STEWARDSHIP SUBCOMMITTEE:

THE WATER FLUX INDICATOR

Part of the Lake Ontario Toxic Management Plan Administered by by the Four Parties:

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EXECUTIVE SUMMARY

I. NATURE OF THE INDICATOR

The quantities of water in the Lake Ontario Basin are strongly determined by what people do with water throughout the Basin. Hence, the stewardship indicator of water fluctuation in Lake Ontario must consider dominant features of the entire water system. The features this indicator considers are estimates of the extent to which human's utilize Lake Ontario Basin water, and how much we divert it.

II. EXPLANATION OF THE GRAPHICS

The graphics and tables show that, at present, the five major diversions in the Great Lakes Basin do not significantly affect the water level of Lake Ontario. The indicator does, however, have greater utility for measuring the potential consequences that proposed diversions will have on lake levels.

The graphics also show that the current rate of consumptive use of Lake Ontario water does not negatively affect its lake level. However, it is projected that the amount of water consumed will more than double by the year 2000. This may create a unnatural fluctuation in Lake Ontario water levels.

III. LIMITATIONS AND UNCERTAINTIES

The greatest drawback of this indicator is the limited amount of information that is currently available on diversions and consumptive uses. For example, data collected on consumptive

uses are based upon 1975 statistics. Likewise, some of the information for diversions are estimates from hypothetical future scenarios. Other limitations are listed in the main text.

IV. INTERPRETATION OF THE INDICATOR

As long as diversions and consumptive uses do not increase or decrease the water level, the indicator expresses positive stewardship. On the other hand, when human activity interferes with the natural ebb and flow of the lake, resulting in fluctuating lake levels, the indicator displays a lack of stewardship.

Prevailing data suggest two important phenomena. First, existing diversions theoretically increase the water level of Lake Ontario (no major diversions are planned for construction in the future). Second, while present consumptive uses do not affect the water levels of Lake Ontario, it is projected that both withdrawals and consumptive uses will increase dramatically by the year 2000.

BACKGROUND

One of the objectives developed by the "Ecosystem Objectives Work Group", or EOWG, is that "**human activities and decisions shall embrace environmental ethics and a commitment to responsible stewardship.**"[1] The Work Group identified several stewardship indicators for the dual purpose of measuring the progress toward the objective as well as evoking action.[2]

This report focuses upon one such indicator submitted to the Stewardship Subcommittee of the EOWG: Most Important Fluxes of Water Levels. In addition to measuring the impact of human activity upon the Lake Ontario ecosystem, the indicator measures our continuing responsibility for "maintaining ecological processes and components of Lake Ontario, preserving its biological diversity and following the principles of sustainable use of resources."[3]

MAIN TEXT

I. PURPOSE OF THE INDICATOR

The water flux indicator estimates the extent to which human's utilize Lake Ontario Basin water, and further, how much is diverted. The estimates are used to assess stewardship of this precious, life-sustaining resource. It is important to note that this indicator considers the implications of quantities of locations of water, not its quality or degree of contamination.

A. Nature of the Indicator

The quantities of water in the Lake Ontario Basin are strongly determined by what people do with water throughout the Basin. Hence, the water flux indicator must consider dominant features of the entire water system, and is divided into three categories: Major Diversion of Water of the Great Lakes; Total Inputs of water into Lake Ontario; and finally, Total Withdrawals of Total Consumptive Uses from Lake Ontario. The indicator will measure how each category affects the lake level of Lake Ontario. By quantifying the changes in the level of water, the indicator suggests how human activity may cause potential instability in the Lake Ontario Basin.

B. Value of the Indicator

The underlying value of the water flux indicator lies in its ability to communicate how human activity affects the natural

equilibrium of the lake. While normal water fluctuations "form a process which is natural to the fish and wildlife inhabiting the Great Lakes, [e]xtreme periods of high and low water levels . . . can compound the effects of natural lake processes and cause undesirable results."[4] For example, high flows can be hazardous to navigation, shore erosion and flooding; low levels can aggravate pollution problems in the Great Lakes by reducing their dilution capacity."[5] When human activity artificially increases or reduces the water level of the Lake, the above results are exacerbated. This is an indication of a lack of stewardship.

II. ILLUSTRATION OF THE INDICATOR

A. Description and Explanation of the Indicator

1. DIVERSIONS

Though Native Americans had constructed water diversions as early as 300 B.C.[6], these projects posed little, if any, environmental threat. It was not until the twentieth century that major interbasin transfer projects have been implemented.

