DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
THE STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCES

HYDROLOGIC INVESTIGATONS
ATLAS HA-376

INTRODUCTION

Sediment in Wisconsin streams causes economic and engineering problems in water management and reduces the value of water for nearly all uses. Sediment produces problems such as reduced reservoir capacity, navigation hazards, increased cost of water treatment, property damage, temporary loss of farmland, destruction of feeding and nesting grounds of fish, and destruction of wildlife habitat. Sediment in water also reduces the aesthetic value of surface waters and is detrimental to the State's tourist and recreation industry.

The yield of sediment from a drainage basin is subject to many environmental influences. Most sediment results from the weathering and erosion of soil and rock materials. Other factors such as rainfall intensity, runoff rate, topography, rock type, soil characteristics, vegetal cover, and land use also influence the rate of sediment production and movement. An understanding of the many parameters that influence sediment yield is a basic need for managing the State's water resources.

The purpose of this report is to describe the magnitude and variability of sediment in Wisconsin streams, to relate sediment yields to the local environment, and to identify areas that need further study. The report is based on sediment data from 44 stream-gaging sites throughout the State. Determination of local areas of erosion and deposition are beyond the scope of the report.

DETERMINATION OF YIELD

Sediment yields, in tons per square mile per year, were determined by periodically collecting water-sediment samples at stream-gaging stations using standard sampling procedures (Inter-Agency Committee on Water Resources, 1963), analyzing the samples in a laboratory for the concentration of suspended sediment in mg/l (milligrams per liter) (Inter-Agency Committee on Water Resources, 1941), and calculating the daily and annual yields for the basin above the station (Jordan and others, 1964, p. 61–62).

A generalized suspended sediment rating curve for each station was developed from many sediment-discharge values that represent a wide range of water-discharge values (Mundorff and Scott, 1964, p. 18). An estimate of the average suspended sediment discharge at each station may be obtained for any given water discharge from these curves. An example is shown for the Big Eau Pleine River near Stratford, Wis.

The short-term annual sediment yield (weighted average) was computed for the period of sediment data collection. The long-term annual sediment discharge was determined by adjusting the short-term, average sediment discharges of all stations to a 23-year base period, 1945–67, based on the average yearly stream discharge at each station for the 23-year period.

The annual volume of transported sediment, in acre-feet, was computed using an average specific weight (dry) of submerged sediment, which is about 79 pounds per cubic foot or 1,720 tons per acre-foot (Spraberry, 1964, p. 20.) This volume is a basin average and should not be confused with the rainfall erosion loss values (Wischmeier and Smith, 1965) used in estimating soil loss from individual fields.

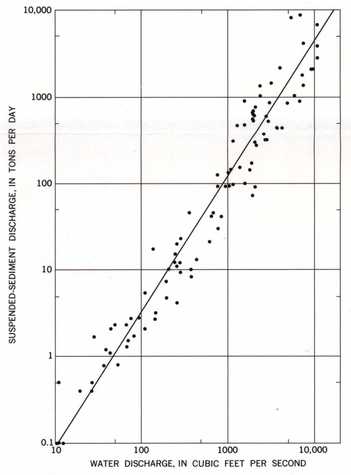
Descriptive terms "low", "intermediate", "high", used to describe the magnitude of sediment yield, apply only to the range of yields in Wisconsin and are not necessarily applicable to other States.

SEDIMENT YIELDS AND GLACIAL DEPOSITS

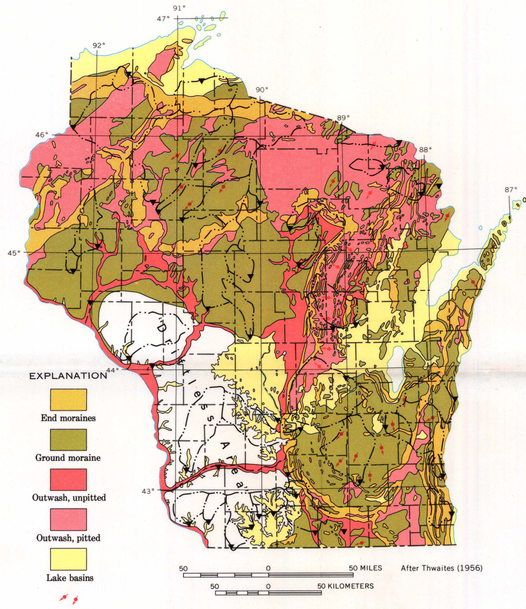
Glacial geology is a major factor affecting sediment yields. Glacial deposits and the topography of glaciated areas influence the rate and amount of runoff and the amount and type of stream-transported sediment.

