

## **B. NON-POINT SOURCES**

Non-point sources contribute sediments, nutrients, and toxic substances to the Area of Concern. Sedimentation rates have been accelerating since the turn of the century as evidenced by paleolimnological analyses of sediment cores from the St. Louis estuary. Modern rates have been estimated as high as 0.37 g. dry sediment weight/square cm/year (Kingston, 1987). Little or no current quantitative information on non-point source loadings of nutrients and toxic substances to the Area of Concern available.

In addition to high sediment loading in the Area of Concern, nutrient loading from non-point sources is of concern. Phosphorous availability and transport through the system may be connected to the high sediment loading. Nutrient (particularly phosphorus) concentrations in the estuary are relatively high, although eutrophication does not appear to be a current problem (See "Eutrophication/Excessive Loading" Section, Chapter IV). In 1972 the National Eutrophication Survey developed a nutrient budget for St. Louis Bay which estimated that 50% of the phosphorus inputs to the Bay were from non-point sources (U.S. EPA, 1975). In 1982, a study of nutrient loadings to the Bay concluded that point source loadings of nutrients had decreased to one fifth of their former inputs (Cook and Ameal, 1983). This study also found that 90% of the nutrient loadings to St. Louis Bay in 1982 were from non-point sources, and that overall loadings were similar between 1972 and 1982 because 1982 was a year of high flow. These nutrient budgets did not consider point source loadings from Wisconsin, and did not take into account the Lake Superior seiche. Although eutrophic conditions have not been noted within the St. Louis estuary in the last decade, nutrient loadings from the system to Lake Superior are of concern.

The types of non-point sources of sediments and other pollutants discussed in this section are agricultural/forestry runoff, stormwater discharge, unsewered communities, marine recreational and commercial activity, spills, and atmospheric deposition.

### **1. Run-off Affected by Land Use Practices**

The impact of non-point source pollution from land uses such as forestry and agricultural practices is not well documented in the Area of Concern. The major non-point source concerns related to silviculture and agriculture are increased sediment loading resulting from past and current forestry practices, nutrient loading from feedlots along the St. Louis and Nemadji Rivers, and pesticide run-off. The following section describes what is known about land use practices and their relation to environmental impacts in the Area of Concern.

## **a. Effects of Land Use Practices in the Watershed on Erosion, Sedimentation, and Nonpoint Source Pollution.**

### **1) Sediment Delivery**

The red clay deposits of the western Lake Superior Basin affect the St. Louis estuary and western Lake Superior. The significance of red clay deposit erosion is highlighted when comparing the St. Louis River and Nemadji River watersheds to annual maintenance dredging volumes in Duluth-Superior Harbor. The St. Louis River drains a 3,500 mi<sup>2</sup> watershed of which 120 miles<sup>2</sup> is red clay deposit. The Nemadji River drains a 360 mi<sup>2</sup> watershed of which 100 mi<sup>2</sup> is red clay. The Nemadji River is responsible for nearly half of the US Army Corps of Engineers annual dredging volume of 200,000 cubic yards. This maintenance dredging volume comes with a disposal cost that has averaged \$7.00/yd<sup>3</sup> (Northwest Regional Planning Commission, 1989). Deer Creek is a typical red clay area tributary of the Nemadji River. Deer Creek's average annual sediment yield exceeds 200 tons/mile<sup>2</sup> and is among the highest in Minnesota (USGS, 1986). An estimated sediment load of 280,000 metric tons per year is transported from the Nemadji River to Lake Superior (Bahnick, 1977). This represents only the sediment fraction which is small enough to stay in suspension and reach the Lake. The Nemadji sediment plume extends as far as 25 km into Lake Superior after storm events (Appendix L - Banks and Brooks, 1992).

### **2) Erosion in the Red Clay Area**

A relatively high rate of erosion is to be expected in the geologically young, highly erodible red clay deposit around western Lake Superior. However, Minnesota Sea Grant sediment core sampling shows that accelerated sedimentation is occurring in the St. Louis River estuary. Core samples showed steadily increasing rates of sedimentation from the 1860's to the present (Minnesota Sea Grant, 1987). Land use and land cover type changes since the mid 1800's has resulted in hydrologic and geologic alteration.

The Red Clay Project of the 1970's concluded that the major source of sediment in the watershed was from stream banks, lakeshore, and other slopes (U.S. EPA, 1979). The Red Clay Project was a joint research and demonstration project of the U.S. Environmental Protection Agency, Soil and Water Conservation Districts and USDA Soil Conservation Service in the Nemadji watershed in Carlton County, MN and Douglas County WI. The project described the erosion and sedimentation in the red clay area as a natural ongoing process exacerbated by human activities. The study looked at the mechanical properties of the clay slopes and the effects of vegetation on the slopes. Stabilization demonstration projects were also conducted on the slopes. However, the effects of hydrological changes in the watershed on the processes of erosion from the slopes was not examined by the project.

The work of the Sedimentation and Erosion Technical Advisory Committee points to the need to expand upon the Red Clay Project to consider watershed-wide processes and their influence on erosion from streambanks and slopes. Upland surface runoff was increased with the removal of the native vegetation during the clear-cut logging in the late nineteenth and early twentieth centuries. The removal of the native vegetation and the changes in land use following removal of the forest cover resulted in drastic changes in the hydrology of the watershed that in turn has affected the processes and rates of erosion and sediment transport. In addition, the existence of sandy parent material beneath the red clay deposits creates an unstable situation where drastic erosion can take place.

### **3) Watershed Processes and Changes Affecting Erosion**

Prior to settlement in the nineteenth century, the watershed cover type was dominated by coniferous boreal forest (Curtis, 1959). Much of the basin was in a climax stage of forest succession. The climax coniferous forest consisted mainly of white pine, spruce, fir, and red pine. The Red Clay Study (1979) describes white pine as the dominant tree in the overstory due to its size and long life span. The study also describes that spruce and balsam fir occurred with near or greater frequency.

The extensive clear-cut logging of this area in the late 19th and early 20th century significantly altered the hydrology of the watershed. Subsequent fires that raged over the region after the forests were cut are believed to have altered the soils in the area. A duff layer of 2-4 inches may have been burned off as a result of the post logging fires. Presently, under the existing predominantly deciduous cover-type, a duff layer of only 0-2 inches can be found (Goerg, USDA SCS, pers. comm.). The intensity and rate of stormwater runoff drastically increased with the removal of timber cover and the loss of the moisture retaining duff layer. Storm events produced higher and more frequent peak river flows because of the degraded hydrologic condition of the watershed. This promoted mass wasting of red clay banks along the river courses (McCawley, USDA SCS, pers. comm.).

Following the logging and fires, much of the land was cleared for agricultural purposes. The remaining woodland grew back to an aspen/maple/spruce/fir covertime. Drainage and landsmoothing activities associated with agriculture and urbanization further increased the runoff rate. Throughout the watershed, cover type has an influence on runoff rates and consequently on erosion. Increased runoff is promoted when approximately 60% or more of a watershed is comprised of open lands and young forest cover types (ages 0-15 years), as found on abandoned agricultural land for example (Verry et.al, 1983). Sustained yield forest management practices that create age class diversity would help avoid the predominance of cover type which encourages increased runoff from the watershed.

