Tributary Flashiness

Overall Assessment
Status: Fair
Trend: Improving
Rationale: The average of ratios of flashiness indices for the most recent ten-year period (2001-2010) declined relative to the average of these ratios for the previous 10-year period (1991-2000). Overall assessment is based on 11 selected tributaries which represent hydrologic conditions in the Great Lakes basin.

River-by-River Assessment – U.S. Rivers
Genesee River (Lake Ontario Basin)
Status: Good
Trend: Unchanging
Rationale: Long-term trend is toward lower R-B Index ($p<0.0001$), but the last two decades have same average index to 3 decimal places.

Maumee River (Lake Erie Basin)
Status: Poor
Trend: Improving
Rationale: Long-term trend is toward higher R-B Index ($p<0.0001$), but the average for the most recent ten-year period is lower than that for the previous period.

Saginaw River (Lake Huron Basin)
Status: Good
Trend: Improving
Rationale: Only 14 years of continuous flow data are available, preventing comparison of two 10-year periods. However, the 14-year trend is downward ($p=0.039$). The most recent 10 year average is lower than the average of the first four years, and the most recent 7 year average is lower than the average of the first 7 years.

Muskegon River (Lake Michigan Basin)
Status: Good
Trend: Deteriorating
Rationale: Long-term trend is toward lower R-B Index ($p<0.0001$), but the average for the most recent ten-year period is higher than that for the previous period.

St. Joseph River (Lake Michigan Basin)
Status: Good
Trend: Improving
Rationale: Long-term trend is toward lower R-B Index ($p<0.0001$). The average for the most recent ten-year period is lower than that for the previous period.

Fox River (Lake Michigan Basin)
Status: Fair
Trend: Deteriorating

Rationale: Long-term trend is very slightly toward lower R-B Index and not statistically significant. The average for the most recent ten-year period is higher than that for the previous period, and the index has increased each of the past 7 years.

St. Louis River (Lake Superior Basin)
Status:Good
Trend: Improving
Rationale: Long-term trend is toward lower R-B Index (p=0.0153). The average for the most recent ten-year period is lower than that for the previous period.

River by River Assessment – Canadian Rivers
Humber River (Lake Ontario Basin)
Status: Fair
Trend: Improving
Rationale: Long-term trend is upward but not significant. The average for the most recent ten-year period is lower than that for the previous period.

Thames River (Lake Erie Basin)
Status: Fair
Trend: Deteriorating
Rationale: Long-term trend is upward but not significant. The average for the most recent ten-year period is higher than that for the previous period.

Saugeen River (Lake Huron Basin)
Status: Fair
Trend: Improving
Rationale: Long-term trend is nearly flat. The average for the most recent ten-year period is lower than that for the previous period.

Pic River (Lake Superior Basin)
Status: Fair
Trend: Deteriorating
Rationale: Long-term trend is downward but not significant. The average for the most recent ten-year period is higher than that for the previous period.

Purpose

- This indicator quantifies the nebulous concept of flashiness, which is an important aspect of the hydrologic regime to which the aquatic ecosystem must be adapted. Increases or decreases in flashiness usually lead to ecosystem stress.
- Tributary Flashiness indicator is used in the Great Lakes indicator suite as a State indicator in the Landscapes and Natural Processes category.

Ecosystem Objective

The ecosystem objective is to avoid hydrologic alteration. Periodic changes in flow rate are characteristic of streams and rivers, and the organisms that live in them are adapted to those changes. Spring floods may be important in opening up spawning areas or nurseries. Higher energies associated with storm runoff flush finer sediment from gravel beds, improving them as habitats for invertebrates and as spawning sites for salmonids. But changes in the hydrologic regime, either by reduced flashiness such as occurs when a dam is constructed, or by increased flashiness

such as occurs with urbanization, require adaptation by the resident organisms; if the changes are great enough, they can lead to the displacement of the native community and its replacement by another, often less desirable community.

Ecological Condition

Measure

The measure is the flashiness of hydrological response of a stream or river to rainfall/snowmelt events. The Richards-Baker Flashiness Index (R-B Index for short) is calculated from mean daily flows from the U.S. Geological Survey or Environment Canada, usually on an annual basis, and is the sum of the absolute values of the changes in flow from one day to the next, divided by the total discharge for the year.

$$\text{R-B Index} = \frac{\sum_{n=1}^{365} |q_n - q_{n-1}|}{\sum_{n=1}^{365} q_n}$$

The rivers used for this indicator are listed in Table 1. Most of these rivers have long flow records and are part of a proposed national monitoring network (http://acwi.gov/monitoring/network/design/; http://www.ec.gc.ca/rhc-wsc/default.asp?lang=En&n=4EED50F1-1). They cover a range of flashiness and land use, but are in the same broad size range (HUC6 or HUC8), although the Canadian rivers are generally smaller.

Endpoint/Target Range

There is no universal scale for the R-B Index, so it is not possible to say that a particular index value is good or bad. Small streams tend to be flashier than large rivers, and this is reflected in the R-B Index values. Streams with steep gradients and/or impervious watersheds will have high index values, even if they are totally unimpacted by human activities (e.g. rock basin mountain streams).