The highest sediment yields in the glaciated areas of the State are from glacial lake deposits, which contain fine-grained clays that are easily eroded. Such clays are near Lake Superior in the northern part of the State and near Green Bay and Lake Winnebago in east-central Wisconsin. Ground and end morainal deposits in the central, western, and southeastern parts of the State usually produce intermediate sediment yields. Outwash areas in the central sand plain and in the northwestern and northeastern parts of the State generally produce the smallest amount of sediment.

The "Driftless Area" of southwestern Wisconsin has the highest sediment yield in the State. Much of the sediment in this area is from loess (aeolian silt), which occurs on ridge tops and valley sides. The thickness of the loess in the "Driftless Area" increases from east (about 2 feet) to west (about 16 feet along the Mississippi River).



RELATIONSHIP OF SEDIMENT DISCHARGE TO WATER DISCHARGE
BIG EAU PLEINE RIVER NEAR STRATFORD, WISCONSIN



GLACIAL DEPOSITS

SEDIMENT YIELDS AND MAJOR SOIL REGIONS

Soil characteristics such as particle size, cohesiveness, porosity, and moisture content are important factors in sediment yields because they partly determine the rate of overland runoff (Colby, 1963, p. A5). The significance of each soil region to sediment yield is discussed briefly below.

Reddish clay loams along Lake Superior and in the Lake Winnebago and Green Bay areas produce high sediment yields. The low permeability of these soils results in rapid runoff during storms; therefore, these soils are very susceptible to erosion where improper land use, clear cutting of forest cover, construction, or road-building practices leave exposed soil. In the Lake Superior area, clay soils occur up to 400 feet above the present lake level. Stream gradients are steep (as much as 100 feet per mile) and natural erosion is severe (Red Clay Inter-Agency Comm., 1967).

Grayish-brown silt loams (glaciated) in southeastern Wisconsin produce intermediate annual sediment yields ranging from 13 to 85 tons per square mile. The topography in this area is gently rolling, and farming is intense.

Grayish-brown silt loams (unglaciated) in the southwestern area produce high annual yields ranging from 300 to 700 tons per square mile. The topography of the "Driftless Area" is steep and the silt-loam soils erode relatively easily, as do silty soils in general (Collier, 1963, p. B33). Exposed sandstone, siltstone, shale, and dolomite on steep valley slopes also erode and increase the sediment yield. Where cattle graze on the slopes and grain and hay are grown on ridges, natural erosion is accelerated.

Pink loams in the northeastern part of the State produce low yields. This area contains many wetlands and forests, and the topography is nearly flat. Farming is limited to dairying and specialty crops.

Grayish-yellow silt loams in north-central Wisconsin have average annual sediment yields of 10 to 70 tons per square mile. The lowest yields are in level areas that have heavy forest cover and contain lakes. There is very little farming.

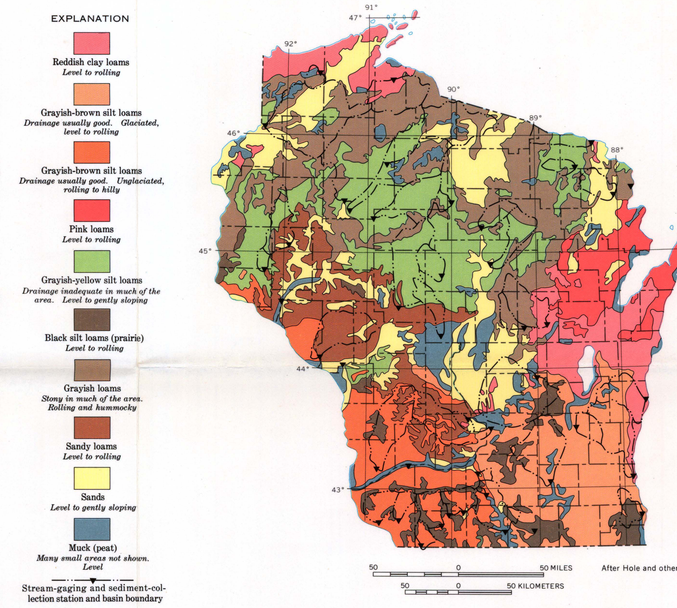
Black silt loams or prairie soils in southern Wisconsin may produce high sediment yields. These silt soils occur on broad, gently rolling uplands, which are farmed intensely.