Core samples and historical documents substantiate an increase in the rate of sedimentation. A three sample core survey of the St. Louis estuary and the Duluth harbor shows a steadily accelerating rate of sedimentation since 1900. These cores, analyzed using diatoms, geochemistry, algal pigments, and pollen record the limnological transition during the last two centuries from relatively clear, low nutrient water to that of high turbidity and high nutrient water. The most notable change took place during the nineteenth century coincident with the deforestation. Carbon-14 dates indicate a much higher rate of deposition during the deforestation period (Seiche, 1987; Kingston, 1987).

The change in forest cover from a predominantly mature boreal forest to open land and mixed hardwood/conifer forest increased runoff rates in many of the western Lake Superior watersheds. The greater energy of elevated peak flows during flood sequences accelerated the rate of geologic erosion along streams. The numerous high red clay banks that presently dominate many areas along the rivers represent evidence of accelerated geologic erosion (McCawley, USDA SCS, pers. comm.).

### **4) Sand Bedloading**

Sand bedloading of stream channels and the St. Louis estuary is thought to be presently occurring at an accelerated rate as compared to what would have naturally occurred under the boreal forest condition of the Lake Basin in the 1800's. The possible sources of this sand have implications for watershed management.

One source may be the sand that occurs in the surface clay soils. The red clay soils of the area typically contain 20-30% sand (Goerg, USDA SCS, pers. comm.). Down cutting of upland drainages and slumping along main river channels may be releasing the sands from these clayey soils and introducing it into the streams.

A second source of sand may be the Copper Falls till layer that underlies the clayey Miller Creek Till. It is possible that portions of some of the streams in the west end of the Lake Superior Basin have cut through the Miller Creek Till layer and are flowing through the sandy Copper Falls Till. Streams flowing through the Copper Falls Till would have an available source of sand adjacent to the stream channels. This sandy till is a loosely bonded matrix that could be very susceptible to cutting by meandering stream action. Also, because it is overlain by the clay till of the Miller Creek Formation the cut banks retain a steep unstable slope profile because the clay acts as a "cap." This clay cap can withstand a large amount of undercutting before the resilient strength of the clay succumbs to gravity, resulting in mass wasting (slumping). This may explain some of the extreme steep "slump banks" that are visible along these streams. Land use practices that cause excessive runoff and create more frequent flooding of streams could be accelerating the undercutting of the banks by wearing away the sandy toes of the clay banks leading to increased slumping. This would prevent stabilization. The rate of streamflow and streambank erosion is affected by land use practices and cover type above these slopes. Under the scenario of a stream cutting through the sand layer beneath the red clay, the prospect of mechanical stabilization of these banks becomes very difficult and efforts to alleviate high runoff from the watershed are important.

## **5) Management on Slopes**

Erosion along slopes is particularly responsive to cover type. Aspen cover types that result in drying and cracking of red clay soils promote erosion because of high transpiration rates. Aspen growth on red clay slopes may exacerbate massive slope failure (Andrews et al., 1980). The Red Clay Project also found that of all vegetation types, climax woody species (such as fir, pine and maple) provide the best erosion control for a combination of the following reasons; stronger root systems, low transpiration rates, and increased interception of rainfall.

Transpiration and interception of moisture by tree crowns influences structural stability and erosion of red clay soils, particularly on slopes along flowing streams and rivers (Andrews et al., 1980). During dry periods, clay soils may dry, shrink, and crack. This is important on the slopes because flowing water will follow cracks and cut into the soil. Decreased structural strength will allow blocks of red clay soil to slide down slope. The magnitude of this drying is reduced under a conifer stand because of the low transpiration rate of the trees and the shading effect of the dense overstory canopies. Under aspen stands, which occupy large areas of the red clay slopes, the clay soil surface is dried to extremely low levels during dry periods. This is due to the ability of aspen and grass, which is often associated as an understory component with the aspen, to transpire large amounts of soil moisture. When this occurs cracks and deep fissures form in the soil surface. These fissures act as avenues for water to infiltrate what would normally be an impermeable clay soil. This moisture causes the clay soil to become plastic, creating zones of rupture in what was once a strongly bonded soil matrix. When this weakened soil condition occurs along these waterways where stream action is constantly eroding the "toes" at the base of steep slopes, large blocks of clay are more easily slumped down slope.

An examination of 1939 aerial photography compared to 1990 photography in a portion of the watershed shows that the eroded banks were much larger and in worse condition 40 years ago. Peak flows immediately after the logging and fire era would, as expected, be higher and consequently more damaging

to the cut banks in the red clay soil region. As the watershed is re-forested, the hydrology has been changing as well. Many of these eroded banks seem to be slowly healing as judged by aerial photographic records.

**b. Agriculture**

The northeastern portion of Minnesota and northwestern Wisconsin are not considered to be an intensive agricultural area, however the total acreage of cropland in Carlton County is 66,492, in St. Louis County is 93,438, and in Douglas County is 26,826, which gives a combined total of 186,756 acres.

The main source of nutrients from agricultural operations is animal waste runoff from the livestock and poultry operations and fertilizer runoff. However, there is no information on the relative importance of these sources to nutrient levels in the estuary. The majority of animal wastes are generated from livestock and poultry operations in Douglas County, Wisconsin and Carlton and lower St. Louis Counties in Minnesota. Lower St. Louis County has 69 dairy operations, ninety five percent of which are situated directly on the St. Louis River or its tributaries. Table V.9 below shows the livestock operations in Carlton, Douglas, and St. Louis counties. Table V.10 shows land acreages treated with commercial fertilizers.

Pesticide runoff to surface waters or seepage to ground water is another potential non-point source pollution problem from agricultural activities. Pesticide uses include control of insects, nematodes, and diseases; control of weeds, grasses, or brush in fields; and control of crop growth, thinning of fruit, and defoliation of areas. The acreage in Carlton, Douglas, and St. Louis counties where agricultural chemicals were applied in 1987 is listed in Table V.10.

**Table V.9 Total Number of Farms and Acreage in the Three Counties in the Area of Concern**

|                          |       | <b>Carlton<br/>County, MN</b> | <b>Douglas<br/>County, WI</b> | <b>St. Louis<br/>County, MN</b> |
|--------------------------|-------|-------------------------------|-------------------------------|---------------------------------|
| <b>Cattle</b>            | Farms | 411                           | 195                           | 506                             |
|                          | Acres | 14,010                        | 8382                          | 14,659                          |
| <b>Hogs &amp; Pigs</b>   | Farms | 27                            | 15                            | 49                              |
|                          | Acres | 470                           | 249                           | 4733                            |
| <b>Poultry</b>           | Farms | 57                            | 34                            | 49                              |
|                          | Acres | 720                           | NA                            | 1386                            |
| <b>Sheep &amp; Lambs</b> | Farms | 17                            | 17                            | 92                              |
|                          | Acres | 489                           | 321                           | 1324                            |

Source: U.S. Department of Agriculture, 1991.

