APPENDIX 2

TIME OF TRAVEL SYNOPSIS

UPPER MISSISSIPPI RIVER SOURCE WATER PROTECTION PROJECT

TIME OF TRAVEL SYNOPSIS

MISSISSIPPI RIVER MAIN STEM AND SELECTED TRIBUTARIES

October 19, 2004

The delineation of source water protection areas for a surface water supplier will be in part a function of transport time from a potential contaminant release point to a water intake. It is necessary for a water supplier to calculate the amount of time necessary in the event of a contaminant release to 1) maximize finished water storage and 2) close surface the water intake. The amount of time necessary to accomplish this will determine the size of the source water protection area, based on time of travel estimates. In the process of preparing source water assessments for St. Cloud, St. Paul, and Minneapolis, an 8-hour time of travel factor was assumed for delineating the "inner emergency response area." (The corresponding area for the source water protection plan is referred to as <u>"Priority Area</u> <u>A."</u>) Each water supplier, in consultation their respective source water protection team, must determine if this 8-hour time of travel factor is appropriate for delineating the "Priority Area A" of the source water protection area. Travel times, and therefore the boundaries of a delineated source water protection area, are a function of the flow conditions (high, medium, or low) that are assumed for delineation purposes.

High flows decrease travel times, expand the size of a delineated source water protection area, and would tend to reduce certain contaminant concentrations. Low flows increase travel times, reduce the size of a delineated source water protection area, and would tend to increase certain contaminant concentrations. Median flows represent a range of flow conditions that would exist for a greater percentage of the time than would high or low flow levels.

Estimating 8-hour time of travel distances relative to the St. Cloud, St. Paul, and Minneapolis intakes entails two separate calculations: 1) travel times on the Mississippi River main stem and 2) travel times on the following Mississippi River tributaries: the Sauk, Elk, Rum, and Crow Rivers and Elm, Coon, and Rice Creeks.

Initially, a "Time of Travel Synopsis," dated May 14, 2004, was prepared on the basis of <u>high flow assumptions</u>. In order for the St. Cloud, St. Paul, and Minneapolis source water protection teams to delineate the source water protection areas for these cities, medium and low flow times of travel are included here.

On the Mississippi River main stem and the seven tributaries, travel times associated with flows at the <u>10% exceedance level</u> (high flows), <u>50% exceedance level</u> (medium flows), and <u>90% exceedance level</u> (low flows) are described.

During the 1990's, the U.S. Army Corps of Engineers developed a tool to predict time of travel on the Mississippi River main stem above the Twin Cities as part of the Mississippi

River Defense Network. The "Riverine Emergency Management Model" ("REMM") includes a hydraulic model by which travel times on the Mississippi River can be predicted based on several variables. During the spring of 2004, the Corps calculated high flow travel times and distances on the Mississippi River main stem, using the REMM hydraulic model. The Corps calculated 1) an 8-hour time of travel distance upstream from the St. Cloud, St. Paul, and Minneapolis intakes; 2) the time of travel from the confluence of the Sauk and Mississippi Rivers to the St. Cloud intake; and 3) the respective times of travel from the Mississippi River confluences of the Elk, Rum, and Crow Rivers and Elm, Coon, and Rice Creeks to the St. Paul and Minneapolis intakes.

During the fall of 2004, the Corps prepared calculations for the Mississippi River main stem reaches noted above assuming medium- and low-flow conditions. In addition, the Corps recalculated its spring 2004 high flow calculations, using assumptions more equivalent to those employed by the U.S. Geological Survey (USGS) on the Mississippi River tributaries. This recalculation resulted in significantly modified high flow times of travel on the Mississippi River main stem from those reported in the May 14, 2004 "Time of Travel Synopsis."

River mile notations on the Mississippi River are measured from the confluence of the Ohio and Mississippi Rivers above Cairo, Illinois.

During the summer of 2003, the U.S. Geological Survey (USGS) conducted a dye trace study on the Sauk River, from approximately Rockville to the Mississippi River confluence. The USGS prepared time of travel estimates for the seven Mississippi River tributaries; these estimates used equations based on many time of travel studies conducted throughout the nation. The Sauk River dye trace study was carried out to verify the reliability of these equation estimates. Travel times were noted from selected locations on each tributary (2-4 locations) to its confluence with the Mississippi River. These locations are noted on the attached tributary watershed maps.

For St. Cloud, an 8-hour time of travel distance upstream on the Mississippi River main stem has been estimated by the Corps of Engineers. An 8-hour time of travel distance also will be estimated by project staff by combining 1) the travel time on the Mississippi River from the Sauk River confluence to the St. Cloud intake and 2) the travel time distance up the Sauk River, based on the USGS estimates, which, in combination with 1), will equal a total 8-hour travel time distance.

For St. Paul and Minneapolis, an 8-hour time of travel distance upstream on the Mississippi River main stem has been estimated by the Corps of Engineers. Eight-hour times of travel distance will be estimated by project staff by combining 1) the travel time on the Mississippi River from each tributary confluence to the respective water intakes and 2) the travel time distance up each tributary, based on the USGS estimates, which, combined with 1), will equal a total 8-hour travel time distance.

All Mississippi River main stem travel times are based on river currents at the surface.

