REGIONAL COPPER-NICKEL STUDY:

STREAM ORDER CLASSIFICATION

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ABSTRACT

Stream order has been suggested as a method of classifying stream communities because stream order generally correlates with factors which affect aquatic organisms. Stream order was determined in Study Area streams so that data collected during the aquatic biology study could be correlated with stream order. Stream miles, number of streams, and average length for each stream order was calculated. Stream order was found to be inversely related to number of stream miles and number of streams and directly related to average length of streams. This is in agreement with data reported in the literature. Stream order was also inversely related to stream gradient in those watersheds where gradient was calculated. Inorganic nutrients generally decreased with increasing stream order while pH decreased.

STREAM CLASSIFICATION

The succession of stream communities along the length of a stream has been discussed by several authors (Hynes 1970; Hawkes 1975). Many stream ecologists attempt to break down this successional gradient into zones; this facilitates the ecological comparisons of independant stream systems. Many systems have been developed to characterize these zones, but no single method has gained wide acceptance.

Each of the following have served as a basis for stream classification: stream origin (Butcher 1933; Craig and McCart 1975), the erosional status (Carpenter 1928; Moon 1939; Harrison 1965), stream gradient (Huet 1946,1959; Trautman 1942), chemical conditions (Dittmar 1955; Harrison and Agnew 1962) and flora and fauna (Tansley 1939; Lagler 1949; Knight and Gåufin 1967). State game and fish departments have developed stream classification systems specifically for use in stream management plans. The Minnesota Department of Natural Resources (Sternberg 1977) developed such a system based on types of fish populations in Minnesota streams.

More comprehensive classification schemes have been proposed based on numerous facors important to stream organisms (Ricker 1934; VanDeusen 1953: Pennak 1971). Factors used in these schemes include stream width and depth, stream flow, temperature, turbidity, hardness of water, amounts of dissoved oxygen, riparian vegetation and soils, as well as other physical-chemical and biological characteristics. A classification scheme developed in Wisconsin (University of Wisconsin 1976) attempted to synthesize many of these factors into a single value. This index holds promise except some necessary data may be unavailable to the biologist.

Abel (1961) proposed a method of classifying streams, for biological purposes, on the basis of watershed drainage patterns. The method is based on the stream order system developed by Horton (1945) and modified by Strahler (1957). In most cases, stream order is directly related to the number and average length of streams, drainage basin size, and stream gradient (Horton 1945). In addition, Strahler (1957) demonstated that stream order is dirctly proportional to channel size and discharge.

CLASSIFICATION BY STREAM ORDER

Several authors have related biological conditions to stream order. Kuehne (1962) reported an increase in the average number of fish species as stream order increased. Kuehne (1962) found similar results when he reevaluated data reported by Shelford (1911). Increased number of fish species with increasing order was also reported by Whiteside and McNatt (1972). Harrel et. al. (1967) calculated correlation coefficients of 0.96 between stream order and fish species diversity. Furthermore, the number of species and species diversity increased between the third and fifth order streams sampled by Harrel and Dorris (1968). However, Harrel and Dorris (1968) found these paramenters decrease in sixth order streams.

All authors suggested that the increase in diversity resulted from increased habitat diversity and decreases in environmental fluctuations as stream order increased.

Cummins (1975,1976) discussed the energy budget in aquatic ecosystems and related them to stream order. He states that although species may differ amoung streams of similar orders, their ecological function is similar. Cummins describes first to third order streams as being dependent upon the terrestrial ecosystem for energy input. These streams are generally small and well shaded by riparian vegetation. Primary production is low because this shading and by limited availability of nutrients in the water. Organisms in first through third order streams process the abundant allochtonous (organic) inputs from the terrestrial environment. (See Regional Copper-Nickel Study 1978 for further details on organic processing.) Moreover, respiration exceeds photosynthesis in these low order streams.

In fourth through sixth order streams, stream size increases and the effects of shading decreases. Primary production increases in importance in these streams and photosynthesis normally exceeds respiration. Organisms, particularly invertebrates, normally occuring in these streams utilize the primary producer organisms and the fine particulate organic moatter which flows into these streams form upstream reaches.

Further changes occur in streams higher than sixth order. The composition of producer organisms shifts from periphytic algae to phytoplankton. Invertebrates found here include primarily filter feeders. Respiration again exceeds photosynthesis in these large rivers.

Classifying streams by order has several drawbacks. First, streams with similar drainage areas may be of different order (Hynes 1970). Second, an adventitious stream (those which enter a stream of higher order) may resemble the stream it enters more closely than it resembles streams of the same order (Harrel and Dorris 1968; Whiteside and McNatt 1972). Finally, aquatic ecosystems change along a steady gradient, and it is not possible to define exact zones (Hynes 1970). This third factor is a problem inherant in any attempt to classify aquatic ecosystems.

Stream order does, however, provide the biologist a simple first look at a stream and also provides a basis for for generalizations about streams without on site inspecitons. The stream order method also has merit because it synthesized many factors biologist previously used separately for stream classification.

Because of its simplicity and apparent relation to community function stream order was used to classify streams within the Regional Copper-Nickel Study Area. This report defines the methods employed in determining stream order in the Study Area and presents a tabulation of Study Area streams and their order. In addition, the relation of stream order to physico-chemical conditions is discussed.

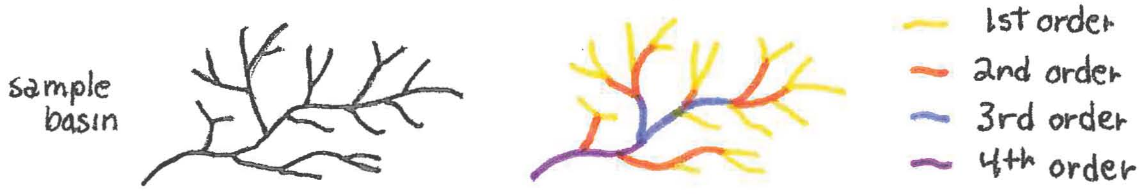
METHODS

STUDY AREA

The study area encompasses 2130 square miles in Lake and St. Louis counties in northeastern Minnesota. The area is divided into two major watersheds by the Laurentian Divide. Water north of the Laurentian Divide flows north to Hudsons Bay and water south flows to Lake Superior. Streams in the study area are generally low gradient, soft-water systems consisting of long stretches of slow water connected by short riffles.

DETERMINATION OF STREAM ORDERS

To determine stream order, the system developed by Horton (1945) and modified by Strahler (1957) was applied. In this method, headwater streams are designated as first-order streams. Two first-order streams meet to form a second-order stream segment; two second-order streams meet to form a third-order and so on. It takes at least two streams of any given order to form a stream of the next highest order. However, more than two streams of a given order may be involved in forming the next higher order (Morisawa 1968).



example of stream basin ordering

For calculating stream order, lakes were viewed as a point on the stream. All streams entering a lake, regardless of lake shape, were viewed as converging on one point. This eliminated the possible confusion arising from numerous tributaries entering a large lake.

Leopold, et. al. (1964) recommended the use of 1 to 24,000 scale maps for determining stream order. USGS 7½ minute quadrangle maps were used for delineating streams whereever possible. USGS 15 minute maps were substituted when 7½ minute maps were unavailable. Hynes (1970) suggested that only perennial streams or those that persist long enough for a biological community to develop be considered in determining stream order. In addition, Abell (1961) recommends that streams which are discontinuous not be considered for stream order determination. Accordingly, only continuous perennial streams were used for order determination. Upstream portions of discontinuous channels are excluded in determining stream order.

Following determination of stream order, each ordered segment length was measured by placing a string over the mapped stream channel. The string was then compared to the graphic scale of miles to compute stream miles. When computing lengths, lakes were treated as a wide spot in the river. Channel location in lakes was estimated and measured along a suitable line. Exceptions were made when discernable stream channels were revealed by isobaths. The required accuracy was set at a maximum of 10% error. Measuring done on 7½ minute topos are estimated at 2 to 3 percent maximum error; measuring done on 15 minute topos are estimated at 5 to 8 percent maximum error. Furthermore, the longer the stream segment, the less the error because the exact endpoints are difficult to mark on the measuring string. Stream segments of less than 3/10 mile of 15 minute maps and 1/10 on 7½ minute maps have a greater potential for error. Total miles of stream for each order and each watershed were computed.

Stream segment gradients were calculated for much of the area. Stream segment endpoint locations were assessed in relation to adjacent contour lines. In interpolating the elevation of segment endpoints, straight linear gradients between contour intervals were assumed. Therefore a stream endpoint occuring halfway between the contour lines of elevation 1350 and 1360 was judged as 1355. There is a potential for sizable error in the estimation of elevation. First, USGS claims an accuracy of plus or minus one-half of a contour interval for contour lines. Second, the application of a straight linear gradient is not necessarily reflective of reality. Elevation differentials encompassing more than three or four contour intervals are needed to assure exceptable accuracy. Many of the stream segments did not have sufficient elevation drop to ensure this level of accuracy.

REFERENCES CITED

Abell, D. L., 1961. The role of drainage analysis in biological work on streams. Verh. Internat. Verein Limnol. 16:533-537.

Butcher, R. W., 1933. Studies on the ecology of rivers. I. on the distribution of macrophytic vegetation in the rivers of Britain. J. Ecol. 21:58-91.

Carpenter, K. E., 1928. Life in inland waters. Sidgwick and Jackson, London. 267 pp.

Craig, P. C. and P. J. McCart, 1975. Classification of stream types in Beaufort Sea drainages between Prudhoe Bay, Alaska, and the Mackenzie Delta, N.W.T. Canada. Artic and Alpine Research. 7(2):183.

Cummins, K. W., 1975. The ecology of running waters; theory and practice. Pages 277-293 in D. B. Baker, W. B. Jackson, B. L. Prater eds. Sandusky River Basin Symposium. International Joint Commission. 475pp.

Cummins, K. W., 1976. The use of macroinvertebrate benthos in evaluating environmental damage. Pages 139-149 in K. S. Rajendra, J. D. Boffington, and J. T. McFadden eds. The Biological significance of environmental impacts. University of Michigan, Ann Arbor, Michigan.

Dittmar, H. 1955. Ein sauerlandbach untersuchungen an einen wiesenmittel gebirgsbach. Arch. Hydrobiol. 50:305-253.

Harrel, R. C., B. J. Davis, and T. C. Dorris. 1967. Stream order and species diversity of fishes in an intermittent Oklahoma stream. Am. Midl. Nat. 78(2):428-436.

Harrel, R. C., and T. C. Dorris. 1968. Stream order, morphometry, physico-chemical conditions, and community structure of benthic macroinvertebrates in an intermittent stream system. Am. Midl. Nat. 80:220-251.

Harrison, A. D., 1965. River zonation in Southern Africa. Arch. Hydrobiol. 61;380-386.

Harrison, A. D. and J. D. Agnew. 1962. The distribution of invertebrates endemic to acid streams in the Western and Southern Cape Province. Ann. Cape Prov. Mus. 2:273-291.

Hawkes, H. A. 1975. River zonation and classification. Pages 312-374 in B. A. Whitton, ed. River ecology. University of California Press, Berkeley.

Horton, R. E., 1945. Erosional development of streams and their drainage basins; hydrographical approach to quantitative morphology. Bull. Geol. Soc. Am. 56:275-370.

Huet, M., 1946. Note preliminaire sur les relations entre la pente et les populations piscioles des eaux courantes. Regle des pentes. Dodonaea 13:232-243.

Huet, M., 1959. Profiles and biology of western European streams as related to fish management. Trans. Am. Fish. Soc. 88(3):155-163.

Hynes, H. B. N., 1970. The ecology of running waters. University of Toronto Press, Toronto 555pp.

Knight, A. W., and A. R. Gaufin. 1967. Stream type selection and associations of stoneflies (plecoptera) in a Colorado river drainage system. J. Kan. Ent. Soc. 40(3):347-352.

Kuehne, R. A. 1962. A classification of streams illustrated by fish distribution in an eastern Kentucky creek. Ecology 43:608-614.

Lagler, K. F. 1949. Studies in freshwater fishery biology. Michigan.

Leopold, L. B., et al. 1964. Fluvial processes in geomorphology. Freeman, San Francisco.

Moon, H. D. 1939. Aspects of the ecology of aquatic insects. Trans. Br. Ent. Soc. 6:39-49.

Morisawa, M. 1968. Streams; their dynamics and morphology. McGraw-Hill Book Co., New York. 175pp.

Pennak, R. W. 1971. Toward a classification of lotic habitats. Hydrobiologia 38(2):321.

Regional Copper-Nickel Study. Lager, T. et al. 1978. Stream benthic invertebrates. Minnesota Environmental Quality Board, St. Paul, Mn.

Ricker, W. E. 1934. An ecological classification of certain Ontario streams. Univ. Toronto Stud. Biol. Ser. 37:1-114.

Shelford, V. E. 1911. Ecological succession. I. Stream fishes and the method of physiographic analysis. Biol. Bull. 21:9-35.

Sternberg, R. B. 1977. Minnesota stream survey manual. Minnesota Department of Natural Resources. Special Publ. No. 120. St. Paul, Mn. 37pp.

Strahler, A.N. 1957. Quantitative analysis of watershed geomorphology. Trans. Am. Geophys. Un. 38:913-920.

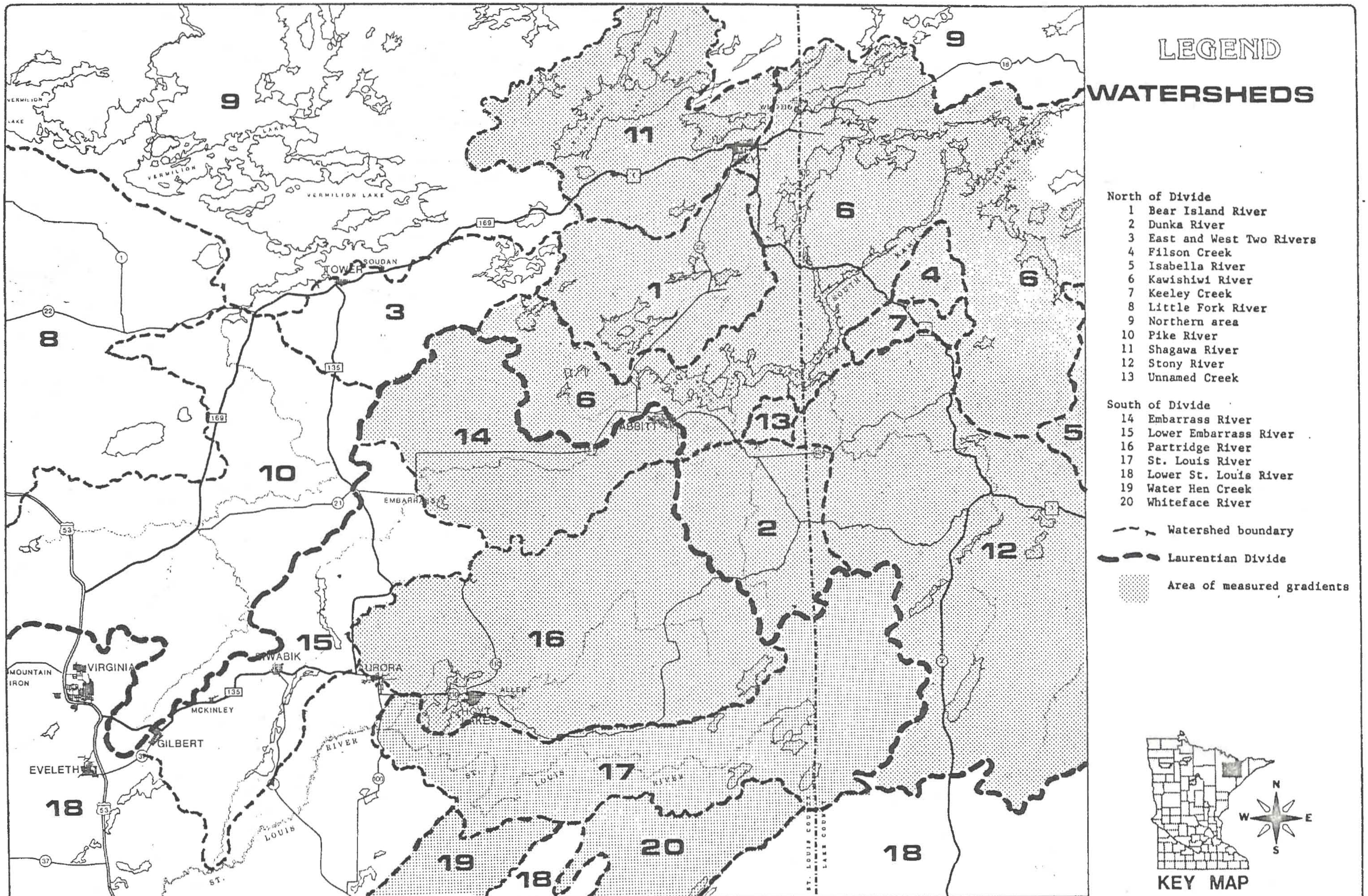
Tansley, A. C. 1939. The British Islands and their vegetation. Cambridge University Press, London. 930pp.