Desirable outcomes are lack of trend in flashiness, or in most cases of altered ecosystems, reductions in flashiness. Urbanizing watersheds typically show increases in flashiness over time that parallel increases in imperviousness.

Status Justification

Good = statistically significant decreasing long-term trend in flashiness in the Great Lakes basin or in a specific river,
Fair = no long-term trend in flashiness in the Great Lakes basin or in a specific river,
Poor = statistically significant increasing long-term trend in flashiness in the Great Lakes basin or in a specific river.

Trend will be evaluated by comparing the average index of the most recent 10 years with the average for the preceding 10 years.

The overall status determination is based on the average, across all rivers, of the ratio of the more recent flashiness index to the one for the previous period. This tends to decrease the influence of the more-variable flashier rivers, in comparison with averaging the flashiness values across all rivers for each 10-year period, and then taking the ratio.

Linkages

Fish habitat, land cover, land conversion, and extreme precipitation events.

Management Challenges/Opportunities

This index offers an integrated perspective on changing hydrology in selected, and hopefully representative, major Great Lakes tributaries. It can be used to track the effects of, and guide decisions about, land use changes as they affect hydrology and its impact on riverine ecosystems. It utilizes basic flow data from the U.S. Geological Survey, which are more likely to be available at times of financial duress and lack of support for environmental monitoring

than other environmental monitoring data. However, this indicator cannot substitute for these other kinds of data, and management systems that fail to recognize this are vulnerable to unpleasant surprises.

Comments from the Author

The R-B Index is easy to calculate from widely available data, and has come into widespread use. Possible range of values is from 0 to 2. Typical values are from 0.05 (very stable) to about 1.2 (very flashy). The Index integrates all flow data, rather than picking a given percentile. It is believed to be the only flashiness index or index of hydrologic alteration which incorporates the temporal sequence of flows, a very important part of the concept of flashiness. The Index is relatively stable from year to year (i.e. insensitive to weather effects), consequently it is relatively sensitive to longer-term trends.

For small streams, the hydrologic response is too rapid to be adequately resolved by daily flow data. For such systems, a version of the R-B Index based on hourly flow data can be used. However, index values derived from hourly data cannot be directly compared with those derived from daily data. Since the best use of the R-B Index is to track the hydrologic response of a stream through time, the index based on daily data is still useful for small streams, even if it under-represents the true flashiness. The watersheds selected for this indicator are large, and flows change relatively slowly, so daily data are adequate for calculating the R-B Index.

More information about the R-B Index, and some applications in the Midwestern United States, can be found in the paper cited below.

Assessing Data Quality

Insert "x" under the statement that best corresponds with each data characteristic

Data Characteristics	Strongly Agree	Agree	Neutral or Unknown	Disagree	Strongly Disagree	Not Applicable
1. Data are documented, validated, or quality-assured by a recognized agency or organization	X					
2. Data are traceable to original sources	X					
3. The source of the data is a known, reliable and respected generator of data	X					
4. Geographic coverage and scale of data are appropriate to the Great Lakes basin	X					
5. Data obtained from sources within the U.S. are comparable to those from Canada	X					
6. Uncertainty and variability in the data are documented and within acceptable limits for this indicator report	X					
Clarifying Notes:						

Acknowledgments

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Information Sources

Literature Citation:

Baker, D.B., R.P. Richards, T.T. Loftus, and J.K. Kramer. 2004. A New Flashiness Index: Characteristics and Applications to Midwestern Rivers and Streams. Journal of the American Water Resources Association 40(2): 503-522.

Data Sources:

Genesee: nwis.waterdata.usgs.gov/ny/nwis/dv/?site_no=04231600
Maumee: nwis.waterdata.usgs.gov/oh/nwis/dv?site_no=04193500
Saginaw: nwis.waterdata.usgs.gov/mi/nwis/dv/?site_no=04157000 (Incomplete series until WY1991)
Muskegon: nwis.waterdata.usgs.gov/mi/nwis/dv/?site_no=04122000 (1950-1993)
Muskegon: nwis.waterdata.usgs.gov/mi/nwis/dv/?site_no=04121970 (No data prior to WY1995)
St. Joseph: nwis.waterdata.usgs.gov/mi/nwis/dv/?site_no=04101500
Fox: nwis.waterdata.usgs.gov/wi/nwis/dv/?site_no=04084500
St. Louis: nwis.waterdata.usgs.gov/mn/nwis/dv/?site_no=04024000
Canadian Rivers: Water Survey of Canada, Environment Canada
http://www.ec.gc.ca/rhc-wsc/default.asp?lang=En&n=4EED50F1-1

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State of the Lakes Ecosystem Conference (SOLEC) 2011

River	Town	County	State/Province	Latitude	Longitude	HUC	Drainage Area
Genesee	Rochester	Monroe	NY	43°08’30.2”	77°36’58.7”	04130003	2474 mi^2
Maumee	Waterville	Lucas	OH	41°30’00”	83°42’46”	04100009	6330 mi^2
Saginaw	Saginaw	Saginaw	MI	43°24’46”	83°57’47”	040802	6060 mi^2
Muskegon	Croton	Newaygo	MI	43°26’05”	85°39’55”	04060102	2313 mi^2
Muskegon	Newaygo	Newaygo	MI	43°25’20”	85°48’07”	04060102	2350 mi^2
St. Joseph	Niles	Berrien	MI	41°49’45”	86°15’35”	04050001	3666 mi^2
Fox	Wrightstown	Brown	WI	44°26’58”	88°03’52”	040302	6110 mi^2
St. Louis	Scanlon	Carlton	MN	46°42’12”	92°25’07”	040102	3430 mi^2
Humber	Elder Mills		ON	43°48'40"	79°37'39"		117 mi^2
Thames	Thamesville		ON	42°32'41"	81°58'2"		1660 mi^2
Saugeen	Port Elgin		ON	44°27'23"	81°19'35"		1529 mi^2
Pic	Marathon		ON	48°46'26"	86°17'47"		1649 mi^2