**Table V.10 Agricultural Chemical Use in Area of Concern  
(Acreage chemical applied to)**

| <b>Chemical Use</b>                            | <b>Carlton<br/>County, MN</b> | <b>Douglas County,<br/>WI</b> | <b>St. Louis County,<br/>MN</b> |
|--|-------------------------------|-------------------------------|---------------------------------|
| Fertilizers                                    | 9,603                         | 4,994                         | 14,738                          |
| Insect, nematode, disease,<br>and weed control | 4,531                         | 1,800                         | 6,393                           |
| Defoliation and crop<br>control                | 104                           | -                             | 90                              |

Source: U.S. Department of Agriculture, 1991.

**c. Other Land Uses**

In addition to agriculture, pesticides are used for a variety of purposes. Some of the uses are listed below.

- 1) lawn and garden use by homeowners
- 2) pest management on golf courses
- 3) maintenance of rights-of-way (roads, pipelines, transmission lines, and railroad tracks)
- 4) preparation for forest replanting
- 5) pest control at grain handling facilities

Table V.11 lists the more commonly used pesticides in the AOC. The most commonly used pesticide is Glyphosate, known by its trade name, Roundup. There is no information on the amount of pesticides used in the AOC for the five purposes listed previously. In addition, there is no information on the impacts of these pesticides on aquatic life.

| <b>Table V.11 Commonly Used Pesticides in the Area of Concern</b> |                                |
|---|--------------------------------|
| <b>Pesticide</b>  | <b>Trade Name</b>              |
| Atrazine  | AAtrex, Atratol                |
| Cyanazine   | Bladex                         |
| EPTC  | Eptam, Eradicane               |
| Glyphosate  | Accord, Roundup, Lorox, Ranger |
| 2,4-D Sol Amine   | Weeder                         |

| <b>Table V.11 cont. Commonly Used Pesticides in the Area of Concern</b> |                   |
|---|-------------------|
| <b>Insecticide</b>  | <b>Trade Name</b> |
| Aldicarb  | Temik             |
| Diazinon  | DZN, Knox-Out     |
| Malathion   | Cynthion          |
| Sevin   | Sevin             |
| <b>Fungicide</b>  | <b>Trade Name</b> |
| Benelate  | Benelate          |
| Captan  | Captan            |

Source: University of Minnesota Extension, 1991

## **2. Stormwater Discharge**

### **a. Effects of Land Use on Stormwater Runoff**

Stormwater discharge from urban areas like Duluth and Superior can be a source of pollutants to water bodies. As areas develop and the land surface is paved and covered, surface runoff from storms increases, since the water can no longer percolate into the ground. Many of the natural depressions that historically stored stormwater are filled in and leveled, thus stormwater storage is eliminated and all runoff is directed straight into sewers and/or water bodies. The end result of altering the natural drainage patterns is that peak rates and volume of runoff increase.

Stormwater picks up pollutants as it runs off parking lots, streets, and sidewalks. The Nationwide Urban Runoff Program, which studied urban runoff on a large scale throughout the United States, found that urban runoff can contain sediment, nutrients, trace metals, oxygen-demanding substances, toxic chemicals, bacteria, hydrocarbons, and chloride (U.S. EPA, 1983). Table V.12 lists urban sources for these pollutants (MPCA, 1989).

The quality of stormwater depends on the activities and land uses in the watershed. The U.S. EPA found that for the most part, mean pollutant concentrations were higher in residential areas than in open/non-urban areas. Table V.13 lists some mean pollutant concentrations for residential and open areas (MPCA, 1989).

Water quality data from nineteen Minneapolis-St. Paul monitoring sites was collected in Minnesota in 1982 by the U.S. Geological Survey and the Metropolitan Council. This data shows extreme variations in water quality according to land use practices within four watersheds. The data represent pollutant concentrations for an area with minimal development (Elm Creek), a residential area under development (Iverson Avenue), a medium to high density residential area in a stabilized watershed (Yates Avenue), and a light industrial area (Sandburg Road). Table V.14 shows the flow-weighted pollutant concentrations and ranges for the different types of watersheds.

**Table V.12 Urban Sources for Pollutants**

| Pollutant   | Source   |
|---|--|
| Sediment  | Runoff from construction sites<br>Streambank erosion due to increased peak rates and volumes of runoff due to urbanization<br>Application of road sand |
| Nutrients (phosphorus, nitrogen)                                | Organic matter - lawn clippings, leaves<br>Improper/excessive use of fertilizers<br>Application of road sand and salt                                  |
| Trace metals<br>(lead, zinc, copper, chromium, cadmium, nickel) | Automobile emissions<br>Galvanizing and chrome plating<br>Application of road sand and salt  |
| Oxygen-demanding substances<br>(BOD, COD)                       | Pet wastes<br>Street litter<br>Organic matter  |
| Toxic chemicals   | Not normally found   |
| Bacteria  | Pet and other animal wastes  |
| Hydrocarbons<br>(e.g. oil, gas)                                 | Spillage at oil storage and fueling facilities<br>Leakage from crankcases<br>Improper disposal of drain oil  |
| Chloride  | Application of road salt<br>Stockpiles of sand and sand-salt mixtures  |

**Table V.13 Mean Pollutant Concentrations for Residential and Open Areas**

|                               | Residential (mg/l) | Open Areas (mg/l) |
|-------------------------------|--------------------|-------------------|
| Chemical Oxygen Demand (COD)  | 83                 | 51                |
| Total Suspended Solids (TSS)  | 140                | 216               |
| Lead                          | 0.18               | 0.054             |
| Zinc                          | 0.18               | 0.23              |
| Total Kjeldahl Nitrogen (TKN) | 2.35               | 1.36              |
| Nitrate/Nitrogen (N/N)        | 0.96               | 0.73              |
| Total Phosphorous (P)         | 0.46               | 0.23              |
| Soluble Phosphorous           | 0.16               | 0.06              |

