Environment Canada

Environment Canada
Inland Waters Directorate

SEDIMENT FACT SHEET

Conservation and Protection
Monitoring and Information Branch

1993 | **ISSUE 1**

ESTIMATED HISTORICAL SEDIMENT LOADINGS FOR SELECTED BASINS IN ONTARIO

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INTRODUCTION

Sediment data are being used and are required in the Province of Ontario for the exploration of a wide variety of topics, involving both quantitative and qualitative issues. Many of these issues are focused on sediment sources and what they carry in the form of potential contaminants, where they go, and how both the volume and quality of sediments affect downstream water quality.

The fine sediment particles in many Ontario streams are particularly effective transporters. For example, these sediments in run-off from various land uses convey phosphorus, trace metals (such as copper and lead), and some pesticides to aquatic environments such as stream channels, wetlands, reservoirs and lakes, and eventually to large bodies of water such as the Great Lakes.

Issues outlined in Canada's Green Plan, when combined with State of the Environment reporting expectations, identified the need for more interpretative information that could clearly be understood by Canadians for better decision making. An estimate of sediment loadings for major basins, based on historical and recently developed databases, is an example of such information.

Under a cost sharing agreement with the Province, the Monitoring and Information Branch [formerly the Water Resources Branch] of Environment Canada is the lead federal agency for monitoring streamflows and sediment transport. The primary strategy employed in the present sediment network design is maximum spatial coverage of stations, while maintaining fiscal responsibility within the monitoring program. This was achieved using the miscellaneous sediment station monitoring approach.

METHODOLOGY

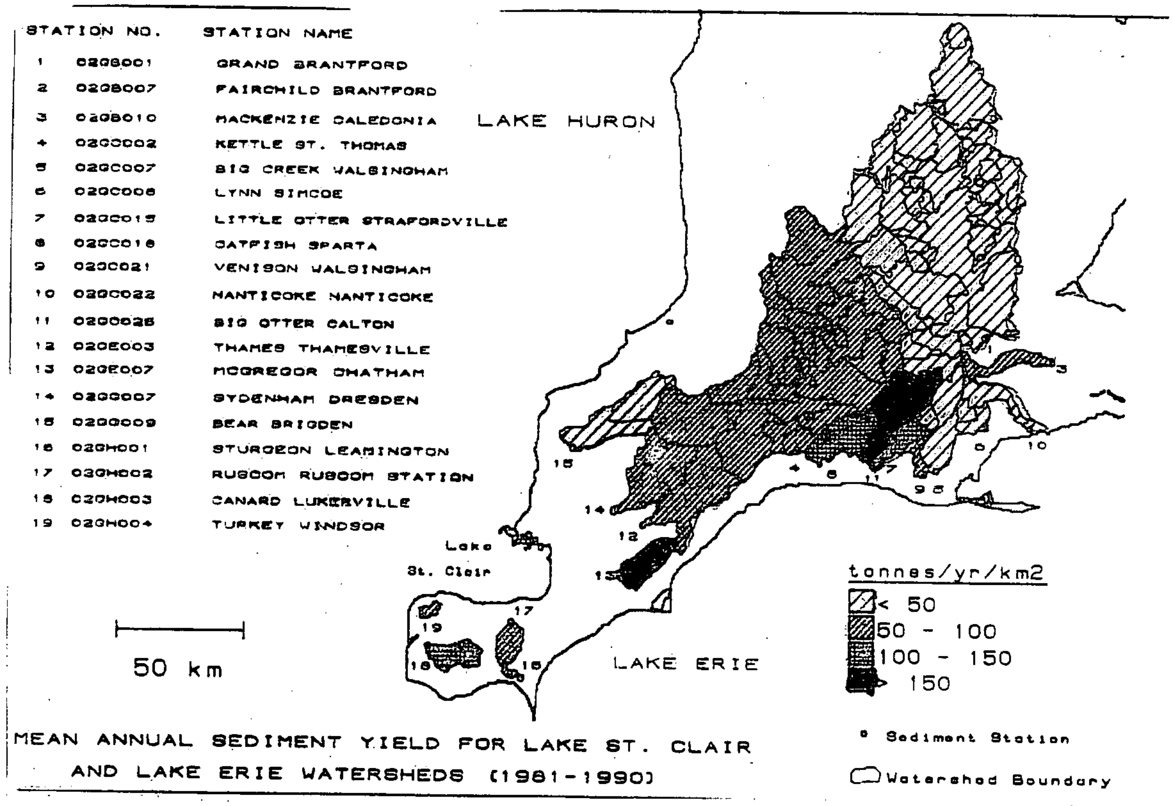
The concept of miscellaneous sediment sampling is simple — collect a limited number of selected samples sufficient to document the fluvial transport regime. Management of this network, however, is not as simple. Greater control of sampling design is required by field staff in order to carefully select flows for which samples are required to attain coverage of the entire flow regime.