Table 1. Rivers used for the Tributary Flashiness Indicator. When a stream includes several HUC8s but does not comprise a complete HUC6, the HUC8 is listed that includes the gaging station from which the flow data are derived.

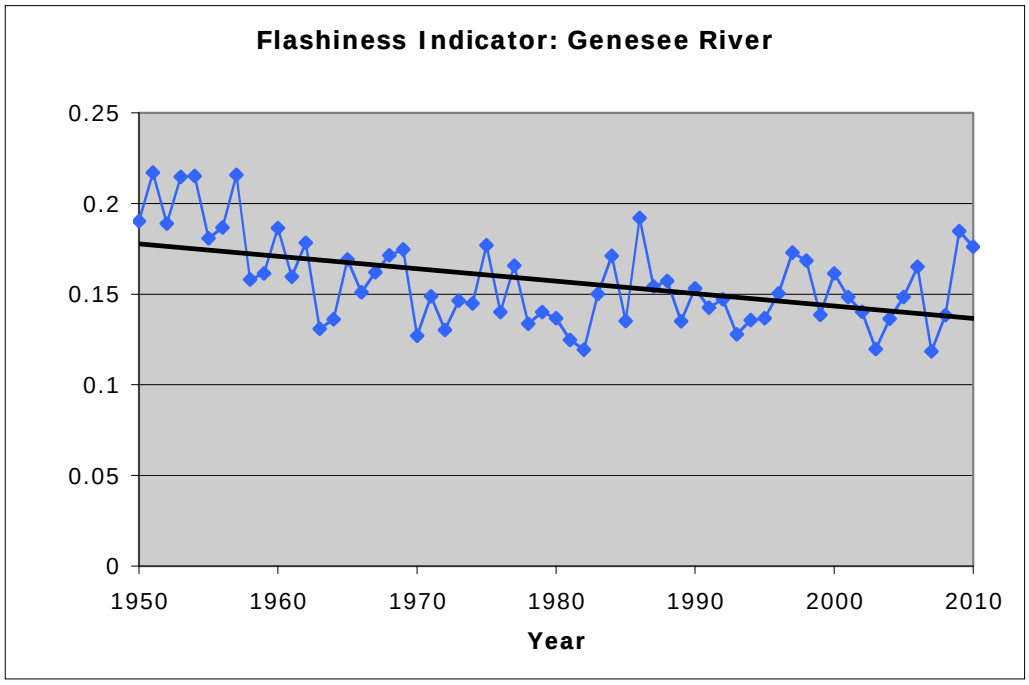

Figure 1. R-B flashiness index for the Genesee River at Rochester, New York, 1950-2010
Source: nwis.waterdata.usgs.gov/ny/nwis/dv/?site_no=04231600

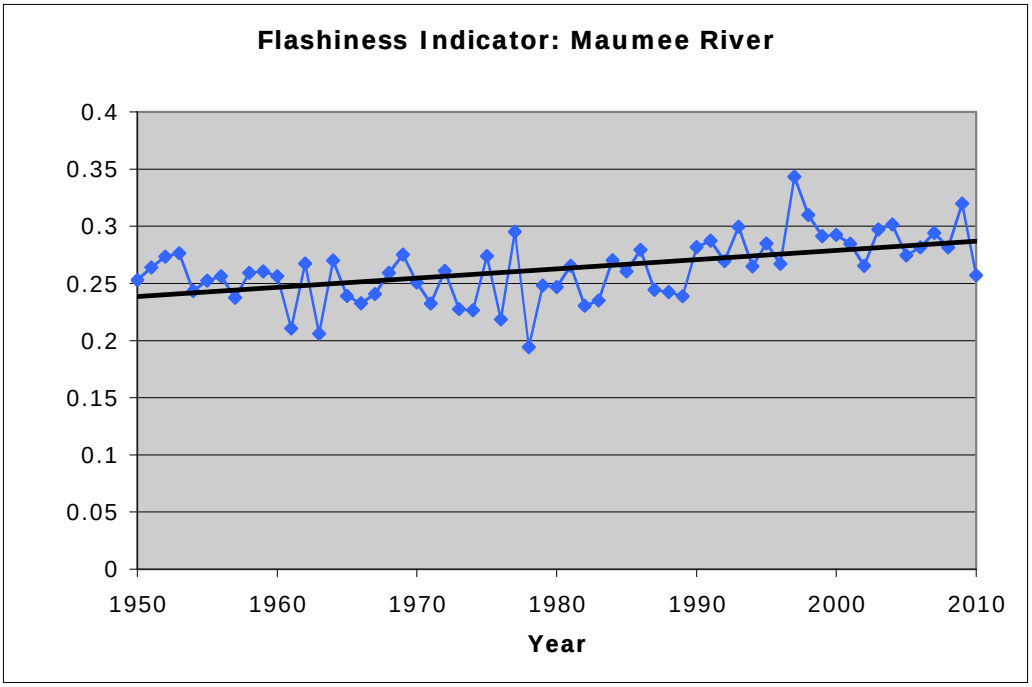

Figure 2. R-B flashiness index for the Maumee River at Waterville, 1950-2010
Source: nwis.waterdata.usgs.gov/oh/nwis/dv?site_no=04193500

