INVENTORY OF INTERBASIN WATER TRANSFERS IN MINNESOTA

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CONVERSION FACTORS AND ABBREVIATIONS

Readers who prefer to use metric (International System) units rather than inch-pound units can make conversions using the following factors:

Multiply Inch-Pound Unit	By	To obtain Metric Unit
mile (mi)	1.609	kilometer (km)
acre	0.4047	square hectometer (hm^2)
acre-foot (acre-ft)	.001233	cubic hectometer (hm^3)
gallon (gal)	.003785	cubic meter (m^3)
million gallon per day (Mgal/d)	.04381	cubic meter per second (m^3/s)

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L.C. Trotta

ABSTRACT

Water-transfer data were collected by the U.S. Geological Survey, in cooperation with the Minnesota Department of Natural Resources, from the 13 hydrologic subregions in Minnesota. About 30,000 acre-feet of water is exported annually from eight of these subregions. Interbasin transfer of water is classified according to type of water conveyance in Minnesota. This information is needed by water-system managers and planners to develop water budgets for major river basins, to examine the extent of existing interbasin transfers, and to evaluate the feasibility of transferring water to meet regional water demands.

KEY TERMS: Interbasin transfers; Minnesota; water conveyance; sewer; ground-water infiltration

INTRODUCTION

The Great Lakes Council of Governors has begun studies leading to regulation of diversions from the Great Lakes Basin (Snavely, 1986, p. 75). Water-transfer information also is needed by water-system managers and planners to develop water budgets for major river basins and to evaluate the feasibility of interbasin transfers in meeting regional water demands. A preliminary inventory of the extent of existing interbasin water transfers is needed as a first step in determining the hydrologic effects of such diversions before they become commonplace in Minnesota.

This report focuses only on areas where water is transferred across subregion boundaries. There are 13 subregions, drained by major rivers, that are wholly or partly in Minnesota (U.S. Geological Survey, 1976). drainage divides were assumed to coincide with ground-water divides for the purpose of this preliminary inventory, in order to be compatible with concurrent national-scale studies. Ground-water divides for the shallow aquifer (whether drift or bedrock) do match the drainage divides fairly well; they have been delineated for many aquifers in Minnesota in hydrologic atlases and regional-aquifer reports published by the U.S. Geological Survey.

A questionnaire (fig. 1) was completed for every probable diversion point in the State within 1/4 mile of each subregion boundary. During this survey, the percentage of ground- or surface-water withdrawals diverted across drainage divides was estimated. This information was supplemented by interviews with water managers and by pumpage reports submitted to the Minnesota Department of Natural Resources (MDNR). When interbasin diversions were found, an information form (fig. 2) was completed and submitted for inclusion in a national-scale study of interbasin transfers (Mooty and Jeffcoat, 1986). On the form, the "point of origin" is defined as the point on the conveyance at which all or most of the water to be transferred is intercepted by the conveyance (for example, a well or stream intake). The "initial delivery point" is defined as the point in the receiving subregion where the exported water is either released to a natural channel, enters a reservoir from which the distribution of that water begins, or reaches a point along a canal or pipeline where the distribution of that water begins (Mooty and Jeffcoat, 1986).

CATEGORIES OF INTERBASIN WATER TRANSFER IN MINNESOTA

The name of conveyance allows Minnesota information forms (fig. 2) to be classified into five categories: public-water supplies, sewer systems, irrigation systems, drainage ditches, and mine dewatering.

Municipal public-water supplies compose a significant part of the interbasin diversions in Minnesota. A municipality's distribution system may pump from one side of the drainage divide and deliver to residential, commercial, and industrial users on the other side of the boundary. Some municipalities that use multiple-well fields pump water across a drainage divide in both directions, a situation that is accounted for by the transfer estimates. Intercity and rural supplies also present the possibility of interbasin transfers of water. A proposal for a rural-supply system to transfer water across Minnesota's northern border (League of Women Voters, 1984) awaits only financing.