**Table V.14 Flow-Weighted Mean Pollutant Concentrations and Ranges for Various Land Uses (Based on 1982 Monitoring of Minneapolis/St. Paul Waters) (mg/l)**

| Pollutant | Monitoring Site <sup>1</sup>       |  |   |                                     |
|-----------|------------------------------------|--|---|-------------------------------------|
|           | Elm Creek<br>(Minimal Development) | Iverson Avenue<br>(Residential-<br>Under Construction) | Yates Avenue<br>(Residential-<br>Stabilized Area) | Sandburg Road<br>(Light Industrial) |
| COD       | 65<br>(45-157)                     | 38<br>(1-697)  | 90<br>(24-879)                                    | 138<br>(10-850)                     |
| TSS       | 10<br>(2-374)                      | 740<br>(17-26,610)                                     | 133<br>(2-758)                                    | 10<br>(2-374)                       |
| Lead      | 0.005<br>(0.001-0.012)             | 0.02<br>(0.008-0.31)                                   | 0.23<br>(0.015-1.8)                               | 0.19<br>(0.003-1.5)                 |
| Zinc      | 0.012<br>(0.005-0.019)             | 0.235<br>(0.028-0.53)                                  | 0.198<br>(0.02-2.2)                               | 0.185<br>(0.02-0.81)                |
| TKN       | 2.1<br>(1.2-5.4)                   | 1.2<br>(1.0-29.2)                                      | 3.6<br>(0.6-28.6)                                 | 25<br>(0.4-16.0)                    |
| N/N       | 0.27<br>(0.05-1.35)                | 0.07<br>(0.05-2.45)                                    | 0.79<br>(0.05-2.45)                               | 0.42<br>(0.05-2.4)                  |
| Total P   | 0.35<br>(0.11-2.23)                | 0.62<br>(0.2-13.1)                                     | 0.63<br>(0.10-3.85)                               | 0.63<br>(0.07-4.3)                  |

<sup>1</sup> Elm Creek - minimal development, relatively open, less than 25% farmed, 14.3 mi<sup>2</sup> watershed  
Iverson Avenue - residential area under construction, 0.15 mi<sup>2</sup> watershed  
Yates Avenue - medium to high density residential, stabilized watershed, 0.35 mi<sup>2</sup> watershed  
Sandburg Road - light industrial, 0.12 mi<sup>2</sup> watershed

Source: MPCA, 1989

**b. Duluth/Superior Stormwater Discharge**

The City of Duluth has separate sanitary and stormwater sewer systems. For the most part, natural creeks and ditches are used as main trunk lines to conduct stormwater from collection points to Lake Superior or the St. Louis Bay. Smaller trunk sewers and laterals feed stormwater from city streets into these creeks and ditches (U.S. Army COE, 1974). Due to the steep topography in much of the city, stormwater retention or detention facilities have not been feasible. However, retention ponds are now required when new development will increase the rate of stormwater flow to the system (H. Berg, Duluth Public Works Dept., pers. comm.). Since much of the new development has occurred over the hill, retention/detention ponds have been built in these areas.

In 1973, the U.S. Army Corps of Engineers (1974) conducted a study of stormwater quality in Duluth. Six sampling and gaging stations were established on five area creeks (Mission, Kingsbury, Miller, Brewery, and Amity) which transport stormwater directly to Lake Superior and St. Louis Bay. Samples and flow measurements were obtained for eight precipitation events from March through October. Class 2A water quality standards for fisheries and recreation were consistently exceeded for turbidity, color, nitrogen as ammonia, and oil and grease. Fecal coliform and chlorides standards were exceeded less often. The study found the highest degree of pollution in streams draining older, more highly developed areas of the city while streams in the extreme west and east portions of the city had the lowest pollution levels. Due to leaky sewer lines near the creeks, it could not be determined whether the creek water quality was representative of urban runoff, sanitary water, or a combination of the two. In 1974 the WLSSD began monitoring 31 creeks in the Duluth area to locate and remediate sources of contamination to the creeks. This effort was discontinued several years ago due to a lack of staffing (J. Stepun, WLSSD, pers. comm.).

The City of Superior underwent a sewer separation project in the 1970's. Sanitary and stormwater sewer systems are now separate except in district #5 which covers South Superior, district #6 which covers Billings Park, and district #2 which covers the downtown. In these unseparated districts the city has holding ponds which store combined sewer overflows during storm events. This water is either treated on-site using the dissolved air flotation method or it is pumped to the main treatment plant and treated before it is discharged. However, two of the three overflow treatment facilities were recently found to be inoperable. Untreated sewage has been discharged into the Nemadji River, St. Louis Bay, Superior Bay, and Bluff Creek. The stormwater in the separated districts is collected and discharged directly into creeks or the bay. Retention or detention facilities are not used. During large storm events the sewer system has experienced infiltration and inflow problems. In the separated districts the infiltration/inflow has resulted in sanitary sewer back-ups into basements of private homes. The city is attempting to determine the source(s) of the infiltration/inflow problem (S. Banz, City of Superior, pers. comm.).

### **c. Construction Site Erosion**

Construction site generated sediment in runoff is a documented problem in the AOC. Elevated levels of total suspended solids in runoff water leaving construction sites result from erosion generated sediment. Construction activities include work on rough grading, utility installation, road construction and improvement as well as residential, industrial, and recreational land development. In 1989, one storm event caused sheet and rill erosion losses exceeding 100 tons/acre on the Duluth-Enger Golf Course expansion project (SCS, 1989). The U.S. EPA has recognized that sediment loss from construction sites commonly exceeds 30 tons/acre/year, many times that of the national average sediment loss from agricultural land. The sediment delivery rate from Duluth construction sites to the St. Louis River, St. Louis Bay, and Lake Superior often reaches 100% due to the extremely steep topography and resultant high velocities attained by runoff water. That is, the sediment picked up by runoff from the construction site does not settle out of the water until it reaches the river, bay, or lake. Due to the flat terrain in Superior, the sediment delivery rates in that city are likely lower.

### **3. Unsewered Communities**

Two municipalities located on the lower St. Louis River are not served by wastewater treatment plants. These unsewered communities, their populations, and number of housing units are listed below.

Fond du Lac, MN: population 315, 128 housing units  
Oliver, WI: population 265, 102 housing units

Area soils make it difficult for septic systems to function properly. Failing septic systems can contribute nutrients and bacteria to the river system. It is unlikely that these unsewered communities significantly affect overall water quality of the lower river, however, localized problems with bacteria could occur. Neither the St. Louis or Douglas County health departments indicated a problem level of failing septic systems or health concerns from wastewater disposal in these communities.

#### **4. Marine Recreational/Commercial Activity**

The St. Louis River estuary includes the Duluth-Superior Harbor, which is a heavily used commercial port. The estuary is also heavily used by recreational boaters. Commercial and recreational vessels can be sources of treated and untreated wastewater which can contribute nutrients, bacteria, and oily waste to the harbor and estuary. Discharges from these sources are of concern relative to excessive nutrient loading, aesthetic impairment of the water (oil and other unsightly waste), and impairment of full or partial body contact recreational uses. The importance of these sources to overall loading of nutrients and bacteria to the estuary are not known. This section explores what is known about the potential for discharges from commercial and recreational vessels to be significant sources of pollutants to the harbor and estuary.

The importance of watercraft discharges to nutrient loading is not known. Wastewater discharges from commercial and recreational vessels may be a significant source of bacteria to the estuary. There has been little recent monitoring of the estuary for fecal coliform levels. The harbor has become increasingly popular for body contact recreation such as swimming, sailboarding, kayaking, and rowing. A mid 1980s survey of Barkers Island beach areas showed low fecal coliform counts, well below 200 mpn/100 ml (S. Banz, City of Superior, unpublished data). Occasional violations of fecal coliform standards are reported at the Superior and Cloquet water intake in Lake Superior that are associated with periods of turbulence and storm activity.