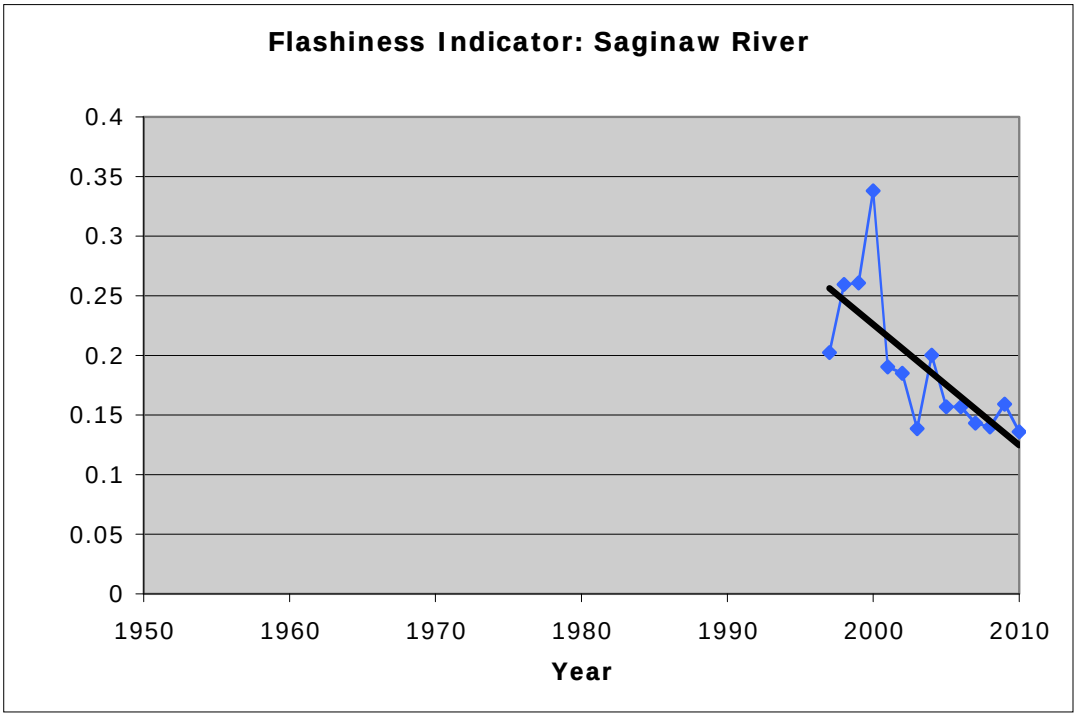

Figure 3. R-B flashiness index for the Saginaw River at Saginaw, Michigan, 1950-2010
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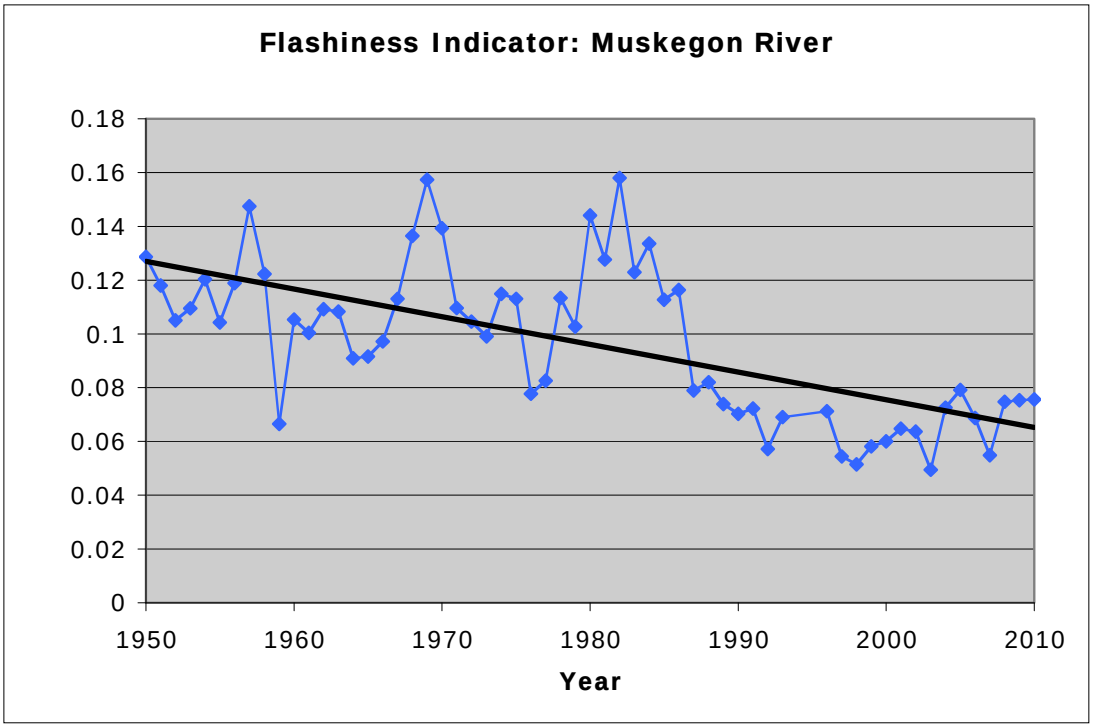