A diversion is defined as "the transfer of water from one watershed (or basin) to another and those transfers that occur totally within one lake or river watershed."[7] Presently, there are five major diversions of water into, out of, or within the Great Lakes system. They include: the diversions into Lake Superior from Long Lac and Ogoki; out of Lake Michigan at Chicago; between Lake Erie and Ontario at the Welland Canal; and, out of the New York State Barge Canal from the Niagara River, with

some water returning to Lake Ontario via the Oswego River, and the remainder discharging into the Hudson River Drainage System (see Figure 1).

At this point in time, the little evidence available illustrates that the above diversions have had a minimal effect on lake levels. To this end, the water flux indicator has only limited value.[a] For example, the International Great Lakes Diversions and Consumptive Uses Study Board [hereinafter "Study Board"] has compiled mean diversion rates for Lake Ontario and their effects on lake levels[8] (see Appendix A, Table 1). The Study Board found that the combined effect of the diversions have increased the water levels of Lake Ontario by 0.08 feet.[9] In other words, if these diversions did not exist, the mean water level would be 0.08 feet lower, a relatively insignificant amount.

The indicator has greater utility for measuring the potential implications of major proposed interbasin transfers. A "number of major diversions . . . have been propounded upon over the past three decades."[10] In response to public concern, three hypothetical diversions (from the Great Lakes to the Missouri, upper Mississippi and Ohio river basins) have been examined by

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[a] This deficiency is in the process of being remedied. In the latter half of the 1980's, the Water Resources Management Committee (WRMC) of the Great Lakes Commission created the Great Lakes Regional Water-Use Data Base (GLRWDB). The data base collects information on a jurisdiction's withdrawals, consumptive uses, and diversions for a variety of water uses. The WRMC compiles this data and documents it in an annual public report to the Governors and Premiers of the Great Lakes and provinces.

the International Joint Commission to estimate their potential cost and environmental effects.[11] The Commission has reviewed these large scale diversions and has concluded that the effect of reducing the water level of Lake Ontario would have adverse consequences for navigation, recreation, power generation, industry and the environment.[12] It can be deduced from the indicator that these hypothetical large-scale diversions would not be responsible stewardship.[13]

2. TOTAL INPUTS OF WATER INTO LAKE ONTARIO

The total input of water into Lake Ontario is approximately 265,000 cfs.[14] This information was derived by adding the flow through connecting channels, the flow through artificial diversions, the runoff into the lake, and the precipitation into the lake[15] (see Appendix B). These factors all increase Lake Ontario's water levels. Except for the flow through artificial diversions, the indicator does not concern this section, because these factors are naturally occurring, and not influenced by humans.

3. TOTAL WITHDRAWALS AND CONSUMPTIVE USES

Withdrawal is defined as "the removal of water from the ground or from surface water for various uses. Such removal, especially from surface water, is often returned in total or in part to approximately the same location."[16] **Consumptive Use** is defined as "that portion of water that has been withdrawn or

withheld from the Great Lakes for various uses, and is either known or assumed to be lost due to evaporation during use, leakage, or incorporation into manufactured products, or for other reasons has not been returned."[17] It should be noted at the outset, however, that while increases in water withdrawals are important, the indicator places more emphasis on consumptive uses. The rationale for this is that since the latter use is not returned to its source, it will have a more profound effect on water levels.

Three graphics accompany this section (see Appendix C, Figures 2, 3, and 4). For two of the graphics, withdrawals and consumptive uses are divided into five categories[b]: public water supply[c]; domestic[d]; agriculture[e]; industry[f]; and power[g].

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[b] All definitions are adapted from the "1989 Annual (Draft) Report of the Great Lakes Regional Water Use Data Base Repository" to the Great Lakes Resources Management Committee. February, 1991. p.4.

[c] Water withdrawn for all uses by public and private water suppliers and delivered to users that do not supply their own water.

[d] Self-supplied water, used for normal household purposes in residential, commercial and institutional settings. This category includes water used for drinking, food preparation, bathing, washing clothes and dishes, flushing toilets and watering lawns.

[e] Self-supplied water used for irrigation and livestock purposes. Irrigation is defined as water artificially applied on lands to assist in the growing of crops and pastures or in the maintenance of recreational lands.

[f] Self-supplied water for manufacturing and mining purposes. Withdrawals and consumptive uses recorded under another category (e.g., public supply) will not be recorded here.