Trautman, M. B. 1942. Fish distribution and abundance correlated with stream gradients as a consideration in stocking programs. Trans. North Am. Wildl. Conf. 7:211-225.

University of Wisconsin. 1976. Non-point source water pollution. Report of the Water Resources Management Workshop. University of Wisconsin, Madison, Wi. 105pp.

Van Deusen, R. D. 1953. Maryland freshwater stream classification by watersheds. Contr. Cheasapeake Biol. Lab. 106:1-30.

Whiteside, B. G., and R. M. McNatt. 1972. Fish species diversity in relation to stream order and physical-chemical conditions in the Plum Creek drainage basin. Am. Midl. Nat. 88:90-101.



MEQB REGIONAL COPPER-NICKEL STUDY

Table 1. miles of stream by order within study area, also number of streams and mean length

	watershed #	1st order			2nd order			3rd order			4th order			5th order			total All orders
North of divide		miles	# streams	$\bar{x}$ length	miles	# streams	$\bar{x}$ length	miles	# streams	$\bar{x}$ length	miles	# streams	$\bar{x}$ length	miles	# streams	$\bar{x}$ length	
Bear Island	1	20.3	16	1.27	13.0	5	2.6	14.45	1*	14.45							47.75
Dunka	2	21.45	14	1.5	9.8	4	2.45	7.95	1*	7.95							39.2
East & West Two River	3	19.4	13	1.49	11.35	4	2.84	12.7	2**	6.35							43.45
Filson	4	8.6	2	4.3	0.15	1*	0.15										8.75
Isabella	5	1.6	1	1.6	0.35	1	0.35	5.3	1	5.3				1.0	1*	1.0	8.25
Kawishiwi	6	77.05	58	1.33	41.55	15	2.77	17.2	3	5.73	28.2	3	9.4	43.75	1	43.75	207.75
Keeley	7	7.1	3	2.4	4.6	1*	4.6										11.7
Little Fork	8	44.05	28	1.57	11.55	7	1.65	19.0	2	9.5							74.6
Northern	9	108.45	71	1.53	76.3	17	4.49	20.3	5	4.06	26.7	1*	26.7	3.0	1*	3.0	234.75
Pike	10	52.2	51	1.02	20.05	13	1.54	26.5	3	8.83	32.1	1*	32.1				130.85
Shagawa	11	31.3	26	1.20	30.3	9	3.4	14.65	2	7.3	1.9	1	1.9				78.15
Stony	12	56.35	66	0.85	43.6	16	2.73	28.55	5	5.71	24.65	1*	24.65				153.15
Unnamed Creek	13	1.75	1*	1.75													1.75
# split streams			1			2			4			3			2		
Total North of Divide		449.6	349	1.29	262.6	91	2.89	166.6	21	7.93	113.55	4	28.39	47.75	1	47.75	1040.1
South of Divide																	
Embarrass	14	24.6	13	1.89	8.1	3	2.7	14.2	1*	14.2							46.9
Lower Embarrass	15	22.75	21	1.08	4.55	2	2.28	34.5	1	34.5							61.8
Partridge	16	50.35	29	1.7	35.6	7	5.1	8.4	2	4.2	19.1	1*	19.1				113.45
St. Louis	17	23.8	21	1.1	8.95	4	2.2	39.75	1	39.75	4.15	1*	4.15				76.65
Lower St. Louis	18	142.5	92		56.4	24		15.75	5		28.95	1	28.95				243.6
Water Hen	19	12.95	12	1.08	5.05	2	2.53										18.0
Whiteface	20	23.35	7	3.34	2.65	2	1.3	5.3	1	5.3							31.3
# split streams			0			0			1			2					
Total South of Divide		300.3	195	1.54	121.3	44	2.76	117.9	10	11.79	522	1	52.2				591.7

Total miles within study area 1631.8

* split streams — ordered segments which cross a watershed boundary — although found in two watersheds, they are counted as one stream

Table 2. Stream miles, number of streams, mean length, and mean gradient in each stream order, for each watershed in shaded portion of Figure 1.⊛

		1st order				2nd order				3rd order				4th order				5th order				TOTALS		
North of divide	watershed #	miles	# streams	x̄ length	x̄ gradient ft/mi	miles	# streams	x̄ length	x̄ gradient ft/mi	miles	# streams	x̄ length	x̄ gradient ft/mi	miles	# streams	x̄ length	x̄ gradient ft/mi	miles	# streams	x̄ length	x̄ gradient ft/mi	miles	# streams	x̄ gradient ft/mi
Bear Island	1	20.3	16	1.27	19.0	13.0	5	2.6	11.8	14.45	1*	14.45	2.9									47.75	22	12.17
Dunka	2	21.45	14	1.5	25.5	9.8	4	2.45	10.0	7.95	1*	7.95	5.2									39.2	19	17.51
Filson	4	8.6	2	4.3	15.8	0.15	1*	0.15	13.3													8.75	3	15.76
Isabella	5	128.85	133	0.97	28.62	93.75	33	2.84	17.49	73.1	9	7.31	11.18	31.1	2	15.6	5.4	11.6	1*	11.6	7.4	338.4	178	18.91
Kawishiwi (-K-6)	6	71.35	55	1.30	21.93	40.05	14	2.86	11.90	17.2	3	5.73	9.83	26.3	3	8.77	3.54	43.75	1	4375	3.39	198.65	76	12.34
Keeley	7	7.1	3	2.4	9.6	4.6	1*	4.6	21.7													11.7	4	14.36
Shagawa	11	36.9	26	1.4	34.6	30.3	9	3.4	9.9	14.65	2	7.3	2.9	1.9	1*	1.9	0.5					83.75	38	19.35
Stony	12	65.25	75	0.87	21.0	50.6	18	2.8	12.7	32.95	5	6.59	11.9	24.65	1*	24.65	10.9					173.45	99	15.41
Unnamed Creek	13	1.75	1*	1.75	35.4																	1.75	1	35.4
*split streams			1				2				2				2				1				8	
total		361.55	324	1.12	25.16	242.25	83	2.92	14.08	160.3	19	8.44	8.99	83.95	5	16.79	6.32	55.35	1	55.35	4.23	903.4	432	16.36
South of Laurentian divide																								
Embarrass	14	24.6	13	1.89	23.0	8.1	3	2.7	10.0	14.2	1	14.2	1.3									46.9	17	14.18
Partridge	16	50.35	29	1.7	22.9	35.6	7	5.1	8.2	8.4	2	4.2	4.3	19.1	1*	19.1	6.2					113.45	39	14.10
St. Louis	17	23.8	21	1.1	12.4	8.95	4	22	10.3	39.75	1	39.75	7.3	4.15	1	4.15	6.5					76.65	27	9.19
Water Hen	19	20.15	12	1.7	22.4	10.75	4	2.7	7.3	10.75	2	5.4	8.3	2.35	1	2.35	0					44.0	19	14.07
Whiteface	20	32.25	8	4.03	14.42	2.65	2	1.3	8.3	16.2	1	16.2	8.8									51.1	11	12.37
*split streams															1								1	
total		151.15	83	1.82	19.39	66.05	20	3.30	8.56	89.3	7	12.76	6.46	25.6	2	12.8	5.68					332.1	112	12.70

Total miles in area of measured gradient 1235.5

X̄ [illegible] gradient 3 from individual watersheds

* split streams- ordered segments which cross a watershed boundary, although found in two watersheds, they are counted as one stream
⊛ Upstream portions of watersheds not within study area included in all calculations except subwatershed K-6.

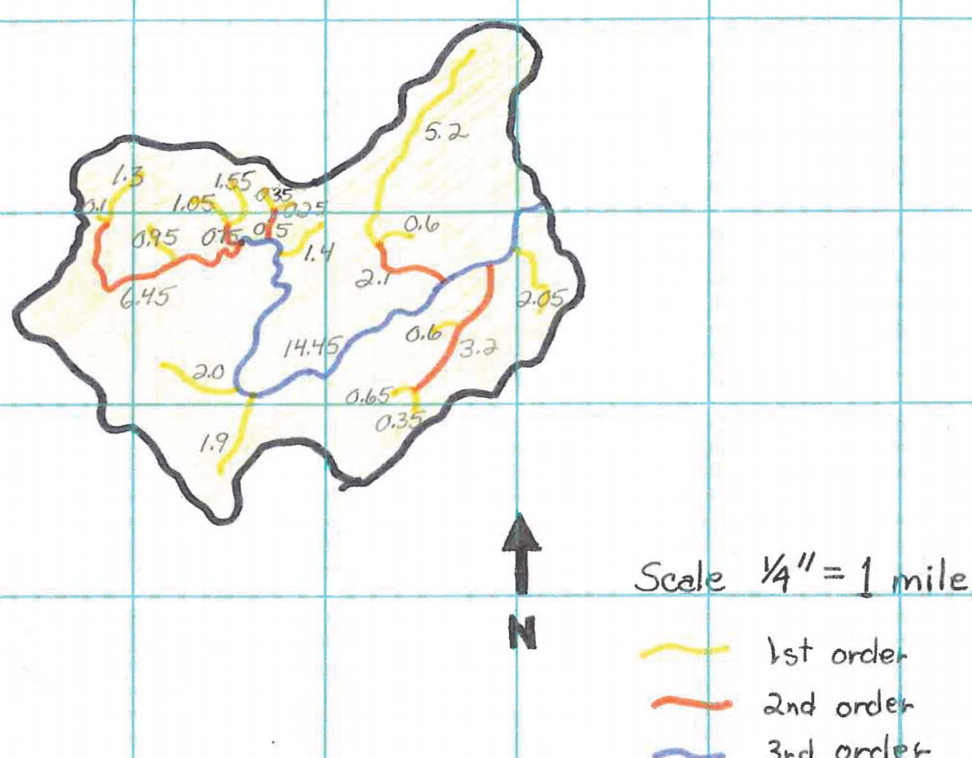
The following section contains data sheets on the watersheds. There are individual maps of each Cu-Ni watershed with streams drawn as ordered segments. On the map are the lenghts, in miles, of the segments. After each map is a table of measured data for each ordered segment. In each table the stream segments are listed by order and in relationship to their location in the watershed. The streams are listed numerically, by order, counting counterclockwise around the basin starting at the mouth of the basin.

In a few cases some stream segments are listed as "connectors". These streams occure only on lakes and are specially classified because of stream ordering guidelines set forth in the methods.

FORM 7181-8 WJ U.S.A.

#1

Bear Island Watershed



Bear Island River Watershed - selected data

stream #	length of segment	start elevation	end elevation	change in elevation	gradient ft/mi
1	0.6	1426	1422	4	6.7
2	5.2	1448	1422	26	5.0
3	1.4	1445	1432	13	9.3
4	0.25	1480	1463	17	68
5	0.35	1504	1463	41	117.1
6	1.55	1512	1465	47	30.3
7	1.05	1516	1465	51	48.6
8	0.95	1498	1437	61	64.2
9	1.3	1530	1498	32	24.6
10	0.1	1499	1498	1	10.0
11	2.0	1420	1418	2	1.0
12	1.9	1419	1418	1	0.5
13	0.6	1413	1409	4	6.7
14	0.65	1445	1424	21	32.3
15	0.35	1429	1424	5	14.3
16	2.05	1467	1408	59	28.8

1st order streams

total length 20.3 mi
mean length 1.27 mi
mean gradient[A] 29.2 ft/mi
ave. gradient[B] 19.0 ft/mi

A) $\text{mean gradient ft/mi} = \frac{\Sigma \text{ gradients (ft/mi)}}{\text{number of streams}}$ B) $\text{ave. gradient} = \frac{\Sigma \ \Delta \text{ elevations (ft)}}{\Sigma \text{ stream lengths (mi)}}$

Bear Island River Watershed con't.

stream #	length of segment (mi)	start elevation	end elevation	change in elevation	gradient ft/mi
1	2.1	1422	1409	13	6.2
2	0.5	1463	1433	30	60.0
3	0.75	1465	1434	31	41.3
4	6.45	1498	1434	64	9.9
5	3.2	1424	1409	15	4.7

2nd order streams

total length 13.0 mi
mean length 2.6 mi
mean gradient[A] 24.4 ft/mi
ave. gradient[B] 11.8 ft/mi

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stream #	length of segment (mi)	start elevation	end elevation	change in elevation	gradient ft/mi
1	14.45	1434	1392	42	2.9

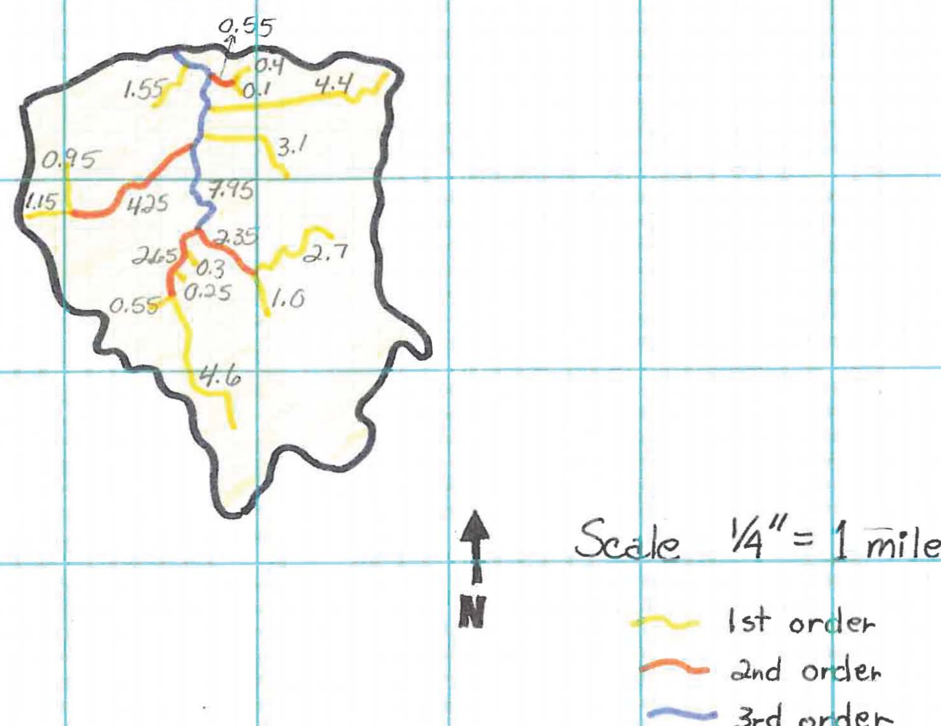
3rd order stream

length 14.45 mi
gradient[B] 2.9 ft/mi

grand total stream length 47.15 mi.

