5

ORGANIC WASTES

USING selected portions of past field investigations as examples, it will be shown in this and succeeding chapters how various water quality constituents can affect aquatic life and how this type of information can be presented to those not intimately familiar with the biological discipline.

Menominee River

In early August 1963, a field study, limited to 12 days, was made on the Brule and Menominee rivers separating Michigan from Wisconsin.* The Brule River rises in northern Wisconsin near the eastern edge of a popular recreational area dotted with many natural lakes. It flows through Wisconsin in an easterly direction becoming the boundary between Michigan and Wisconsin. Downstream the Brule joins the Michigamme River to form the Menominee River, which continues as the states boundary flowing in a southeasterly direction for about 115 miles to the Menominee, Michigan-Marinette, Wisconsin, area where it enters the Green Bay arm of Lake Michigan (figure 18).

The Brule and Menominee rivers pass through a gently rolling, thickly wooded valley, which exhibits a restful scenic beauty. The virgin white pine forests of the valley, which once provided a major national source of white pine lumber, have largely been replaced by the attractive quaking aspen, interspaced with groups of a variety of conifers and an occasional hardwood.

The cool, swift waters of the upper reaches of the Brule River provide an ideal habitat for trout; the warmer waters of the Menominee support sturgeon, walleye, bass, bluegill, and other sport fishes. Between Florence, Wis., and the Memominee-Marinette area there are eleven dams that im-

* Report on Pollution of the Interstate Waters of the Menominee and Brule Rivers, Michigan-Wisconsin, by A. W. West, K. M. Mackenthun, L. E. Keup and F. W. Kittrell. U.S. Department of Health, Education and Welfare, Public Health Service, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, November 1963.

Figure 18. Location map for the Brule and Menominee Rivers, Wisconsin-Michigan.

pound run-of-the-river pools on the Menominee River. During the 12 days of the survey, the mean daily river discharges averaged 300 cubic feet per second (c.f.s.) at the mouth of the Brule River, 1,200 c.f.s. in the upper Menominee River and 1,400 c.f.s. in the downstream reaches of the Menominee. In addition to sewage effluent representing various degrees of treatment, the rivers received pollutants from important industrial operations including iron ore, pulp and paper, and organic chemicals.

The Brule River received from its tributary, the Iron River, the acid mine drainage from four iron mines and the effluents from four municipal sewage treatment plants. About 1 year prior to the study the Iron River had received gross acid mine drainage pollution.

The Brule River stream bed was composed of rock, rubble, and gravel with occasional sand. The current was swift and water depths ranged from 6 inches to 2 feet in areas sampled. Samples of stream bed associated organisms were collected in a 20-mile stream reach. Findings indicated that conditions upstream from the confluence of the Iron and Brule rivers were adequate to support a bottom organism community that is typically associated with unpolluted water including stoneflies, riffle beetles, mayflies, and caddisflies. Downstream from this confluence, many organisms sensitive to adverse conditions were reduced drastically in population while those organisms that were able to secure their food supply

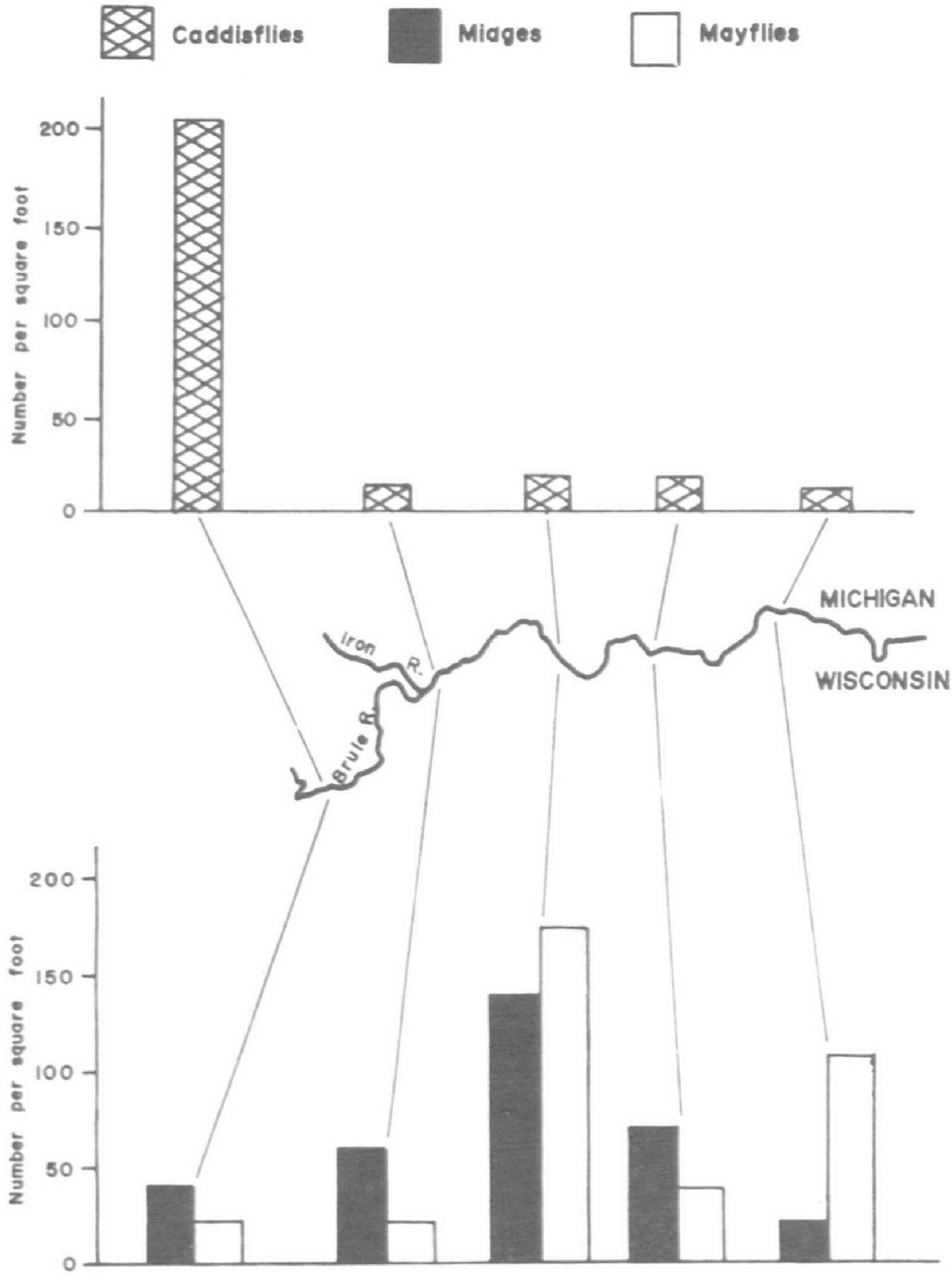

Figure 19. Populations of selected benthic organisms in the Brule River, 1963.

while living in close association with a dense growth of filamentous green algae prospered in numbers (figure 19).

In the Kingsford-Iron Mountain, Mich., area, samples for bottom associated organisms were taken at river mile 96.4, 200 yards downstream from the sewage treatment plant, and in Upper Quinnesec reservoir at mileage 93.7 (figure 20). Upstream from the organic waste source, there was a balanced bottom dwelling community with many organisms sensitive towards pollution and relatively few tolerant sludgeworms or other organism types that tolerate and thrive in organic wastes (figure 21).