Appendix C, Figure 2 shows the total consumptive use of water withdrawn from Lake Ontario over a three year period (1987-1989).[18] In absolute terms, public water supply consumes the most water. This is followed by power, industry, agriculture, and finally domestic water use. Appendix C, Figure 3, illustrates the percent consumed of total withdrawal during the same time period.[19] Agriculture dominates this area, but the three year trend shows a possible decline in percentage consumed. Power is not expressed on Figure 3 because the percent of water consumed from total withdrawal is less than 0.01%.

Like diversions, consumptive uses has the potential to "affect water levels and flows by reducing or removing the water supply that would otherwise flow into the Great Lakes."[20] That consumptive uses reduce lake levels is of concern because "of adverse economic and environmental impacts associated with progressively lower lake levels."[21] At present, however, any impact upon water levels of Lake Ontario resulting from consumptive uses is at best negligible. To this end, such measurement is an indication of positive stewardship.

Consumptive use of water from the Great Lakes is expected to increase over time. Although there is no data yet available on Lake Ontario itself, "the amount of consumptive use increases progressively though the Great Lakes system. Thus, the effect on water levels is least on Lake Superior, and greatest on Lake

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[9] Self-supplied water includes fossil fuel plants, nuclear plants, and hydroelectric power. Hydroelectric power is <u>not</u> considered a consumptive use.

Ontario."[22]

Three different projections predict that consumptive use of water from the entire Great Lakes region will escalate dramatically by the year 2000:[23]

a. The Study Board predicts an increase from 3199.48 million gallons per day (mil g/day) in 1975 to 6392.48 mil g/day in 2000.[24] These projections are based on Most Likely Projections (MLP).[25]

b. The International Joint Commission first predicts an increase from 3199.48 mil g/ day in 1975 to 5442.34 mil g/day in 2000. These projections are based on the Commission updating the findings of the Study Board.[26]

c. The International Joint Commission also predicts an increase from 1796.86 mil g/day in 1980 to 3664.83 mil g/ day in 2000. These projections are based on United States Geological Survey estimate of existing consumption and the Commission's projected increases.[27]

(see Appendix C, Figure 3).

The effect of these projected increases in consumptive uses is a reduction in lake levels. The Study Board found that based on the figures for the year 2000, "consumptive uses could reduce mean lake levels in Lake Superior by 0.07 feet and Lakes Michigan-Huron-Erie by 0.20 feet."[28] Lake Ontario levels are not quoted because "under one methodology, levels would fall, while under another they actually rise because of the way the current regulation Plan 1958-D responds to the consumptive use projec-

tions and water supplies."[29]

Based on the above projections, the amount of water that will be consumed will potentially double by the end of the decade. This increase of consumptive use will decrease the levels of the lake. Since externalities (i.e. human activity) are artificially reducing the normal lake level, the indicator would, under these circumstances, depict a lack of stewardship.

III. LIMITATIONS AND UNCERTAINTIES

1. Some of the data compiled in this report, especially in the Diversion section, are taken from the IJC's "Great Lakes Diversions and Consumptive Uses" report. This report relies on 1975 data.

2. The effects the diversions have on water levels are theoretical. The numbers were derived by reducing the current rates to zero, individually and in combination.[30]

3. The New York State Barge Canal and other lesser diversions are not considered because their influences on water levels are relatively minor.[31]

4. It should be reinforced that the Study Board analyzed only hypothetical diversions. "No major diversions from the Great Lakes basin is under formal consideration and that none of these concepts is currently proposed or endorsed by any government directly involved in the management of the water." [32]

5. The data compiled for the future trends in consumptive uses are based on Most Likely Projections, and are thus only

rough estimates of what may happen in the future.

IV. INTERPRETATION OF THE INDICATOR

The indicator shows two important phenomena. First, existing diversions theoretically increase the water level of Lake Ontario (no major diversions are planned for construction in the future). Second, while present consumptive uses do not affect the water levels of Lake Ontario, it is projected that both withdrawals and consumptive uses will increase dramatically by the year 2000.

In other words, human activity may be having a meaningful impact on the water levels of Lake Ontario. Changes caused by artificial factors reflect the growing instability of the Lake Ontario system, expressing itself via unpredictable lake levels. This instability invariably impacts property owners, recreationists, habitat and wetlands. Basin-wide instability may also be a precursor for increased litigation.