Municipal sewer systems redirect water to a treatment plant or other disposal site, in some cases across a drainage divide. Water redirected through these sewers can amount to 20 percent of the water initially supplied (H. H. Jeffcoat, U.S. Geological Survey, oral commun., 1985). With ground-water infiltration and occasional storm runoff added to these amounts, Minnesota wastewater releases were estimated at 96 percent of municipal withdrawals in 1985. The locations of ground-water infiltration and storm sewers were unknown. Diversion amounts were based on the number of sewer connections on each side of the drainage divide. Offsets of sewer exports by public-supply imports also were accounted for in estimating net gain or loss.

Irrigation systems constitute another category of interbasin transfer in Minnesota. Irrigation wells pumping over 10,000 gallons per day that have been plotted by the MDNR (Diane Glinsman, Minnesota Department of Natural Resources, written commun., 1983) were used to locate potential interbasin transfers. After confirming an irrigation transfer by telephone, the percent of irrigated

1) City name: ____________________

2) Information source (person's name): ____________________

3) Does ____________________ have a public supply? ____
city/village/town

3b) Does the conveyance have a name?

____

Note: some systems have names for channels, canals, pipelines, reservoirs, if this is not true in your case please leave blank.

4) Is the source from wells or surface water? ____________

4b) If from well(s), how many ___, and where is/are the well(s) located? (Please mark the well location on a map.)

4c) If from surface water, how many ___, and where is/are the intakes located? (Please plot on a map.)

5) What year was the conveyance put into operation? ________

6) Do you have records of total pumpage for the/each conveyance on an annual basis for the last 10 years? (fill in as much information as you have readily available for this system).

Year	Pumpage		

7) How is that amount measured? ____________

8) Can you estimate the number of service connections on each side of the drainage divide? Please express the amounts as a percentage of the total service connections.

________ amount

________ direction relative to the divide

________ amount

________ direction relative to the divide

9) Can you further breakdown the amount of water pumped that is used specifically in relation to the drainage divide?

Use	Amount	Direction Relative to Divide
Industrial		
Commercial		
Power Plant		
Institutional		
Residential		

10) Is this breakdown based on metering or estimation? ________

Note: Estimated figures may be given as the number of service connections for each specific use. If amounts are given from metering, the units should be consistent with pumpage units.

11) Are there any other major delivery points, (water towers, reservoirs, open release, etc.) to which water is conveyed? Please locate delivery points on a map.

11b) Can you determine or estimate (please circle one) the quality delivered to this/these points? ________

12) Where is the sewage disposal located? Please locate on a map.

13) Do you use lift pumps to deliver to the disposal site? ____

13b) If yes: Can you determine or estimate the quantity delivered through the pumping station(s)?

Year		Pumpage	

14) Could you determine or estimate the total amount delivered to the disposal site?

Year	Amount	Year	Amount

15) Do you know of any water that is used twice in your area?

For example: Is water at the sewage treatment plant reclaimed?

Does the sewage treatment plant use treated effluent for irrigation?

Does the sewage treatment plant backwash filters with treated effluent?

Might any industries in town use wastewater (either municipal or private) for irrigation? Air conditioning? Fire protection? Etc?

15b) Could you determine or estimate (please circle one) the amounts for any of the above?

Year	Amount

Figure 1.--*Water Export Data Questionaire*

CONVEYANCE-INFORMATION FORM

For interbasin transfer of water between water resources subregions

Name of conveyance ____________________

____

Owner (or owners) of conveyance ____________________

____

Year placed in operation __________

	Location Information	
	Point of Origin	Initial Delivery Point
Water body name	________	________
State code	________	________
County code	________	________
8-digit hydrologic unit code	________	________

Annual Diversion in Acre-Feet for Water Year

1973 ________	1974 ________	1975 ________
1976 ________	1977 ________	1978 ________
1979 ________	1980 ________	1981 ________
1982 ________		

Location of measurement point(s) (gage numbers, well numbers, or latitude and longitude of gages or wells) ____________________

Data sources ____________________

____

Remarks on accuracy of estimates ____________________

____

Other remarks ____________________

____

Figure 2.--*Conveyance information form for interbasin transfer of water between water-resources subregions*

fields outside of the source drainage basin was applied to determine amounts transferred. This method assumes that the flow rate is constant throughout a particular irrigation system.

