1075	7.30	1554
4.85	732	6.10	1091	7.35	1577
4.90	744	6.15	1108	7.40	1600
4.95	757	6.20	1126	7.45	1624
5.00	769	6.25	1143	7.50	1647
5.05	782	6.30	1161	7.55	1669
5.10	795	6.35	1179	7.60	1692
5.15	808	6.40	1197	7.65	1715
5.20	820	6.45	1215	7.70	1738
5.25	834	6.50	1232	7.75	1761
5.30	849	6.55	1250	7.80	1785
5.35	863	6.60	1269	7.85	1810
5.40	878	6.65	1288	7.90	1835
5.45	892	6.70	1307	7.95	1860
8.00	1885	9.25	2556	10.50	3438
8.05	1910	9.30	2587	10.55	3479
8.10	1935	9.35	2619	10.60	3520
8.15	1961	9.40	2651	10.65	3561
8.20	1987	9.45	2683	10.70	3602
8.25	2013	9.50	2715	10.75	3643
8.30	2039	9.55	2747	10.80	3684
8.35	2065	9.60	2779	10.85	3725
8.40	2091	9.65	2811	10.90	3770
8.45	2117	9.70	2843	10.95	3816
8.50	2143	9.75	2875	11.00	3862
8.55	2169	9.80	2911	11.05	3908
8.60	2196	9.85	2947	11.10	3954
8.65	2223	9.90	2983	11.15	4000
8.70	2250	9.95	3019	11.20	4050
8.75	2277	10.00	3055	11.25	4100
8.80	2304	10.05	3091	11.30	4150
8.85	2331	10.10	3127	11.35	4200
8.90	2358	10.15	3164	11.40	4250
8.95	2385	10.20	3201	11.45	4300
9.00	2413	10.25	3238	11.50	4350
9.05	2441	10.30	3275		
9.10	2469	10.35	3315		
9.15	2497	10.40	3356		
9.20	2525	10.45	3397		

NORMAL PROBABLE FLOOD FLOW

FLOOD STAGE 8'

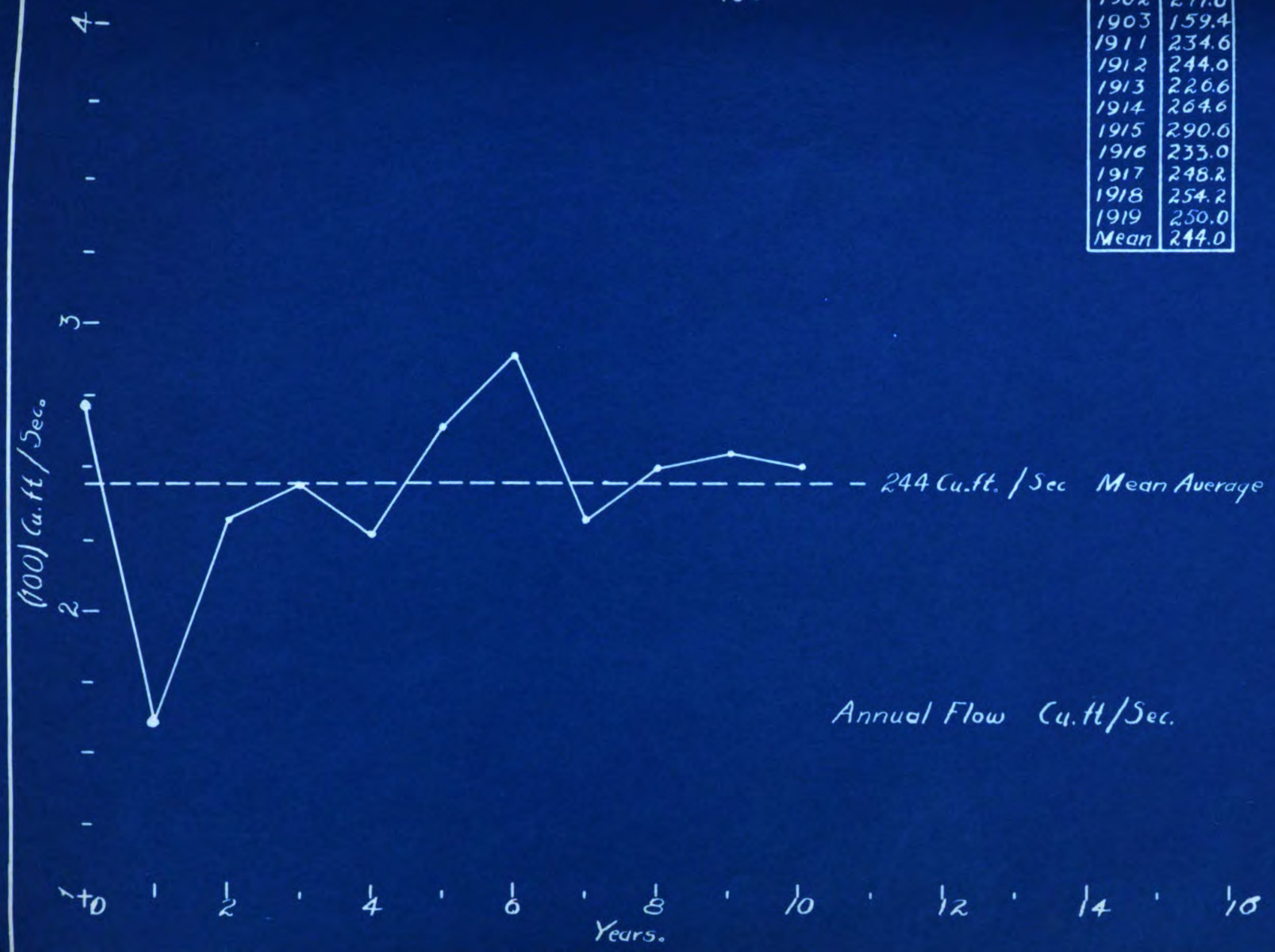
G- gage ht. feet.
1- Q Cu.ft/sec.
2- No. of occurences
3- Σ of occurences
4- Calculated % of Future Floods
5- Interval in years of floods that will equal or exceed Q