Future projections suggest that if we remain on our present course, this scenario will not improve. The potential for major diversions and the prediction of increased consumptive uses will heighten the problem of fluctuating lake levels.

The indicator will be successful if water flux data is collected on a consistent basis (annually, for example). Fortunately, this activity has already begun with the creation of the GLRWDB. With this information, it will be possible to compare the new data with the existing data and identify trends of

responsible stewardship (or lack thereof). For example, erecting large-scale diversions will reduce lake levels, and thus cause instability in the Lake Ontario basin. If no such diversions are constructed, the indicator demonstrates responsible stewardship. Similarly, three different projections calculate that consumptive uses will steadily increase. If efforts are not made to thwart this prediction, the indicator will reflect a lack of responsible stewardship.

FIGURE 1

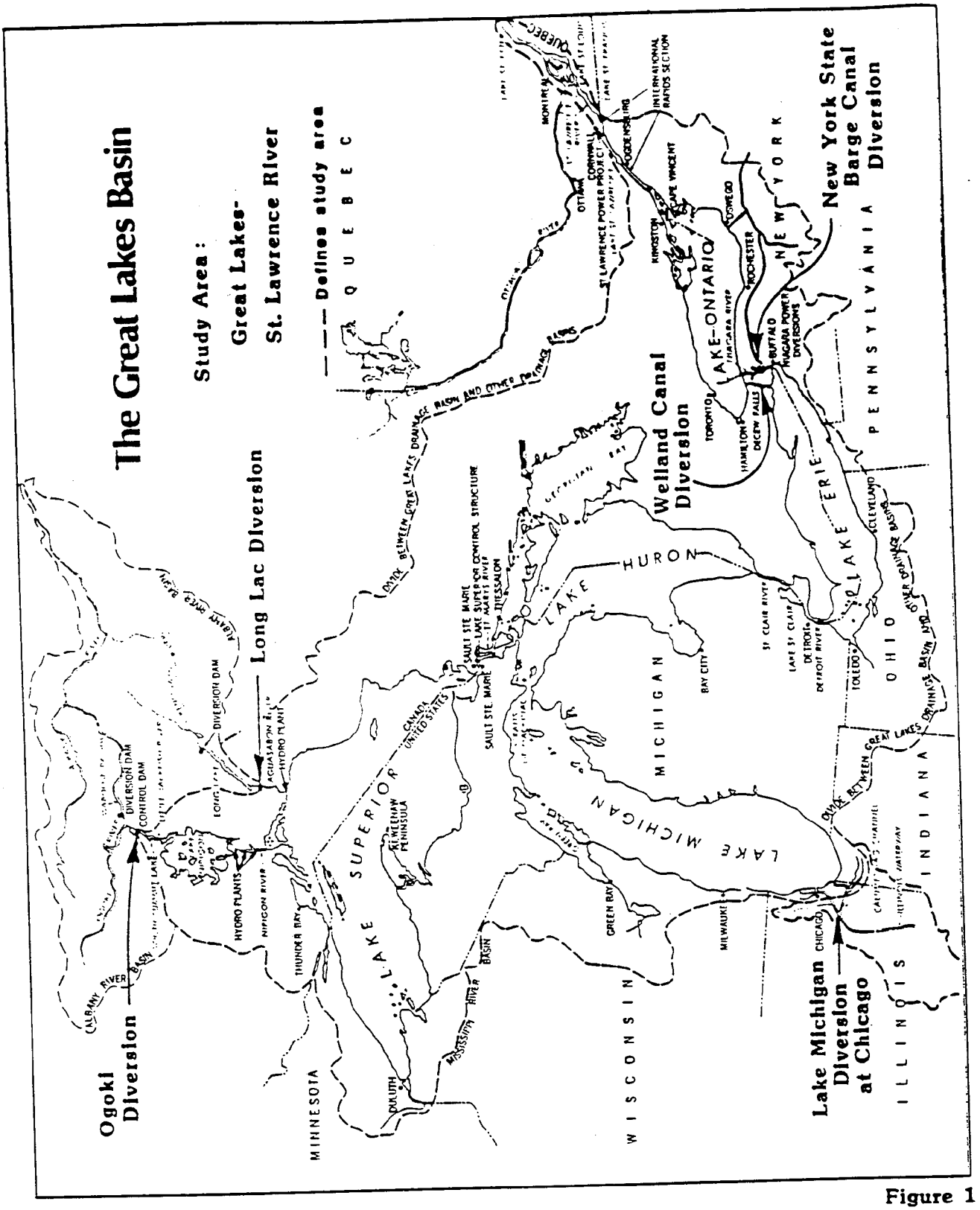


Figure 1

APPENDIX A

TABLE 1: Theoretical Effects of Existing Diversion Rates on Lake Ontario Water Levels[h]