Grayish loams in northern Wisconsin have a very low annual sediment yield ranging from 5 to 15 tons per square mile. In this area the topography is gently rolling, there are many lakes, and most of the land is forested. Grayish loams are the most permeable loams in the State, and runoff rates are low.

Sandy loams in west-central Wisconsin have intermediate average annual sediment yields ranging between 20 to 50 tons per square mile. The topography is rolling, and farming is intense.

Sand regions in isolated patches in central and northern Wisconsin have average annual sediment yields less than 20 tons per square mile. Sediment yields are low despite severe wind erosion in truck farming areas because of rapid infiltration rates, extensive forest cover, and gentle topography.

Muck (peat) regions are too small and scattered to estimate the sediment yield. Organic material is common in sediments derived from these areas. Generally sediment yields are low because of the flat topography and the abundance of lakes and wetlands that trap sediments.



MAJOR SOIL REGIONS

SEDIMENT YIELDS AND LAND USE AND COVER

Land use is a constantly changing factor that alters natural rates of sediment yield. Land uses such as forests, farming, wetlands, and urbanization have different effects on the sediment yield of a basin.

Many agricultural areas have high sediment yields because farming requires that the land be without protective vegetal cover for part of the year. However, the type of crops planted and the agricultural practices of the farmer also affect sedimentation. Cover crops such as hay and small grains result in less sediment than row crops such as corn (Enlow, 1939, p. 17).

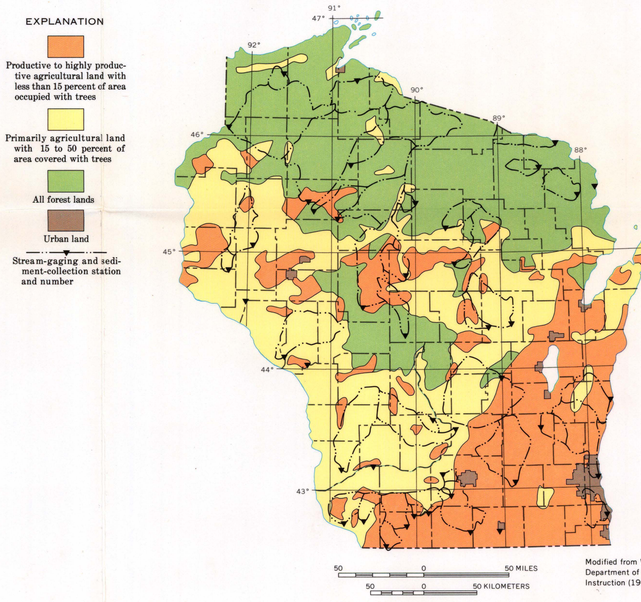
In large agricultural areas sediment yield ranges from about 20 to several hundred tons per square mile per year. The average basin yield, however, is smaller in agricultural areas that have more than 15-percent tree cover than in areas that have less than 15-percent tree cover.

Sediment yield is low in most of the northern one-third of the State, where there is much forest cover and little agriculture. This low yield, generally less than 20 tons per square mile per year, indicates that forests retard soil erosion (Lutz and Chandler, 1946, p. 453).

Sediment yields in urban areas tend to be higher than sediment yields in adjacent rural areas. Impermeable surfaces such as roads, parking lots, and building roofs reduce infiltration and increase the rate of runoff. Straightening and dredging of stream channels increase the rate of runoff and erosion of the stream channel. Construction activities cause a sharp, temporary increase in erosion rates because the land surface is denuded.

Wetland areas in the State are being continually reduced by drainage for agricultural purposes. Drained areas have more rapid runoff than undrained wetlands, producing higher sediment yields.

Sediment yields, as discussed above, are in part a result of past land-management practices. Improved management practices may decrease the size of future sediment yields.