G	1	2	3	4	5
8	1885	2	23	98	.48
8.2	1985	2	21	89.1	.54
8.4	2085	1	19	80.4	.59
8.6	2185	1	18	76.1	.63
8.75	2285	0	17	71.7	.66
8.95	2385	0	17	71.7	.66
9.15	2485	1	17	71.7	.66
9.30	2585	2	16	67.4	.71
9.45	2685	4	14	58.7	.81
9.60	2785	2	10	41.3	1.16
9.75	2885	1	8	32.6	1.47
9.90	2985	0	7	28.3	1.69
10.05	3085	2	7	28.3	1.69
10.18	3185	0	5	19.6	2.44
10.30	3285	0	5	19.6	2.44
10.45	3385	0	5	19.6	2.44
10.55	3485	0	5	19.6	2.44
10.70	3585	0	5	19.6	2.44
10.80	3685	0	5	19.6	2.44
10.90	3785	0	5	19.6	2.44
11.00	3885	2	5	19.6	2.44
11.15	3985	0	3	10.9	4.39
11.25	4085	0	3	10.9	4.39
11.35	4185	1	3	10.9	4.39
11.45	4285	0	2	10.9	4.39
11.50	4350	1	2	6.5	7.26
12.00	6000	1	1	2.7	22.00

2.