Since the travel times estimated by the USGS on the Mississippi River tributaries are associated with specific locations on each tributary, a degree of extrapolation by the source water assessment teams will be necessary to estimate an exact 8-hour travel time distance.

1. Eight hour time of travel locations upstream of the St. Cloud, St. Paul, and Minneapolis intakes on the Mississippi River main stem

A. The eight-hour time of travel locations upstream of the St. Cloud intake are:

River Mile 936.0
River Mile 933.35
River Mile 932.67

B. The eight-hour time of travel locations upstream of the St. Paul intake are:

<u>High flows</u> :	River	Mile	874.91
<u>Medium flows</u> :	River	Mile	867.75
Low flows:	River	Mile	866.55

C. The eight-hour time of travel locations upstream of the Minneapolis intake are:

High flows:	River Mile 871.1
Medium flows:	River Mile 866.51
Low flows:	River Mile 862.4

- 2. Time of travel on the Mississippi River from the confluences of the Mississippi River and certain tributaries to the St. Cloud, St. Paul, and Minneapolis intakes
 - A. The times of travel from the Sauk River to the St. Cloud intake are

<u>High flows</u> :	0 hours 55 minutes
Medium flows:	2 hours 29 minutes
Low flows:	4 hours 50 minutes

B. The times of travel from the Elk, Crow, and Rum Rivers and Elm, Coon, and Rice Creeks to the St. Paul intake are as follows.

	High flows	Medium flows	Low flows
Elk River	12 hrs 03 mins	33 hrs 40 mins	88 hrs 03 mins
Crow River	10 hrs 07 mins	29 hrs 21 mins	76 hrs 36 mins

Rum River	06 hrs 08 mins	19 hrs 32 mins	50 hrs 39 mins
Elm Creek	05 hrs 53 mins	18 hrs 54 mins	48 hrs 57 mins
Coon Creek	01 hrs 06 mins	02 hrs 10 mins	04 hrs 12 mins
Rice Creek	N/A	N/A	N/A

C. The times of travel from the Elk, Crow, and Rum Rivers and Elm, Coon, and Rice Creeks to the Minneapolis intake are as follows.

	<u>High flows</u>	Medium flows	Low flows
Elk River	14 hrs 06 mins	37 hrs 49 mins	96 hrs 53 mins
Crow River	12 hrs 10 mins	33 hrs 30 mins	85 hrs 27 mins
Rum River	08 hrs 10 mins	23 hrs 40 mins	59 hrs 29 mins
Elm Creek	07 hrs 56 mins	23 hrs 02 mins	57 hrs 48 mins
Coon Creek	03 hrs 09 mins	06 hrs 19 mins	13 hrs 03 mins
Rice Creek	01 hrs 34 mins	03 hrs 11 mins	06 hrs 55 mins

3. Time of travel locations for high, medium, and low flow conditions on certain tributaries upstream of their respective confluences with the Mississippi River

The USGS estimated time of travel to the Mississippi River confluence from selected locations on the Sauk, Elk, Crow, and Rum Rivers and Elm, Coon, and Rice Creeks (shown on the following maps). A list of these locations, by tributary, and the estimated time of travel (in hours) for the leading edge of a contaminant plume from each location to the Mississippi River confluence follows.

Sauk River	High flows	Medium flows	Low flows
County Road 1	0.03 hr	0.04 hr	0.1 hr
Veterans Drive	2.01 hr	2.51 hr	6.79 hr
County Road 121	5.10 hr	6.33 hr	16.84 hr
Interstate 94 Bridge	5.69 hr	7.07 hr	18.75 hr
County Road 139 (Rockville) 8.56 hr	10.62 hr	27.89 hr
Elk River	High flows	Medium flows	Low flows
Orono Lake Dam	0.61 hr	1.05 hr	1.48 hr
Orono Lake inlet	2.25 hr	3.77 hr	5.23 hr
BN Railroad	4.38 hr	7.35 hr	10.21 hr
USGS gauge 5.	95 hr	9.98 hr 13.	84 hr
Crow River	High flows	Medium flows	Low flows
Interstate 94 Bridge	3.42 hr	8.39 hr	15.24 hr
St. Michael WWTP	5.68 hr	14.20 hr	26.48 hr
Rockford USGS gauge	10.9 hr	27.25 hr	50.84 hr
Rum River	High flows	Medium flows	Low flows
Below Trott Brook	5.78 hr	10.14 hr	15.44 hr
County Road 22 USGS gaug	je 9.84 hr	17.28 hr	26.41 hr

Elm Creek	High flows	Medium flows	Low flows
US 169	0.31 hr	0.75 hr	1.18 hr
Elm Creek Road USGS gauge	4.28 hr	9.60 hr	14.23 hr
Below Rush Creek confluence	5.46 hr	12.24 hr	18.11 hr
93 rd Ave N	8.89 hr	20.09 hr	29.93 hr
Coon Creek	High flows	Medium flows	Low flows
Northdale Blvd	4.95 hr	6.98 hr	11.58 hr
S Coon Creek Drive	8.82 hr	12.41 hr	20.49 hr
Rice Creek	High flows	Medium flows	Low flows
Long Lake Rd	4.61 hr	6.39 hr	11.20 hr
Baldwin Lake outlet	10.43 hr	14.37 hr	24.79 hr