In the biological data display for this report, three very broad organism classifications were used. These consisted of those sensitive organisms including immature stoneflies, caddisflies, mayflies, riffle beetles and hellgrammites; those organisms very tolerant towards organic wastes including sludgeworms, several species of midges with ventral blood gills, the pond leech *Helobdella stagnalis* (Linnaeus), and worm-like organisms that are associated closely with this group; and a large group of organisms

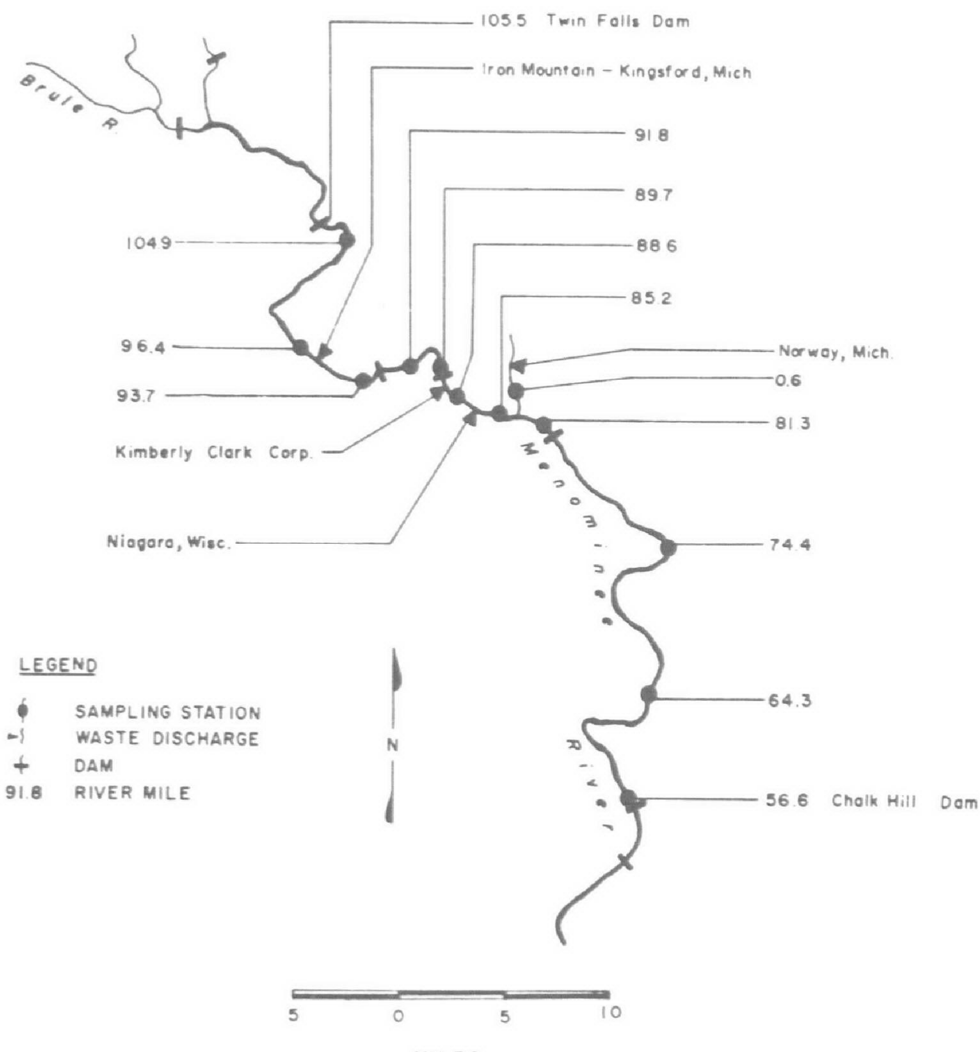

Figure 20. Sampling station location map for the Menominee River.

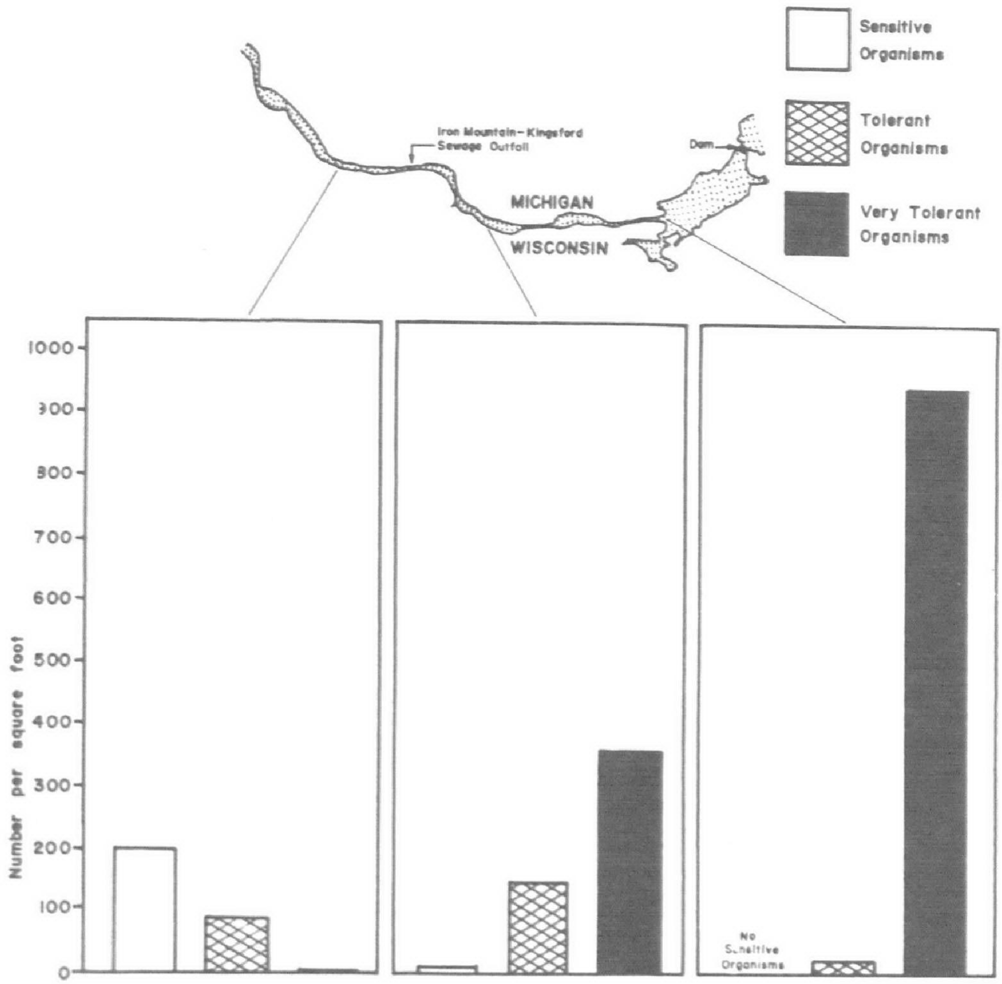

Figure 21. Bottom organism populations—Iron Mountain-Kingsford area, Menominee River, August, 1963.

that are termed tolerant because they are not now known to fit either of the other two groups.