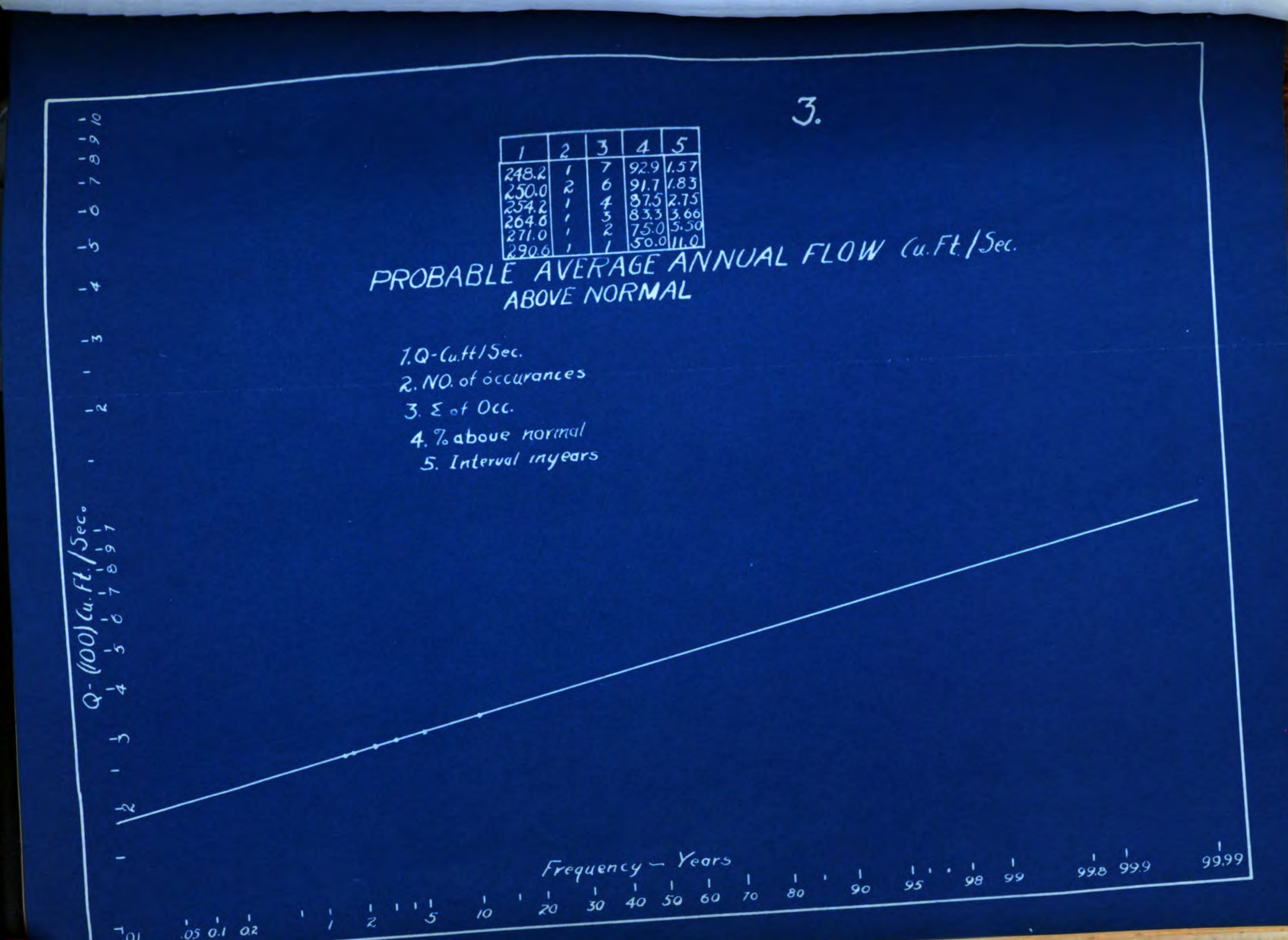
Year	Q
1902	271.0
1903	159.4
1911	234.6
1912	244.0
1913	226.6
1914	264.6
1915	290.6
1916	233.0
1917	248.2
1918	254.2
1919	250.0
Mean	244.0



1	2	3	4	5
248.2	1	7	92.9	1.57
250.0	2	6	91.7	1.83
254.2	1	4	87.5	2.75
264.0	1	3	83.3	3.66
271.0	1	2	75.0	5.50
290.6	1	1	50.0	11.0

PROBABLE AVERAGE ANNUAL FLOW Cu. Ft./Sec.
ABOVE NORMAL

1. Q-Cu.ft/Sec.
2. NO. of occurances
3. Σ of Occ.
4. % aboue normal
5. Interval inyears



4.

1	2	3	4	5
234.6	1	4	87.5	2.75
233.0	1	3	83.3	3.60
226.6	1	2	75.0	5.5
159.4	1	1	50.0	11.0

1-Q Annual Flow below Normal

2- NO. of Occurences

3- Σ of occurences

4- % of Droughts

5- Interval between Dry Years equal or less than Q

PROBABLE AVERAGE ANNUAL FLOW - Cu.ft/Sec.
BELOW NORMAL

Q (100) Cu. ft/sec.

0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1 2 3 4 5 6 7 8 9 1

Frequency - Years.

.05 .01 .02 1/4 1/2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.99

Revision of Vermuele's Formula

This formula gave results which were consistently too low, so it was revised to give better results for the Red Cedar. The revision was accomplished by taking values for mean annual temperature, mean annual rainfall, and known values of mean annual flow, and substituting in the formula and solving for a new constant c.