Drainage ditches constitute another category of interbasin transfer. As much as 19 percent of Minnesota was covered by wetlands in the 1830's (Palmer, 1915). Even before the inception of the first drainage act in 1858, these wetlands were looked at as a "common enemy" and were ditched and drained to expand agricultural land. Though drainage slowed after 1920, it was not until the ecological awakening of the 1960's that drainage law reflected a management desire to protect the waters of the State (King, 1980, p. 2-13). Owing to increased costs of draining and reduced crop prices, it is no longer profitable to drain the marshes for cropland (Larry Swanson, Nebraska Agricultural Extension, written commun., 1987). Although drainage-ditch inventories (for example, Minnesota Department of Natural Resources, 1974; Quade and others, 1980) and county ditch maps exist, flow measurements are scarce, making it difficult to quantify the historical effects of interbasin transfers via drainage ditches. A topographic high or surface-water divide (however minor) commonly was crossed to drain relatively flat regions. The drained water then would be transferred across this divide and usually routed into a stream or lake, essentially expanding the basin. Only about 2 percent of the State is now covered by wetlands (Sandy Fecht, Minnesota Department of Natural Resources, oral commun., 1987). Though not all comprised "subregion transfer," about 16 percent of the State (8,600,000 acres) was drained from 1830 to the present.

A current analysis suggests that interbasin transfer by drainage ditches is small. A general area of surface-water transfer exists in the wetlands between Rapid River and Upper Red Lake in northern Minnesota (fig. 3) that may be concentrated in the drainage ditches. Direction of movement here is unknown and may change with the wind. Elsewhere, leakage through a drainage ditch may affect the ground-water flow system (Faustini and Bradbury, 1985).

Mine dewatering presents the final category of subregion transfer in Minnesota. Like drainage ditches, the goal of mine dewatering is to remove water to present a dry working environment. Although this category may have been more significant in the past, only dewatering at one site currently satisfies inventory criteria.

There may be other categories of interbasin diversions in Minnesota, but no evidence has been found at the subregion boundaries. Privately owned wastewater pipelines, which are difficult to locate, may cross drainage divides. None were found in the detailed facility file records searched for this report (Gianessi, 1981).