#2

Dunka River Watershed



Dunka River Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient in ft/mi
1	1.55	1595	1496	99	63.9
2	0.4	1530	1519	11	27.5
3	0.95	1608	1588	20	21.1
4	1.15	1595	1588	7	6.1
5	0.55	1546	1537	9	16.4
6	4.6	1684	1537	147	32.0
7	0.25	1539	1536	3	12.0
8	0.3	1540	1535	5	16.7
9	1.0	1588	1547	41	41
10	2.7	1637	1547	90	33.3
11	3.1	1561	1520	41	13.2
12	4.4	1575	1516	59	13.4
13	0.1	1530	1527	3	30
14	0.4	1540	1527	13	32.5

1st order streams

total length	21.45 mi
mean length	1.5 mi
mean gradient[A]	25.6 ft/mi
ave. gradient[B]	25.5 ft/mi

A) mean gradient (ft/mi) = Σ gradients (ft/mi) ÷ number of streams

B) ave. gradient (ft/mi) = Σ Δ elevations (ft) ÷ Σ stream lengths (mi)

Dunka River Watershed

stream #	length of segment	start elevation	end elevation	change in elevation	gradient ft/mi
1	4.25	1588	1521	67	15.8
2	2.65	1537	1533	4	1.5
3	2.35	1547	1533	14	6.0
4	0.55	1527	1514	13	23.6

2nd order streams

total length 9.8 mi
mean length 2.45 mi
mean gradient[A] 11.7 ft/mi
ave. gradient[B] 10.0 ft/mi

1	7.95	1533	1492	41	5.2

3rd order stream

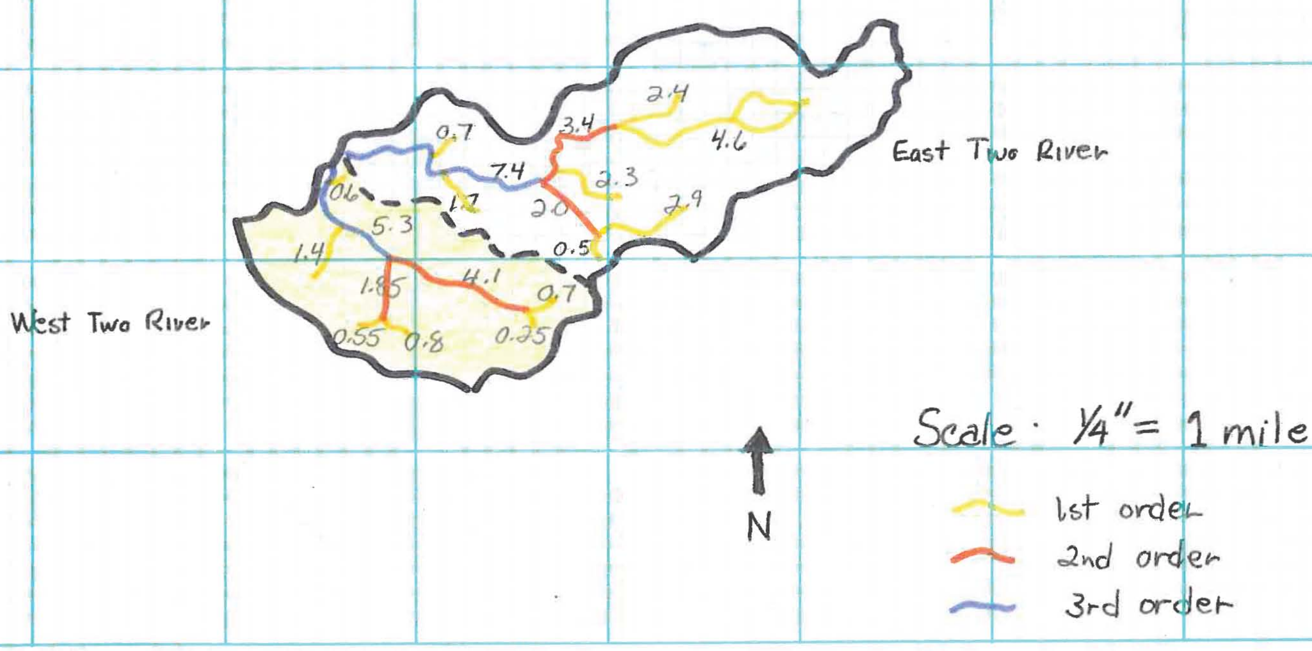
length 7.95 mi
gradient[B] 5.2 ft/mi

grand total stream length 39.2 mi.

3

FORM 7181-8 WJ U.S.A.

East and West Two Rivers Watershed



NORTH OF DIVIDE

EAST TWO RIVER WATERSHED

stream #	segment length	comments
1	1.7	
2	0.5	
3	2.9	
4	2.3	
5	4.6	
6	2.4	
7	0.7	
	15.1	total
	2.16	X̄

1st order

segment length	comments
2.0	
3.4	
5.4	total
2.7	X̄

2nd order

segment length	comments
7.4	TO MOUTH AT LAKE VERMILLION
7.4	total
7.4	X̄

3rd order.

watershed stream length	
grand total	27.9 mi

North of DIVIDE

WEST TWO RIVER WATERSHED

stream #	segment length	comments
1	1.4	
2	0.55	
3	0.8	
4	0.25	
5	0.7	
6	0.6	
	4.3	total
	0.72	$\bar{X}$

1st order

segment length	comments
1.85	
4.1	
5.95	total
2.98	$\bar{X}$

2nd order

segment length	comments
5.3	TO MOUTH AT LAKE VERMILLION
5.3	total
5.3	$\bar{X}$

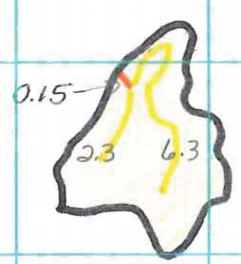
3rd order

watershed stream length

grand total 15.55 mi

#4

Filson Creek Watershed



N

Scale 1/4" = 1 mile

1st order

2nd order

Filson Creek Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	2.3	1497	1438	59	25.7
2	6.3	1515	1438	77	12.2

1st order Streams

total length 8.6 mi
mean length 4.3 mi
mean gradient[A] 19.0 ft/mi
ave. gradient[B] 15.8 ft/mi

1	0.15	1438	1436	2	13.3

2nd order stream

length 0.15 mi
gradient[B] 13.3 ft/mi

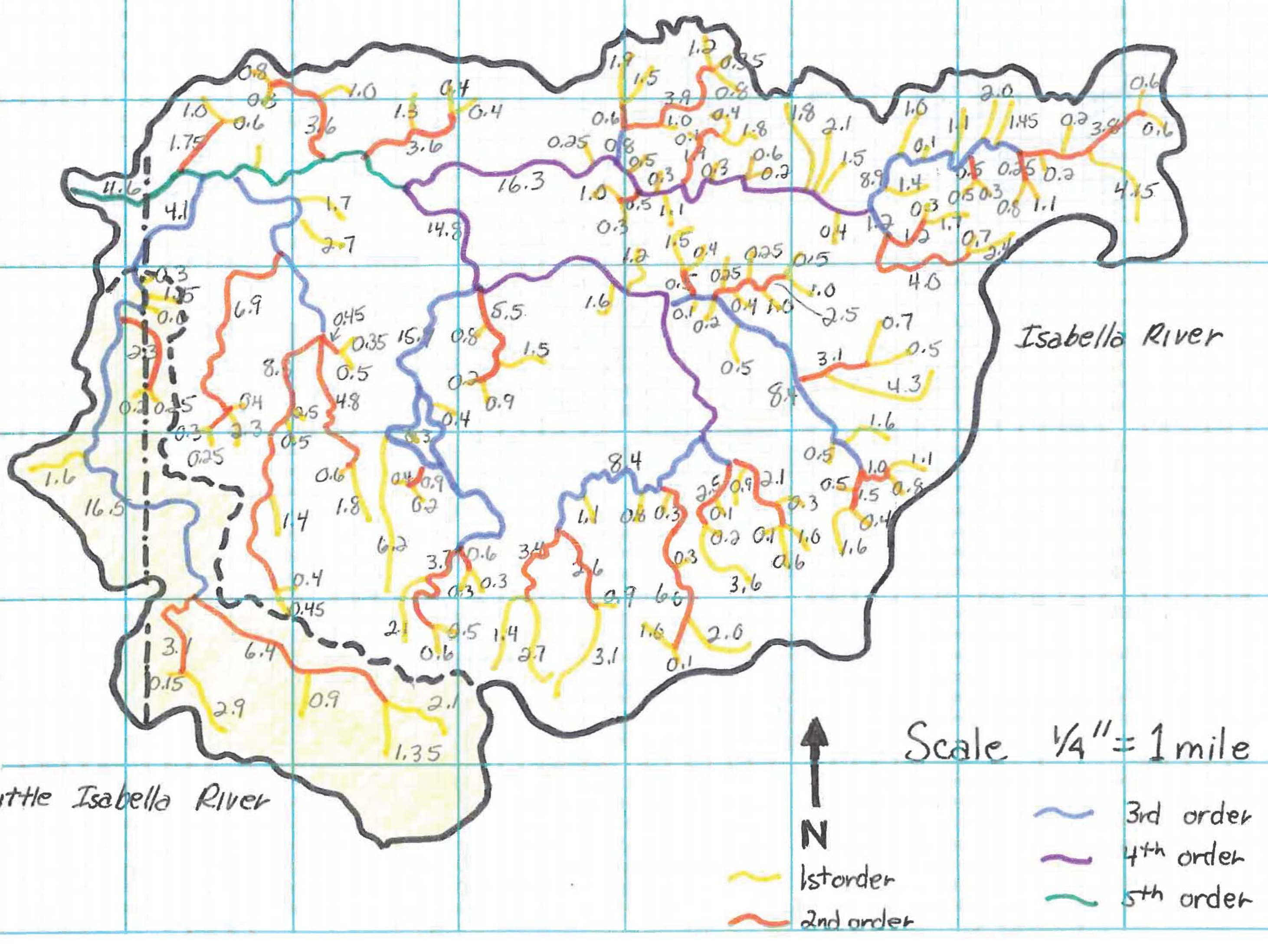
grand total stream length 8.75 mi

A) mean gradient (ft/mi) = Σ gradients (ft/mi) ÷ number of streams

B) ave. gradient (ft/mi) = Σ Δ elevations (ft) ÷ Σ stream lengths (mi)

#5

Isabella Watershed



Isabella River Watershed – selected data

stream #	length of segment	start elevation	end elevation	change in elevation	gradient ft/mi
1	0.3	1605	1598	7	23.3
2	0.25	1600	1598	2	8
3	2.3	1667	1593	74	32.2
4	0.4	1602	1592	10	25
5	0.45	1752	1746	6	13.3
6	0.4	1751	1746	5	12.5
7	1.4	1722	1689	33	23.6
8	0.5	1638	1628	10	20
9	0.5	1638	1627	11	22
10	0.6	1679	1669	10	16.7
11	1.8	1725	1669	56	31.1
12	0.5	1619	1603	16	32
13	0.35	1625	1603	22	62.9
14	2.7	1577	1544	33	12.2
15	1.7	1566	1537	29	17.1
16	0.25	1622	1618	4	16
17	6.2	1810	1648	162	26.1
18	0.4	1687	1670	17	42.5
19	0.2	1681	1670	11	55
20	2.1	1844	1753	91	43.3
21	0.6	1812	1775	37	61.7
22	0.5	1785	1775	10	20
23	0.3	1759	1751	8	26.7
24	0.3	1759	1751	8	26.7
25	0.3	1651	1645	6	20
26	0.4	1653	1637	16	40
27	0.8	1601	1593	8	10

Isabella cont.

stream #	length of segment	start elevation	end elevation	change in elevation	gradient ft/mi
28	0.2	1652	1649	3	1.5
29	0.9	1678	1649	29	32.2
30	1.5	1670	1645	25	16.7
31	1.6	1610	1572	38	23.8
32	1.4	1815	1756	59	42.1
33	2.7	1928	1756	172	63.7
34	3.1	1945	1839	106	34.2
35	0.9	1849	1839	10	11.1
36	1.1	1698	1675	23	20.9
37	0.8	1678	1669	9	11.3
38	0.3	1680	1674	6	20
39	1.0	1852	1804	48	48
40	0.1	1811	1804	7	70
41	2.0	1794	1776	18	9
42	0.3	1757	1754	3	10
43	3.6	1744	1687	57	15.8
44	0.2	1688	1687	1	5
45	0.1	1683	1682	1	10
46	0.9	1694	1659	35	38.9
47	0.1	1705	1704	1	10
48	0.6	1719	1704	15	25
49	1.0	1720	1691	29	29
50	0.3	1713	1685	28	93.3
51	0.1	1600	1579	21	210
52	0.2	1606	1588	18	90
53	0.5	1645	1605	40	80
54	0.5	1648	1645	3	6

Isabella cont.

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
55	0.5	1693	1684	9	18
56	1.6	1738	1688	50	31.3
57	0.4	1689	1688	1	2.5
58	0.8	1717	1698	19	23.8
59	1.1	1737	1698	39	35.5
60	1.6	1701	1645	56	35
61	4.3	1741	1650	91	21.2
62	0.5	1678	1651	27	54
63	0.7	1678	1651	27	38.6
64	0.4	1623	1600	23	57.5
65	1.0	1624	1609	15	15
66	1.0	1632	1615	17	17
67	0.5	1619	1615	4	8
68	0.25	1613	1609	4	16
69	0.25	1597	1595	2	8
70	0.4	1696	1681	15	37.5
71	1.5	1712	1681	31	20.7
72	1.2	1579	1572	7	5.8
73	1.0	1568	1564	4	4
74	0.3	1571	1564	7	23.3
75	1.1	1595	1568	27	24.5
76	0.4	1618	1615	3	7.5
77	2.4	1774	1718	56	23.3
78	0.7	1736	1718	18	25.7
79	1.7	1680	1662	18	10.6
80	0.3	1671	1662	9	30
81	1.4	1641	1619	22	15.7

Isabella cont.

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
82	0.5	1678	1660	18	36
83	0.3	1679	1660	19	63.3
84	0.8	1770	1737	33	41.3
85	1.1	1792	1737	55	50
86	0.2	1764	1756	8	40
87	4.15	1861	1749	112	27
88	0.6	1843	1777	66	110
89	0.6	1796	1777	19	31.7
90	0.2	1748	1746	2	10
91	1.45	1744	1672	72	49.7
92	2.0	1762	1653	109	54.5
93	1.1	1678	1641	37	33.6
94	0.1	1638	1637	1	10
95	1.0	1655	1632	23	23
96	1.5	1626	1615	11	7.3
97	2.1	1636	1615	21	10
98	1.8	1637	1615	22	12.2
99	0.2	1615	1607	8	40
100	0.6	1670	1607	63	105
101	0.3	1623	1597	26	86.7
102	1.8	1670	1632	38	21.1
103	0.4	1645	1632	13	32.5
104	0.1	1611	1609	2	20
105	0.3	1583	1568	15	50
106	0.5	1584	1557	27	54
107	1.0	1607	1568	39	39
108	0.8	1649	1635	14	17.5

Isabella cont.

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
109	0.35	1655	1635	20	57.1
110	1.2	1685	1633	52	43.3
111	1.5	1659	1585	74	49.3
112	1.9	1646	1585	61	32.1
113	0.25	1562	1551	11	44
114	0.4	1558	1553	5	12.5
115	0.4	1559	1553	6	15
116	1.3	1558	1550	8	6.2
117	1.0	1537	1524	13	13
118	0.8	1556	1543	13	16.3
119	0.3	1557	1543	14	46.7
120	0.7	1522	1511	11	15.7
121	0.6	1538	1535	3	5
122	1.0	1556	1535	21	21

1st order streams

total length	117 mi
mean length	0.96 mi
mean gradient A	31.4 ft/mi
ave gradient B	28.1 ft/mi

A) mean gradient (ft/mi) = Σ gradients (ft/mi) ÷ number of streams

B) ave. gradient (ft/mi) = Σ Δ elevations (ft) ÷ Σ stream lengths (mi)

Isabella cont.

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	6.9	1598	1550	48	7.0
2	8.3	1746	1570	176	21.2
3	4.8	1669	1575	94	19.6
4	0.45	1603	1575	28	62.2
5	0.9	1670	1665	5	5.6
6	3.7	1775	1724	51	13.8
7	0.6	1751	1724	27	45
8	5.5	1649	1551	98	17.8
9	3.4	1756	1688	68	20
10	2.6	1839	1688	151	58.1
11	6.0	1804	1668	136	22.7
12	2.5	1687	1657	30	12
13	2.1	1704	1657	47	22.4
14	1.5	1688	1682	6	4
15	1.0	1698	1682	16	16
16	3.1	1651	1644	7	2.3
17	2.5	1615	1587	28	11.2
18	0.5	1681	1678	3	6
19	0.5	1564	1562	2	4
20	4.0	1718	1625	93	23.3
21	1.2	1662	1625	37	30.8
22	0.5	1660	1656	4	8
23	0.25	1737	1725	12	48
24	3.8	1777	1725	52	13.7
25	1.9	1632	1577	55	28.9
26	3.9	1635	1565	70	17.9
27	0.6	1585	1565	20	33.3

Isabella cont.

Stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
28	3.6	1553	1536	17	4.7
29	3.6	1543	1535	8	2.2
30	1.75	1535	1497	38	21.7

2nd order streams

total length 81.95 mi
mean length 2.7 mi
mean gradient [A] 20.1 ft/mi
ave. gradient [B] 17.4 ft/mi

1	4.1	1533	1505	28	6.8
2	7.6	1575	1510	65	8.6
3	15.9	1724	1551	173	10.9
4	8.4	1688	1636	52	6.2
5	1.3	1657	1636	21	16.2
6	8.4	1682	1574	108	12.9
7	1.2	1625	1615	10	8.3
8	8.9	1725	1615	110	12.4
9	0.8	1565	1551	14	17.5

3rd order streams

total length 56.6 mi
mean length 6.3 mi
mean gradient [A] 11.1 ft/mi
ave gradient [B] 10.3 ft/mi

Isabella cont.

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	14.8	1636	1542	94	6.4
2	16.3	1615	1542	73	4.5

4th order streams

total length	31.1	mi
mean length	15.6	mi
mean gradient A	5.5	ft/mi
ave gradient B	5.4	ft/mi

1	11.6	1542	1456	86	7.4

5th order stream

length	11.6	mi
gradient B	7.4	ft/mi

grand total length 298.25

Little Isabella Watershed - selected data

stream #	length of segment	start elevation	end elevation	change in elevation	gradient ft/mi
1	1.6	1676	1638	38	23.8
2	0.15	1800	1799	1	6.7
3	2.9	1883	1799	84	29
4	0.9	1925	1845	80	88.9
5	1.35	1923	1890	33	24.4
6	2.1	1936	1890	46	21.9
7	0.2	1635	1630	5	25
8	0.25	1633	1630	3	12
9	0.6	1589	1559	30	50
10	1.5	1625	1558	67	44.7
11	0.3	1555	1543	12	40

1st order streams

total length	11.85	mi
mean length	1.1	mi
mean gradient[A]	33.3	ft/mi
ave. gradient[B]	33.7	ft/mi

A) $\text{mean gradient (ft/mi)} = \dfrac{\Sigma \text{ gradients (ft/mi)}}{\text{number of streams}}$

B) $\text{ave. gradient (ft/mi)} = \dfrac{\Sigma \text{ change in elevations (ft)}}{\Sigma \text{ stream lengths (mi)}}$

Little Isabella Watershed – cont.

stream #	length of segment	start elevation	end elevation	change in elevation	gradient ft/mi
1	3.1	1799	1768	31	10
2	6.4	1890	1768	122	19.1
3	2.3	1630	1570	60	26.1

2nd order streams

total length 11.8 mi
mean length 3.9 mi
mean gradient[A] 18.4 ft/mi
ave. gradient[B] 18.1 ft/mi

1	16.5	1768	1533	235	14.2

3rd order stream

length 16.5 mi
gradient[B] 14.2 ft/mi

grand total length 40.15 mi

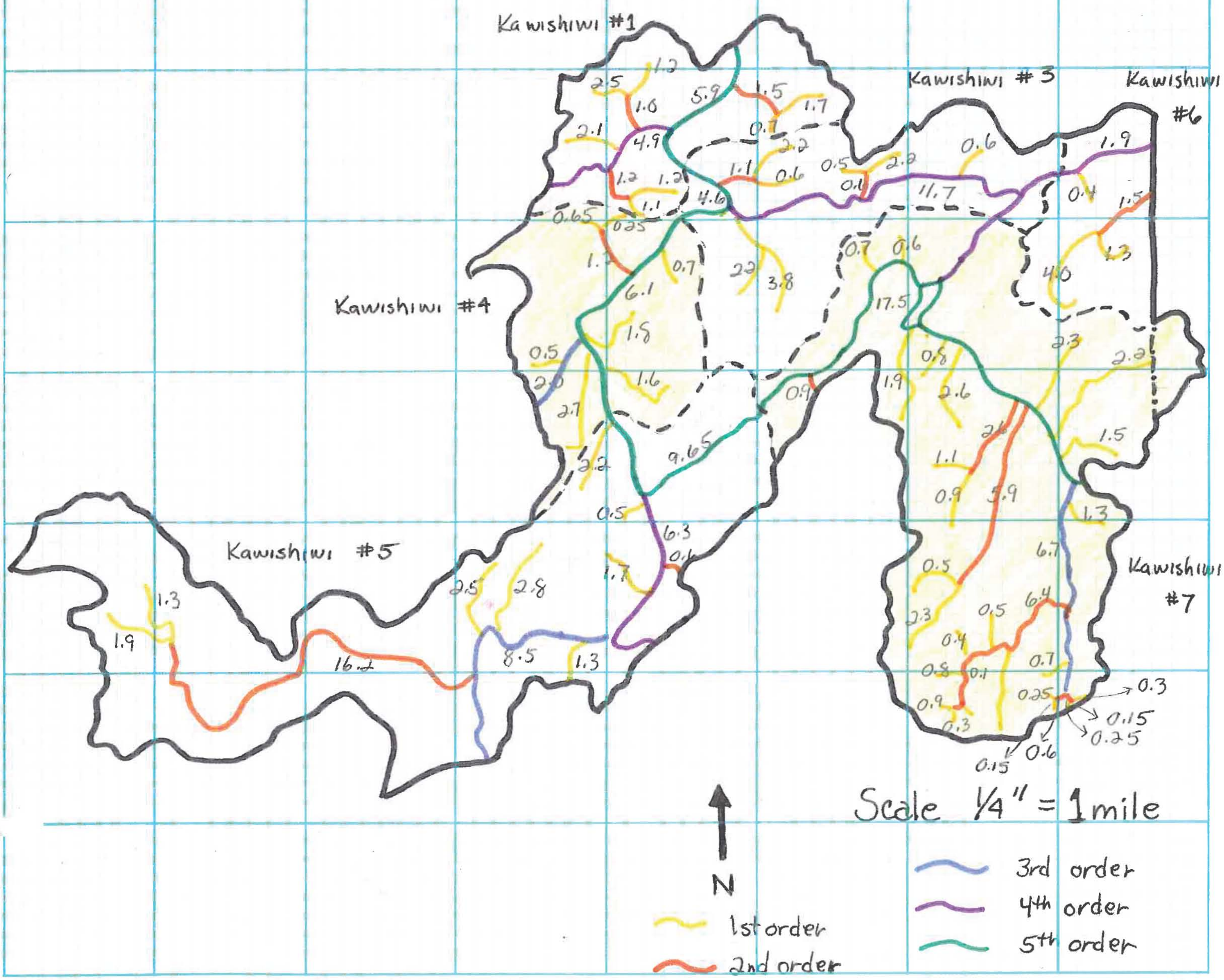
FORM 7181-8 WJ U.S.A.

#6

Kawishiwi River Watershed

253 mi²

K-6
K-7



Kawishiwi K-1 Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	1.2	1366	1358	8	6.7
2	2.5	1394	1358	36	14.4
3	2.1	1344	1319	25	11.9
4	1.1	1409	1369	40	36.4
5	1.2	1395	1369	26	21.7
6	0.7	1332	1318	14	20.0
7	1.7	1343	1318	25	14.7

1st order streams

total length 10.5 mi

mean length 1.5 mi

mean gradient [A] 17.97 ft/mi

ave. gradient [B] 16.57 ft/mi

1	1.6	1358	1319	39	39
2	1.2	1369	1319	50	41.7
3	1.5	1318	1315	3	2.0

2nd order streams

total length 3.7 mi

mean length 1.2 mi

mean gradient [A] 27.57 ft/mi

ave. gradient [B] 24.86 ft/mi

A) mean gradient (ft/mi) = Σ gradients (ft/mi) ÷ number of streams

B) ave. gradient (ft/mi) = Σ Δ elevations (ft) ÷ Σ stream lengths (mi)

Kawishiwi K-1 Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	4.9	1336	1319	17	3.5

4th order stream
length 4.9 mi.
gradient[B] 3.5 ft/mi

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	5.9	1388	1307	81	13.7

5th order stream
length 5.9 mi
gradient[B] 13.7 ft/mi

Kawishiwi K-3 Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	2.2	1430	1388	42	19.1
2	3.8	1457	1388	69	18.2
3	0.6	1455	1442	13	21.7
4	2.2	1470	1395	75	34.1
5	0.5	1402	1395	7	14
6	0.6	1416	1404	12	20
7	2.2	1432	1404	28	12.7

1st order streams

total length 12.1 mi
mean length 1.7 mi
mean gradient [A] 19.97 ft/mi
ave. gradient [B] 20.33 ft/mi

1	0.6	1395	1388	7	11.7
2	1.1	1404	1388	16	14.6

2nd order streams

total length 1.7 mi
mean length 0.85 mi
mean gradient [A] 13.2 ft/mi
ave. gradient [B] 13.5 ft/mi

1	11.7	1455	1388	67	5.7

4th order stream

length 11.7 mi
gradient [B] 5.7 ft/mi

Kawishiwi K-3 Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	4.6	1388	1388	0	0

5th order stream

length 4.6 mi

gradient B 0 ft/mi

Kawishiwi K-4 Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	0.25	1389	1388	1	4
2	0.65	1408	1388	20	30.8
3	0.5	1389	1388	1	2
4	2.7	1427	1388	39	14.4
5	1.6	1452	1388	64	40
6	1.8	1389	1388	1	0.6
7	0.7	1391	1388	3	4.3

1st order streams

total length 8.2 mi
mean length 1.2 mi
mean gradient[A] 13.73 ft/mi
ave. gradient[B] 15.73 ft/mi

1	1.2	1388	1388	0	0

2nd order streams

length 1.2 mi
gradient[B] 0 ft/mi

1	2.0	1392	1388	4	2

3rd order stream

length 2.0 mi
gradient[B] 2 ft/mi

Kawishiwi K-4 Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	6.1	1400	1388	12	1.97

5th order stream
length 6.1 mi
gradient B 1.97 ft/mi

Kawishiwi (K-5) Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	2.2	1472	1412	60	27.3
2	0.5	1442	1418	24	48.0
3	1.7	1495	1418	77	45.3
4	2.8	1472	1418	54	19.3
5	2.5	1454	1418	36	14.4
6	1.3	1480	1458	22	16.9
7	1.9	1490	1458	32	16.8
8	1.3	1418	1418	0	0
9	0.5	1427	1412	15	30.0

1st order streams

total length 14.7 mi
mean length 1.6 mi
mean gradient[A] 24.2 ft/mi
ave. gradient[B] 21.8 ft/mi

1	16.2	1458	1418	40	2.5
2	0.6	1418	1418	0	0

2nd order streams

total length 16.8 mi
mean length 8.4 mi
mean gradient[A] 1.25 ft/mi
ave gradient[B] 2.4 ft/mi

Kawishiwi K-5 Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	8.5	1492	1418	74	8.7

3rd order stream
length 8.5 mi
gradient[B] 8.7 ft/mi

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	6.3	1421	1418	3	0.5

4th order stream
length 6.3 mi
gradient[B] 0.5 ft/mi

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	9.65	1424	1400	24	2.5

5th order stream
length 9.65 mi
gradient[B] 2.5 ft/mi

Kawishiwi (K-6) Watershed

	segment length	
1	0.4	
2	4.0	
3	1.3	
	5.7	total
	1.9	$\bar{x}$

1st order

segment length	
1.5	
1.5	total
1.5	$\bar{x}$

2nd order

segment length	
1.9	
1.9	total
1.9	$\bar{x}$

4th order

watershed stream length
grand total = 9.1 miles

Kawishiwi (K-7) Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	1.9	1487	1453	34	17.9
2	0.8	1463	1453	10	12.5
3	2.6	1522	1453	69	26.5
4	1.1	1603	1546	57	51.8
5	0.9	1592	1546	46	51
6	0.5	1538	1524	14	28.0
7	2.3	1576	1524	52	22.6
8	0.5	1540	1537	3	6
9	0.4	1560	1548	12	30
10	0.8	1575	1563	12	15
11	0.9	1600	1568	32	35.6
12	0.3	1572	1568	4	13.3
13	0.1	1555	1550	5	50
14	2.6	1584	1536	48	18.5
15	0.7	1549	1537	12	17.1
16	0.25	1570	1567	3	12
17	0.15	1570	1567	3	20
18	0.15	1549	1547	2	13.3
19	0.3	1557	1547	10	33.3
20	1.3	1506	1453	53	40.8
21	1.5	1517	1453	64	42.7
22	2.2	1512	1453	59	26.8
23	2.3	1516	1453	63	27.4
24	0.6	1434	1432	2	3.3
25	0.7	1444	1431	13	18.6

Kawishiwi (K-7) Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi

1st order streams

total length 25.85 mi
mean length 1.03 mi
mean gradient[A] 25.4 ft/mi
ave. gradient[B] 26.9 ft/mi

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	0.9	1436	1425	11	12.2
2	2.6	1546	1453	93	35.8
3	5.9	1524	1453	71	12.0
*4	6.4	1568	1535	33	5.2
5	0.6	1567	1544	23	38.3
6	0.25	1547	1544	3	12

2nd order streams

total length 16.65 mi
mean length 2.8 mi
mean gradient[A] 14.1
ave. gradient[B] 19.3

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	6.7	1544	1453	91	13.6

3rd order stream

length 6.7 mi
gradient[B] 13.6 ft/mi

Kawishiwi (K-7) Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1.	3.4	1440	1434	6	1.8

4th order stream
length 3.4 mi
gradient[B] 1.8 ft/mi

1	17.5	1456	1424	32	1.8

5th order stream
length 17.5 mi
gradient[B] 1.8 ft/mi

FORM 7181-8 WJ U.S.A.

#7

Keeley Creek Watershed

N

Scale 1/4" = 1 mile

1st order

2nd order

Keeley Creek Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	0.6	1535	1518	17	28.3
2	4.9	1555	1518	37	7.6
3	1.6	1479	1465	14	8.8

1st order streams

total length 7.1 mi
mean length 2.4 mi
mean gradient [A] 14.9 ft/mi
ave. gradient [B] 9.6 ft/mi

1	4.6	1518	1418	100	21.7

2nd order stream

length 4.6 mi
gradient [B] 21.7 mi

grand total stream length 11.7

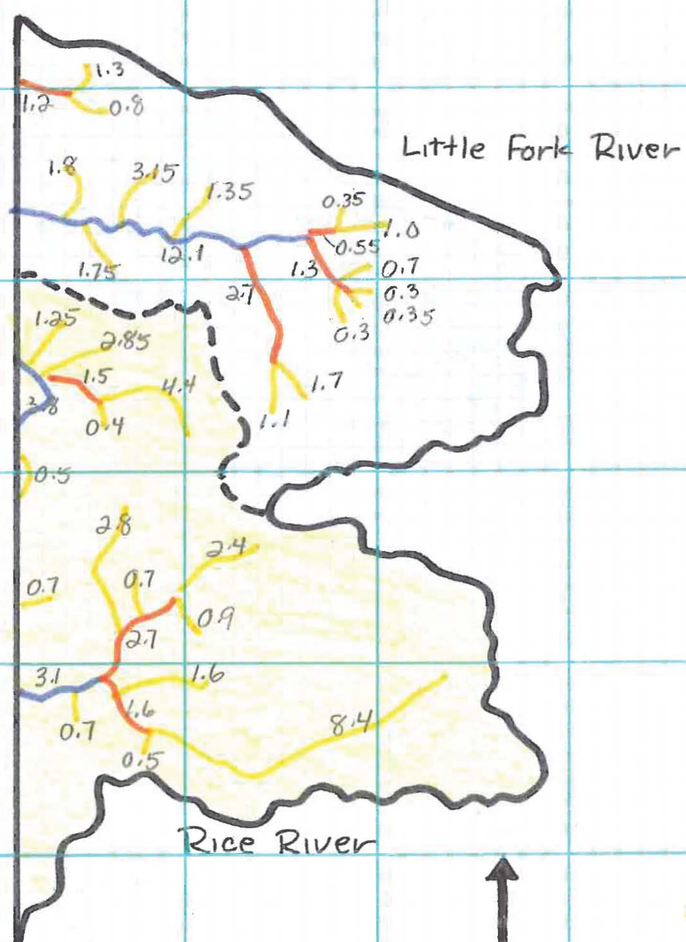
A) mean gradient (ft/mi) = Σ gradients (ft/mi) ÷ number of streams

B) ave. gradient (ft/mi) = Σ Δ elevations (ft) ÷ Σ stream lengths (mi)

FORM 7181-8 WJ U.S.A.