The final objective is to produce an accurate relationship between sediment and streamflow for the computation of sediment loads. The relationship between instantaneous discharge and concentration should be represented over the full range of flow conditions at a station. Once this has occurred, the relationship or rating curve can be established with a higher degree of confidence.

From this approach, the data set for any sediment station are essentially unique. The total number of sediment samples is entirely dependant upon the complexity of the concentration-discharge relationship (the length of record and changes in the basin which produce more or less sediment in runoff events).

A total of 115 stations currently monitored for flow have been identified as Great Lakes Hudson-James Bay sediment tributary loading stations. Miscellaneous sediment stations have been established at existing hydrometric sites nearest the Lakes. Of this 115 stations, 109 have an adequate sediment database that allows the development of the concentration-discharge relationship. The remaining stations have yet to have this relationship established. For this reason, these stations have been given a high priority for subsequent data collection years.

Sampling design for all stations is controlled and managed by a Station Management Plan. One method used in management of the above plan, is the Station Review Plot Package. This allows the samples to be plotted which provides an overall picture of the concentration discharge relationship. Annual and historical plots allow the current year's sampling design to be reviewed and revised to achieve the full range of flow coverage criteria. When achieved, although not final, an equation is developed using the assumption that the instantaneous discharge-concentration relationship is similar to the daily mean flow- concentration relationship for the majority of tributaries.



MEAN ANNUAL SEDIMENT YIELD FOR LAKE ST. CLAIR AND LAKE ERIE WATERSHEDS (1981-1990)

This assumption was made to enable use of the extensive hydrometric data base HYDAT, which is in CD-ROM format. Data from the CD-ROM was transformed into Lotus format which allowed the development of regression equations to calculate daily suspended loads. These loads were than summarized into annual loadings for each tributary to each Great Lake.

The various figures that follow show the results of these efforts. Additional figures are also included using another assumption which is based on the particle size distribution of the suspended sediment loads. At stations where samples were analyzed by the laboratory for particle sizes, the percentage of sands, silts and clays were determined. Since contaminants, toxics and other water quality parameters have been associated with the silt-clay fractions, the percentage silt-clay was applied to the total sediment load calculations. The net result is the load which is anticipated to be transported entirely into the Great Lakes.

RESULTS

*** Bar charts were produced for each Great Lake and for Hudson-James Bay,indicating the percentage contribution of the total suspended sediment load by each tributary monitored in Ontario by Environment Canada. Note: There are a number of smaller tributaries not monitored in each of these basins. These have not been estimated in this study and do not appear on the bar charts or tables. ***

Hudson - James Bay

Of the 10 Ontario stations currently monitored for suspended sediment loadings, four (Moose, Albany, Abitibi, and Severn) account for over 88 per cent of the total Hudson-James Bay load. It is anticipated that the majority of loads are of the silt-clay fractions and are transported entirely to the Bays. The Moose River is the primary contributor at 40 per cent of the total load, and with its fine-grained nature could pose future water quality concerns.

Lake Superior

A total of 20 stations are currently monitored for Lake Superior. In addition, a considerable number of ungauged watersheds also occur, many of which are found throughout the clay plains adjacent to this lake. Four stations (Black, Pic, Magpie, Batchawana) contribute 89 per cent of the total load. These stations are located on the clay plains adjacent to the existing shorelines, and have concentrations during high flow events in excess of 2500 Mg/L, 80 per cent of which is silt-clay size fractions. One of these stations (Pic) contributes 63 per cent of total lake loads and is located in *Local Areas of Concern*. This latter point is important from a qualitative perspective.

Lake Huron

There are a total of 30 stations presently being monitored on Lake Huron. However, the importance of one station to total lake loading is very apparent. This station (French River): contributes 70 per cent of the entire lake loads, a result of the tremendous size of this watershed.