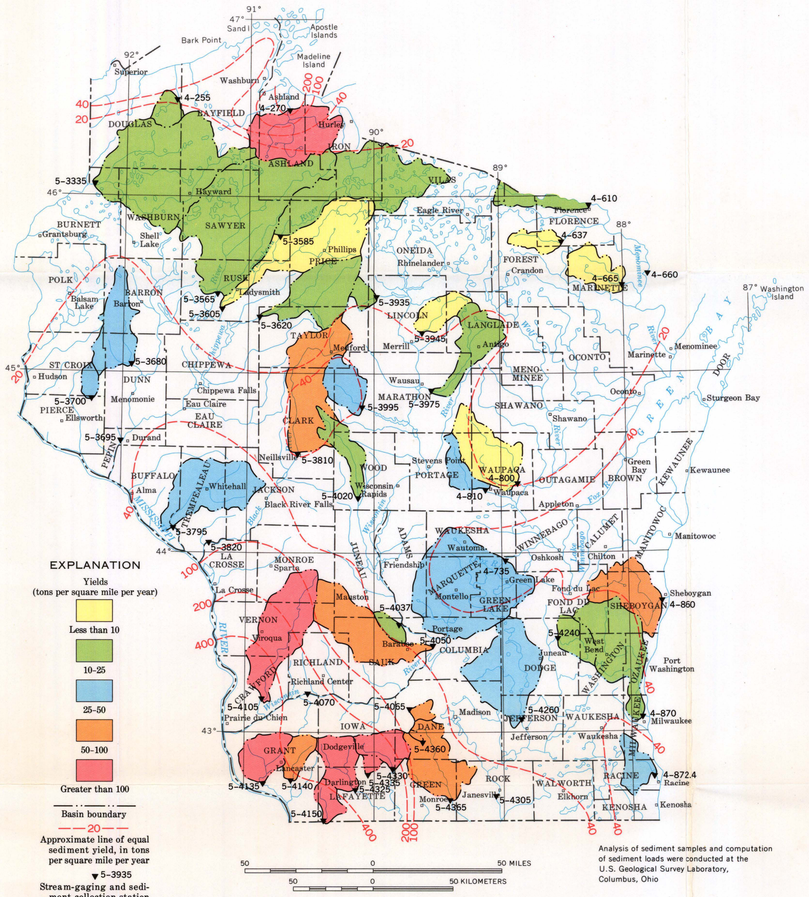


LAND USE AND COVER

SEDIMENT YIELD AND RELATED FACTORS

Station number	Stream and location[3]	Drainage area (sq mi)	Average discharge (cfs)	Annual sediment yields: Short term[1] (tons per sq mi)	Long term[2] (tons per sq mi)	Weighted mean concentration (mg/l)	Volume (acre-feet)	Factors controlling sediment yields (−) Factor promotes low sediment yields (+) Factor promotes high sediment yields: Glacial deposits	Soil types	Topography	Land use and cover	Hydraulic features	Long-term Sediment yield
4-800	Little Wolf River at Royalton	514	394	5.0	4.8	6	1.4	Outwash, pitted (−) End moraines (+) Outwash, unpitted (−)	Loams (−) Clay loams (+)	Flat (−) Rolling (+)	Agricultural (+)	Reservoir (−).	Less than 10
5-3605	Flambeau River near Bruce	1,897	1,735	5.6	6.3	5	7.0	Ground moraine (−) Outwash, pitted (−)	Silt loams (+) Sands (−) Loams (−)	Gently rolling (−) Flat (−)	Forest (−)	Lakes (−). Swamps (−).	
4-637	Popple River near Fence	131	115	6.1	6.6	6	0.5	Outwash, pitted (−)	Silt loams (+)	Flat (−) Gently rolling (−)	Forest (−)	None (+).	
4-665	Pike River at Amberg	253	216	7.7	7.6	9	1.1	Outwash, pitted (−) End moraines (+) Ground moraine (−)	Sands (−) Silt loams (+)	Rolling (+)	Forest (−)	None (+).	
5-3945	Prairie River near Merrill	181	180	9.5	9.1	10	1.0	End moraines (+) Ground moraine (−) Outwash, unpitted (−)	Loams (−) Silt loams (+)	Flat (−) Gently rolling (−)	Forest (−)	Lakes (−). Swamps (−).	
5-3335	St. Croix River near Danbury	1,588	1,278	10	11	12	10	Outwash, pitted (−) Ground moraine (−) End moraines (+)	Sands (−) Loams (−) Silt loams (+) Peat (−)	Flat (−) Gently sloping (−) Rolling (+)	Forest (−)	Lakes (−). Swamps (−).	10–25
5-3565	Chippewa River near Bruce	1,630	1,406	10	11	11	10	Ground moraine (−) Outwash, pitted (−) End moraines (+)	Sandy loams (−)	Flat (−) Gently sloping (−) Rolling (+)	Forest (−)	Lakes (−). Swamps (−). Reservoirs (−).	
5-3585	Flambeau River at Babbs Island near Winter	1,000	962	11	12	12	7.0	Ground moraine (−) Outwash, pitted (−) End moraines (+)	Loams (−) Sands (−) Silt loams (+)	Flat (−) Gently sloping (−) Rolling (+)	Forest (−)	Lakes (−). Swamps (−). Reservoirs (−).	
5-3620	Jump River at Sheldon	574	504	12	12	14	4.0	Ground moraine (−) End moraines (+)	Silt loams (+) Loams (−)	Gently sloping (−)	Forest (−)	Lakes (−). Swamps (−).	
5-3935	Spirit River at Spirit Falls	82	79.7	12	13	13	0.6	Ground moraine (−) End moraines (+)	Silt loams (+) Loams (−)	Flat (−) Gently sloping (−)	Forest (−) Agriculture (+)	Swamps (−).	
4-610	Brule River near Florence	389	343	12	13	13	2.9	Ground moraine (−) Outwash, pitted (−)	Silt loams (+) Loams (−)	Gently sloping (−) Rolling (+)	Forest (−)	Lakes (−).	
5-4240	East Branch Rock River near Mayville	179	85.3	13	14	25	1.5	Ground moraine (−) End moraines (+)	Silt loams (+)	Rolling (+)	Agricultural (+)	Reservoir (−).	