#8

Little Fork River Watershed



Scale 1/4" = 1 mile

- 1st order
- 2nd order
- 3rd order

LITTLE FORK RIVER WATERSHED

stream #	segment length	
1	1.75	
2	1.1	
3	1.7	
4	0.3	
5	0.35	
6	0.3	
7	0.7	
8	1.0	
9	0.35	
10	1.35	
11	3.15	
12	1.8	
13	0.8	
14	1.3	
	15.95	total
	1.14	$\bar{x}$

1st order

segment length	
2.7	
1.3	
0.55	
1.2	PARTIAL
5.75	total
1.44	$\bar{x}$

2nd order

segment length	
12.1	PARTIAL
12.1	total
12.1	$\bar{x}$

3rd order

watershed stream length

grand total 33.8 miles

RICE RIVER WATERSHED

stream #	segment length	
1	0.7	
2	0.5	
3	8.4	
4	1.6	
5	0.9	
6	2.4	
7	0.7	
8	2.8	
9	0.7	PARTIAL
10	0.5	PARTIAL
11	0.4	
12	4.4	
13	2.85	
14	1.25	
	28.1	total
	2.01	$\bar{x}$

1st order

segment length	
1.6	
2.7	
1.5	
5.8	total
1.93	$\bar{x}$

2nd order

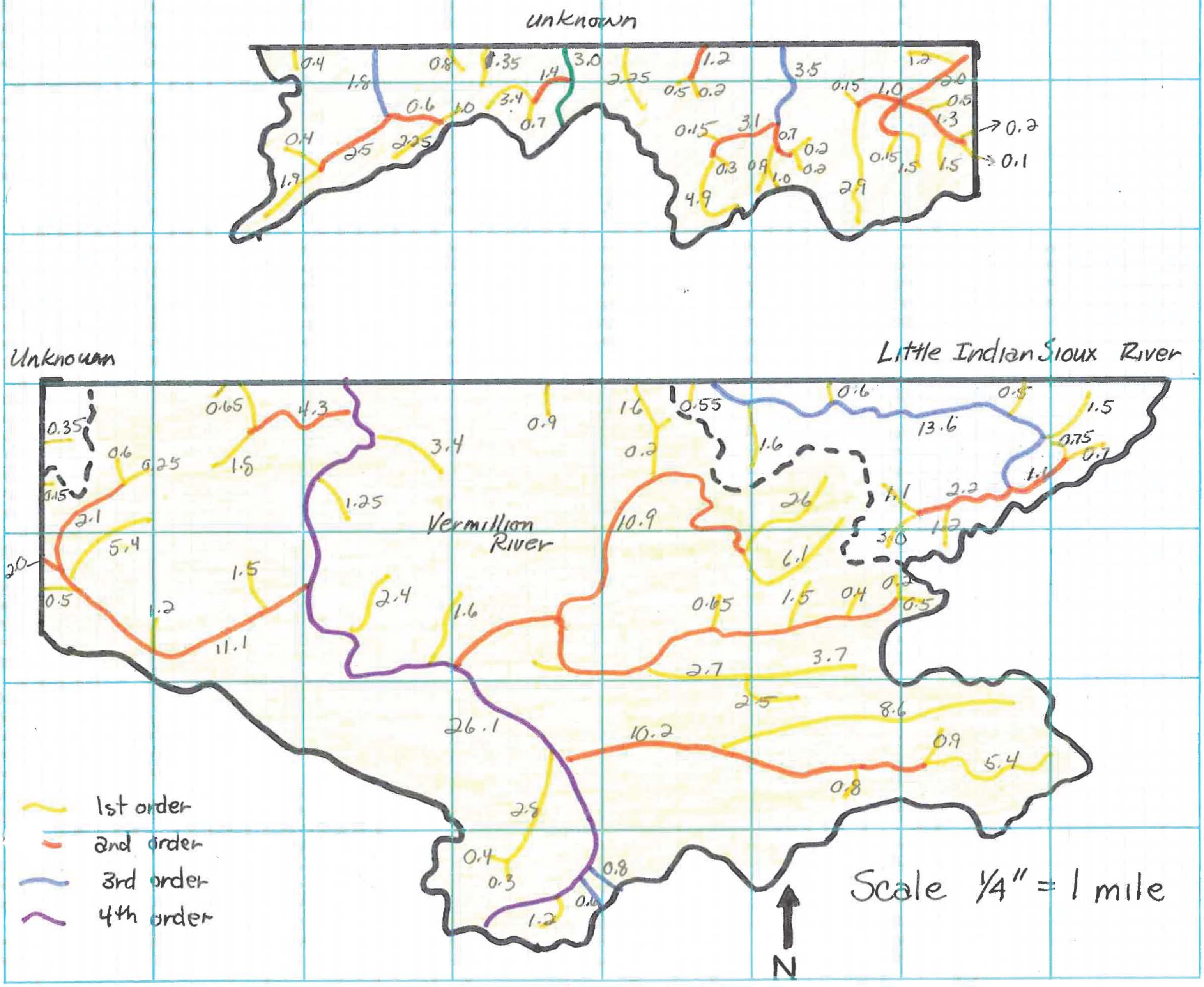
segment length	
6.9	2 PORTIONS PARTIAL
6.9	total
6.9	$\bar{x}$

3rd order

watershed stream length

grand total 40.8 miles

Northern area Watershed



UNKNOWN NORTH OF K-1 & K-3

stream #	segment length	
1	0.4	PARTIAL
2	0.4	
3	1.9	
4	2.25	
5	1.0	
6	0.8	PARTIAL
7	1.35	PARTIAL
8	3.4	
9	0.7	
10	2.25	PARTIAL
11	0.5	
12	0.2	
13	0.15	
14	4.9	
15	0.3	
16	0.9	
17	1.0	
18	0.3	
19	0.2	
20	1.2	
21	0.15	
22	2.9	
23	0.15	
24	1.5	
25	1.5	
26	0.1	PARTIAL
27	0.2	PARTIAL

1st order ↑ ↓

segment length	
2.5	
0.6	
1.4	
1.2	PARTIAL
3.1	
0.7	
1.0	
0.9	
1.3	
2.0	connector
14.7	total (including connector)
1.47	$\bar{X}$

2nd order

segment length	
1.8	PARTIAL
3.5	PARTIAL
5.3	total
2.65	$\bar{X}$

3rd order

segment length	
3.0	PARTIAL
3.0	total
3.0	$\bar{X}$

5th order

North of K-1 and K-3 cont.

stream #	segment length	
28	0.5	
	31.1	total
	1.11	$\bar{x}$

1st order

grand total 54.1 miles

VERMILLION RIVER WATERSHED

1st order

stream #	segment length	
1	0.65	PARTIAL
2	1.8	
3	1.5	
4	1.2	
5	5.4	
6	0.25	
7	0.6	
8	0.15	PARTIAL
9	0.5	PARTIAL
10	0.4	
11	0.3	
12	1.2	
13	0.8	
14	5.4	
15	0.9	
16	8.6	
17	0.75	
18	2.5	
19	3.7	
20	0.5	
21	0.2	
22	0.4	
23	1.5	
24	0.65	
25	6.1	
26	2.6	
27	1.0	

15X

↓

2nd order

segment length	
4.3	
2.1	
2.0	PARTIAL
10.2	
13.4	
10.9	
56.8	total
9.47	$\bar{x}$

(including 2nd connectors)

4th order

segment length	
26.7	PARTIAL
26.7	total
26.7	$\bar{x}$

3rd order

segment length	
0.8	
0.6	
1.4	total
0.7	$\bar{x}$

connectors

	segment length
1st	2.8
1st	2.7
1st	0.2
2nd	11.1
2nd	2.8

Vermillion cont.

28	1.6	PARTIAL
29	1.6	
30	2.4	
31	1.25	
32	3.4	
	65.5	total
	2.05	$\bar{x}$

(including 1st order connectors)

1st order

grand total

LITTLE ENDIAN SIOUX WATERSHED

1st order

stream #	segment length mi	comments
1	0.55	PARTIAL
2	1.6	
3	1.1	
4	3.0	
5	1.2	
6	0.7	
7	0.75	
8	1.5	
9	0.5	PARTIAL
10	0.6	PARTIAL
	11.5	total
	1.15	$\bar{X}$

2nd order

stream #	segment length mi	comments
1	2.2	
2	1.6	
	3.8	total
	1.9	$\bar{X}$

3rd order

stream #	segment length mi	comments
1	13.6	PARTIAL
	13.6	total
	13.6	$\bar{X}$

watershed stream length

grand total 28.9 mi

(UNKNOWN) WATERSHED

stream #	segment length	comments
1	0.35	PARTIAL
	0.35	total
	0.35	$\bar{X}$

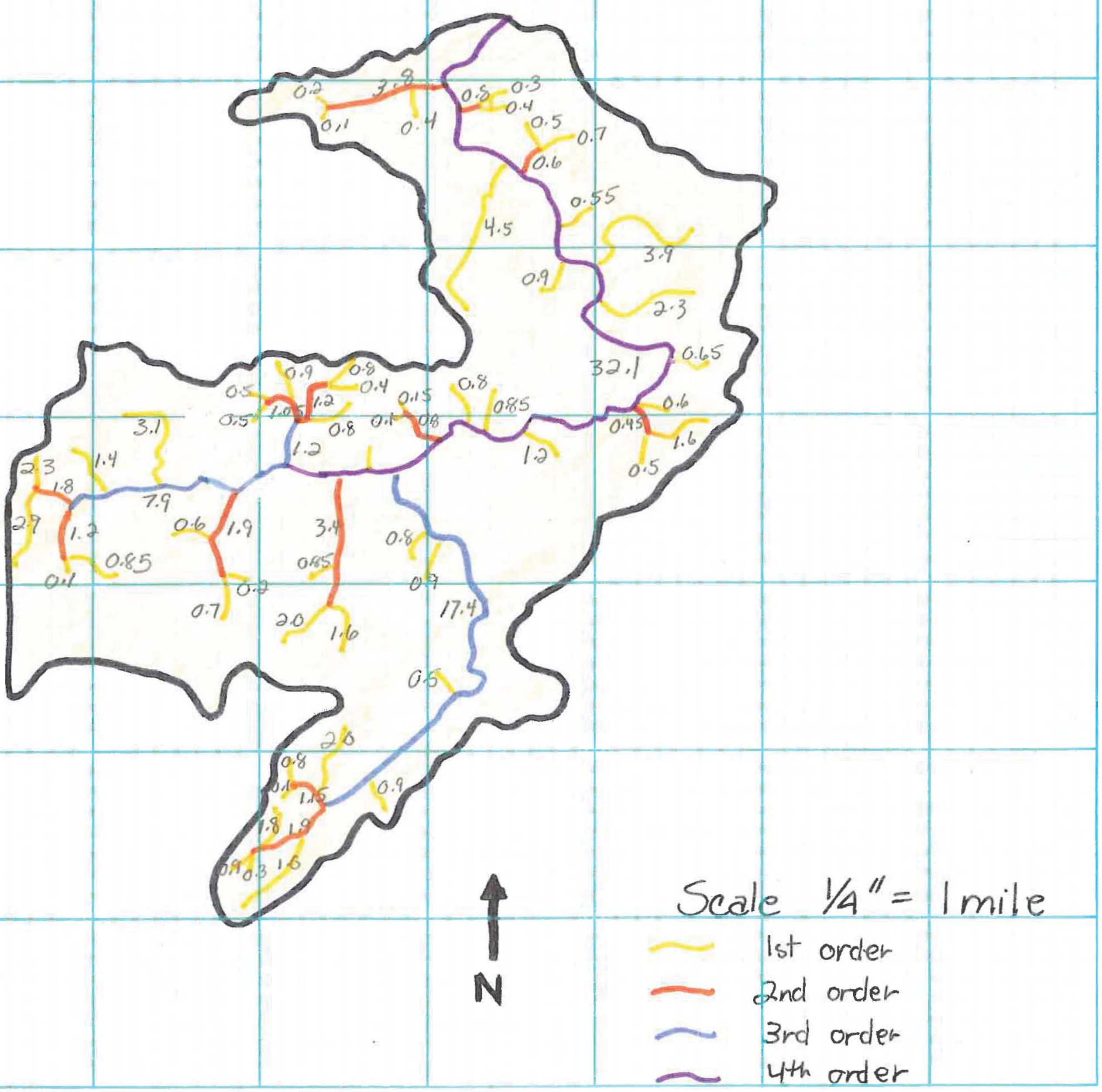
watershed stream length

total length 0.35 mi

FORM 7181-8 WJ U.S.A.

#10

Pike River Watershed



PIKE RIVER WATERSHED

stream #	segment length
1	0.2
2	0.1
3	0.4
4	4.5
5	0.9
6	0.85
7	0.8
8	0.15
9	0.1
10	0.5
11	0.8
12	0.4
13	0.8
14	0.9
15	0.5
16	0.5
17	3.1
18	1.4
19	2.3
20	2.9
21	0.1
22	0.85
23	0.6
24	0.7
25	0.2
26	0.85
27	2.0

1st order ↓

segment length	
3.8	
0.8	
1.2	
1.05	
1.8	
1.2	
1.9	
3.4	
1.15	
1.9	
0.45	
0.6	
0.8	
20.05	total
1.54	$\bar{x}$

2nd order

segment length	
1.2	
7.9	
17.4	
26.5	total
8.83	$\bar{x}$

3rd order

	segment length
	32.1
total	32.1
$\bar{x}$	32.1

4th order

PIKE RIVER WATERSHED

stream #	segment length	
28	1.6	
29	0.8	
30	0.9	
31	0.5	
32	2.0	
33	0.8	
34	0.1	
35	1.8	
36	0.9	
37	0.3	
38	1.0	
39	0.9	
40	1.2	
41	0.5	
42	1.6	
43	0.6	
44	0.65	
45	2.3	
46	3.9	
47	0.55	
48	0.7	
49	0.5	
50	0.4	
51	0.3	
	52.2	total
	1.02	$\bar{X}$

1st order

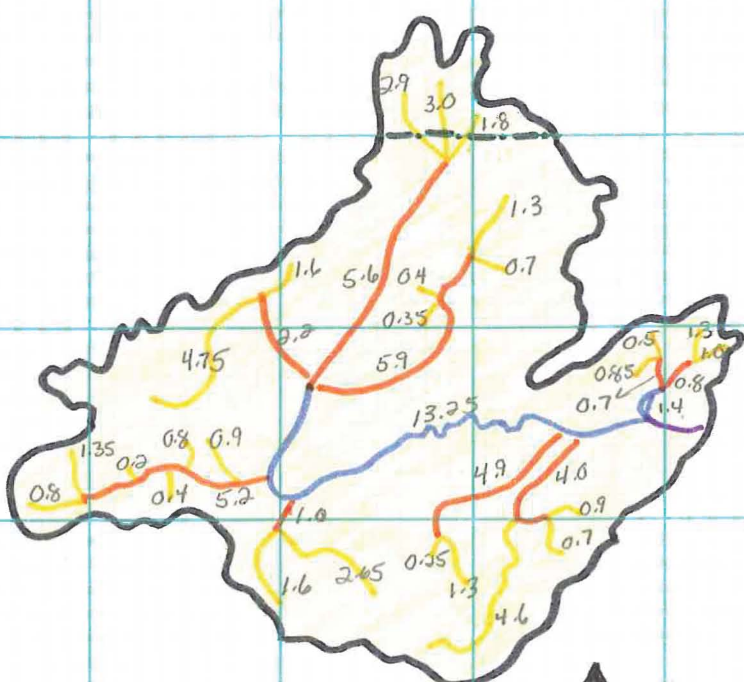
watershed stream length

grand total 130.85 miles

FORM 7181-8 WJ U.S.A.