Diversions	Rates(cfs)	Mean	Max	Min	Range
1. Long Lac/Ogoki[i]	5600[j]	+ .22	+1.26	+1.47	- .21
2. Lake Michigan at Chicago	3200[k]	- .10	-1.82	- .48	-1.34
3. Welland Canal	9400[l]	0	- .07	+ .01	- .08
4. Combined	-	+ .08	+ .64	+ .59	+ .05

[h] This information is provided by the International Joint Commission in their report "Great Lakes Diversions and Consumptive Uses". January 1985. p.21. The (+) indicates an increase in water level; the (-) indicates a decrease in the water level.

[i] For purposes of this study, Long Lac and Ogoki are considered one unit.

[j] averaged from July 1943 to December 1979. GLDCU, p.13.

[k] averaged since 1938. Ibid. p.15.

[l] Averaged since 1973. Ibid. p.18.

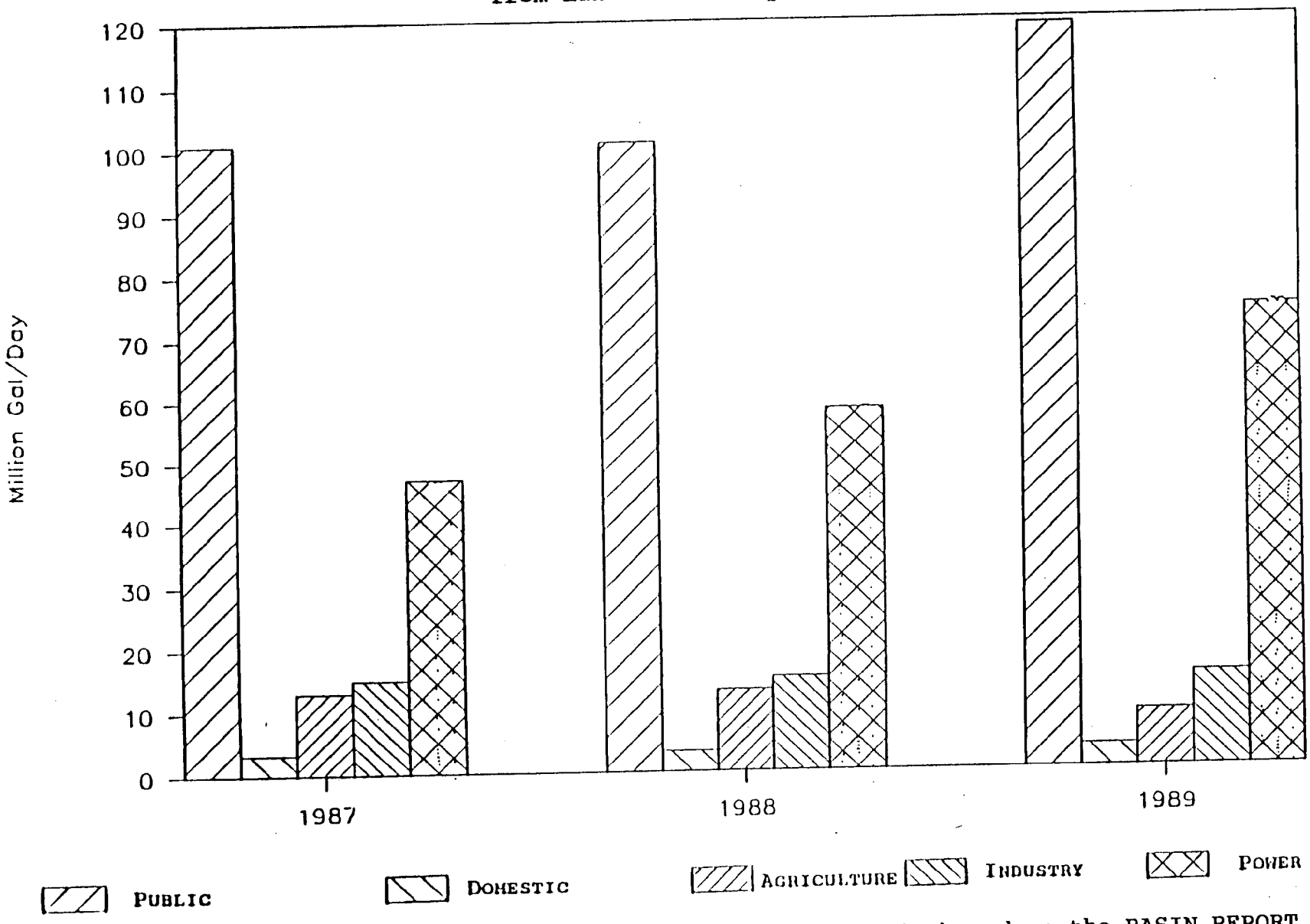
APPENDIX B - TOTAL INPUT OF WATER INTO LAKE ONTARIO[m]