Figure 4. R-B flashiness index for the Muskegon River at Croton, Michigan, 1950-2010
Source: nwis.waterdata.usgs.gov/mi/nwis/dv/?site_no=04122000 (1950-1993)
nwis.waterdata.usgs.gov/mi/nwis/dv/?site_no=04121970 (No data prior to WY1995)

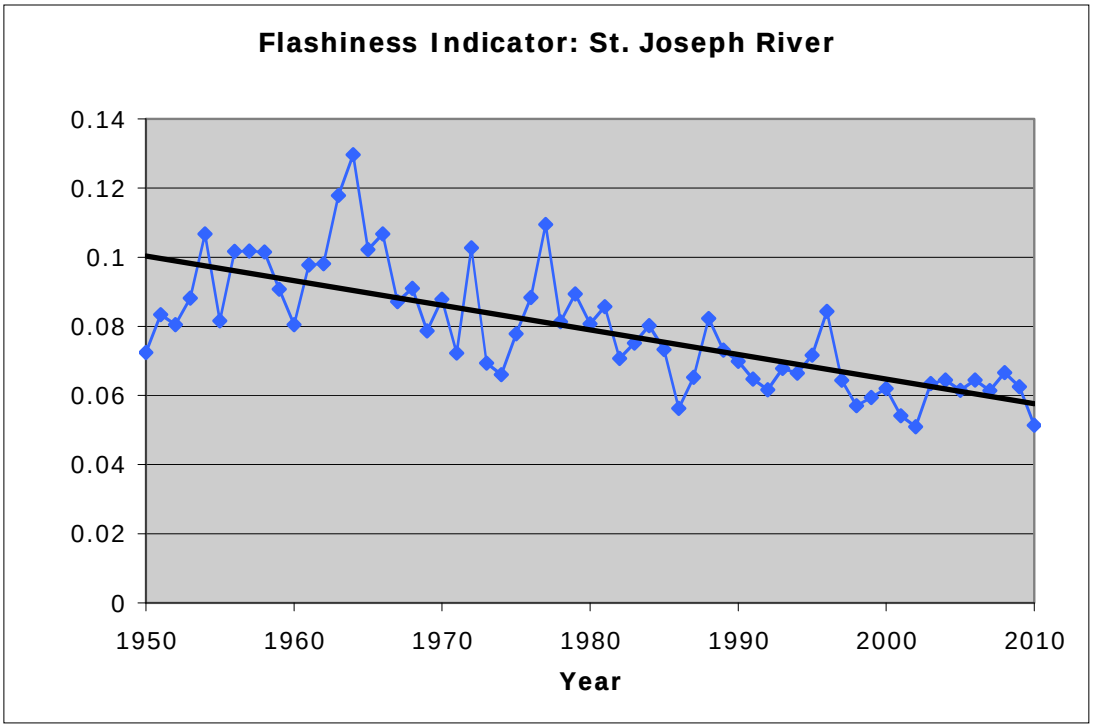

Figure 5. R-B flashiness index for the St. Joseph River at Niles, Michigan, 1950-2010
Source: nwis.waterdata.usgs.gov/mi/nwis/dv/?site_no=04101500