#11

Shagawa River Watershed



Scale 1/4" = 1 mile

1st order
2nd order
3rd order
4th order

Shagawa River (K-2) Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	1.0	1390	1355	35	35
2	1.3	1454	1355	99	76.2
3	0.5	1422	1414	8	16
4	0.85	1439	1414	25	29.4
5	0.7	1393	1371	22	31.4
6	1.3	1377	1371	6	4.6
7	0.4	1390	1371	19	47.5
8	0.35	1389	1371	18	51.4
9	1.8	1400	1371	29	16.1
10	3.0	1475	1371	104	34.7
11	2.9	1478	1371	107	36.9
12	1.6	1480	1395	85	53.1
13	4.75	1476	1395	81	17.1
14	0.9	1395	1371	24	26.7
15	0.8	1420	1371	49	61.3
16	0.2	1414	1413	1	5
17	1.35	1519	1441	78	57.8
18	0.8	1448	1441	7	8.8
19	0.4	1372	1371	1	2.5
20	1.6	1447	1397	50	31.3
21	2.65	1488	1397	91	34.3
22	0.25	1378	1375	3	12
23	1.3	1456	1375	81	62.3
24	4.6	1522	1376	146	31.7
25	0.7	1449	1389	60	85.7
26	0.9	1435	1389	46	51.1

Shagawa River (K-2) Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
		1st order streams			
		total length		36.9 mi	
		mean length		1.4 mi	
		mean gradient [A]		35.4 ft/mi	
		ave. gradient [B]		34.6 ft/mi	
1	0.8	1355	1346	9	11.3
2	0.7	1414	1346	68	97.1
3	5.9	1371	1371	0	0
4	5.6	1371	1371	0	0
5	2.2	1395	1371	24	10.9
6	5.2	1441	1371	70	13.5
7	1.0	1397	1357	40	40
8	4.9	1375	1337	38	7.8
9	4.0	1389	1337	52	13
		2nd order streams			
		total length		30.3 mi	
		mean length		3.4 mi	
		mean gradient [A]		21.5 ft/mi	
		ave. gradient [B]		9.9 ft/mi	

Shagawa River (K-2) Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	1.4	1346	1337	9	6.4
2	13.25	1371	1337	34	2.6

3rd order streams

total length	14.65	mi
mean length	7.3	mi
mean gradient[A]	4.4	ft/mi
ave. gradient[B]	2.9	ft/mi

1	1.9	1337	1336	1	0.5

4th order stream

length	1.9 mi.
gradient[B]	0.5 ft/mi

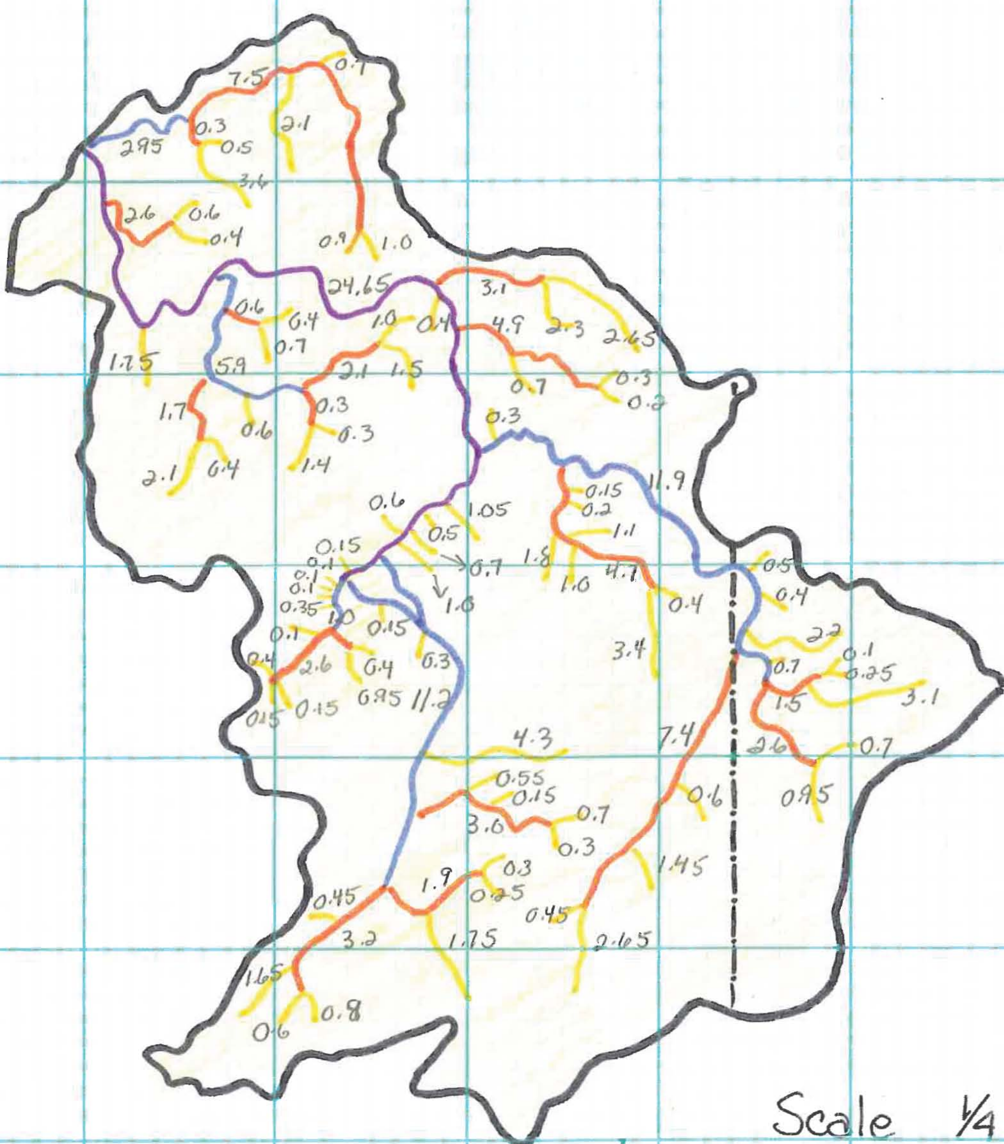
A) mean gradient (ft/mi) = Σ gradients (ft/mi) ÷ number of streams

B) ave. gradient (ft/mi) = Σ Δ elevations (ft) ÷ Σ stream lengths (miles)

FORM 7181-8 WJ U.S.A.

#12

Stony River Watershed



Scale 1/4" = 1 mile

1st order

2nd order

3rd order

4th order

Stony River Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	1.75	1637	1586	51	29.1
2	2.1	1690	1659	31	14.8
3	0.4	1668	1659	9	22.5
4	0.6	1665	1649	16	26.7
5	1.4	1680	1668	12	8.6
6	0.3	1673	1668	5	16.7
7	1.5	1687	1683	4	2.7
8	1.0	1684	1684	1	1
9	0.7	1649	1630	19	27.1
10	0.4	1638	1630	8	20
11	0.4	1667	1644	23	57.5
12	0.6	1697	1689	8	13.3
13	0.15	1693	1691	2	13.3
14	0.1	1692	1691	1	1
15	0.1	1693	1691	2	20
16	0.1	1693	1691	2	20
17	0.35	1695	1691	4	11.4
18	0.1	1695	1691	4	40
19	0.4	1694	1692	2	5
20	0.15	1694	1693	1	6.7
21	0.15	1694	1693	1	6.7
22	0.95	1728	1699	29	30.5
23	0.4	1718	1699	19	47.5
24	0.15	1724	1723	1	6.7
25	0.3	1736	1729	7	23.3
26	0.45	1791	1778	13	28.9
27	1.65	1800	1780	20	12.1

Stony River Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
28	0.6	1799	1788	11	18.3
29	0.8	1801	1788	13	16.3
30	1.75	1850	1789	61	34.9
31	0.25	1799	1798	1	4
32	0.3	1799	1798	1	3.3
33	0.3	1840	1833	7	23.3
34	0.7	1841	1833	8	11.4
35	0.15	1800	1797	3	20
36	0.55	1790	1784	6	10.9
37	4.3	1838	1777	61	14.2
38	1.0	1725	1689	36	36
39	0.7	1719	1689	28	40
40	0.5	1710	1689	21	42
41	1.05	1730	1689	41	39.0
42	1.8	1751	1736	15	8.3
43	1.0	1751	1736	15	15
44	3.4	1851	1808	43	12.6
45	0.4	1812	1808	4	10
46	1.1	1787	1736	51	46.3
47	0.2	1737	1736	1	5
48	0.15	1739	1736	2	13.3
49	0.45	1870	1862	8	17.8
50	2.65	1899	1862	37	14.0
51	1.45	1898	1859	39	26.9
52	0.6	1891	1868	23	38.3
53	0.95	1943	1936	7	7.4
54	0.7	1940	1936	4	5.7

Stony River Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
55	3.1	1993	1930	63	20.3
56	0.25	1948	1941	7	28
57	0.1	1944	1941	3	30
58	0.7	1900	1858	42	60
59	2.2	1905	1818	87	39.5
60	0.4	1846	1818	28	70
61	0.5	1828	1817	11	22
62	0.3	1693	1692	1	3.3
63	0.7	1699	1679	20	28.6
64	0.2	1706	1705	1	5
65	0.3	1710	1705	5	16.7
66	2.3	1680	1668	12	5.2
67	2.65	1707	1668	39	14.7
68	0.4	1549	1538	11	27.5
69	0.6	1548	1538	10	16.7
70	3.6	1600	1515	85	23.6
71	0.5	1518	1515	3	6
72	2.1	1578	1516	62	29.5
73	0.9	1605	1596	9	10
74	1.0	1615	1596	19	19
75	0.7	1529	1516	13	18.6

1st order streams

total length	65.25 mi
mean length	0.87 mi
mean gradient A	20.6 ft/mi
ave. gradient B	21.0 ft/mi

Stony River Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	1.7	1659	1642	17	10
2	0.3	1668	1666	2	6.7
3	2.1	1683	1666	17	8.1
4	0.6	1630	1617	13	21.7
5	2.6	1693	1692	1	0.4
6	0.6	1699	1691	8	13.3
7	3.2	1788	1778	10	3.1
8	1.9	1798	1778	20	10.5
9	3.0	1833	1778	55	18.3
10	4.7	1808	1736	72	15.3
11	7.4	1862	1818	44	5.9
12	2.6	1936	1859	77	29.6
13	1.5	1941	1859	82	54.7
14	4.9	1705	1661	44	9.0
15	3.1	1668	1643	25	8.1
16	2.6	1538	1472	66	25.4
17	0.3	1515	1511	4	13.3
18	7.5	1596	1511	85	11.3

2nd order streams

total length 50.6 mi
mean length 2.8 mi
mean gradient[A] 14.7 ft/mi
ave. gradient[B] 12.7 ft/mi

Stony River Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	5.9	1666	1603	63	10.7
2	1.0	1691	1690	1	1
3	11.2	1778	1690	88	7.9
4	11.9	1859	1689	170	14.3
5	2.95	1511	1442	69	23.4

3rd order streams

total length 32.95 mi
mean length 6.59 mi
mean gradient [A] 11.5 ft/mi
ave. gradient [B] 11.9 ft/mi

1	24.65	1690	1421	269	10.9

4th order stream

length 24.65 mi
gradient [B] 10.9 ft/mi

A) mean gradient (ft/mi) = Σ gradients (ft/mi) ÷ number of streams

B) ave. gradient (ft/mi) = Σ Δ elevations (ft) ÷ Σ stream lengths (mi)

FORM 7181-8 WJ U.S.A.

#13

Unnamed Creek Watershed (Bob Bay)

N

Scale 1/4" = 1 mile

1st order

Bob Bay (unnamed creek) watershed

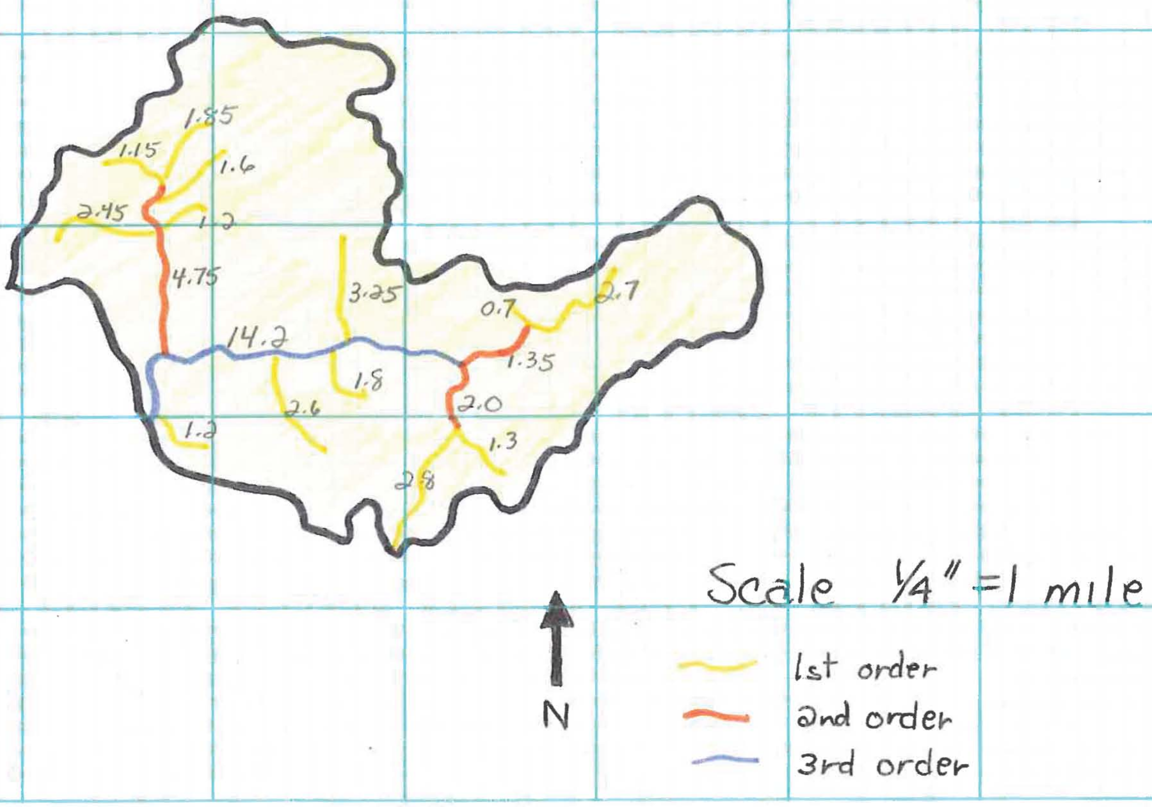
	length of segment	start elevation	end elevation	change in elevation	gradient ft/mi
1	1.75	1480	1418	62	35.4

1st order stream

length 1.75 mi
gradient 35.4 ft/mi

#14

Embarrass River Watershed



Embarrass River Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient in ft/mi
1	1.2	1438	1412	26	21.7
2	2.6	1459	1422	37	14.2
3	1.8	1446	1424	22	12.2
4	2.8	1677	1481	196	70.0
5	1.3	1565	1481	84	64.6
6	2.7	1465	1430	35	13.0
7	0.7	1448	1430	18	25.7
8	3.25	1471	1424	47	14.5
9	1.2	1453	1433	20	16.7
10	1.6	1463	1441	22	13.8
11	1.85	1471	1445	26	14.1
12	1.15	1455	1445	10	8.7
13	2.45	1455	1433	22	9.0

1st order streams

total length	24.6 mi
mean length	1.89 mi
mean gradient A	22.9 ft/mi
ave. gradient B	23.0 ft/mi

Embarrass River Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	2.0	1481	1429	52	26.0
2	1.35	1430	1429	1	0.7
3	4.75	1445	1417	28	10.9

2nd order streams

total length 8.1 mi
mean length 2.7 mi
mean gradient [A] 10.9 ft/mi
ave. gradient [B] 10.0 ft/mi