INPUT	AMOUNT (in cfs)
1. Inflow from Niagara River	205000
2. Inflow from Welland Canal	7000
3. Runoff to Lake Ontario	34000
4. Precipitation into Lake Ontario	19000
TOTAL	265000 cfs

[m] This information was derived from data originally published in "The Great Lakes: An Environmental Atlas and Resource Book." Produced by the U.S. EPA and Environment Canada. 1988. p.10.

Total Consumptive Use

from Lake Ontario by Source

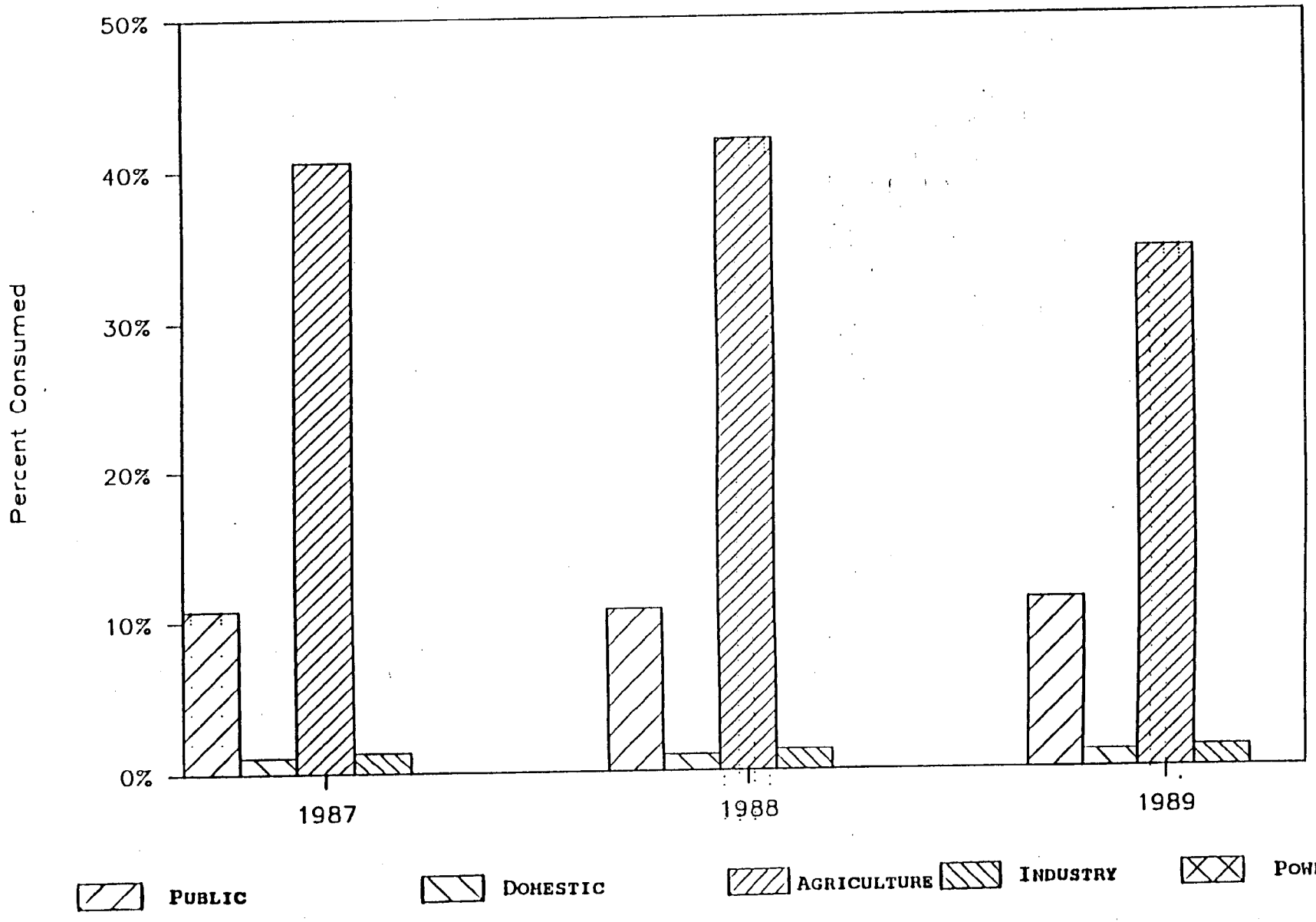


The data used to create this graphics is based on the BASIN REPORT - LAKE ONTRARIO from the 1989, 1990, and 1991 Annual Report of the Great Lakes Regional Water Use Data Base Repository" to the Great Lakes Resources Management Committee.