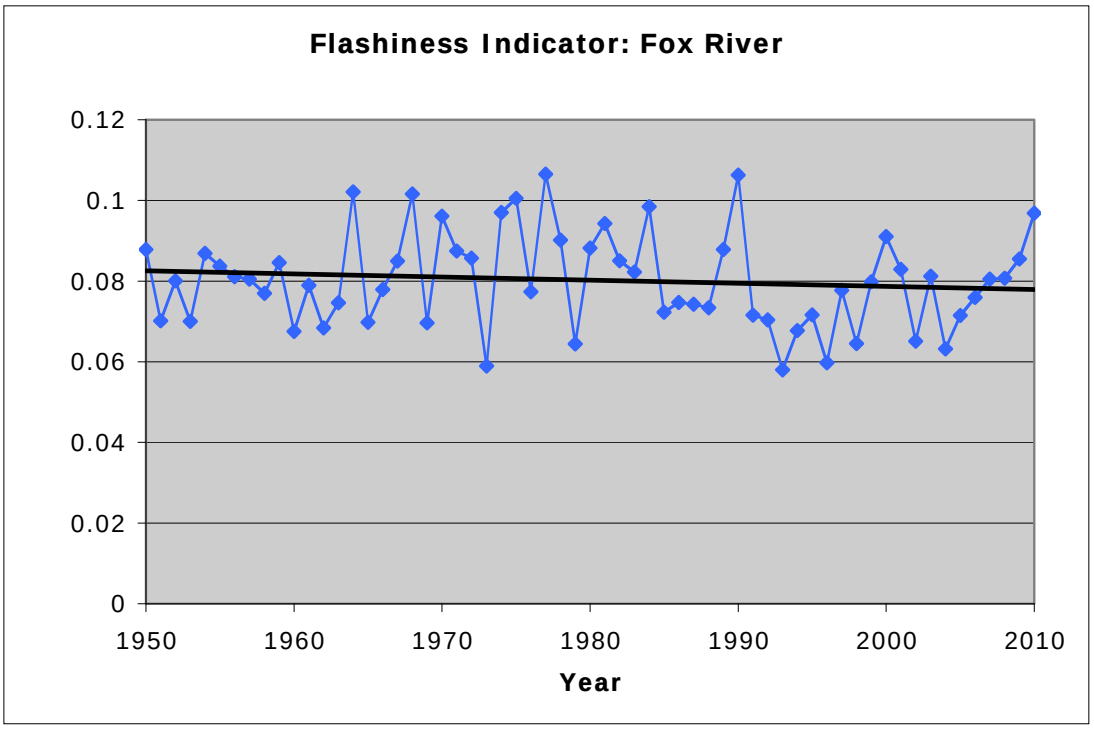

Figure 6. R-B flashiness index for the Fox River at Wrightstown, Wisconsin, 1950-2010
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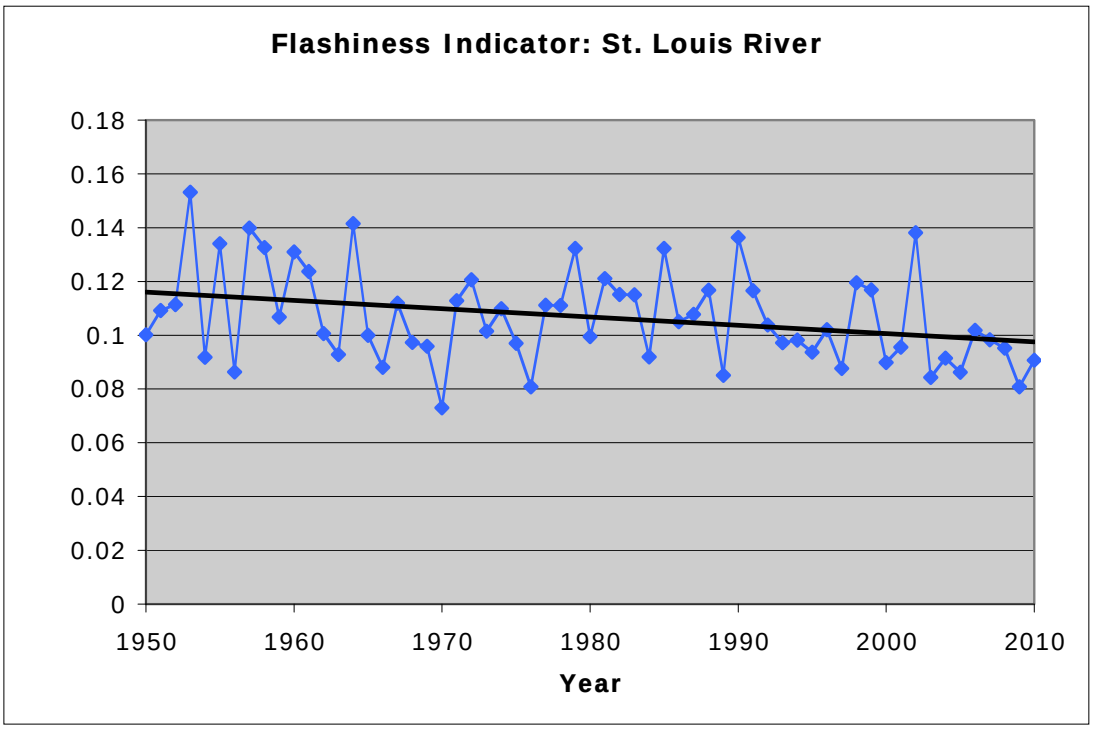

Figure 7. R-B flashiness index for the St. Louis River at Scanlon, Minnesota, 1950-2010
Source: nwis.waterdata.usgs.gov/mn/nwis/dv/?site_no=04024000