The display of biological data in the aforementioned manner is very effective because the dramatic environmental change in the very few stream miles from a point upstream from the waste source to the uppermost reaches of a receiving reservoir is largely self-evident (figure 21). The clean water associated forms decreased from a plentiful population that would furnish food for an abundant fish population to zero in three successive stations. Likewise, pollution tolerant organisms increased at the same three stations from barely discernible numbers to 950 per square foot, which is representative of a waterway bed covered with organic sludge.

To ascertain effects on sluggish water environments from Niagara, Wis., area pollution, bottom samples were collected from two reservoirs bracketing the area at river miles 89.7 and 81.3 respectively (figure 22). The population of bottom associated organisms found in the uppermost reservoir was considered typical for a clean water environment with a well diversified organism complex containing caddisflies and mayflies. The or-

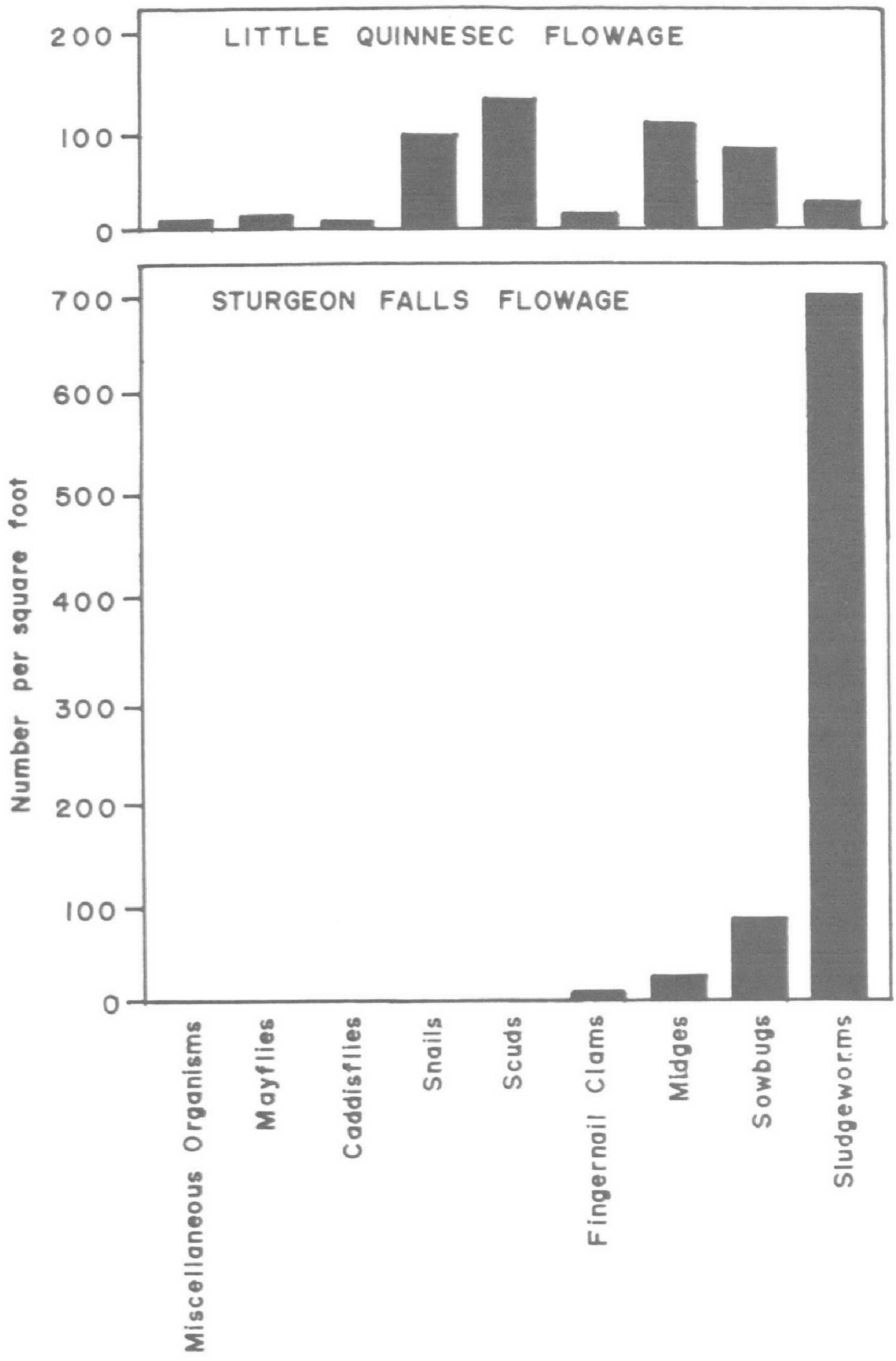

Figure 22. Comparison of bottom organism populations in two upper Menominee River reservoirs.

ganism assemblage in the Sturgeon Falls reservoir downstream was one depicting a polluted environment. Sensitive forms were eliminated; pollution tolerant forms were greatly increased compared to the upstream reservoir. Sludge and wood chips were found in areas of reduced current; wood fibers and slime bacteria were present.

Surber (1957) conducted a survey of lake reports and found that

". . . an abundance of tubificids in excess of 100 per square foot apparently truly represented polluted habitats." After more than a decade, this interpretative observation still seems sound.

That portion studied in the Lower Menominee River encompassed just slightly more than 3½ miles. An unpolluted environment was indicated at the upstream sampling station where sensitive burrowing mayflies were plentiful (figure 23). Downstream from the first organic waste source a