4-870	Milwaukee River at Milwaukee	686	381	16	14	24	5.6	Ground moraine (−) End moraines (+) Outwash, pitted (−)	Silt loams (+) Clay loams (+)	Rolling (+)	Urban (+) Agricultural (+)	Reservoir (−).	
5-4020	Yellow River at Babcock	223	121	21	17	28	2.2	Ground moraine (−)	Sandy loams (−) Peat (−) Silt loams (+)	Flat (−) Rolling (+)	Forest (−) Agricultural (+)	Swamps (−). Bogs (−).	
5-3695	Chippewa River at Durand	9,010	7,206	17	18	21	95	[4]	[4]	[4]	Forest (−) Agricultural (+)	Reservoirs (−).	
5-3975	Eau Claire River at Kelly	326	244	24	21	28	4.0	Ground moraine (−) End moraines (+) Outwash, unpitted (−)	Silt loams (+) Loams (−)	Rolling (+) Gently sloping (−)	Agricultural (+) Forest (−)	None (+).	
5-4037	Dell Creek near Lake Delton[5]	44.9	27.6	20	22	18	0.6	Lake basins (+)	Sandy loams (−)	Steep (+) Gently rolling (−)	Agricultural (+) Forest (−)	None (+).	
4-255	Bois Brule River at Brule	113	169	24	25	12	1.7	End moraines (+) Outwash, pitted (−) Lake basins (+)	Loams (−) Peat (−) Clay loams (+)	Flat (−) Steep (+)	Forest (−)	Swamps (−).	
5-3700	Eau Galle River at Spring Valley	64.8	25.8	35	29	54	1.1	Loess (+) Lake basins (+)	Silt loams (+)	Steep (+) Gently rolling (−)	Agricultural (+) Forest (−)	None (+).	
4-3305	Rock River at Afton	3,300	1,703	26	30	55	58	Ground moraine (−) End moraines (+) Outwash, unpitted (−)	Silt loams (+)	Low rolling (−)	Agricultural (+) Urban (+)	Reservoirs (−).	
4-810	Waupaca River near Waupaca	271	237	34	34	40	5.4	Outwash, pitted (−) End moraines (+)	Loams (−) Sands (−)	Rolling (+)	Agricultural (+) Forest (−)	None (+).	
5-4070	Wisconsin River at Muscoda	10,300	8,423	38	38	46	230	[4]	[4]	[4]	Agricultural (+) Forest (−)	Reservoirs (−).	
5-3680	Hay River at Wheeler	426	265	43	40	59	9.9	Ground moraine (−) End moraines (+) Outwash, pitted (−)	Sandy loams (−) Silt loams (+) Sands (−)	Steep (+) Gently rolling (−)	Agricultural (+) Forest (−)	None (+).	
4-735	Fox River at Berlin	1,430	1,084	39	43	54	36	Lake basins (+) Outwash, pitted (−) Ground moraine (−) End moraines (+)	Sands (−) Silt loams (+) Peat (−)	Rolling (+)	Agricultural (+) Forest (−)	Lakes (−). Swamps (−).	25–50
5-4260	Crawfish River at Milford	732	329	37	44	83	19	Ground moraine (−)	Silt loams (+)	Gently rolling (−)	Agricultural (+) Urban (+)	Reservoirs (−).	
4-660	Menominee River near Pembine	3,240	2,888	47	48	48	72	Outwash, pitted (−) End moraines (+) Ground moraine (−)	Silt loams (+) Loams (−) Sands (−)	Flat (−) Gently rolling (−)	Forest (−)	Lakes (−). Reservoirs (−).	
5-3820	Black River near Galesville	2,120	1,606	53	48	62	59	Loess (+) Ground moraine (−)	Sandy loams (−) Sands (−) Silt loams, unglaciated (+)	Hilly (+) Rolling (+)	Agricultural (+) Forest (−)	Reservoirs (−).	