Since this French River station was unique, it was removed and the entire data sets re-evaluated. This revealed that three other stations (Mississagi, Saugeen, Ausable) accounted for 57 per cent of the remaining lake loading total. Particle size data of these stations indicated a silt-clay load of 90 to 100 per cent. Although these three stations are located in different areas of the lake, they all traverse the isolated clay plains surrounding the shoreline. The adjustment to total loads by this silt-clay factor, however, only reduced total loading by 0.5 per cent.

Lake St. Clair

Five tributaries are monitored for sediment loadings into Lake St Clair. These stations all exhibit high silt-clay loads from 90 to 95 per cent. This is a result of old glacial clay Lake deposits through which all these rivers traverse. Some urbanization and heavy agricultural use of these watersheds combined with the fine-grained transported material raise concerns from a quality perspective.

Lake Erie

Fourteen stations are presently monitored here, two of which account for over 65 per cent of total lake loading. Sand that is transported through these watersheds is the highest of all the Great Lakes and when this component is applied to total lake loads, a reduction from 20 to 50 per cent is often applied. Fine-grained material that is still transported to the lake may have quality significance from the intensive agricultural application of pesticides and fertilizers.

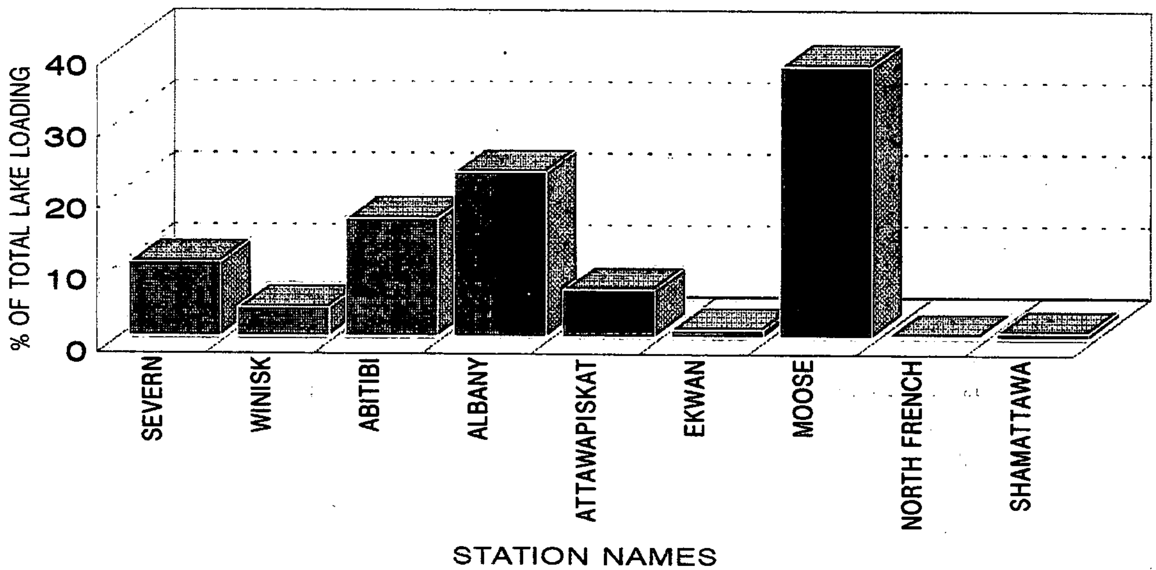
The two watersheds of the Grand and Big Otter (the primary sediment loaders to Lake Erie) show an interesting comparison which bears brief discussion. Before adjusting the sediment loads of these watersheds for their sand components, these two tributaries transported almost identical loads. However, after adjustments for sands, the loads from Big Otter were significantly reduced. After this reduction, these two tributaries still predominate lake loading. Urbanization, through its influence on the Grand River, certainly contributes to less sand at the downstream gauging station due to the many control structures that are effective sediment traps. These control structures further influence slopes of this river and, thus, its erosive and transportation capacities.