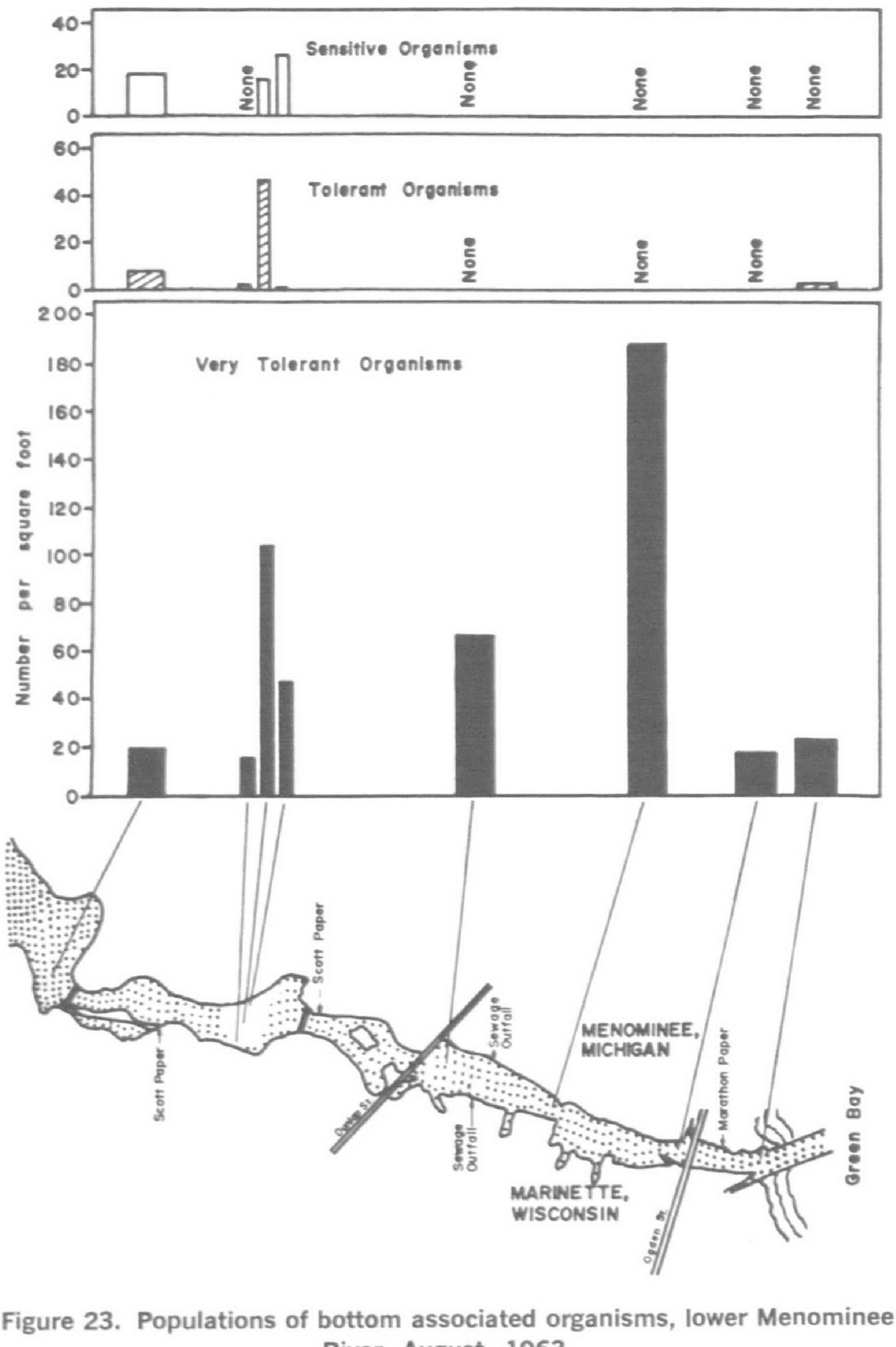

Figure 23. Populations of bottom associated organisms, lower Menominee River, August, 1963.

polluted habitat was found on the waste source side and a habitat only slightly defiled was found near the opposite bank, because of waste channeling in the receiving stream. Downstream from the waste source, sludge deposits, wood chips, wood fibers, and slime bacteria occasionally boiled to the surface as a mass, creating an unsightly and odoriferous condition, gradually dispersing and sinking at some point downstream to reform a sludge deposit and extend, physically, the zone of active decomposition.

When pulp and paper wastes had become fully mixed with the receiving waters, sensitive clean water organisms were eliminated from the polluted habitat as were those in the intermediate tolerant group. Only the pollution tolerant sludgeworms and bloodworms were found among wood chips, fibers, and slimes. The population of these increased downstream from sewage treatment plant waste sources, but decreased markedly downstream near the river's mouth because of toxic components within the sludge.

It is to be noted that in figures 19, 21, 22, and 23, biological data are presented clearly and concisely, and in a form that a layman can understand readily. The figures are not cluttered with too much detail and the bars in graphs are broad and easily distinguishable one from another to permit easy recognition of population trends and broad, significant differences among sampling areas. Data depicted for a particular station represented the average of samples taken at that station.

Blackstone River

The Blackstone River begins in the southern part of Worcester, Massachusetts, and flows in a southeasterly direction for 42 miles to Pawtucket, R.I., then southerly for 7 miles to its mouth at the Seekonk River. Principal tributaries include the Mumford and West Rivers from Massachusetts, and the Branch River from Rhode Island. Water quality data were obtained from field studies conducted during March and August, 1964.*

The Blackstone River drains an area of 540 square miles; its fall averages about 10 feet per mile. Formerly it tumbled over many rocky rapids, but these have long been buried beneath impoundments to create power. The first use of the water power of the Blackstone took place in 1671 and by the early 1700's many grist and sawmills were furnished power by low head dams in the basin. Some of these dams have been abandoned, but more than 30 still exist.

The most significant types of wastes in the Blackstone River drainage area are municipal sewage and woolen textile wastes. At the time of the survey, the river was receiving biochemical oxygen demanding sewage

* Report on Pollution of Interstate Waters of the Blackstone and Ten Mile Rivers, Mass.-R.I. K. M. Mackenthun, A. W. West, R. K. Ballentine, and F. W. Kittrell. U.S. Department of Health, Education, and Welfare, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, January 1965.

wastes from a population equivalent to 93,000 persons. Forty-three percent of this organic load was introduced where the stream was relatively small near its headwaters, and where wastewater impact on aquatic life would be expected to be most noticeable. Recreational use and all fishery pursuits were severely limited because of organic pollution.

The suitability of the Blackstone River to support aquatic life at the time of the study was dramatically illustrated in figure 24 and 25 where the low organism diversity in upstream reaches corresponded with high populations of pollution tolerant organisms, principally sludgeworms. Near the river's headwaters, sludge deposits, oily substances, and slime growths supported over 20,000 sludgeworms per square foot. The sludge worm population increased in numbers following the introduction of sewage treatment plant wastes and then gradually decreased downstream as stream self-purification took place. Before the population could be diminished to a reasonable level (less than 100 per square foot) another source of organic waste was introduced to boost again the sludgeworm population. At river mile 22 (figure 25) a tributary carrying variously colored wool fibers and other materials introduced toxic materials into the Blackstone River that reduced bottom organism populations. Extensive sludge deposits, floating balls of fibers that were microscopically identified as being wool impregnated with grease, and slimes on bottom materials were observed.

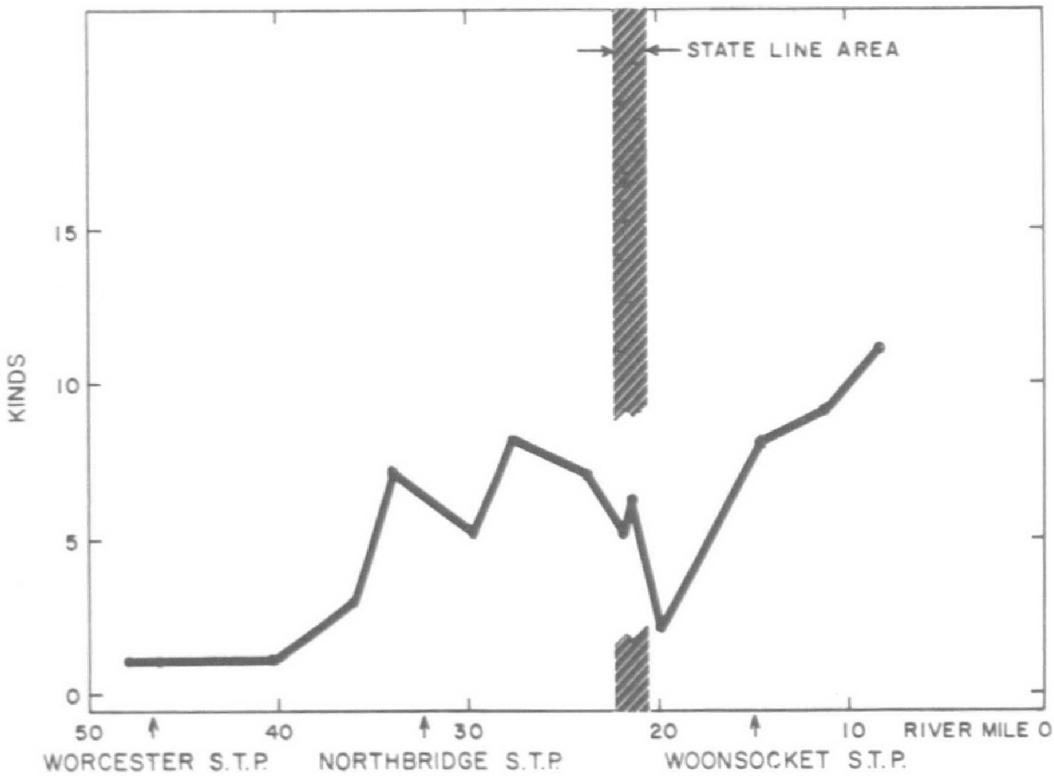

Figure 24. Kinds of bottom organisms, Blackstone River, August, 1964.