Since the mean annual flow was known for ten years, ten values of c were found and the mean value determined. The computations are as follows:

1903

$$26.2F = 271$$

$$F = 10.34$$

$$10.34 = 37.24 - (11+37.24c)(.035x45.4-.65)$$

$$10.34 = 37.24 - 10.33 - 35.2c$$

$$35.2c = 37.24 - 10.33 - 10.34$$

$$c = .47$$

1911

$$26.2F = 159.4$$

$$F = 6.1$$

$$6.1 = 31.12 - (11 + 31.12c)(.035 \times 47.9 - .65)$$

$$6.1 = 31.12 - 11.3 - 31.9c$$

$$31.9c = 31.12 - 11.3 - 6.1$$

$$c = .43$$

1912

$$26.2F = 234.6$$

$$F = 8.97$$

$$8.97 = 33.5 - (11 + 33.5c)(.035 \times 44.3 - .65)$$

$$8.97 = 33.5 - 9.9 - 30.1c$$

$$30.1c = 33.5 - 9.9 - 8.97$$

$$c = .487$$

1913

$$F = 9.5$$

$$9.5 = 31.05 - 11.2 - 31.7c$$

$$31.7c = 31.05 - 11.2 - 9.5$$

$$c = .327$$

1914

$$26.2F = 226.6$$

$$F = 8.67$$

$$8.67 = 30.37 - (11 + 30.37c)(.035 \times 46.2 - .65)$$

$$8.67 = 30.37 - 10.6 - 29.3c$$

$$29.3c = 30.37 - 10.6 - 8.67$$

$$c = .379$$

1915

$$26.2F = 264.6$$

$$F = 10.1$$

$$10.1 = 32.41 - (11 + 32.41c)(.035 \times 46.2 - .65)$$

$$10.1 = 32.41 - 10.6 - 31.3c$$

$$31.3c = 32.41 - 10.6 - 10.1$$

$$c = .374$$

1916

$$26.2F = 290.6$$

$$F = 11.1$$

$$11.1 = 29.48 - (11 + 29.48c)(.035 \times 46.3 - .65)$$

$$11.1 = 29.48 - 10.65 - 28.8c$$

$$28.8c = 29.48 - 10.65 - 11.1$$

$$c = .268$$

1917

$$26.2F = 233$$

$$F = 8.9$$

$$8.9 = 32.68 - (11 + 32.68c)(.035 \times 43.2 - .65)$$

$$8.9 = 32.68 - 9.46 - 28.1c$$

$$28.1c = 32.68 - 9.46 - 8.9$$

$$c = .51$$

1918

$$26.2F = 250$$

$$F = 9.55$$

$$9.55 = 31.95 - (11 + 31.95c)(.035 \times 46.5 - .65)$$

$$9.55 = 31.95 - 10.75 - 31.2c$$

$$31.2c = 31.95 - 10.75 - 9.55$$

$$c = .374$$

1919

$$26.2F = 254.2$$

$$F = 9.72$$

$$9.72 = 31.47 - (11 + 31.47c)(.035 \times 47.7 - .65)$$

$$9.72 = 31.47 - 11.2 - 32.1c$$

$$32.1c = 31.47 - 11.2 - 9.72$$

$$c = .329$$

.470
.430
.487
.327
.379
.374
.268
.510
.374
.329

10 | 3.948

.3948 Mean Value for C for 10 years.

9.72
9.55
8.90
11.10
10.10
8.67
9.50
8.97
6.10
10.34

10 | 92.95

9.295 Mean Value for F for 10 years

1. The original of Vermuele's formula was taken from the Hydro-Electric Hand Book by Creager and Justin, page 39. The possible error for any specific year was found by using a formula from statistical methods,

$$E = \pm 0.6745 \sqrt{\frac{\Sigma V^2}{n-1}} \quad ,$$

where ΣV^2 equals the sum of the squares of the differences between actual and computed flow. (n) equals the number of observations used. (E) was found to be 21%. That is, the maximum possible error is a plus or minus 21% for any definite year and is exact for an average year and an average of years.

F Mean =

$31.43 - (11 + .395 \times 31.43)(.035 \times 46.8 - .65)$

$= 31.43 - (23.4)(.99)$

$= 8.3$

Mean Value of F found by using 10 year value for c and Normal Precipitation and Temperature.