Lake Ontario

Thirty-six tributaries are monitored for sediment loadings into this lake with five accounting for over 60 per cent of total lake loads. These five stations are the Don, Credit, Humber, Welland and Trent, and, although they transport some sands, their importance is from an urban quality perspective on harbour and bay loadings of the fine-grained materials. An example of this is the area around Toronto, which includes Toronto Harbour and Humber Bay. At the present time, five tributaries are monitored in this area which contribute 38 per cent of the annual lake loads. These stations contribute a large portion of these fine materials directly into the harbour or bay areas. Due to the heavy urbanization and industrialization in these watersheds they undoubtedly also contribute high contaminant loads. Another station that transports a 98 per cent fine load and traverses industrialized areas is the Welland River. This single station accounts for over 11 per cent of the total lake load.

JAMES HUDSON BAY HISTORICAL SEDIMENT LOADINGS

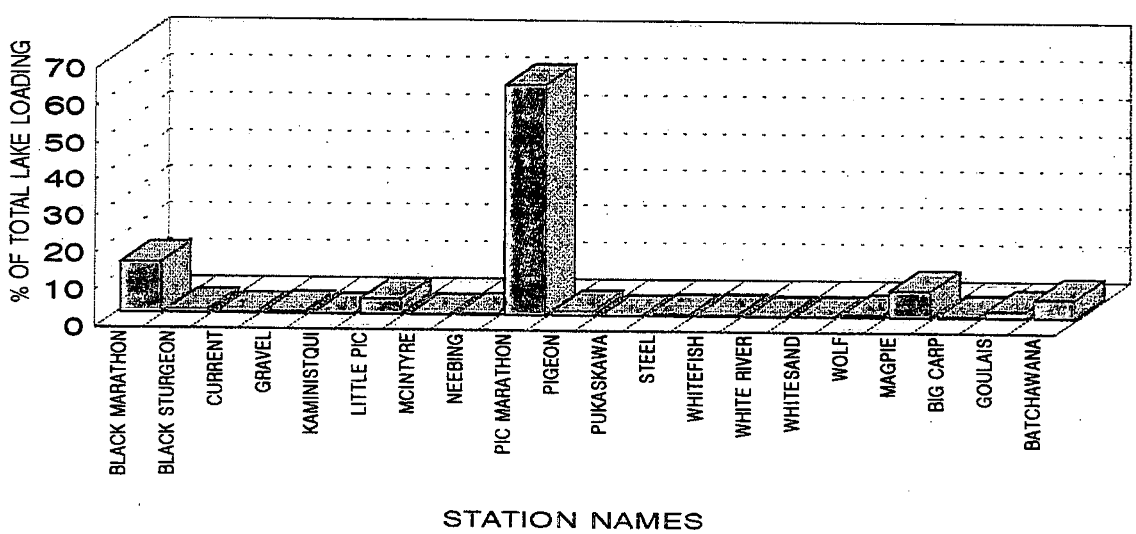
1972 - 1990



MEAN 1972 - 1990

LAKE SUPERIOR HISTORICAL SEDIMENT LOADINGS

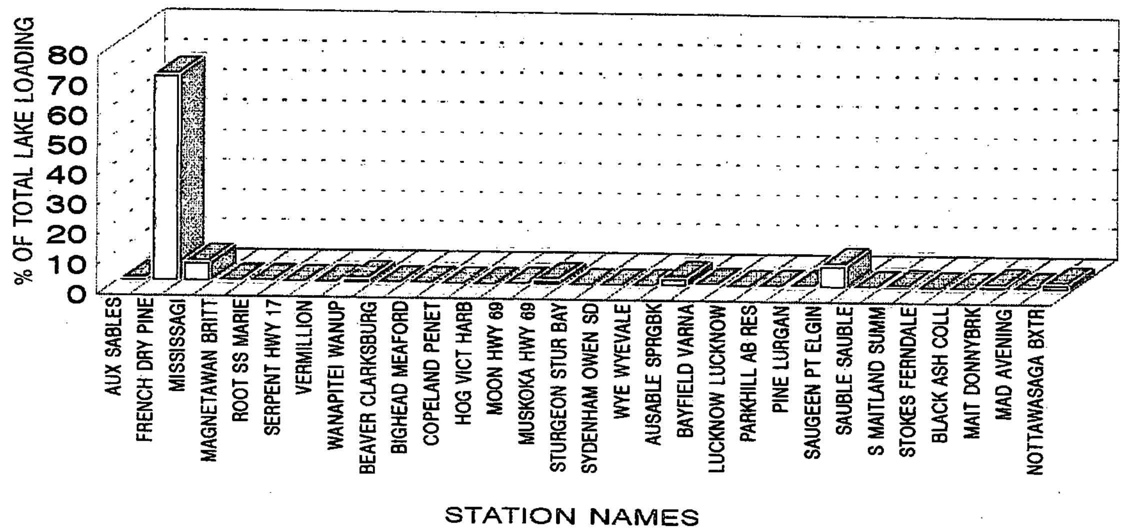
1972 - 1990



MEAN 1972 - 1990

LAKE HURON HISTORICAL SEDIMENT LOADINGS

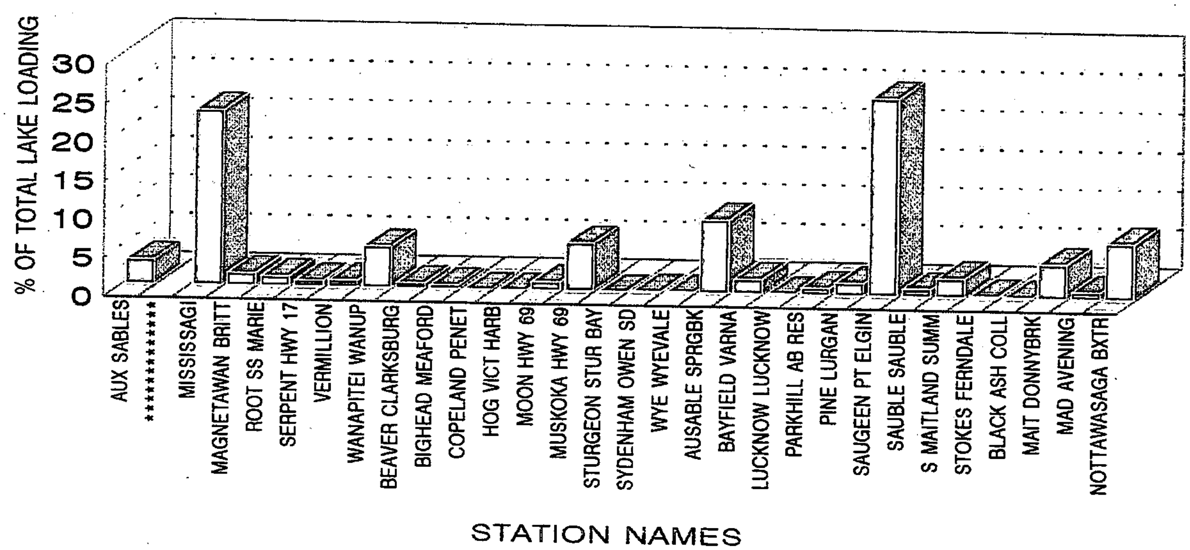
1972 - 1990



MEAN 1972 - 1990

LAKE HURON HISTORICAL SEDIMENT LOADING

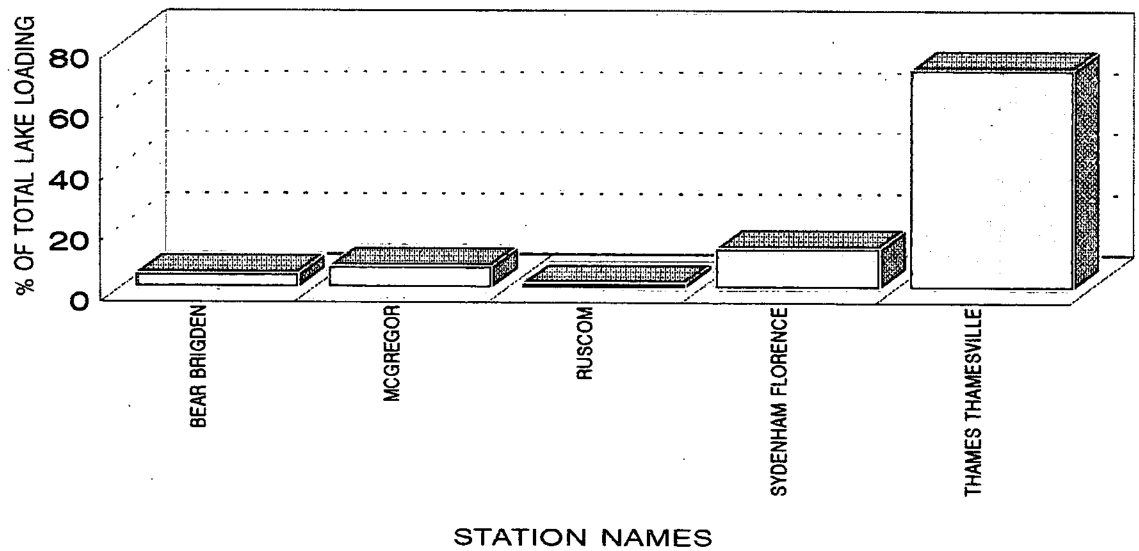
1972 - 1990



MEAN 1972 - 1990

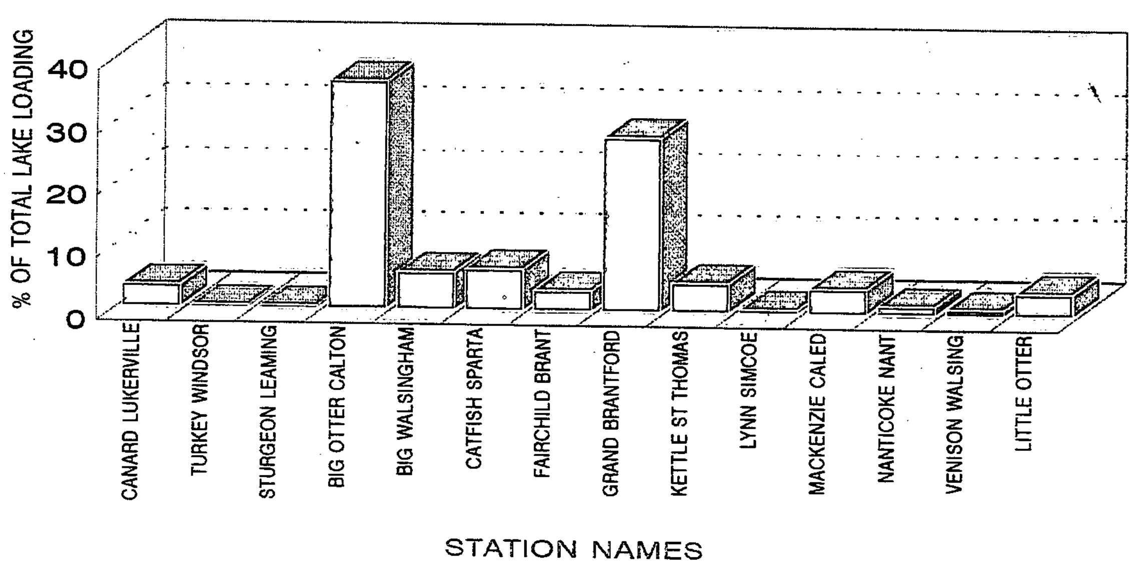
***** COMPUTED WITHOUT FRENCH R. DRY PINE BAY DATA ***