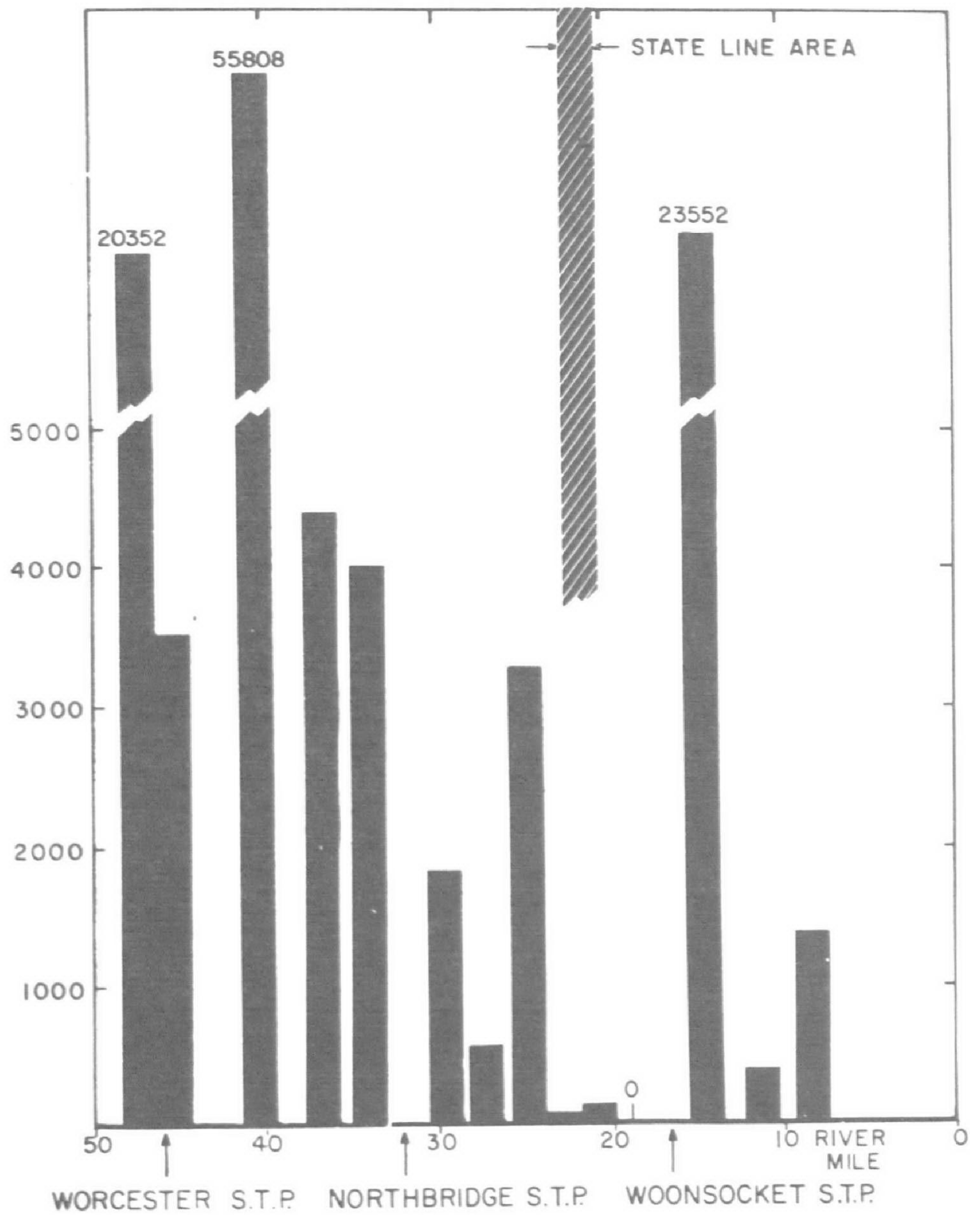

Figure 25. Numbers of pollution-tolerant bottom organisms per square foot, Blackstone River, August, 1964.

Wisconsin River

An intermittent 11-year biological study of the stream bottom life of the Wisconsin River, Wis., indicated no marked differences in bottom conditions at a given station among any of the years under investigation.* Prolific growths of filamentous bacterial slimes occurred in several stream reaches during both summer and winter periods. Unsuitable bottom habitats for organisms were created because of severely decreased dissolved oxygen and the blanketing effects of settleable solids and bacterial slimes. The area studied extended from mile 360 to mile 190 (figure 26).

* Mackenthun, K. M. 1961. The Impact of Pollution Upon Stream Biota in the Wisconsin River. 19 pp., mimeo.

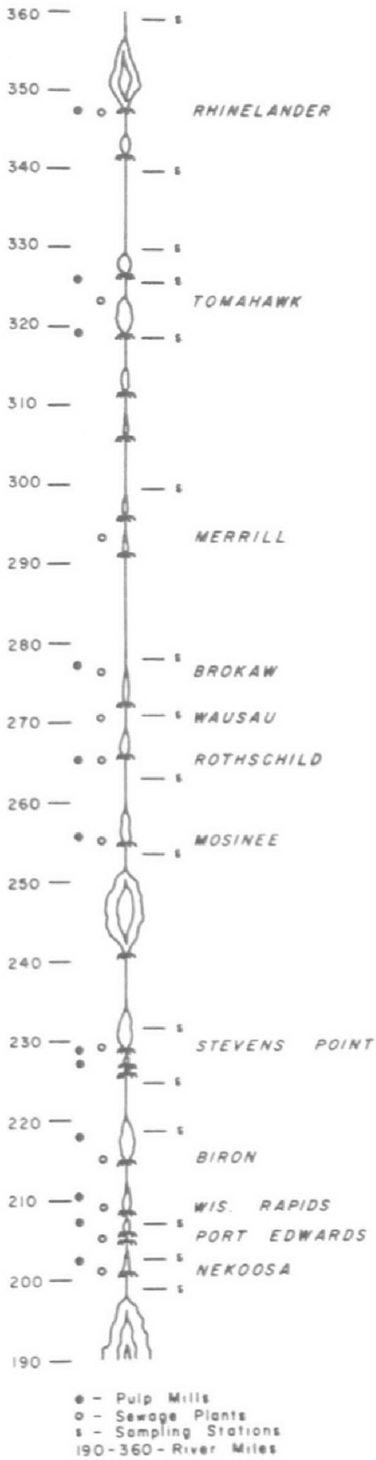

Figure 26. Wisconsin River profile with mileage designations, pollution sources, and sampling stations.