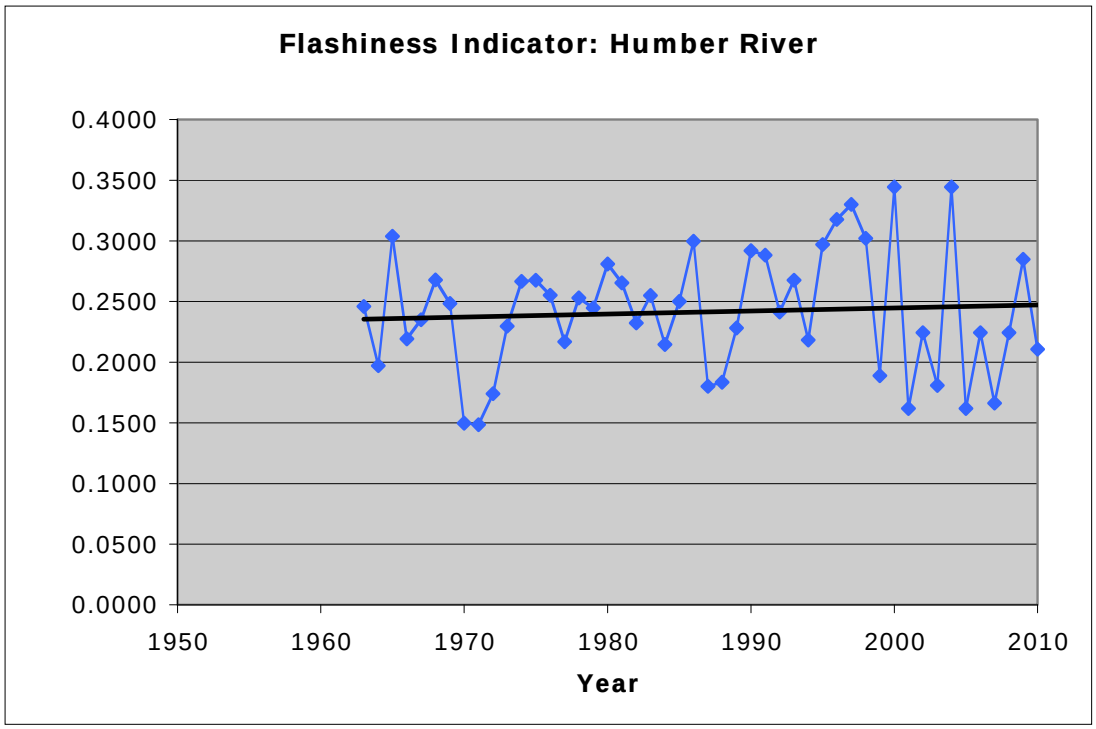

Figure 8. R-B flashiness index for the Humber River at Elder Mills, Ontario, 1950-2010
Source: Water Survey of Canada, Environment Canada
http://www.ec.gc.ca/rhc-wsc/default.asp?lang=En&n=4EED50F1-1