LAKE ST CLAIR HISTORICAL SEDIMENT LOADINGS
1972 - 1990



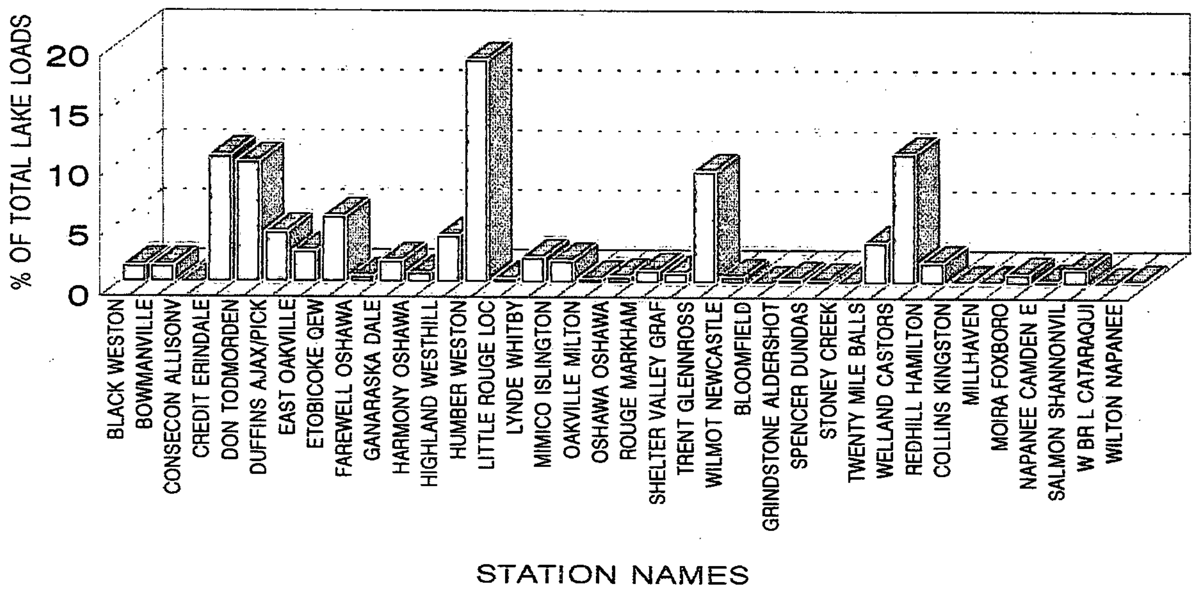
MEAN 1972 -1990

LAKE ERIE HISTORICAL SEDIMENT LOADINGS
1972 - 1990

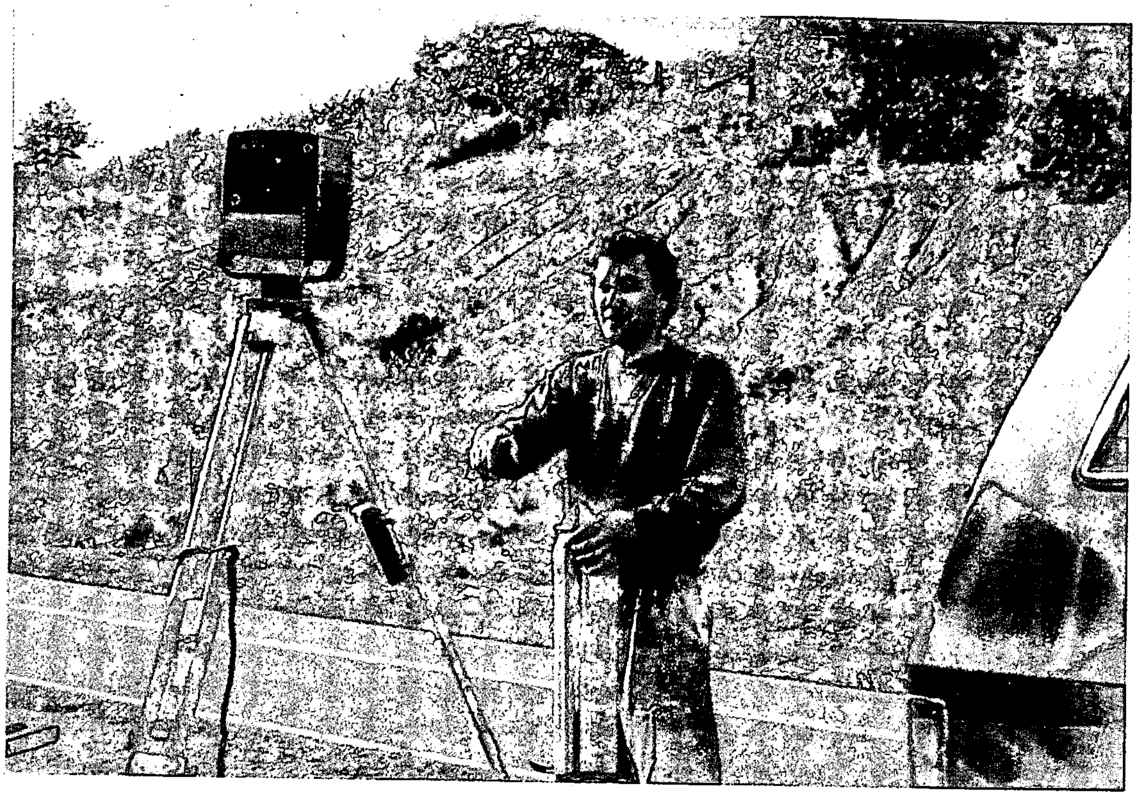


MEAN 1972 - 1990

LAKE ONTARIO HISTORICAL SEDIMENT LOADINGS
1972 - 1990



MEAN 1972 - 1990



LAKE ERIE HISTORICAL SEDIMENT LOADINGS 1972 – 1990

STATIONS	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
CANARD	14151	19067	13038	12683	9045	16475	8333	8956	8142	16522
TURKEY	1655	2601	1462	1402	1876	1476	1250	1931	1969	1315
STURGEON LE	1650	2850	1420	1350	1920	1437	1175	1988	2035	1250
BIG OTTER	126335	149726	143429	127148	129464	176538	108388	187340	194881	114138
BIG CREEK	20825	22420	27907	21982	28889	33766	26564	30423	26269	20476
CATFISH	18584	23452	20304	24497	34492	39199	27670	37320	19779	20328
FAIRCHILD	12200	15403	16178	10410	16754	16799	12169	17290	10234	3002
GRAND BRANT	143450	96601	193809	111083	147081	136076	99782	189885	69429	78743
KETTLE ST	16506	14055	16016	19260	26280	32570	18219	30264	12479	12702
LYNN SIMCOE	1932	1659	2273	1638	3414	2568	2546	2289	1988	1485
MACKENZIE	13755	20500	19471	7659	26844	20428	23951	20463	10765	10324
NANTICOKE	4815	5516	5726	4235	7981	8443	4126	6119	4387	2775
VENISON	2929	2816	3446	3066	5775	4878	4244	4662	3656	2755
LITTLE OTTER	13214	12325	10998	10028	21162	17307	15270	17691	10558	10200
TOTALS	15617978	388993	475477	356451	460977	507958	353887	556621	376551	302015

STATIONS	1982	1983	1984	1985	1986	1987	1988	1989	1990	TOT LOAD	MEAN %
CANARD	16480	15298	12325	24516	17072	9755	2877	26670	31663	283088	3.6
TURKEY	5828	1582	787	1793	1043	1079	446	696	2568	32759	0.4
STURGEON LE	5247	1122	883	1606	1669	756	258	1321	2046	31983	0.4
BIG OTTER	258040	236604	199360	181544	164125	90523	59000	35100	167000	2848685	36.5
BIG CREEK	42810	23323	24149	29499	22797	15470	12223	9675	26630	466107	6.0
CATFISH	30324	41463	42991	47764	21818	12140	6876	3537	39310	512048	6.6
FAIRCHILD	16276	11906	17187	23158	14570	10230	6406	5254	16554	257980	3.3