The long-term average flow for the several stations of record on the Wisconsin River is shown on the dilution chart (figure 27). The 50 percent duration value for the section under consideration ranges from slightly less than 1,000 c.f.s. at Rhinelander to slightly more than 3,000 c.f.s. at Nekoosa. Other things being equal, a given load discharged to a stream

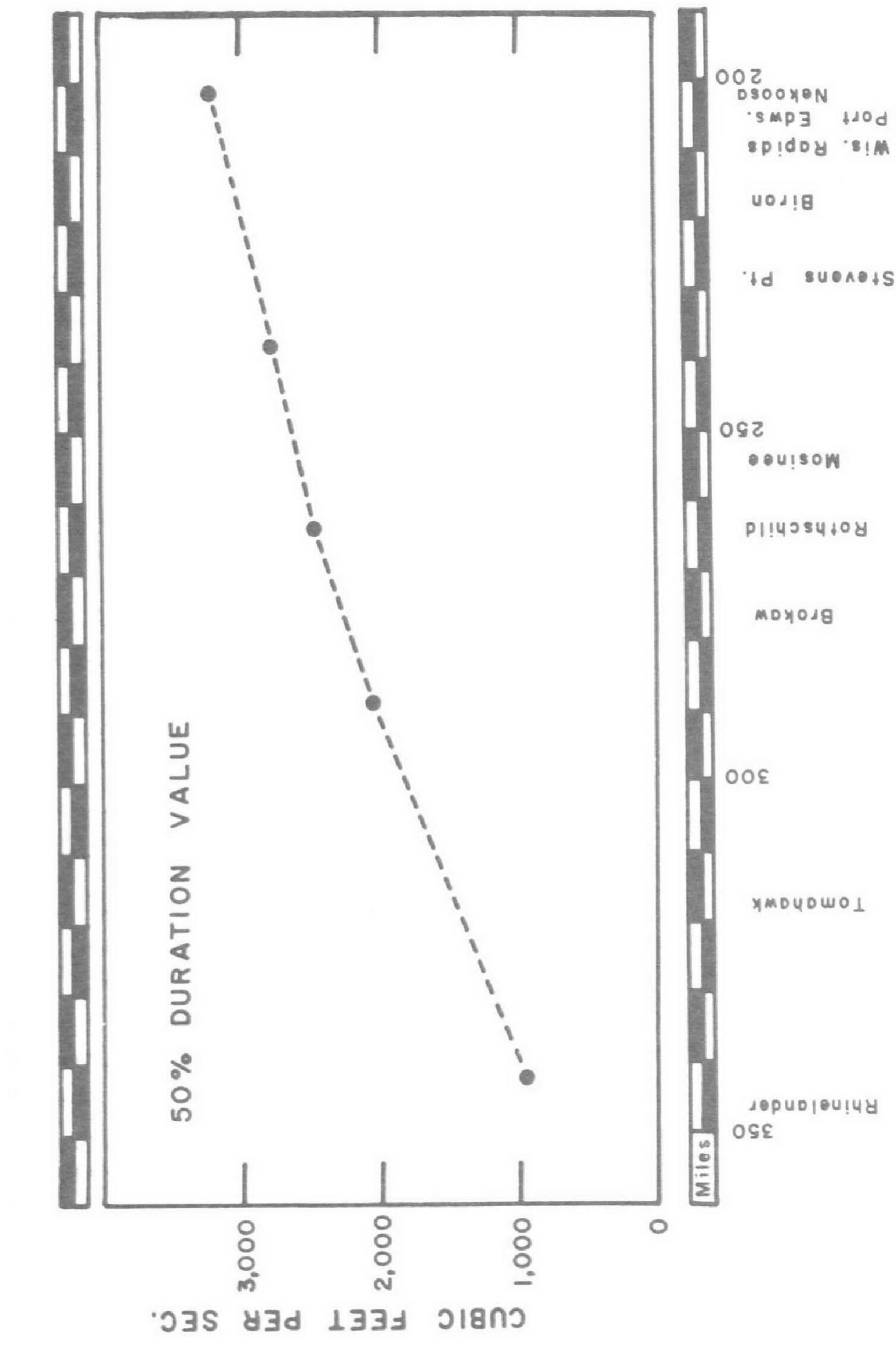

Figure 27. Wisconsin River Dilution Chart

having, for example, a 2,000 c.f.s. flow has the same degradation effect as one-half of the hypothetical load discharged at a point in the stream having only 1,000 c.f.s. flow.

Stream bed samples were collected both in August and in March under ice cover. March data indicate no intolerant (sensitive) bottom fauna downstream from Rhinelander, Wis., for a distance of about 50 miles (figure 28). A similar paucity of sensitive organisms existed downstream from Brokaw for a distance of about 45 miles. Along with the species abundance shown as the number, the relative population abundance in number per square foot and the population characteristic shown as the percentage of the population abundance were depicted in this chart. Much can be said for such a presentation from the standpoint of careful interpretation of graphic materials, but the presentation is somewhat cluttered with too much detail and is difficult for the general reader to follow. Indeed, the August data were presented in similar fashion for 5 years for the entire river reach studied and the results of this presentation attempt precluded suitable reduction to picture here.

In general, the March biological data showed a slight reduction in bottom organism species abundance and some reduction in the population abundance. There was a general tendency to have a greater proportion of the population comprised of very tolerant forms. Especially in the areas upstream from Merrill and Brokaw, a reduction was noted in both species number and population abundance of the clean water forms. These two areas were influenced by the effects of upstream pollution during the winter months with a subsequent growth of filamentous bacteria that covered the bottom formations. Consequently, these areas fluctuated between periods of degradation in the winter and recovery during the summer. Thus, sampling beneath the ice in late winter showed that the zone of active decomposition had moved downstream from the source of organic pollution during winter. A stream reach that appeared unpolluted during summer supported growths of *Sphaerotilus* and associated bacteria with a reduction in sensitive organisms during winter.

A slightly earlier (1958) effort to display some of the same data was even more complicated, graphically (figure 29). A tremendous amount of data are shown in this figure: Stream mileages, major cities, location of dams, location of pulp and paper mills, organism numbers, percentages of sensitive, tolerant, and very tolerant organism numbers, zones of pollution, and variations among 4 years of sampling! Depicting the stream zones of pollution has merit for public interpretation providing sufficient explanatory material is presented. But, it is difficult, if not impossible, to present so much information graphically in clear understandable fashion on one page–interpretation would be challenging even to the professional.

South Platte River

Wastewaters entering the South Platte River in Denver, Colo., are of mixed origin.* They come from municipal treatment facilities, industries,

* From "Effects of Pollution on the Aquatic Life Resources of the South Platte River Basin." South Platte River Basin Project, Denver, Colo., and Technical Advisory and Investigations Branch, Cincinnati, Ohio, Federal Water Pollution Control Administration, U.S. Department of the Interior, December 1967, prepared by Lowell E. Keup.