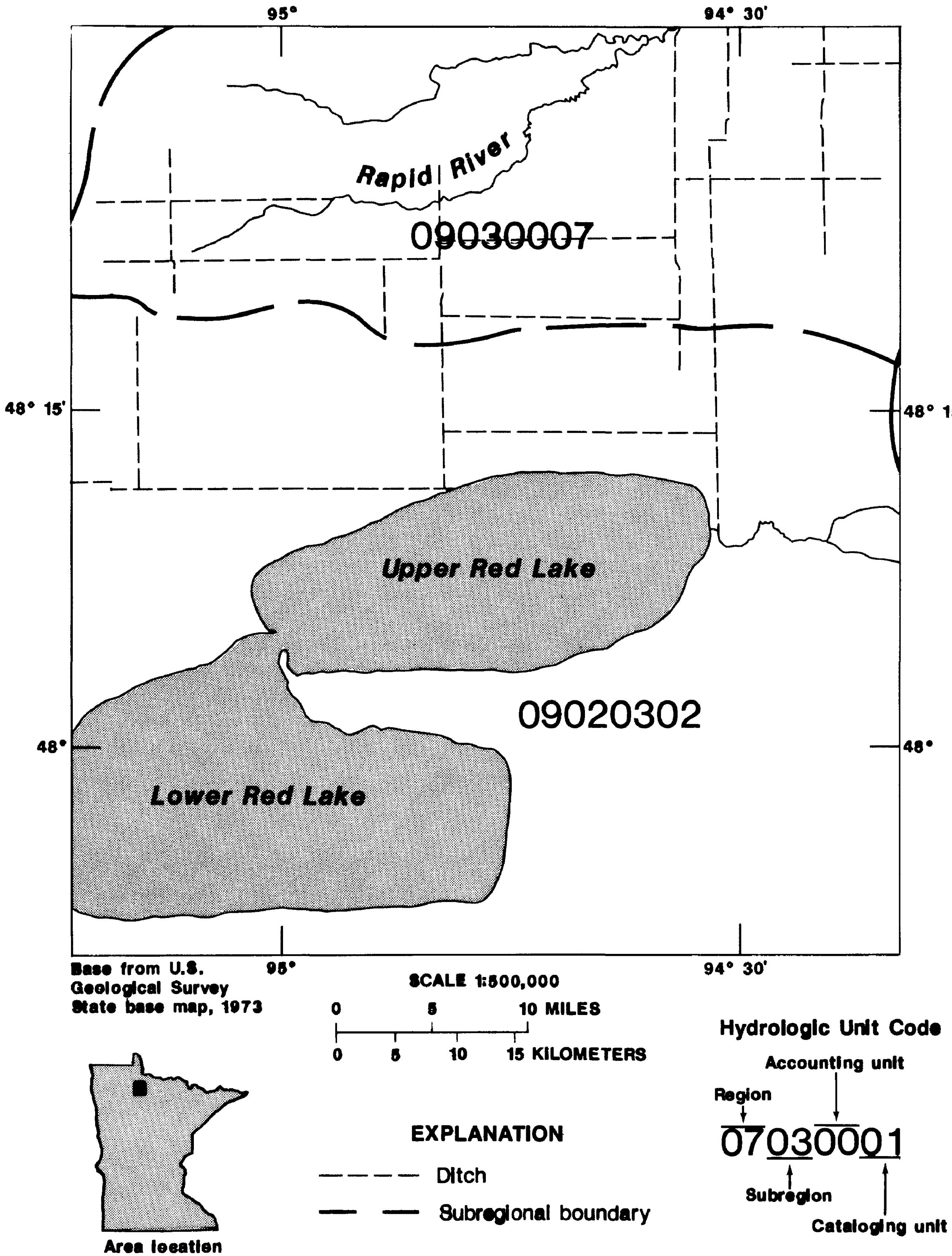

Figure 3.--Rapid River, Upper Red Lake area

ORGANIZATION OF INVENTORY DATA

The conveyance information in this report is presented in tables 1 and 2 in the back of this report.

Table 1--Lists a conveyance reference number, the permit number, the transfer category, the county in which the conveyance originates, and the conveyance owner.

Reference number--An assigned number used to identify each conveyance in tables 1 and 2, and in figure 4.

Permit number--The water appropriation permit number assigned by the Minnesota Department of Natural Resources, Division of Waters, to the well or intake withdrawing the water supplied to the conveyance. Or, in the case of sewer systems, the National Pollution Discharge Elimination System (NPDES) number assigned by the Minnesota Pollution Control Agency to the outflow or discharge point of the conveyance.

Category--The transfer category as described in the previous section of this report.

County--The County name at the conveyance point of origin.

Owner--The entity that owns the conveyance. The listed entity for some conveyances may be the entity currently responsible for the operation of the conveyance.

Table 2--For each conveyance, table 2 lists the year the conveyance was placed in operation, the percentage of withdrawal exported from the source basin by the conveyance, the hydrologic unit code (see U.S. Geological Survey, 1976) for the point of origin (From) and the initial delivery point (To), the average export of water in Mgal/d (million gallons per day) for 1985, subtotals of 1985 exports for one water-resources subregion to another, total 1985 exports from each subregion, and a grand total of 1985 exports from all subregions. The net gain or loss due to interbasin transfer is portrayed graphically for each subregion on figure 4.