Wastewater discharges from boats are classified as personal waste which consists primarily of sewage ("black water") and "gray water" which is composed of galley and washwater. Bilge water is considered operational wastewater and is associated with the vessel's mode of propulsion (IJC, 1977). Estimating the quantity of these wastewater discharges is difficult, due to inadequate monitoring of disposal practices. Federal regulations prohibit discharge of sewage or any discharge to navigable waters that causes an oily sheen, sludge or emulsion to the water.

##### **a. Commercial Vessels**

The Seaway Port Authority of Duluth ship traffic reports for 1989 and 1990 showed that 1,293 and 1,318 vessels, respectively, entered the Duluth-Superior harbor. Of the total, 217 were ocean-going vessels and 2,394 were lakers. Most of the 1,318 vessels that entered the harbor in 1990 were vessels making repeat trips. Staff at the Corps of Engineers Marine Museum estimate that approximately 60 different ocean vessels and 65 different lakers entered the harbor in 1990.

Discharge of treated sanitary waste by commercial vessels is allowed in the Duluth-Superior harbor and in western Lake Superior. Wisconsin had applied to the U.S. EPA to designate the Wisconsin portion of Lake Superior as a "no-discharge zone" but this request was denied.

Under federal regulations (33 CFR Part 159), commercial vessels are required to use one of the following three marine sanitation devices:

Type I- Produces an effluent having a fecal coliform bacteria count less than or equal to 1000

mpn/100 ml and no visible floating solids.

Type II- Produces an effluent having a fecal coliform bacteria count less than or equal to 200 mpn/100 ml and suspended solids less than or equal to 150 mg/l.

Type III- Designed to prevent the overboard discharge of treated or untreated sewage or any waste derived from sewage.

Vessels greater than 65 feet in length must use a Type II or Type III marine sanitation device unless a Type I device was installed on the vessel prior to January 31, 1978 and the device is still operable (33 CFR 159.7). The majority of lakers have Type II marine sanitation devices (K. Alway, U.S. Coast Guard, pers. comm.). That is, the vessels treat the sanitary waste and discharge the effluent into a waterbody.

Ocean-going vessels can have any type of marine sanitation device so long as they do not discharge untreated waste into navigable waters of the U.S. These vessels may utilize a holding tank when operating in the U.S. waters or they may treat the waste and discharge it into a waterbody (J. Amson, U.S. EPA, pers. comm.).

While Type I and II sanitation devices are designed to meet specific effluent limits, it is questionable whether these devices perform up to standard. A 1980-81 Coast Guard survey of marine sanitation device discharges from 99 ships in the Duluth-Superior harbor showed that the discharges from 51% of the ships exceeded the 200 mpn/ml limit. The average fecal coliform value was 2788 mpn/100 ml. These results are consistent with the levels found by the Canadian government in the mid 1980's. Another study of waste treatment effectiveness was conducted in the 9th Coast Guard District at Cleveland, Ohio. The Type II sanitation device discharges from between 700 to 1000 commercial vessels were examined for fecal coliform and suspended solids. Approximately 75% of the vessels had fecal coliform levels greater than 200 mpn/100 ml: 50% of the vessels had fecal coliform levels of 3000 to 7000 mpn/100 ml and 25% had coliform levels higher than 7000 mpn/100 ml. The study concluded that the marine sanitation devices were not serviced regularly and thus were not effectively treating the waste (J. Amson, U.S. EPA, pers. comm.).

Degradation of water quality in the Duluth-Superior harbor can occur if 1) ships with Type I marine sanitation devices discharge into the water or 2) if ships with poorly operating Type II marine sanitation devices discharge into the water. It is unlikely that ships on the Great Lakes would still have operable Type I devices. However, most of the lakers and possibly the ocean-going vessels use Type II devices. Past studies have shown that lack of servicing has led to marine sanitation devices that provide only minimal treatment of sanitary waste. It is possible that half of the ships using Type II devices are discharging wastewater that exceeds the fecal coliform limit. Based on a design estimate of 30 gallons of sanitary water/person/day and a 13-person crew, a ship will discharge about 400 gallons of treated wastewater per day (J. Amson, U.S. EPA, pers. comm.).

Because of the magnitude of marine traffic, ships may be a significant source of wastewater discharged to the Duluth-Superior Harbor. An estimate of wastewater discharge volume can be made based on conservative assumptions. In 1989-1990, there were an average of 1197 visits by lakers to the harbor per shipping season. For this estimate, it was assumed that the duration per visit was one day, although many lakers may remain in the harbor for a longer period of time. Assuming all of these lakers are equipped with Type II wastewater treatment devices, one can estimate that 0.48 million gallons of treated wastewater is discharged from lake vessels into the harbor per year.

Gray water from galley and wash facilities is discharged directly into the lake or harbor. Approximately 90 to 120 gallons of gray water are produced per person per day. With a 13-person crew a ship will discharge around 1200 to 1500 gallons of gray water per day. The three major constituents of gray water are soaps, oils and greases, and fecal coliform. To reduce oils and greases, galleys must contain grease traps that remove the majority of oils and greases. Fecal coliform levels should be fairly low (J. Amson, U.S. EPA, pers. comm.). Using the same assumptions as stated in the previous paragraph, and assuming 1200 gallons of gray water per ship per day, it can be estimated that 1.4 million gallons of gray water per shipping season is discharged from lake vessels into the harbor.

Bilge water disposal is dependent on the type of commercial vessel. The majority of ocean-going vessels have oily water separators and holding tanks. Bilge water is run through the separators and then discharged into the waterbody. An oil sensor monitors the discharge and an alarm sounds if oil is detected. The oil that is removed from the bilge water is stored in a holding tank until it can be pumped out into tank truck on land. The bilge water in the tank trucks is taken to a treatment/disposal site. OSI Environmental, a company located in Virginia, Minnesota, offers this kind of service for ships. In the 1990 shipping season, they serviced 14 ships in the Great Lakes Fleet (S. Hendrickson, OSI, pers. comm.). They treat the water first if it contains oil and then dispose of the water at the WLSSD facility (J. Stepun, WLSSD, pers. comm.). An estimated 100 to 300 gallons of bilge water containing 2 to 3 gallons of oil can be produced by a ship in one day (J. Sharrow, Great Lakes Fleet, Duluth, pers. comm.).

Bilge water disposal from commercial vessels has apparently changed within the last years due to requirements of the Clean Water Act. Indications from local, state, and federal agencies reveal that the majority of commercial vessels are complying with the federal law that prohibits the discharge of oil (e.g. bilge water) into the Great Lakes which are a zero discharge area for oil. However, occasional accidental discharges of 5 to 10 gallons of oil have occurred (J. Sharrow, Great Lakes Fleet, Duluth, pers. comm.). Any oily sheen in the water would constitute a reportable quantity and would have to be reported to the U.S. Coast Guard National Response Center.