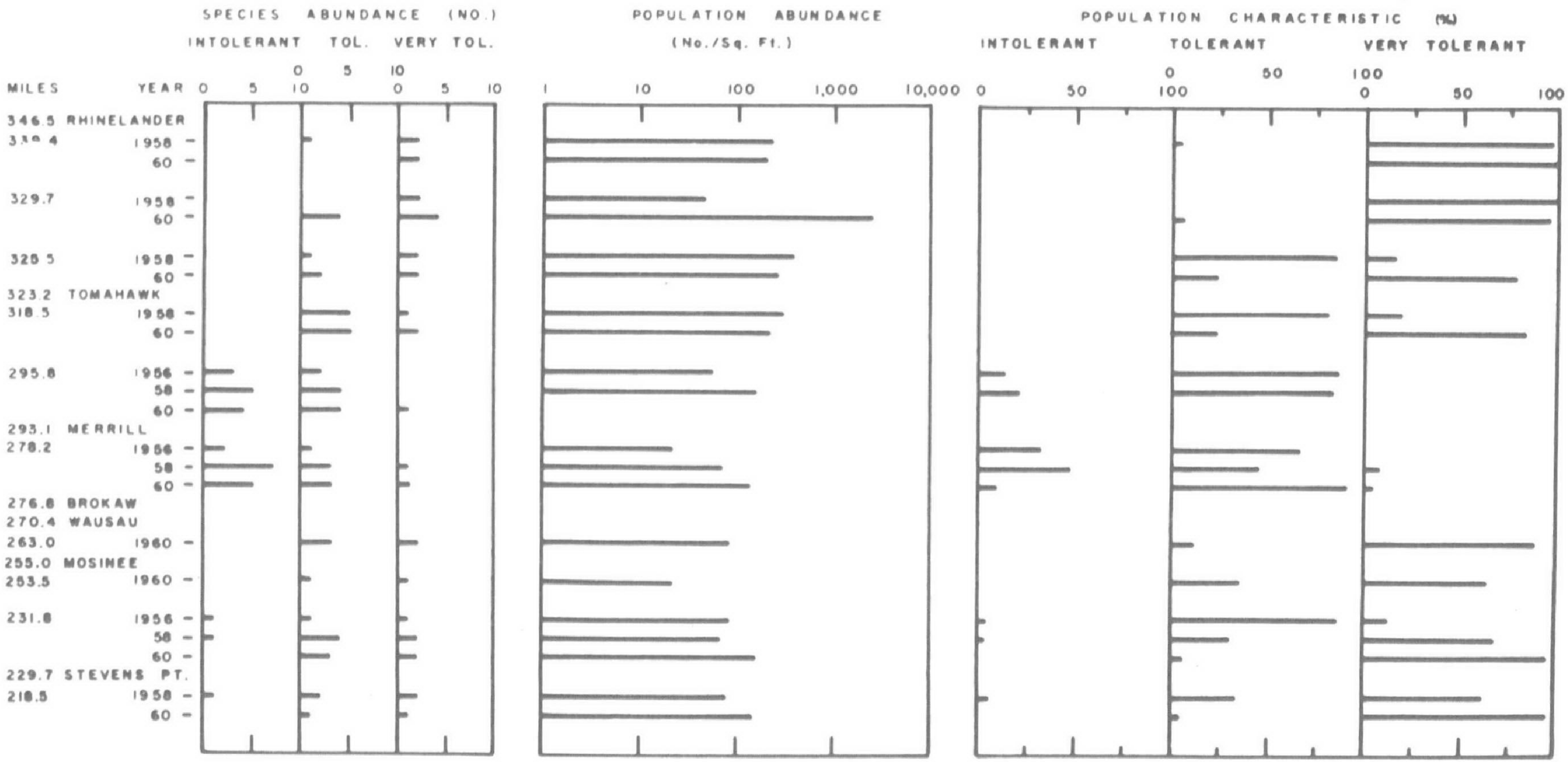

Figure 28. Wisconsin River bottom fauna—March data.

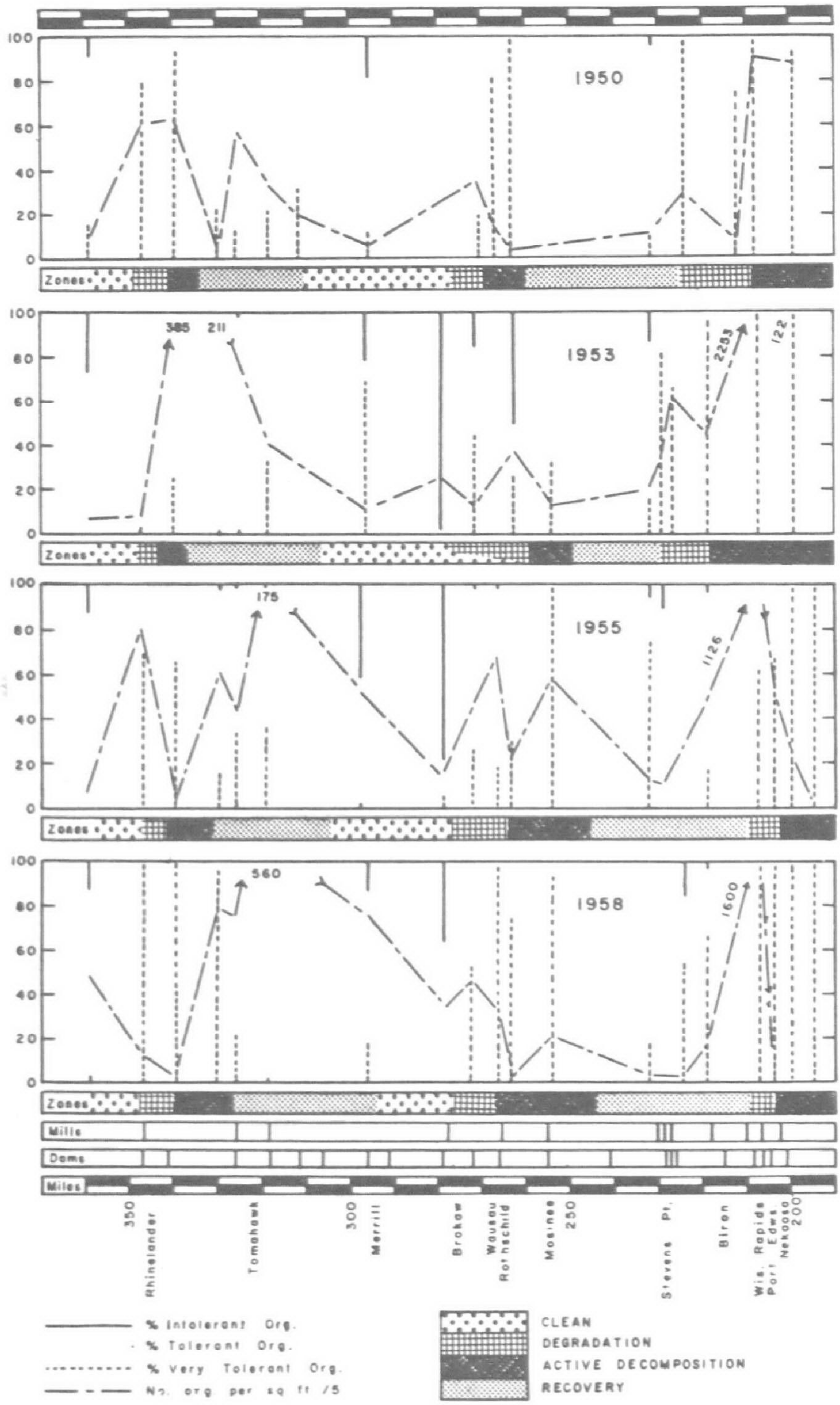

Figure 29. Biotic conditions in the Wisconsin River during August.

cattle holding pens, storm sewers, and polluted tributaries. The major pollutant is organic solid materials, both suspended and settled. Other pollutants are present, but their effects are masked by the preponderant organic materials.