APPENDIX C, FIGURE 2

Percent Consumed of Total Withdrawal

from Lake Ontario by Source

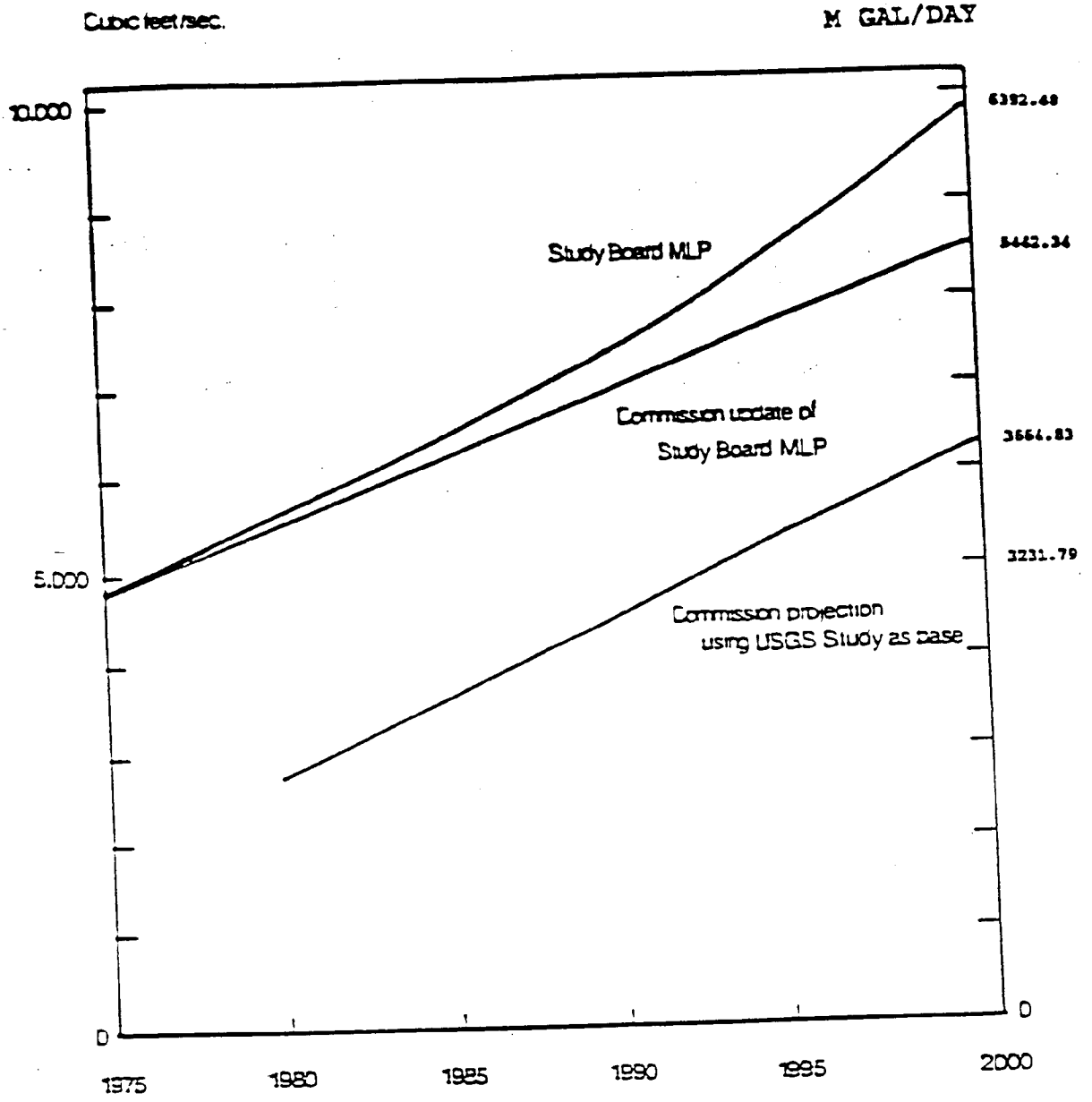


The data used to create this graphics is based on the BASIN REPORT - LAKE ONTRARIO from the 1989, 1990, and 1991 Annual Report of the Great Lakes Regional Water Use Data Base Repository" to the Great

PPENDIX C, FIGURE 3

APPENDIX C, FIGURE 4

Three Projections of Future Trends
of Total Consumptive Uses Throughout
the Great Lakes Basin



* This information was taken directly from the International Joint Commission's "Great Lakes Diversions and Consumptive Uses" report. January, 1985. p.34. As stated in the main text, this data is based on total consumptive uses throughout the entire Great Lakes.

The data was converted to million gallons per day by:
1 cfs = 7.481 mgd

Endnotes

1. "Ecosystem Objectives for Lake Ontario", Prepared by the Parties to the Great Lakes Water Quality Agreement. p.10

2. O"Connor, Joel. "EOWG Stewardship Subcommittee: Guidance for Documenting Indicators of Responsible Stewardship." p.1.

3. Ecosystem Objectives for Lake Ontario, p.11.

4. "Great Lakes Water Levels". Published by Environment Canada. Third printing, January, 1989. p.14.

5. Ibid.

6. Meador, Michael R. "Inter-basin Water Transfer: Ecological Concerns". Fisheries, vol. 17, No. 2. p.17.

7. "Great Lakes Diversions and Consumptive Uses", International Joint Commission. January, 1985. p.4.

8. Ibid. p.21.

9. Ibid.

10. Ibid. p.44.

11. Ibid. p.44. It is important to note that the Study Board analyzed only speculative diversions. In fact, "no major diversions from the Great Lakes basin is under formal consideration and that none of these concepts is currently proposed or endorsed by any government directly involved in the management of the water." Ibid.

12. Ibid.