#### **b. Recreational Vessels**

Currently, there are four major marinas (Spirit Lake Marine, Inc., Harbor Cove Marina, Lakehead Boat Basin, and Barker's Island Marina) located within the Duluth-Superior port and St. Louis Bay (G. Kreag, MN Sea Grant, pers. comm.). There are approximately 724 seasonal and 35 transient boat slips available at the marinas. A 1984 study of Western Lake Superior Marinas showed that percent occupancy within the Duluth-Superior marinas was 90% during full season, while transient slip percent occupancy was 43% on week days and 63% on week-end days. The majority of motorboats housed at these facilities were 16-39 feet, while the same held true for sailboats (Dawson and Plass, 1985). Craft that were approximately 26 feet and larger were most likely to contain holding tanks, thus utilizing pumpout facilities. Three of the marinas have pumpout facilities for "black water" disposal, while boats from the Harbor Cove Marina utilize pumpout facilities at Lakehead Boat Basin.

There are two other areas within the Duluth/Superior port that have docking facilities for recreational crafts. One facility is located at the Minnesota (Meierhoff) Slip and is used by charter captains and the Duluth Yacht Club. The other facility is located on Park Point and houses approximately seventeen 30-40 foot motorboats. This facility is privately owned and includes pumpout services.

Discussion with the marina owners and staff revealed that the majority of watercraft owners utilize the pumpout facilities for "black water" disposal. However "gray water" and bilge waters are pumped directly into the bay or lake. Conscientious boaters might pump their oily bilge water into barrels, allowing the

oil and water to separate before pumping the water into the lake. Oil absorbent rags might also be used in separating the oil from the bilge water (J. Radtke, Barkers Island Marina, pers. comm.). The Coast Guard investigates all reports of sheens, sludges or emulsions, thus they would respond to an oil sheen in a marina caused by improper bilge water disposed. Based on the low number of reported spills and the high probability of a spill in a marina being reported, the Coast Guard believes that oily bilge water is not routinely discharged from recreational watercraft (C. Fust, U.S. Coast Guard, pers. comm.). By and large, wastewater discharges from recreational watercraft are not monitored and therefore the impacts of improper disposal are difficult to ascertain.

### **c. Ballast**

Currently, the United States and Canada have agreed to a voluntary exchange of ballast water before entering the St. Lawrence Seaway. The Canadians, along with St. Lawrence Seaway Commission staff, are boarding the ships at the first lock and requesting the ships' captains to fill out a form certifying that their ballast water was exchanged prior to entry into the Seaway. This method of ballast water exchange has about a 90% compliance rate. The 10% non-compliance rate is high when you consider that the ballast water from just one ship is enough to provide a founding population for some exotics. The standards for ballast water exchange are printed in the March 15, 1991 Federal Register.

## **5. Spills**

Spills in the St. Louis River estuary, Lake Superior, and throughout the St. Louis River system may pose a threat to water quality and biota. Many of the spills documented in the area have not occurred directly to waterways, but may indirectly contribute contaminants to the aquatic system through movements of contaminated groundwater and surface runoff. At this time, it is not possible to quantify contaminant loading to the aquatic environment from spills.

A spill in the St. Louis River or harbor would be subject to the reversing river flows and the oscillations of water in the harbor due to the Lake Superior seiches. A U.S. EPA study (1980) determined that a momentary spill of a dissolved pollutant near the Midwest Energy coal docks in Superior would reach areas of the harbor extending from the Burlington Northern Railway Bridge, which is 2.5 km upriver from the coal dock, to the lake outlets. If the pollutant was uniformly distributed throughout the channel adjacent to the coal dock, it would take from 8 to 21 days for the pollutant to reach Lake Superior at a peak concentration. A peak concentration is defined as a concentration that is from 0.05% to 0.1% of the initial concentration in the loading channel. At 0.1% concentration level, the spill would extend over 30% of the harbor and would remain at this concentration for 30-40 days.

Appendix J is a listing of the spills documented by the MPCA and WDNR in the last ten years in the St. Louis River watershed. A total of 375 spills were reported in Minnesota and 96 were reported in Wisconsin. The most common types of spills in the Twin Ports have been spills of petroleum products, sewage and industrial wastewater. The quantities vary from a few pints to millions of gallons depending on the material and the type of spill. The WLSSD facility in Duluth was the most frequently reported facility, with 16% of the reported spills in Minnesota. These spills of wastewater and sewage were attributed to causes which included overflow during storm events, sewer main breaks, and pump failures. The primary type of spill reported in the Superior area is petroleum products. Spills at the Murphy Oil facility accounted for 46% of the reported spills in Wisconsin. Above-ground tank failures, valve failures, overflows, and leaking lines have all been cited frequently in the spill reports as causes of petroleum product releases. In the last ten years, spills and dumping of PCBs have been documented in the upstream

portions of the watershed on the Iron Range, in Cloquet, and in Duluth and Superior.

The United States Coast Guard and the two state agencies, MPCA and WDNR, are responsible for spill remediation. The U.S. Coast Guard based in the Twin Ports has the responsibility for navigable water for the entire Port, including the St. Louis River to the Fond Du Lac dam, and for Lake Superior from the Twin Ports to the Canadian Border and to the Keweenaw Peninsula in Michigan on the south shore. The Coast Guard has a contingency plan for handling spills, which can involve utilization of the Atlantic Strike Team based in the State of Virginia. Responsibility for other waters and land in the watershed rests with MPCA in Minnesota and WDNR in Wisconsin.

## **6. Atmospheric Deposition**

Atmospheric deposition is considered to play a major role in the delivery of pollutants/toxics to the Great Lakes. Due to the lake's large surface area and relative paucity of inputs, Lake Superior is especially influenced by atmospheric loads as compared to the other Great Lakes.

In 1974, studies of the accumulation of selected persistent organic residues in fish species of Lake Superior indicated increased levels of PCBs and toxaphene in the flesh of fish taken from Siskiwit Lake on Isle Royale. Since this lake is remote from inhabited areas and has no local source of PCBs or toxaphene, the results of the study were unexpected. Further research showed atmospheric deposition as the source of the organic compounds. In addition, since toxaphene was primarily used for agricultural purposes in the southern U.S., the presence of toxaphene in Siskiwit Lake fish indicated that chemicals are transported long distances through the atmosphere to the Great Lakes basin (Arimoto, 1989).

Since the research at Siskiwit Lake in the early 1970's, considerable work has been done on long-range transport of atmospheric contaminant loads to the Great Lakes. In northern Minnesota most air pollution arrives via long-range transport from urban areas to the south, notably the lower Ohio River Valley and St. Louis, Missouri region, and as far away as the Texas/Louisiana oil fields and chemical plants. These contaminant loads can be highly episodic, e.g., when an extension of the North Atlantic Subtropical High (the Bermuda High) generates a northward airflow throughout the central U.S. which is usually quite stable and therefore highly contaminated.