ANALYSIS

A study focusing on the boundaries between all 81 tributary streams defined as major drainage basins by the State (Minnesota Department of Natural Resources, 1979) would doubtless uncover more transfers. In some cases, the choice of subregion boundaries as the base unit for definition of water transfer may limit the application of results. For instance, where the source of the water transferred is ground water, the ground-water divide then would be the more appropriate boundary of transfer. Water transported from the Mount Simon-Hinckley aquifer may cross a subregion boundary without crossing the potentiometric divide for that aquifer. Flow calculations listed in table 2 are, therefore, of little use to models of deeper aquifers.

Table 1.--*Conveyance Reference Number, Permit Number, Category, County and Owner*
(Dashes indicate that number is not determined)

Reference number	Permit number	Category	County	Owner
1	MN0003069	Sewer system	Otter Tail	City of New York Mills
2	754228	Public water supply	Kandiyohi	City of Willmar
3	-------	Sewer system	Hennepin	City of Deephaven
4	731119	Public water supply	Hennepin	City of Edina
5	-------	Sewer system	Hennepin	City of Excelsior
6	-------	Sewer system	Hennepin	City of Greenwood
7	756245	Public water supply	Hennepin	City of Hopkins
8	MN0029874	Sewer system	Hennepin	City of Long Lake
9	731429	Public water supply	Hennepin	City of Minneapolis
10	-------	Sewer system	Hennepin	City of Minnetonka
11	-------	Sewer system	Hennepin	City of Minnetonka Beach
12	-------	Sewer system	Hennepin	City of Minnetrista
13	-------	Sewer system	Hennepin	City of Mound
14	MN0024414	Sewer system	Hennepin	City of Orono
15	620691	Public water supply	Hennepin	City of Richfield
16	-------	Sewer system	Hennepin	City of Shorewood
17	-------	Sewer system	Hennepin	City of Spring Park
18	-------	Sewer system	Hennepin	City of St Bonifacius
19	756227	Public water supply	Ramsey	City of St Paul
20	-------	Sewer system	Hennepin	City of Tonka Bay
21	-------	Sewer system	Carver	City of Victoria
22	-------	Sewer system	Hennepin	City of Wayzata
23	none	Irrigation	Washington	Steve Houle
24	753209	Public water supply	Isanti	City of Braham
25	754228	Public water supply	Kandiyohi	City of Willmar
26	MN0025259	Sewer system	Kandiyohi	City of Willmar
27	811164	Irrigation	Pope	Dwayne Lent
28	761431	Irrigation	Pope	Larry Freeman

Table 1.--*Conveyance Reference Number, Permit Number, Category, County and Owner* --Continued

Reference number	Permit number	Category	County	Owner
29	796309	Public water supply	Carver	City of Norwood
30	665841	Public water supply	McLeod	City of Steware
31	MN0025003	Sewer system	McLeod	City of Steward
32	776448	Public water supply	Carver	City of Young America
33	MN0046159	Sewer system	Hennepin	City of Edina
34	756245	Public water supply	Hennepin	City of Hopkins
35	-------	Sewer system	Hennepin	City of Hopkins
36	796207	Public water supply	Hennepin	City of Minnetonka
37	-------	Sewer system	Hennepin	City of Richfield
38	-------	Sewer system	Le Sueur	City of Elysian
39	804148	Public water supply	Waseca	City of Waseca
40	650815	Public water supply	Washington	City of Forest Lake
41	MN0029815	Sewer system	Washington	City of Forest Lake
42	776294	Irrigation	Washington	Keith J. McCallum
43	784220	Public water supply	Le Sueur	City of Elysian
44	804148	Public water supply	Waseca	City of Waseca
45	795170	Public water supply	Fillmore	City of Harmony
46	MN0022322	Sewer system	Fillmore	City of Harmony
47	600885	Public water supply	Stevens	City of Donnelly
48	710507	Irrigation	Otter Tail	Arvin & Delvin Menze
49	801164	Public water supply	Otter Tail	City of Henning
50	-------	Sewer system	Otter Tail	City of Henning
51	751153	Public water supply	Otter Tail	City of New York Mills
52	580353	Mine dewatering	St. Louis	City of Virginia
53	MN0030163	Sewer system	St. Louis	City of Virginia
54	794114	Public water supply	Lincoln	Lincoln & Pipestone Cnty
55	794114	Public water supply	Lincoln	Lincoln & Pipestone Cnty
56	794114	Public water supply	Lincoln	Lincoln & Pipestone Cnty
57	631128	Public water supply	Nobles	City of Worthington