5-3995	Big Eau Pleine River near Stratford	224	166	56	48	63	63	Ground moraine (−)	Silt loam (+)	Flat (−) Rolling (+)	Agricultural (+)	None (+).	
5-3795	Trempealeau River at Dodge	643	388	45	50	84	19	Loess (+) Lake basins (+)	Sandy loams (−)	Hilly (+) Rolling (+)	Agricultural (+) Forest (−)	None (+).	
4-872.4	Root River at Racine	187	75	67	47	110	6.2	End moraines (+) Ground moraine (−)	Silt loams (+)	Flat (−) Gently rolling (−)	Agricultural (+) Urban (+)	Channel straightening (+).	
5-4365	Sugar River near Broadhead	527	336	50	60	90	18	Lake basins (+) End moraines (+) Ground moraine (−)	Silt loams, unglaciated (+) Peat (−)	Rolling (+) Hilly (+)	Agricultural (+)	Reservoir (−).	50–100
5-4050	Baraboo River near Baraboo	600	369	59	63	98	22	Lake basins (+) Loess (+)	Sandy loams (−) Silt loams, unglaciated (+)	Hilly (+)	Agricultural (+) Forest (−)	Reservoir (−).	
4-860	Sheboygan River at Sheboygan	432	232	79	68	122	17	Ground moraine (−) End moraines (+)	Silt loams (+) Clay loams (+)	Flat (−) Gently rolling (−)	Agricultural (+)	Swamps (−).	
5-3810	Black River at Neillsville	756	566	78	71	99	31	Ground moraine (−) End moraines (+)	Silt loams (+) Loams (−)	Flat (−) Rolling (+)	Agricultural (+) Forest (−)	Reservoirs (−).	
5-4140	Platte River near Rockville	139	95	62	77	109	6.2	Loess (+)	Silt loams, unglaciated (+)	Hilly (+) Gently rolling (−)	Agricultural (+)	None (+).	
5-4065	Black Earth Creek at Black Earth[6]	46.4	30.0	69	85	129	2.3	Loess (+) Outwash, pitted (−) End moraines (+)	Silt loams (+)	Steep (+)	Agricultural (+)	None (+).	
5-4360	Mt. Vernon Creek near Mt. Vernon[7]	16.1	16.5	92	100	850	0.9	Lake basins (+) Loess (+)	Silt loams (+)	Steep (+)	Agricultural (+)	None (+).	
5-4330	East Branch Pecatonica River near Blanchardville	221	139	207	250	357	32	Lake basins (+) Loess (+)	Silt loams, unglaciated (+)	Steep (+)	Agricultural (+)	None (+).	
4-270	Bad River near Odanah	611	600	266	274	245	97	Lake basins (+) End moraines (+) Ground moraine (−)	Clay loams (+) Loams (−)	Steep (+) Gently rolling (−)	Forest (−)	Lakes (−). Swamps (−).	Greater than 100
5-4325	Pecatonica River at Darlington	274	183	302	323	619	51	Lake basins (+) Loess (+)	Silt loams, unglaciated (+)	Steep (+)	Agricultural (+)	None (+).	
5-4335	Yellowstone River near Blanchardville[7]	29.1	15.9	335	373	585	6.3	Loess (+)	Silt loams, unglaciated (+)	Steep (+)	Agricultural (+)	None (+).	
5-4105	Kickapoo River at Steuben	690	453	400	408	533	160	Loess (+)	Silt loams, unglaciated (+) Sandy loams (−)	Steep (+)	Agricultural (+)	None (+).	
5-4150	Galena River at Buncombe[8]	128	75	668	668	1,020	50	Loess (+)	Silt loams, unglaciated (+)	Steep (+)	Agricultural (+)	None (+).	
5-4135	Grant River at Burton	267	164	518	704	1,030	110	Loess (+)	Silt loams, unglaciated (+)	Steep (+)	Agricultural (+)	None (+).	