Clearly, long-range transport is important to atmospheric inputs to Lake Superior. The magnitude of atmospheric inputs to the St. Louis River, via long-range transport or from local sources is largely unknown. With the exception of Glass' et al. (1990) work on mercury, there has been no study of the relative importance of contaminant loading from atmospheric sources to the St. Louis River system.

Atmospheric sources within the Area of Concern could contribute contaminants to the St. Louis River and to Lake Superior. The Duluth-Superior area is susceptible to low-level inversions which trap air in the harbor region. The stable lake air and the topography of the region are factors which periodically prohibit mixing in low-wind regimes.

Within the St. Louis River watershed there are a total of 63 facilities which have state regulated discharges to the atmosphere of total suspended particulates, lead, carbon monoxide, sulfur dioxide, nitrogen oxides, and/or total volatile organic chemicals. These facilities include a petroleum refinery, paper mills, forest products plants, iron mining and taconite production facilities, grain elevators, coal transfer facilities, a regional treatment plant, and other miscellaneous industries.

Some of these facilities emit toxic chemicals into the atmosphere. Under Section 313 of the Superfund

Amendments and Reauthorization Act (SARA), manufacturing facilities which produce or use certain toxic chemicals in excess of specified amounts, must annually submit reports on the amounts of these chemicals released to the environment. Tables V.15 and V.16 list stack air and fugitive air emissions of toxic substances that facilities must report under SARA reporting requirements. Stack air emissions are measured within a smoke stack; fugitive air emissions are measured on-site, but outside of the smoke stack. An estimated 712,000 pounds of toxic emissions were reported from Minnesota and Wisconsin facilities within the St. Louis River watershed. Appendix K lists the facilities and their estimated emissions.

**Table V.15 1989 Estimated Emissions: MN Portion of AOC**

|                          | Fugitive Air (lbs) | Stack Air (lbs) |
|--------------------------|--------------------|-----------------|
| Aluminum oxide (fibrous) | 1040               | 250             |
| Ammonia                  | 21,000             | -               |
| Chlorine dioxide         | 250                | 19,000          |
| Chromium and compounds   | 500                | 250             |
| Copper and compounds     | 250                | 750             |
| Formaldehyde             | 250                | 500             |
| Hydrochloric acid        | -                  | 180,000         |
| Maleic anhydride         | -                  | 3               |
| Manganese and compounds  | 250                | 250             |
| Methanol                 | 20,000             | 130,000         |
| Phenol                   | -                  | 250             |
| Sulfuric acid            | -                  | 19,000          |
| 1,1,1 - Trichloroethane  | 96,200             | -               |
| <b>TOTAL EMISSIONS</b>   | <b>139,740</b>     | <b>350,253</b>  |

Source: MN Dept. of Public Safety, 1990.

**Table V.16 1989 Estimated Emissions: WI Portion of AOC**

|                        | Fugitive Air (lbs) | Stack Air (lbs) |
|------------------------|--------------------|-----------------|
| Aluminum oxide         | -                  | 37,400          |
| Anthracene             | 20                 | 20              |
| Benzene                | 2,550              | 1,190           |
| Cumene                 | -                  | 250             |
| Cyclohexane            | 2,090              | 400             |
| Dibenzofuran           | 30                 | 40              |
| Ethylbenzene           | 1,700              | 7,800           |
| Ethylene               | 2,480              | 1,180           |
| Manganese              | 250                | 250             |
| Napthalene             | 280                | 550             |
| Propylene              | 12,560             | 2,300           |
| Toluene                | 7,550              | 20,340          |
| Xylene                 | 5,470              | 112,300         |
| 1,2,4-Trimethylbenzene | -                  | 2,970           |
| <b>TOTAL EMISSIONS</b> | <b>35,000</b>      | <b>186,990</b>  |

Source: WDNR, 1990

### a. Mercury

Atmospheric deposition of mercury has been cited as a source of mercury to the St. Louis River estuary. A 1988 study (Glass et al., 1990) of mercury concentrations in rain and snow near Lester Park in eastern Duluth, showed average mercury concentrations of 22 ng/L. The summation of over one year of measurements indicates that approximately 14 µg of total mercury was deposited as wet deposition per square meter of estuary surface area. This precipitation loading rate applied equally over the 4700-hectare surface area of the St. Louis River estuary yields about 660 grams of mercury/year or 1.8 grams of mercury/day.

In addition to the mercury derived from wet deposition directly to the estuary, there is a larger source of mercury from upstream sources (15 grams of mercury/day) that could be from atmospheric deposition. If the upstream source of mercury is assumed to be mostly from atmospheric deposition (wet and dry) then the total input to the estuary from precipitation would be approximately 17 grams of mercury/day. This is a small input compared to the input from the WLSSD wastewater discharge which was estimated to contribute 60 grams of mercury/day and was believed to contribute 66% of the mercury in the St. Louis River estuary (Glass et al., 1990). Since WLSSD has instituted a mercury reduction program, the WLSSD discharge contributes 27.2 grams of mercury/day (See Table VI.3).

The mercury in the atmosphere is from both local and distant sources. Locally dry deposition of mercury from the WLSSD sludge/garbage incinerator has been estimated at 70 to 125 grams of mercury/day; however, this has not been measured. Other urban air emissions can also be a source of mercury to the atmosphere. Estimates from model calculations (particulates only) indicate that 5-7% of total local

emissions may be deposited within 50 kilometers of the source through both wet and dry deposition (Glass et al., 1990).

The Wisconsin DNR (1986) estimated that in 1983 there were 88 pounds of mercury emitted to the atmosphere by local facilities and activities within Douglas County. The following table lists the sources of the mercury emissions and the emissions in pounds:

|   |                 |
|---|-----------------|
| Minor coal emissions (coal combustion and washing)      | 1 pound         |
| Oil emissions (oil combustion)                          | 7 pounds        |
| Paint use (mercury used as preservative and mildewcide) | 56 pounds       |
| Disposal of electric lamps                              | 5 pounds        |
| Lime Kilns  | 19 pounds       |
| Total   | <hr/> 88 pounds |

Long distance sources of mercury are contributing to the mercury levels seen in the precipitation in the Duluth-Superior region. Studies from Minnesota and surrounding areas show a tripling in sediment concentrations of mercury over the past 150 years. Kemp et al. (1978) showed that mercury concentrations in six Lake Superior cores increased by an average of 2.6 times. Rada et al. (1989) showed an average mercury increase of 2.7 times from analyses of cores from 11 lakes in north-central Wisconsin. Henning et al. (1989) showed an average mercury level increase of 3.4 to 3.9 times for at least 10 cores from 4 lakes in north-east Minnesota. In addition, they concluded that direct atmospheric deposition to the lake surface could account for 60-80% of the measured rate of mercury deposition in the lakes. The consistency of these data suggests that atmospheric deposition of mercury is spatially constant, at least across northern Minnesota, if not for the Upper Midwest (Swain, 1989).