Table 2.--*Exports of Water from Hydrologic Units, 1985 Calendar Year*

Conveyance						
Reference number	Year placed in operation	Percent pumpage exported	Hydrologic Unit Code From	Hydrologic Unit Code To		1985 exports (million gallons per day)
1	1935	15	07010107	09020103		0.02

			0701	0902	Subtotal	0.02
2	1890	500	07010205	07020004		0.43
3	1973	----1/	07010206	07020012		0.26
4	1937	50	07010206	07020012		0.31
5	1972	327	07010206	07020012		0.35
6	1972	144	07010206	07020012		0.06
7	1954	23	07010206	07020012		0.04
8	1981	200	07010206	07020012		0.30
9	1961	245	07010206	07020012		2.70
10	1973	43	07010206	07020012		2.75
11	1981	150	07010206	07020012		0.07
12	1974	445	07010206	07020012		0.19
13	1974	1171	07010206	07020012		1.28
14	1981	324	07010206	07020012		0.58
15	1963	34	07010206	07020012		0.06
16	1973	1919	07010206	07020012		0.71
17	1974	317	07010206	07020012		0.30
18	1973	229	07010206	07020012		0.09
19	1962	0	07010206	07020012		0.02
20	1972	311	07010206	07020012		0.20
21	1973	1319	07010206	07020012		0.16
22	1971	1406	07010206	07020012		0.69

			0701	0702	Subtotal	11.55
23	1978	62	07010206	07030005		<0.01
24	1936	30	07010207	07030004		0.04

			0701	0703	Subtotal	0.04

			0701		Total	11.61

Table 2.--*Exports of Water from Hydrologic Units, 1985 Calendar Year*--Continued

Conveyance						
Reference number	Year placed in operation	Percent pumpage exported	Hydrologic Unit Code From	Hydrologic Unit Code To		1985 exports (million gallons per day)
25	1890	60	07020004	07010205		0.05
26	1912	1320	07020004	07010205		1.15
27	1981	40	07020005	07010204		0.04
28	1977	51	07020005	07010204		0.02
29	1926	5	07020012	07010205		<0.01
30	1907	25	07020012	07010205		0.02
31	1957	91	07020012	07010205		0.06
32	1946	40	07020012	07010205		0.03
33	1923	557	07020012	07010206		3.45
34	1880	27	07020012	07010206		0.04
35	1971	19	07020012	07010206		1.30
36	1962	34	07020012	07010206		2.17
37	1952	579	07020012	07010206		0.97

			0702	0701	Subtotal	9.30
38	1973	660	07020011	07040002		<0.01
39	1923	180	07020011	07040002		1.09

			0702	0704	Subtotal	1.09

			0702		Total	10.39
40	1931	113	07030005	07010206		0.22
41	1919	88	07030005	07010206		0.56
42	1977	25	07030005	07010206		<0.01