13. Ibid. p.44. Furthermore, the Study Board concluded that although technically feasible, "the [diversions would] have little political support; they could be undertaken only at enormous, and presently unjustifiable costs; and they would have unknown but likely significant social and environmental effects."

14. "The Great Lakes: An Environmental Atlas and Resource Book." Produced by the U.S. EPA and Environment Canada. 1988. p.10.

15. Ibid.

16. Op. Cit., "Great Lakes Diversions and Consumptive Uses". p.4.

17. Ibid.

18. The data used to create this figure is based on the BASIN REPORT - LAKE ONTARIO in the following reports:
    a) "1991 (Draft) Annual Report of the Great Lakes Regional Water Use Data Base Repository" to the Great Lakes Resources Management Committee. February, 1991. **No page number.**
    b) "1990 Annual Report of the Great Lakes Regional Water Use Data Base Repository" to the Great Lakes Resources Management Committee. March, 1990. **No page number.**
    c) "1989 Annual Report of the Great Lakes Regional Water Use Data Base Repository" to the Great Lakes Resources Management Committee. February, 1989. **No page number.**

19. Ibid.

20. Op. Cit. "Great Lakes Diversions and Consumptive Uses", p.27.

21. Op. Cit. "Great Lakes Water Levels". p.12.

22. Ibid. p.12.

23. Op. Cit. "Great Lakes Diversions and Consumptive Uses", p.35.

24. Ibid. p.28, 36.

25. Ibid. The Study Board based their MLP on the following assumptions:
    a. annual population growth rate of 0.9% in the U.S. portion of the basin and 1.4% in the Canadian portion of the basin to the year 2000;
    b. continuation of existing uses of energy;
    c. attainment by the year 2000 of U.S. requirements under the Clean Water Act of 1977, and continuation of exiting practices in Canada;
    d. annual growth of the gross national product at 3.2 % in the U.S. portion of the basin and at 3.5% to 4.0% in Ontario.

26. Ibid. p.36.

27. Ibid. p.35-36.

28. Ibid. p.36.

29. Ibid.

30. Ibid. p.20.

31. Ibid.

32. Ibid. p.44.