Two mercury deposition studies conducted in 1982-83 (Glass et al., 1986) and in 1987-90 (Glass et al., 1991), calculated air parcel back-trajectories (origins) for precipitation events to determine source areas for airborne mercury. The 1982-83 study examined back-trajectories for a 48-hour period while the 1987-90 study examined back-trajectories for a 72-hour period. The 1982-83 study found that the predominant source regions for the highest airborne mercury concentrations were the northwest and the southwest and the lowest concentrations were from the south, west, and northeast sectors. The 1987-90 study found that possible source regions within 72-hour travel time were located to the south, southeast, and southwest. The Ohio River Valley was consistently noted as a source of mercury to the atmosphere. However, no direct correlation between source direction and levels of mercury in precipitation can be made due to factors such as prior precipitation events that decrease the levels of mercury in the air mass by the time it reaches Duluth.

#### **b. PCBs**

It has been estimated by Strachan and Eisenreich (1988) that 90% of the total inputs of PCBs to Lake Superior are attributable to atmospheric deposition. The remaining 10% of the inputs are primarily from tributaries. The rivers that flow into Lake Superior primarily drain nonindustrialized, forested land thus PCB inputs from the tributaries are minimal. The annual PCB budget for Lake Superior is estimated as follows:

### Inputs

|                             |              |
|-----------------------------|--------------|
| Atmosphere - wet deposition | 312 kg       |
| - dry deposition            | 236 kg       |
| Tributaries                 | 54 kg        |
| Municipal/industrial        | 4 kg         |
| Total                       | <hr/> 606 kg |

### Outputs

|                                |               |
|--------------------------------|---------------|
| Water-to air transport (vapor) | 1900 kg       |
| Sedimentation                  | 246 kg        |
| Outflow                        | 43 kg         |
| Total                          | <hr/> 2189 kg |

It is interesting to note that outputs of PCBs from Lake Superior exceed inputs by a factor of 3.6.

Since the St. Louis River and harbor has much less surface area than Lake Superior, the atmospheric contribution of PCBs is most likely less than that for the lake. Local point and nonpoint discharges to the water probably play a greater role in PCB loading to the system. To date, atmospheric deposition of PCBs to the St. Louis River and harbor has not been quantified. The information on atmospheric deposition of PCBs to Lake Superior is the best information presently available even though it cannot be directly applied to the St. Louis River system.

Total PCB concentrations in air over Lake Superior have been measured at the following levels (Baker & Eisenreich, 1990):

|      | <u>Average (ng/m<sup>3</sup>)</u> | <u>Range (ng/m<sup>3</sup>)</u> |
|------|-----------------------------------|---------------------------------|
| 1978 | 1.5                               | 0.9 - 3.5                       |
| 1979 | 0.9                               | 0.4 - 1.4                       |
| 1980 | 1.0                               | 0.1 - 0.6                       |
| 1981 | 0.3                               | 0.1 - 0.6                       |
| 1983 | 3.2                               | 1.5 - 5.2                       |
| 1986 | 1.2                               | 0.9 - 2.0                       |

These levels are similar to the total background PCB concentration in air over North America which remains relatively constant at approximately 1 ng/m<sup>3</sup>.

Despite decreased water column concentrations and decreased estimated PCB loadings to the Great Lakes, atmospheric levels of PCBs over all the lakes have remained relatively constant over the last 10 years at 1 ng/m<sup>3</sup>. Recent research by Baker and Eisenreich (1990) has shown that the open waters of Lake Superior are in equilibrium with atmospheric loadings; however, this equilibrium varies with the seasons. Organic chemicals such as PCBs are deposited in the lake through both wet and dry deposition. Precipitation events though, are responsible for intense episodic inputs of PCBs to the lake. During interceding dry periods in the summer, a percent of the PCBs and other organics are volatilized and return to the atmosphere. Thus during the summer, Lake Superior can be a source of organic contaminants to

the atmosphere. Indeed, the 1988 estimates of inputs and outputs to the lake show that about 548 kg of PCBs enter the lake annually due to atmospheric deposition and 1900 kg leave the lake due to volatilization.

PCBs can be emitted to the atmosphere through municipal waste combustion, sewage sludge incineration, hospital waste incineration, and waste oil combustion (U.S. EPA, 1988). Locally the WLSSD sludge incinerator is the only permitted facility of this type. While the incinerator has the potential to emit PCBs, it has not been considered a major source of PCBs in the area. If the facility discharges PCBs, they are at concentrations below the detection limit (J. Stepun, WLSSD, pers. comm.). While several of the area hospitals used to incinerate their medical wastes, they have all discontinued this practice in the last several years due to stricter incinerator regulations. There is one permitted used oil burner facility, Superwood Co., within the St. Louis River watershed. In addition to this facility, there are other oil burning facilities which do not require permits. Facilities in Minnesota that produce used oil through their work practices may burn their oil and any oil they receive from do-it-yourselfers. The companies must burn the oil in a space heater that burns at a rate less than or equal to 0.5 million BTU/hour. Companies that fall in this category would include trucking firms and vehicle repair service stations (P. Matuseski, MPCA, pers. comm.).

The source of the PCBs may be distant since PCBs can be transported long distances in the atmosphere. Eisenreich (1987) found that approximately 90 percent of the PCBs were transported as vapor and 10 percent were transported on particulates in the atmosphere. Atmospheric residence times for particulates range from 6 days - 2 weeks for particles > 1 µm and 1-3 years for smaller particles (Strachan and Eisenreich, 1988). Eisenreich (1987) found that the PCBs were sorbed to particles in the 0.1-1.0 µm range, thus some of the PCBs could be from extremely distant emissions.

### **c. Dioxin**

There is little or no information available on atmospheric deposition of dioxin to the St. Louis River system or even Lake Superior.

A 1990 Government of Canada report listed the primary sources of dioxin to the environment as manufacture and use of commercial chemicals, incineration of municipal waste, and pulp and paper mills that use chlorine in their bleaching process. Following is a list of the major chemicals that have been considered sources of dioxin contamination in Canada.

- Pentachlorophenol (wood preservative)
- Sodium pentachlorophenate and tetrachlorophenate
- 2,4,5-T (herbicide)
- 2,4-D (herbicide)
- Hexachlorophene (anti-bacterial agent)

The largest atmospheric source of dioxins in Canada is municipal incinerators. Locally, the WLSSD sludge incinerator in Duluth releases an average of 0.12 ng of dioxin per dry standard cubic meter. Due to the use of chlorine in its bleaching process, Potlatch also discharges dioxins to the environment. However, most of the dioxins from Potlatch are discharged in the wastewater that is treated at WLSSD. Potlatch presently discharges  $4.48 \times 10^{-7}$  pounds/day of dioxin to WLSSD (MPCA, 1991). While the Potlatch waste is considered a source of dioxins at WLSSD, municipal waste is also considered to be a contributor of dioxins.

The dioxin in the St. Louis River system can also be from distant emissions. Studies have shown that dioxin can travel long distances in the atmosphere. For example, arctic bears, seals, and whales have dioxins in their tissues, yet they are far from any dioxin sources.