GRAND BRANT	177685	47742	85268	228354	163772	63407	37020	32813	81145	2183145	28.0
KETTLE ST	31376	18488	19890	31134	17382	8823	4983	3650	33631	367708	4.7
LYNN SIMCOE	3120	2387	3137	3841	3071	1724	1283	997	2532	43882	0.6
MACKENZIE	23578	12733	20451	33102	15818	7739	2416	4005	22215	316217	4.0
NANTICOKE	8084	6685	7672	11865	6756	3452	2713	1986	8232	111548	1.4
VENISON	5831	3608	5260	6895	5074	2422	1539	1654	4694	75204	1.0
LITTLE OTTER	24107	14000	23449	27042	17484	7184	4521	3648	18417	278605	3.6
TOTALS	648786	436941	462809	652113	472451	234704	142561	131006	456637	7808939	

CONCLUSIONS

As development is sure to progress towards the north, it was felt that the James-Hudson Bay area should be included as part of any sediment loading estimation for Ontario. With the exception of Lake Ontario, one general conclusion from a preliminary review of the data is that each lake has at least two major tributaries contributing from 61 to 85 per cent of each lake's total sediment load. Lake Ontario, however, has four tributaries, contributing about 51 per cent of the total load, all about equal in contributions. Lake Huron is the other anomaly, where one station contributes approximately 70 per cent of the total load.

FUTURE DIRECTIONS

Continued refinement, additions and review of the sediment-flow relationships for all stations on the Great Lakes and Hudson-James Bay, is planned and as the coverage of flow ranges is attained, will continue to be the primary direction for this study. Of further importance is the application of this study to the integrated water quality database that will, or should, allow calculations of contaminant and other quality parameter loads.

For Further Information

For further information on available databases referred to in this fact sheet, please contact the following:
Head, Integrated Projects, or Sediment Surveys Officer, Environment Canada, Monitoring and Information Branch, Water Survey of Canada, 75 Farquhar Street, Guelph, Ontario. N1H 3N4.
Fax # 1-519-821-5002, Tele: 1-519-821-0110.