Formula Suggested for Red Cedar:

$Q = 26.2 \left[P - (11 + .395P)(.035T - .65) \right]$

Q = Years average rate of flow in cu.ft. / sec.

P = Total precipitation for the year considered

T = Average temperature for year considered

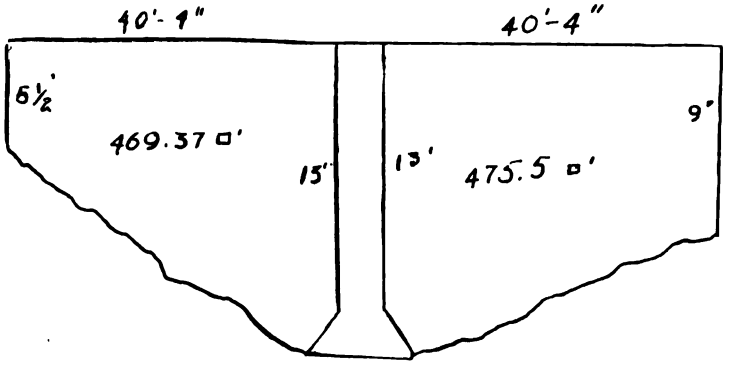
Formula for S. Mich. Streams

$F = R - (11 + .395R)(.035T - 0.65)$

R = Rainfall T = Temp. F = depth of run off

Since the erection of the concrete bridge across the Red Cedar River, called the Athletic Field Bridge, a road way on an earthen embankment has been built across the original flood plain. This leaves the bridge as the only outlet for discharge.

A detailed study was made to determine what head would be necessary to discharge the flood flow that is likely to occur during the life-time of the bridge. A cross section under the bridge was plotted, and the area determined.



Wetted perimeter (r) $= \frac{A}{p} = \frac{944.8}{203.2} = 4.65$

Using Bernoullis' Theorem,

$$\frac{V_1^2}{2g} + \frac{p_1}{w} + Z_1 = \frac{V_2^2}{2g} + \frac{p_2}{w} + Z_2 + h_f$$

We were able to determine if the head necessary to push the flood flow thru the bridge, was so high that it would wash away the earthen embankment of the raodway.

The crest of the road is four feet above the upper level of the opening in the bridge. Flood flow was taken as 10,000 cu. ft. per second.

We considered the head of the discharging end of the bridge to be level with the upper part of the opening and equal to zero.

Head Necessary to Force Flood Water under Bridge.

The area under the Bridge equals 944.8 square '

$$Q = AV$$

$$V = \frac{Q}{A} = \frac{10,000}{944.8} = 10.6 \text{ ft./sec.}$$

$$\frac{V^2}{2q} + \frac{p}{w} + Z' = \frac{V_2^2}{2q} + \frac{P_2}{W} + Z_2 + hf$$

$$0 + \frac{p}{w} + o = \frac{10.6^2}{64.4} + o + o + hf$$

$$V = o\sqrt{r\,\frac{hf}{2}}$$

$$10.6 = 140\sqrt{4.65 \text{ X } \frac{hf}{46}}$$

$$112.5 = 19600 \text{ X } 4.65 \text{ X } \frac{hf}{46}$$

$$hf = \frac{46 \text{ X } 112.5}{19600 \text{ X } 4.65} = .0565$$

then

$$\frac{p}{62.4} = \frac{112.5}{64.4} + .0565$$

$$p = 62.4 \text{ X } \frac{112.5}{64.4} + .0565$$

$$p = 62.4 \text{ X } 1.797$$

$$h = \frac{62.4 \text{ X } 1.797}{62.4} = 1.8' \text{ head}$$

Room available = 4' O.K.

CONCLUSIONS

The data used in this work was collected from daily guage readings on the Red Cedar River. The readings for 1902 and 1903 were taken by Clifford Walters for the United States Geodetic survey. Those for 1911 to 1919 inclusive were taken by the United States Weather Bureau. Those for 1925 and 1926 were taken by Preston and Wrench, senior students at Michigan State College, as part of their work on a thesis submitted to the faculty in 1926.