1	14.2	1429	1411	18	1.3

3rd order streams

length 14.2 mi
gradient [B] 1.3 ft/mi

grand total stream length 46.9

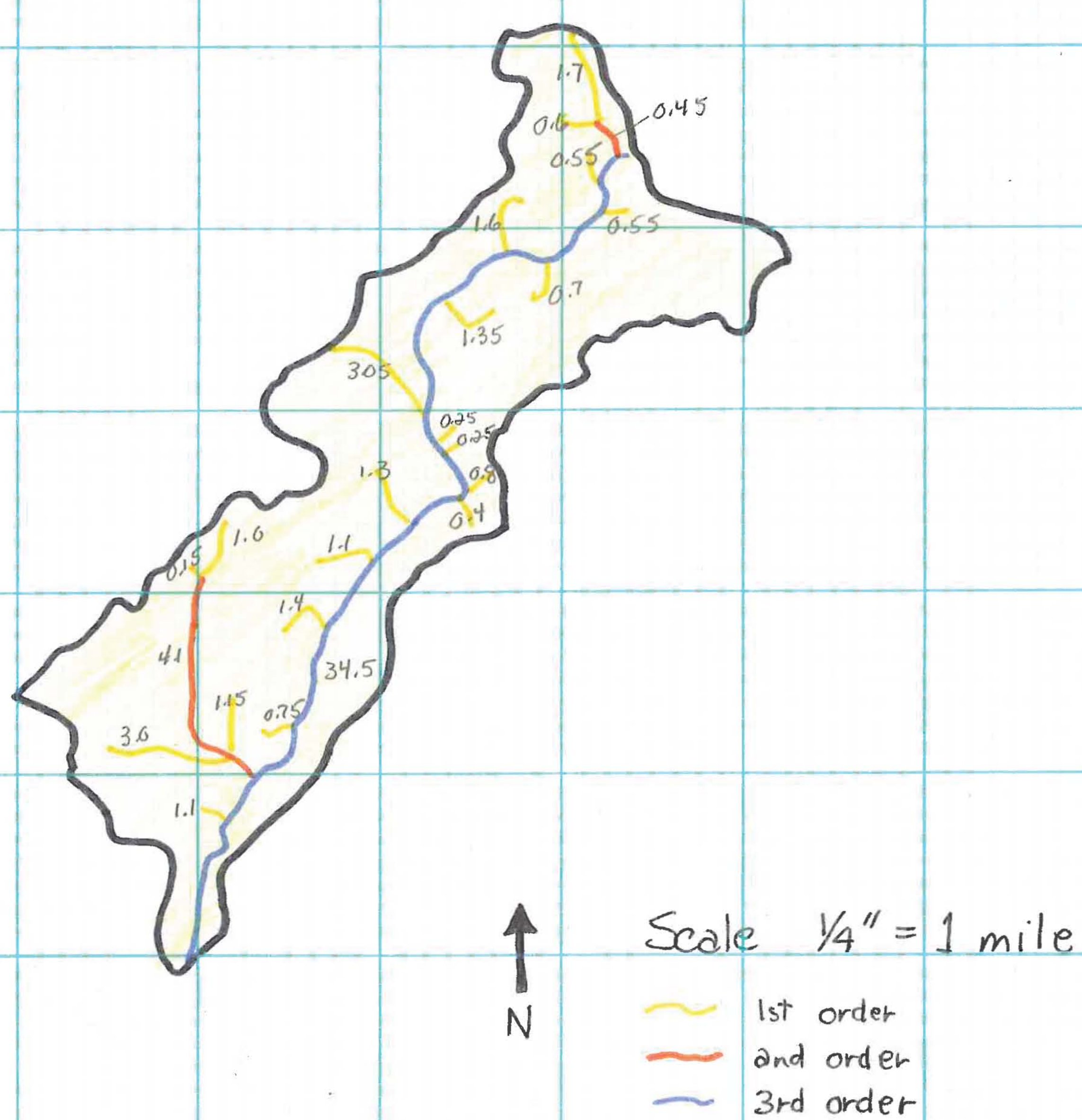
A) mean gradient (ft/mi) = Σ gradients (ft/mi) ÷ number of streams

B) ave. gradient (ft/mi) = Σ Δ elevations (ft) ÷ Σ stream lengths (mi)

FORM 7181-8 WJ U.S.A.

#15

Lower Embarrass River Watershed



LOWER EMBARRASS RIVER WATERSHED

stream #	segment length	
1	0.4	
2	0.8	
3	0.25	
4	0.25	
5	1.35	
6	0.7	
7	0.55	
8	1.7	
9	0.6	
10	0.55	
11	1.6	
12	3.05	
13	1.3	
14	1.1	
15	1.4	
16	0.75	
17	1.15	
18	1.6	
19	0.15	
20	3.0	
21	1.1	
	2275	total
	1.08	x̄

1st order

segment length	
0.45	
4.1	
4.55	total
2.28	x̄

2nd order

segment length	
34.5	
34.5	total
34.5	x̄

3rd order

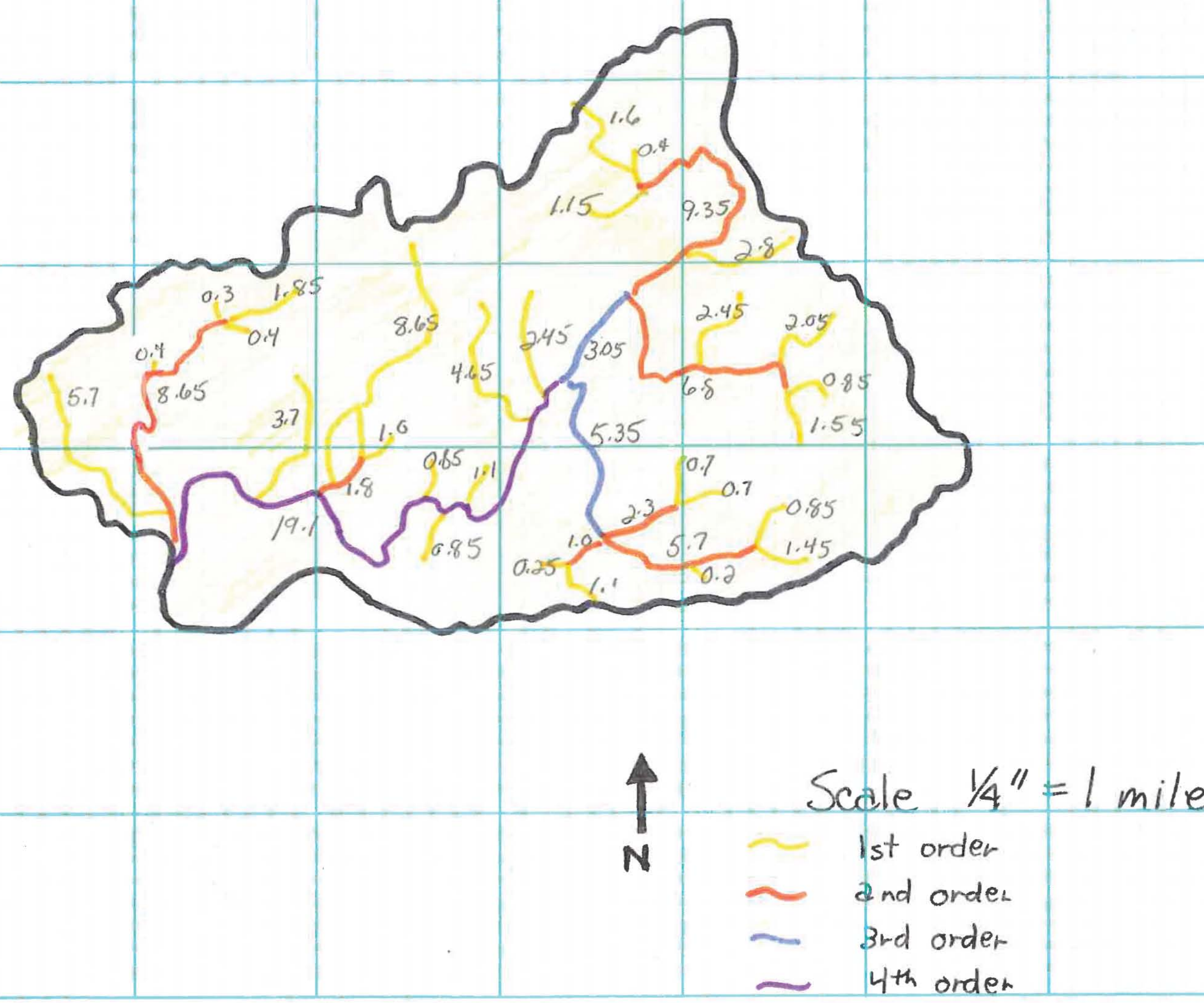
watershed stream length

grand total 61.8 miles

FORM 7181-8 WJ U.S.A.

#16

Partridge River Watershed



Partridge River Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	0.85	1517	1497	20	23.5
2	0.25	1546	1544	2	8.0
3	1.1	1560	1544	16	14.5
4	0.2	1572	1558	14	70
5	1.45	1670	1580	90	62.1
6	0.85	1631	1580	51	60.0
7	0.7	1570	1559	11	15.7
8	0.7	1580	1559	21	30.6
9	1.55	1637	1577	60	38.7
10	0.85	1613	1577	36	42.4
11	2.05	1594	1569	25	12.2
12	2.45	1599	1538	61	24.9
13	2.8	1572	1536	36	12.9
14	0.4	1609	1599	10	25.0
15	1.6	1688	1599	89	55.6
16	1.15	1607	1598	9	7.8
17	2.45	1577	1518	59	24.1
18	4.65	1580	1516	64	13.8
19	1.1	1522	1498	24	21.8
20	0.85	1528	1495	33	38.8
21	1.0	1510	1483	27	27
22	8.65	1609	1483	126	14.6
23	3.7	1533	1439	94	25.4
24	0.35	1442	1439	3	8.6
25	0.4	1485	1483	2	5.0
26	1.85	1495	1483	12	6.5
27	0.3	1483	1482	1	3.3

Pertridge River Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
28	0.4	1469	1460	9	22.5
29	5.7	1559	1409	150	26.3

1st order streams

total length 50.35 mi
mean length 1.7 mi
mean gradient[A] 25.6 ft/mi
ave. gradient[B] 22.9 ft/mi

1	1.0	1544	1539	5	5
2	5.7	1580	1549	31	5.4
3	2.3	1559	1549	10	4.3
4	6.8	1577	1527	50	7.4
5	9.35	1599	1527	72	7.7
6	1.8	1483	1439	44	24.4
7	8.65	1483	1402	81	9.4

2nd order streams

total length 35.6 mi
mean length 5.1 mi
mean gradient[A] 9.1 ft/mi
ave. gradient[B] 8.2 ft/mi

Partridge River Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	5.35	1549	1520	29	5.4
2	3.05	1527	1520	7	2.3

3rd order streams

total length 8.4 mi

mean length 4.2 mi

mean gradient[A] 3.85 ft/mi

ave. gradient[B] 4.3 ft/mi

1	19.1	1520	1401	119	6.2

4th order stream

length 19.1 mi

gradient[B] 6.2 ft/mi

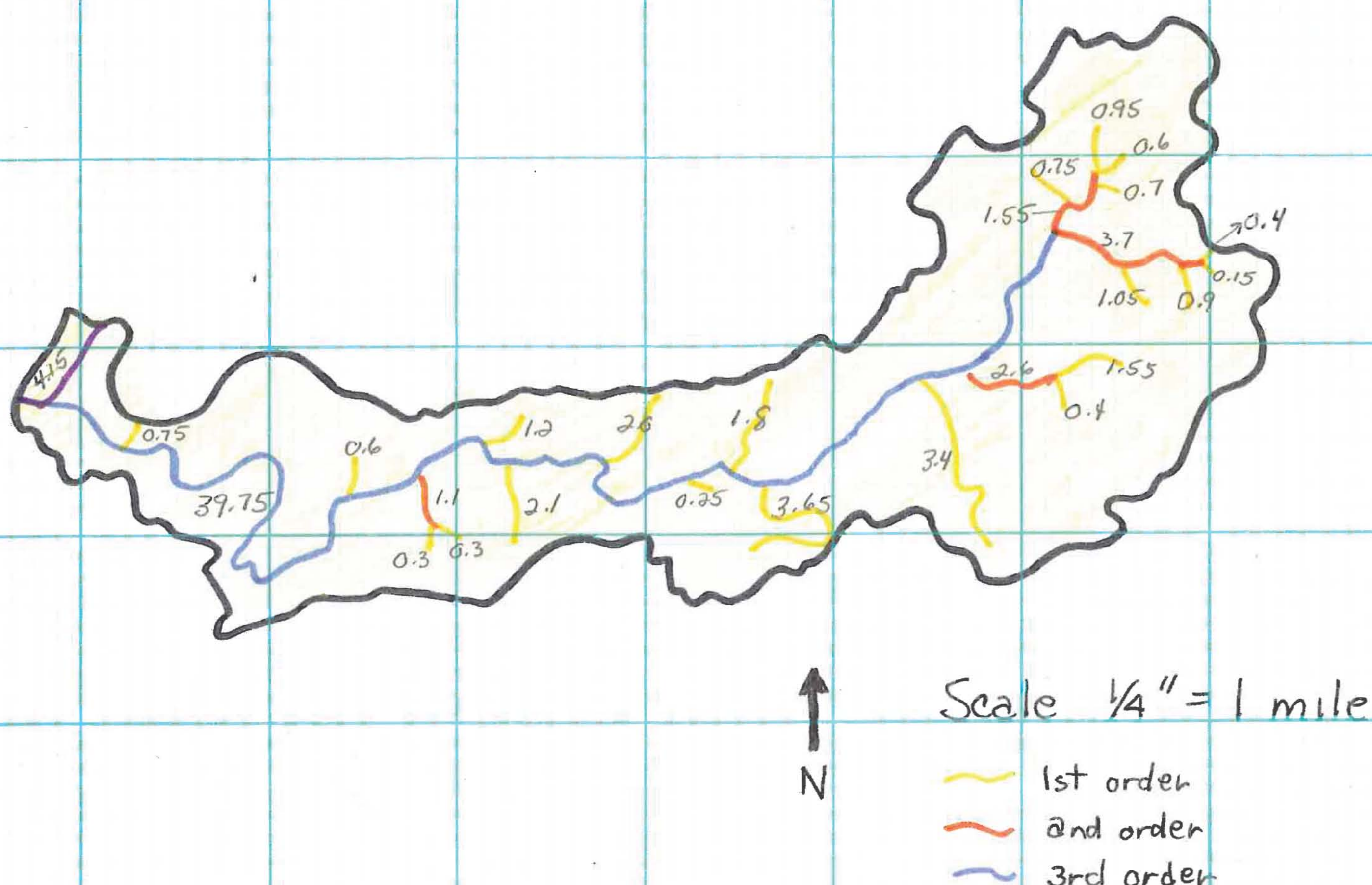
grand total stream length 113.45

A) mean gradient (ft/mi) = Σ gradients (ft/mi) $\div$ number of streams

B) ave. gradient (ft/mi) = Σ Δ elevations (ft) $\div$ Σ stream lengths (mi)

#17

St. Louis River Watershed



St. Louis River Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	0.3	1550	1546	4	13.3
2	0.3	1551	1546	5	16.7
3	2.1	1598	1556	42	20.0
4	0.25	1653	1651	2	8.0
5	3.65	1665	1655	10	2.7
6	3.4	1708	1669	39	11.5
7	0.4	1699	1688	11	27.5
8	1.55	1718	1688	30	19.4
9	1.05	1700	1689	11	10.5
10	0.9	1709	1699	10	11.1
11	0.15	1707	1702	5	33.3
12	0.4	1709	1702	7	17.5
13	0.7	1683	1677	6	8.6
14	0.6	1682	1679	3	5.0
15	0.95	1691	1679	12	12.6
16	0.75	1687	1676	11	14.7
17	1.8	1669	1654	15	8.3
18	2.0	1620	1588	32	16.0
19	1.2	1563	1542	21	17.5
20	0.6	1512	1504	8	13.3
21	0.75	1409	1399	10	13.3

1st order streams

total length 23.8 mi

mean length 1.1 mi

mean gradient[A] 14.3 ft/mi

ave. gradient[B] 12.4 ft/mi

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	1.1	1546	1508	38	34.6
2	2.6	1688	1669	19	7.3
3	3.7	1702	1673	29	7.8
4	1.55	1679	1673	6	3.9

2nd order streams

total length 8.95 mi
mean length 2.2 mi
mean gradient[A] 13.4 ft/mi
ave. gradient[B] 10.3 ft/mi