			0703	0701	Subtotal	0.78

			0703		Total	0.78
43	1938	3320	07040002	07020011		0.02
44	1980	13	07040002	07020011		0.08

			0704	0702	Subtotal	0.10

Table 2.--*Exports of Water from Hydrologic Units, 1985 Calendar Year*--Continued

Conveyance						
Reference number	Year placed in operation	Percent pumpage exported	Hydrologic Unit Code From	Hydrologic Unit Code To		1985 exports (million gallons per day)
45	1950	48	07040008	07060002		0.02
46	1923	146	07040008	07060002		0.07

			0704	0706	Subtotal	0.09

			0704		Total	0.19
47	1960	51	09020102	07020002		0.01

			0902	0702	Subtotal	0.01
48	1971	30	09020103	07010106		0.03
49	1936	27	09020103	07010107		0.02
50	1938	177	09020103	07010107		0.12
51	1936	15	09020103	07010107		0.01

			0902	0701	Subtotal	0.18

			0902		Total	0.19
52	1942	60	09030002	04010201		1.12
53	1907	58	09030002	04010201		1.08

			0903	0401	Subtotal	2.20

			0903		Total	2.20
54	1979	32	10170203	07020003		0.07
55	1979	32	10170203	07020004		0.07
56	1979	53	10170203	07020006		0.11