As eight feet is considered flood stage by the United States Weather Bureau, only readings of eight feet or above were considered in handling the computations for the probability curve for floods. These readings were listed in rotation according to numerical value starting with eight feet. The number of occurrences of each flood was listed next. From the number of occurrences of each flood the summation of occurrences of floods equal to, or greater than, each one was found. By using the formula, $P = 100\left(\frac{n-0.5}{m}\right)$ the percentage of occurrences of each flood, with reference to the total number of floods, was found. In this formula p = percentage of occurrences

n = summation of occurrences

m = total number of occurrences

The interval between floods of each stage was found by dividing the summation of occurrences minus five tenths by the number of years for which records were taken: eleven in this case.

A curve was plotted with discharge as the ordinate and frequency in years as the abscissa. This curve was plotted on paper which had a logarithmic scale for both ordinate and abscissa, because this was found to give very close to a straight line curve. This curve was extended to give readings of discharges of floods with a frequency of one hundred years. The average life of works on a stream is somewhat less than this figure, so a fifty-year frequency should be sufficient. This shows a discharge of 10,000 cubic feet per second.

These results were checked by Kuichling's formula which is known to give values which are low. By this formula

$$Q = \frac{127000}{358 - 370} + 7.4 = 183.9 \text{ cubic feet per second per square mile.}$$

$Q_t = 183.9 \times 358 = 6600$ cubic feet per second.

Table I and Curve I show the calculations and results of this work.

Because of danger to life and property and the low cost of construction of any work on a stream such as the Red Cedar, it is best and most economical to construct works which will safely handle the greatest flood apt to occur in the lifetime

of the structure. The flood considered should be at a rate of at least 10,000 cubic feet per second.

The concrete bridge and roadway from the gymnasium to the armory is a critical point at high flood stage. A determination was made to find out if these works were designed and erected in a manner to safely handle the maximum flood. It was found that they were entirely safe.

The average rate of flow for each year used in this work was found. The average of these averages was determined. Since all the records gave data which were consistent with the curves and computations made, it was considered that the average of the yearly average rates of flow could be safely taken as the constant average rate of flow. This figure was found to be two-hundred and forty-four cubic feet per second. This would be the rate of flow if the water from floods and wet years could be stored up used during dry periods to maintain a constant rate of discharge. In other words, this figure gives the amount of water which could be utilized year after year for water supply or power developement if sufficient and properly designed works were erected. Such works would be very good flood protection as they would control the rate of flow and thus control the whole flood. Therefore, if any works are erected they should be sufficient to maintain this average rate of flow of two-hundred and forty-four cubic feet per second.

The derivation of this average rate of flow is shown graphically in curve II.

Dry years and wet years very seldom occur in any definite order. Frequently one wet year is followed by another or maybe three or four. Dry periods often last for several years. Knowing these facts it was thought advisable to determine some means of estimating the frequency and extent of these two things. This was done in a manner similar to the one used for determining the frequency and discharge curve for floods in part I. Yearly average rates of flow were used in place of daily rates of discharge. The values below the mean yearly average of two hundred and forty-four cubic feet per second were used to construct the dry year frequency curve. The values above this figure were used to construct the wet year frequency curve. Curves III and IV show the results of this work.

These curves would aid greatly in making the estimates and plans for flood control, water supply, or power development works. They give the data necessary for calculating storage capacity to maintain the mean yearly rate of flow.

Realizing the insufficiency of available data on the Red Cedar River, an attempt was made to find a formula which would give some usable data from rainfall temperature records which are available at the United States Weather Bureau in East Lansing. Several formulae were tried and discarded because they gave values which were inconsistent. Vermuele's formula gave values which were

consistent but too low. It was found that this formula was devised for rivers in New England which do not compare favorably with the Red Cedar. Because of the consistency of the results of this formula it was chosen as the one to be used. It had to be revised before it was of value for this stream. The revision was accomplished by substituting the average annual temperature and rainfall and the annual run-off in the formula and solving for the coefficient by which the rainfall is multiplied in the formula. This was done with ten years records which could be used. The mean value of the coefficient was .395. This replaces the value of .29 given by Vermuele.

The revised formula was checked by a formula from statistical methods and was found to give results correct, to a plus or minus 21 %.

This formula could be used on any similar stream; especially the smaller streams in Southern Michigan. The error which arises from the use of this formula are not errors in the formula itself but rather variations due to irregular conditions of run-off, temperature, and rainfall. For example, any rainfall on frozen ground gives a very high rate of run-off while any rainfall on warm dry ground gives very little rainfall.

[redacted]

[redacted]