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	39.75	1673	1372	291	7.3

3rd order stream

length 39.75 mi
gradient[B] 7.3 ft/mi

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	4.15	1401	1374	27	6.5

4th order stream

length 4.15 mi
gradient[B] 6.5 ft/mi

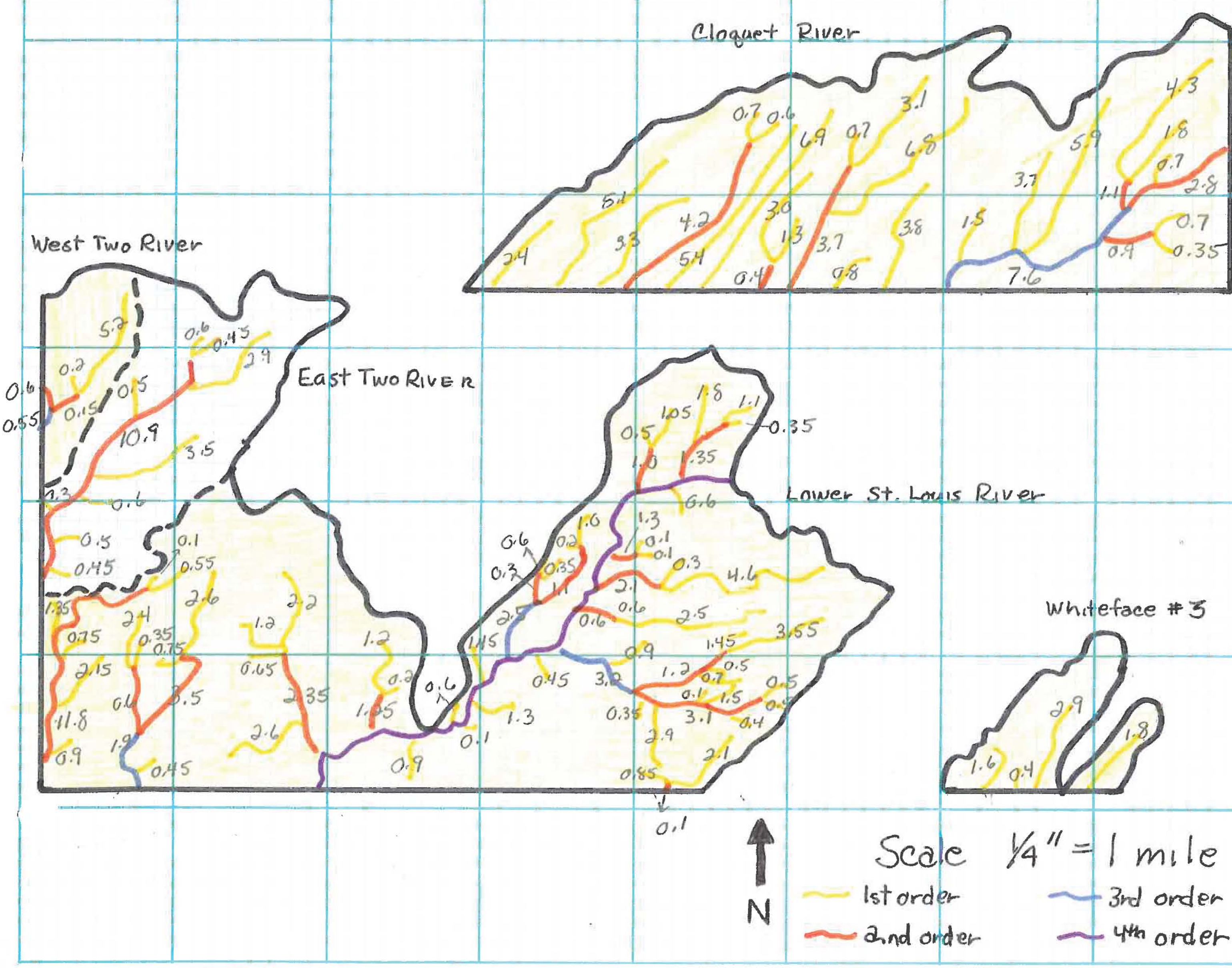
grand total stream length 76.65 mi.

A) mean gradient (ft/mi) = Σ gradients (ft/mi) ÷ number of streams

B) ave. gradient (ft/mi) = Σ Δ elevations (ft) ÷ Σ stream lengths (mi)

#18

Lower St. Louis River Watershed



LOWER ST. LOUIS WATERSHED

1st order

stream #	segment length
1	0.9
2	0.1
3	1.3
4	0.45
5	0.35
6	2.9
7	0.4
8	0.5
9	0.5
10	1.5
11	0.1
12	0.7
13	0.5
14	3.55
15	1.45
16	0.9
17	2.5
18	0.6
19	4.6
20	0.3
21	0.1
22	0.1
23	0.6
24	0.35
25	1.1
26	1.8
27	1.05

↓

2nd order

segment length	
3.1	
1.2	
0.6	
2.1	
1.3	
1.35	
1.0	
1.1	
0.3	
1.25	
2.35	
3.5	
0.6	
11.8	
31.55	total
2.25	$\bar{x}$

3rd order

segment length	
3.2	
2.5	
1.9	
7.6	total
2.53	$\bar{x}$

4th order

	segment length
	28.95
total	28.95
$\bar{x}$	28.95

LOWER ST LOUIS WATERSHED

stream #	segment length
28	0.5
29	1.0
30	0.2
31	0.35
32	0.6
33	1.45
34	0.6
35	0.2
36	1.2
37	2.2
38	1.2
39	0.65
40	2.6
41	0.2
42	0.45
43	2.6
44	0.75
45	0.35
46	2.4
47	0.3
48	0.9
49	2.15
50	0.75
51	0.55
52	0.1
53	1.35

54.8 total

1.03 X̄

1st order

watershed stream length

grand total 122.9

Mud Hen Creek Watershed

stream #	segment length	
1	2.1	
2	0.85	
	2.95	total
	1.48	mean

1st order

segment length	
0.1	PARTIAL
0.1	total
0.1	mean

2nd order

watershed streom length	
grand total	3.05

UNKNOWN SOUTH OF ST. LOUIS

stream #	segment length	
1	1.8	PARTIAL
2	2.9	PARTIAL
3	0.4	PARTIAL
4	1.6	PARTIAL
	6.7	total
	1.68	$\bar{X}$

1st order

UNKNOWN SOUTH OF ST. LOUIS & STONEY

stream #	segment length	
1	0.35	
2	0.7	
3	0.7	
4	1.8	
5	4.3	
6	5.9	
7	3.7	
8	1.5	
9	3.8	PARTIAL
10	0.8	PARTIAL
11	6.8	
12	3.1	
13	0.7	
14	1.3	
15	3.0	
16	6.9	PARTIAL
17	5.4	PARTIAL
18	0.6	
19	0.7	
20	3.3	PARTIAL
21	5.1	PARTIAL
22	2.4	PARTIAL
	62.85	total
	2.86	mean

1st order

segment length	
0.9	
2.8	PARTIAL
1.1	
3.7	PARTIAL
0.4	PARTIAL
4.2	PARTIAL
13.1	total
2.18	mean

2nd order

segment length	
7.6	PARTIAL
7.6	total
7.6	mean

3rd order

watershed stream length

grand total 83.55

SOUTH OF DIVIDE

EAST TWO RIVER WATERSHED

stream #	segment length	comments
1	0.45	
2	0.5	
3	0.6	
4	3.5	
5	2.9	
6	0.45	
7	0.6	
8	0.5	
9	0.3	PARTIAL
	9.8	total
	1.09	$\bar{X}$

1st order

segment length	comments
10.9	PARTIAL
10.9	total
10.9	$\bar{X}$

2nd order

watershed stream length

grand total 20.7 mi

SOUTH OF DIVIDE

WEST TWO RIVER WATERSHED

1st order

stream #	segment length	comment
1	5.2	
2	0.2	
	5.4	total
	2.7	$\bar{x}$

2nd order

segment length	comments
0.15	
0.6	PARTIAL
0.75	total
0.38	$\bar{x}$

3rd order

segment length	comments
0.55	PARTIAL
0.55	total
0.55	$\bar{x}$

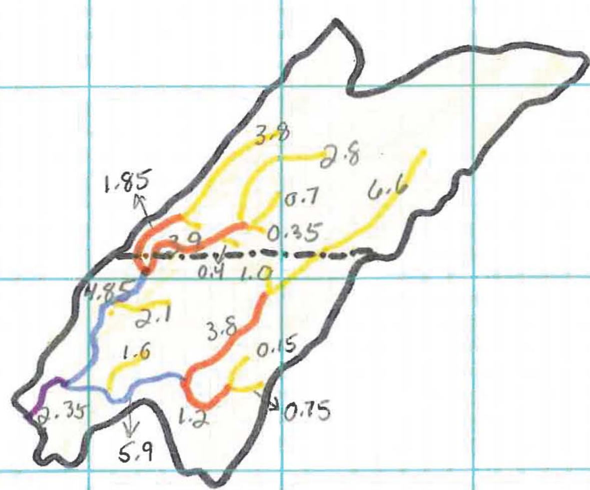
watershed stream length

grand total 6.7 mi

FORM 7181-8 WJ U.S.A.

#19

Water Hen Creek Watershed



N

Scale 1/4" = 1 mile

1st order

2nd order

3rd order

4th order

Water hen Creek Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	0.75	1443	1431	12	16
2	0.15	1433	1431	2	13.3
3	6.6	1519	1435	84	12.7
4	1.0	1475	1435	40	40
5	1.0	1393	1392	1	1
6	2.1	1440	1383	57	27.1
7	0.4	1427	1410	17	42.5
8	0.35	1461	1424	37	105.7
9	0.7	1458	1424	34	48.6
10	2.8	1518	1417	101	36.1
11	0.5	1410	1402	8	16
12	3.8	1460	1402	58	15.3

1st order streams

total length	20.15	mi
mean length	1.7	mi
mean gradient [A]	31.2	ft/mi
ave. gradient [B]	22.4	ft/mi

A) mean gradient (ft/mi) = Σ gradient (ft/mi) ÷ number of streams

B) ave. gradient (ft/mi) = $\Sigma \Delta$ elevations (ft) ÷ Σ stream lengths (mi)

Water Hen Creek Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	1.2	1431	1419	12	10
2	3.8	1435	1419	16	4.2
3	3.9	1424	1388	36	9.2
4	1.85	1402	1388	14	7.6

2nd order streams

total length 10.75 mi
mean length 2.7 mi
mean gradient[A] 7.7 ft/mi
ave. gradient[B] 7.3 ft/mi

1	5.9	1419	1359	60	10.2
2	4.85	1388	1359	29	6.0

3rd order streams

total length 10.75 mi
mean length 5.4 mi
mean gradient[A] 8.1 ft/mi
ave. gradient[B] 8.3 ft/mi

1	2.35	1359	1359	0	0

4th order streams

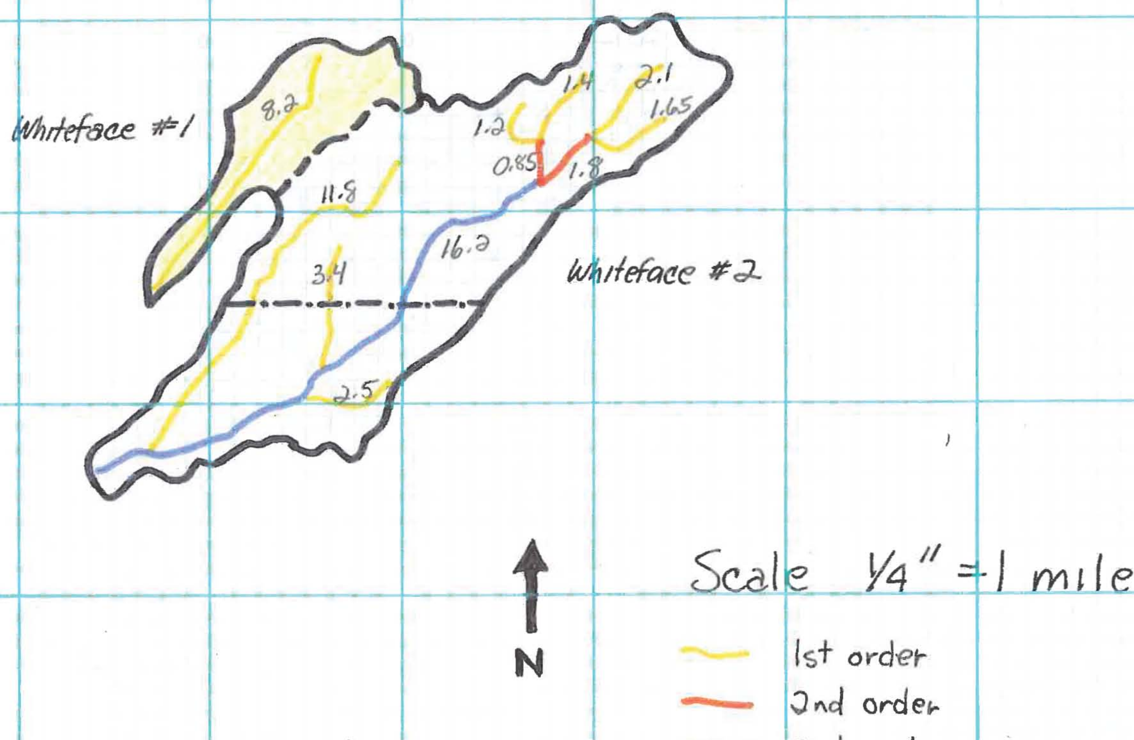
length 2.35 mi
gradient[B] 0 ft/mi

grand total stream length 44.0 mi

FORM 7181-8 WJ U.S.A.

#20

Whiteface River Watershed



Whiteface #1 Shiver Creek Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	8.2	1608	1501	107	13.0

length 8.2 mi
gradient 13.0 ft/mi

Whiteface #2 North Branch Whiteface River Watershed

stream #	segment length	start elevation	end elevation	change in elevation	gradient ft/mi
1	2.5	1600	1577	23	9.2
2	1.65	1708	1636	72	43.6
3	2.1	1670	1636	34	16.2
4	1.4	1648	1636	12	8.6
5	1.2	1652	1636	16	13.3
6	3.4	1620	1582	38	11.2
7	11.8	1669	1506	163	13.8

1st order streams

total length 24.05 mi
mean length 3.4 mi
mean gradient [A] 16.6 ft/mi
ave. gradient [B] 14.9 ft/mi

1	1.8	1636	1625	11	6.1
2	0.85	1636	1625	11	12.9

2nd order streams

total length 2.65 mi
mean length 1.3 mi
mean gradient [A] 9.5 ft/mi
ave. gradient [B] 8.3 ft/mi

1	16.2	1625	1483	142	8.8

3rd order streams

length 16.2 mi
gradient [B] 8.8 ft/mi

A) mean gradient (ft/mi) = Σ gradients (ft/mi) ÷ number of streams

B) ave. gradient (ft/mi) = Σ Δ elevations (ft) ÷ Σ stream lengths (mi)

DRAINAGE AREAS OF COPPER-NICKEL STUDY WATERSHEDS

SOURCE: U.S.G.S.

North of Laurentian Divide (Rainy River Drainage)

Code	Subwatershed Name	Drainage Area of Subwatershed km^2	Feeder Subwatersheds (using code)	Total Drainage through Subwatershed km^2
A	Little Isabella	132	none	132
B	Isabella (il)	751	A	883
C	Filson (fl)	27	none	27
D	Keeley Creek (kcl)	29	none	29
E	Stony (sr 5)	125	none	125
F	Stony (sr 4)	161	none	161
G	Stony (sr 3)	180	F+E	466
H	Stony (sr 2)	101	G+F+E	567
I	Stony (sr 1)	65	H+G+F+E	632
J	Unnamed Creek (bbl)	11	none	11
K	Dunka (d2)	44	none	44
L	Dunka (dl)	84	K	128
M	Bear Island (bil)	177	none	177
N	Shagawa (shl)	256	none	256
O	Kawishiwi (k6)	655	none	655
P	Kawishiwi (k7)	236[a]	½O+A+B+C	1474[a]
Q	Kawishiwi (k5)	262[a]	P+½O+A+B+C +D+E+F+G+H +I+J+K+L	2536[a]
R	Kawishiwi (k4)	66[a]	Q+P+½O+A+B +C+D+E+F+G +I+J+K+L+M+H	2779[a]
S	Kawishiwi (k3)	64	R+Q+P+O+A+ B+C+D+E+F+ G+H+I+J+K+ L+M	3170

North of Laurentian Divide (Rainy River Drainage)

Code	Subwatershed Name	Drainage Area of Subwatershed km^2	Feeder Subwatersheds (using code)	Total Drainage through Subwatershed km^2
T	Kawishiwi (k1)	63	S+R+Q+P+O +A+B+C+D +E+F+G+H +I+J+K+L +M+N	3489

a) Drainage areas estimated because of North/South Kawishiwi River split.

South of Laurentian Divide (Rainy River Drainage)

Code	Subwatershed Name	Drainage Area of Subwatershed km^2	Feeder Subwatersheds (using code)	Total Drainage through Subwatershed km^2
U	Embarrass (e2)	46	none	46
V	Embarrass (e1)	183	U	229
W	Partridge (p5)	32	none	32
X	Partridge (p4)	48	none	48
Y	Partridge (p3)	47	none	47
Z	Partridge (p2)	137[b]	Y+X+W	264[b]
1	Partridge (p1)	71	Z+Y+X+W	335[b]
2	St. Louis (s13)	157	none	157
3	St. Louis (s12)	86	2	243
4	St. Louis (s11)	107	3+2+1+8 +Z+Y+X+W	754[b]
5	Whiteface (wf1)	24	none	24
6	Whiteface (wf2)	124	none	124
7	Waterhen (w1)	118	none	118
8	Second Creek	69	none	69

b) Includes $13 km^2$ in watershed P-2 defined by U.S.G.S. as noncontributing.