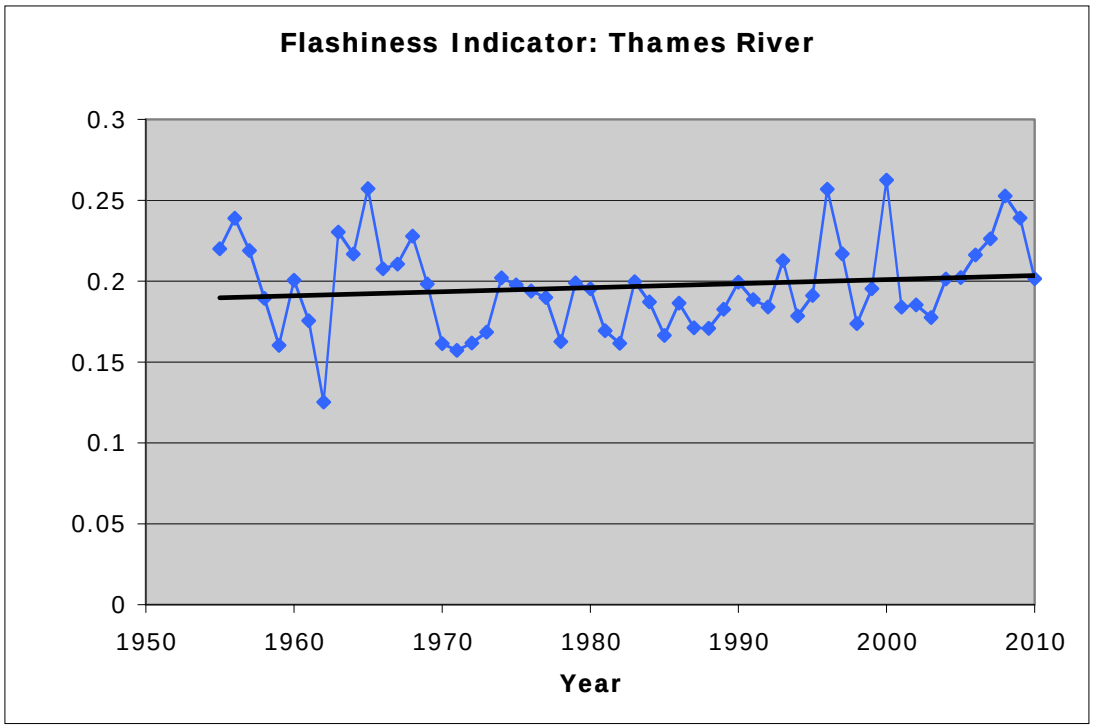

Figure 9. R-B flashiness index for the Thames River at Thamesville, Ontario, 1950-2010
Source: Water Survey of Canada, Environment Canada
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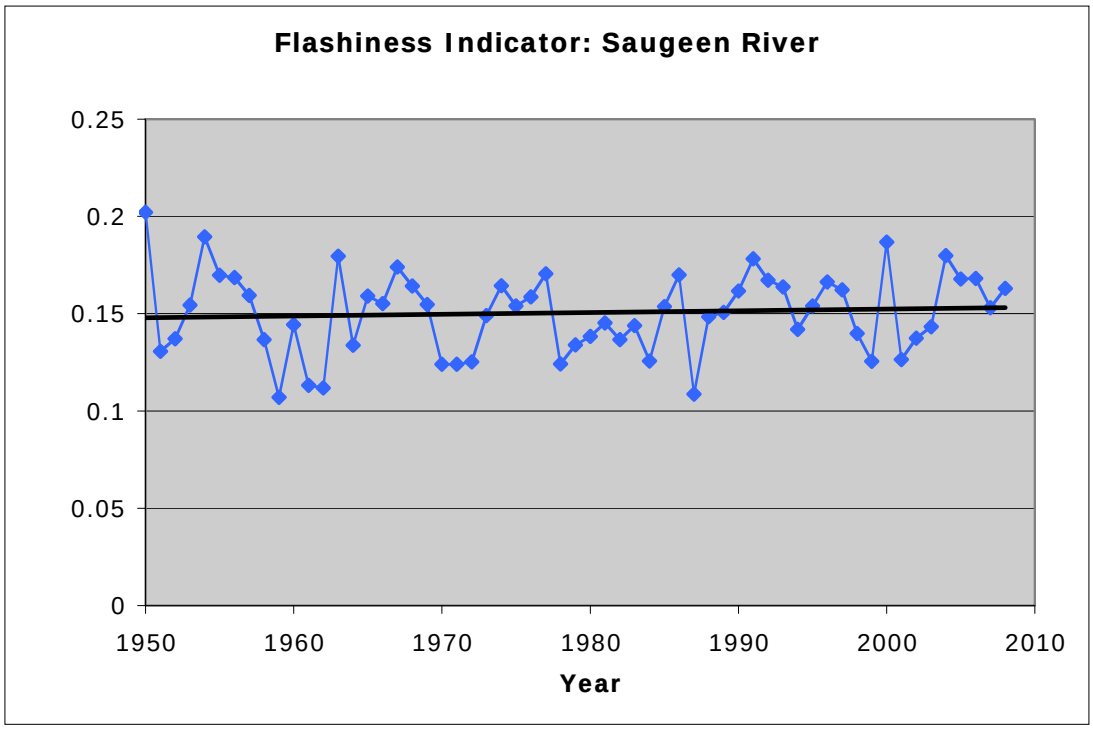

Figure 10. R-B flashiness index for the Saugeen River at Port Elgin, Ontario, 1950-2010
Source: Water Survey of Canada, Environment Canada
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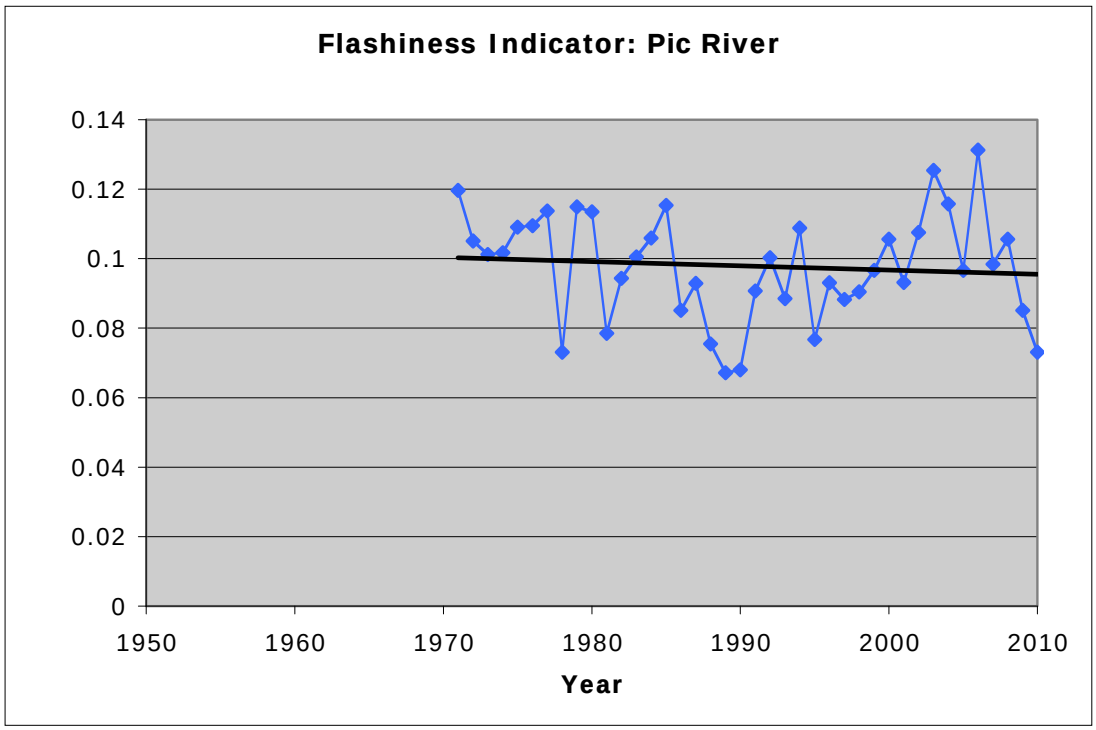

Figure 11. R-B flashiness index for the Pic River near Marathon, Ontario, 1950-2010
Source: Source: Water Survey of Canada, Environment Canada
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