			1017	0702	Subtotal	0.25

			1017		Total	0.25
57	1900	60	10230003	07100001		1.17

			1023	0710	Subtotal	1.17

			1023		Total	1.17
						====
					Grand Total	26.78

1/ Not applicable, most of city not on public supply

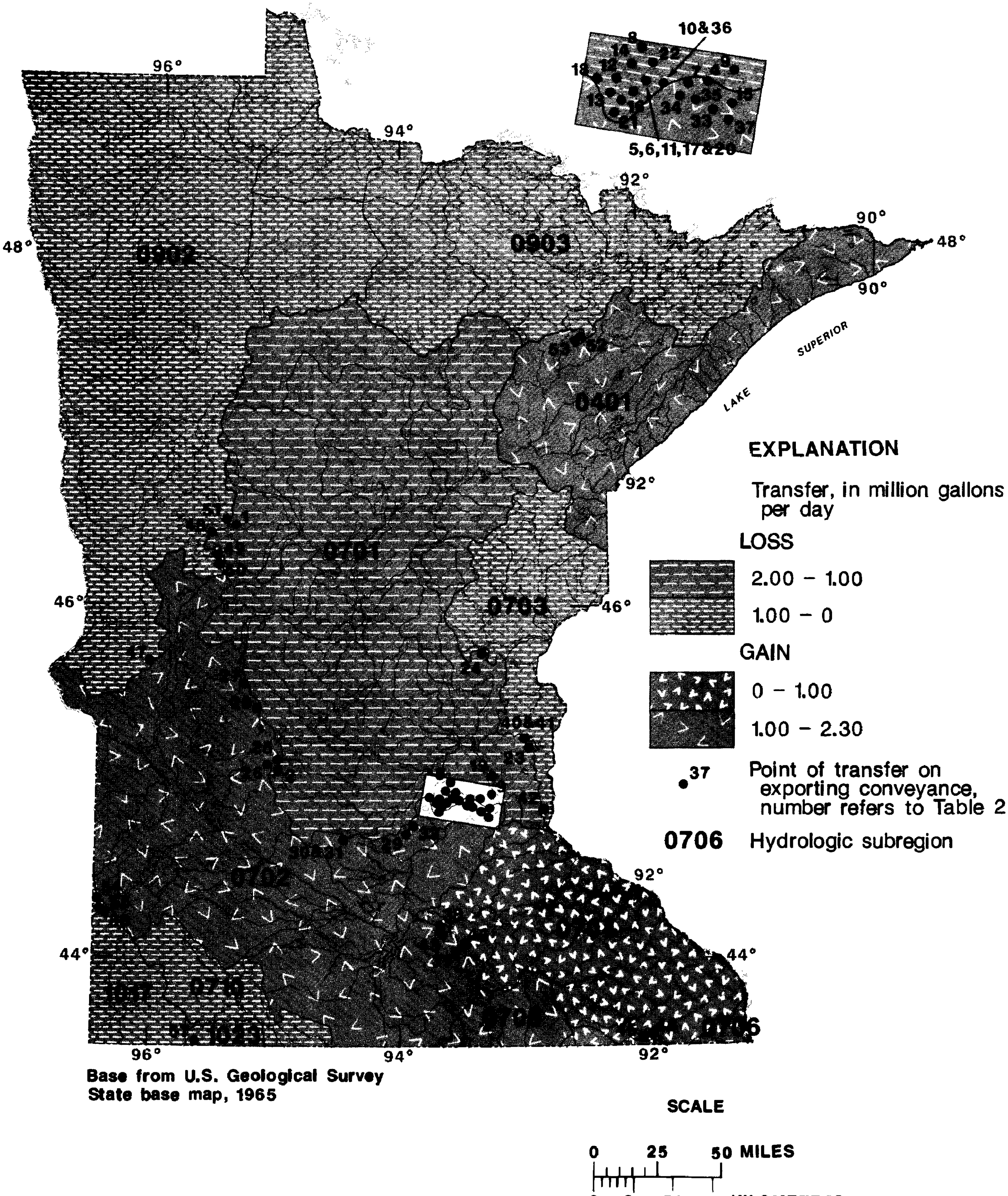

Figure 4.--1985 net gains or losses due to interbasin transfer.

A suggested refinement of this study would be improvement and analysis of the percentage of withdrawal exported, given in table 2. These percentages are commonly gross estimates based on topographic maps and data reported either in the Minnesota Water-Use Data System, by Oberts (1984), or by the Metropolitan Waste Control Commission (1984). The accuracy of the estimates could be refined with further study by local water managers. For consistency, the percentage estimates assume that any ground-water infiltration or connection of storm sewers occurs on the source side of the boundary. Analysis of these percentages may provide useful insights. For instance, flowmeter measurements of the sewer system in the City of Harmony (reference number 46) indicate that a maximum of 25 percent of public-supply withdrawals enters the sewers and that ground-water infiltration probably is the major source of interbasin diversion along this conveyance. A drought which lowers the water table below the sewer pipe could greatly affect the amount exported.

Subsequent studies are needed to determine the effect of diversions identified in this study on the quantity and quality of the water resources.

These studies might include:

1) better definition of ground-water divides to assess the effect of pumpage on interbasin diversions.

2) documentation of historical changes in water quality in source and receiving waters.

3) generalization of hydrologic effects by transfer category and comparison to similar effects in other geographic or geologic areas.

4) modeling of water budgets for subregions incorporating interbasin-transfer data.

5) assessment of the risk that the diversion might negatively affect future economic development in the source area by restricting the availability of water.

SUMMARY

Water is exported from 8 of the 13 subregions examined in this study using 57 conveyances. These conveyances originate in 16 counties and range from the 4 conveyances exporting less than 0.01 Mgal/d to an export of 3.45 Mgal/d from the City of Edina's sewer system conveyance (reference number 33). Four of the conveyances (reference numbers 9, 10, 33 and 36 on fig. 4) account for 41 percent of the exports between subregions. The total amount of water exported by the 57 conveyances was about 26.8 Mgal/d in 1985. The City of Hopkins public-supply conveyance (reference number 34), built in 1880, is the oldest conveyance. Historical trends can be examined by applying the percentage of export in table 2 to historical pumpage totals available in the Minnesota Water Use Data System. Data for 1973-82 are listed by Mooty and Jeffcoat (1986, table 3) for several conveyances. The history of interbasin transfer in the drainage-ditch category gives insight to the hydrologic effects of large transfers of water and provides information needed by water-system managers and planners in developing water budgets.

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