[1] Short term, period of suspended sediment record
[2] Long term, extrapolated to a 23-year base period, 1945–67
[3] All stations have data collected monthly and during high flow (May 1964–Sept. 1967), unless otherwise noted
[4] Basin too diverse to determine the effects of individual factors
[5] Daily records (1957–65)
[6] Daily records (1954–65)
[7] Daily records (1954–60)
[8] U.S. Army Corps of Engineers sampling station. Mostly data (1942–67)



SEDIMENT YIELDS

The sediment yields of Wisconsin streams are generally low; however, yields differ greatly from one basin to another. The average sediment concentration of the 44 sampled sites is 157 mg/l. The major area of low yield is the forested area of northern Wisconsin, and the areas of high yield are the hilly terrane of the southwestern part of the State and the Lake Superior red clay area. The extremes in sediment yield are in the Little Wolf River basin (less than 5 tons per sq mi) and in the Grant River basin (greater than 700 tons per sq mi). Areas of intermediate sediment yield are in the agricultural areas of central and eastern Wisconsin.

Because of the lack of data, sediment-yield determinations in some areas of the State are interpolated from erosion controlling factors, such as topography, geology, soil type, land use, and land cover.

Sediment yields are not indicated on the above map for a few of the sampling stations because upstream reservoirs and other controlling factors within those basins prevent regional correlation.

SUMMARY

Wisconsin is fortunate to have low sediment yields in most streams. The average concentration of sediment for the 44 sampled sites throughout the State is 157 mg/l. In comparison, only 50 percent of the United States produces sediment concentrations less than 600 mg/l in its rivers (Rainwater, 1962).

Annual basin yields range from 5 to 700 tons per square mile and from 0.5 to 290 acre feet of sediment volume. Soil types, parent glacial deposits, land use and cover, and topography greatly influence sediment yields. Natural and artificial channel controls also affect sediment yields. Lowest yields generally come from forested, sandy areas with low topographic relief. The highest yields are from land that is intensely farmed, hilly, and partly covered by loose wind-blown silt. Intermediate yields are from areas of intense agricultural development, where tilled soils are exposed to erosion during a large part of each year.

The sediment yield map, prepared from calculated long-term yields and by inference from knowledge of land use, soils, and glacial geology, is useful for estimating sediment yields in most areas of the State. A detailed knowledge of sediment yields in problem areas requires local data on streamflow; sediment volume, source, and character; and changes in land use.

RECOMMENDATIONS FOR ADDITIONAL STUDIES

1. Monitor sediment yields in streams draining areas of expanding urbanization in southeastern Wisconsin. Studies should include land use and erosion; deposition in lakes, reservoirs, and wetlands; and storm-sewer runoff.
2. Establish an intense data network in the agricultural area of southwestern Wisconsin to study the erosion problems as an aid to further improvement of land-management practices and water quality.
3. Determine erosion rates and specific areas of erosion in the red clay area bordering Lake Superior. Such studies should help to improve land-management practices and could possibly result in reduced sediment deposition in Lake Superior.
4. Expand the statewide sediment monitoring program to obtain data necessary to compare the character, source, and distribution of sediments as related to land-use practices.

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SEDIMENT YIELDS OF WISCONSIN STREAMS

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