Excessive quantities of organic wastes, undergoing rapid decomposition, alter the chemical characteristics of the waterway by producing large quantities of sulfides, methane and other products of decomposition, and by reducing the quantity of dissolved oxygen. The settleable solids settle to the stream bottom forming organic rich sludgebeds that "blanket" the original bottom of gravel, rubble, or soil thereby altering the physical environment. These chemical and physical changes are not tolerated by sensitive organisms such as the aquatic stages of stoneflies, mayfies, and caddisflies, that are found in unpolluted habitats. Surviving pollution tolerant animals, such as sludgeworms, bloodworms, leeches and sewage flies increase in numbers because of a lack of competition from the eliminated forms. Sludgebeds may produce a large increase in numbers because they increase the habitable area and the available food for these "aquatic manure worms." Pollution may become so severe that even these relatively tolerant forms may be reduced in numbers or eliminated. Figure 30 illustrates the elimination of sensitive bottom animals and the rapid increase in the population of pollution tolerant organisms in May as the river enters the city of Denver. In August, 1964, near the confluence of Cherry Creek and at Platteville sludgeworm numbers were 38,000 and 19,500 per square foot, respectively.

During May and August, from the York Street bridge downstream to Fort Lupton, Colo., pollution by decomposing organics was severe enough to reduce pollution tolerant organisms (figure 30). At Franklin Street, the large quantity of decomposing organic material sufficiently lowered water quality so that even pollution tolerant organisms were eliminated. Here, the stream bed was covered with sludges, estimated at 45,000 tons wet weight, which were obviously rotting cow manure and undoubtedly originated from the cattle holding pens along this river reach.

After flowing 40 miles, the river recovered enough to allow large numbers of pollution tolerant sludgeworms and bloodworms to reappear in the bottom sludges at Platteville, Colo. (figure 30). In August large red patches of sludgeworms (19,500 per square foot) could be seen here on top of the sludge deposits. Filamentous slime growths were less extensive than they were upstream. Within a short distance from Platteville, much of this polluted water was diverted for irrigation and the areas downstream from here were influenced more by pollution from local sources than from the Denver Metropolitan Area.

East Pearl River

A diverse population of bottom fauna was found in the East and West Hobolochitto creeks and in Farr's Slough upstream from pollutional effects from Picayune, Miss., on the East Pearl River.* At one station, more than 40 species of bottom fauna were found (figure 31). Down-

* From Report on Pollution of Interstate Waters of the Pearl and East Pearl Rivers, L.-Miss., U.S. Department of Health, Education, and Welfare, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, and Region IV Office, Atlanta, Ga., September 1963.

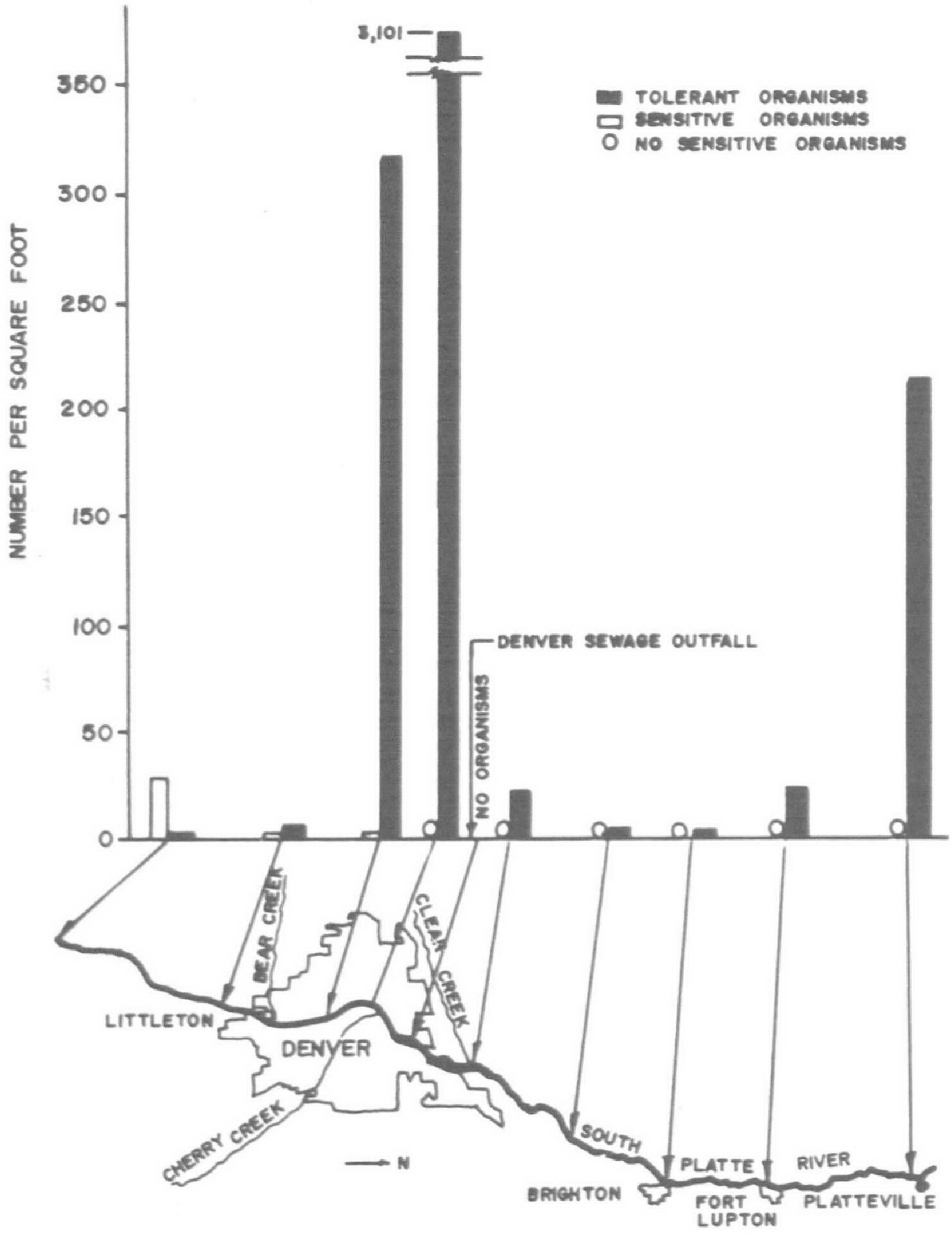

Figure 30. Populations of bottom animals, South Platte River, Denver Metropolitan Area, May, 1964.

stream from Picayune, and the discharge of a chemical company, biological samples showed distinct adverse effects from pollution on the stream bottom. Species numbers were reduced to four in this reach compared to upstream reaches where more than 10 and often 20 species were found. Pollution tolerant sludgeworms and blood worms increased here, sensitive mayflies and caddisflies were absent but were plentiful at upstream stations, and bacterial slimes were obvious on higher aquatic plants and other supporting objects. The stream recovered rapidly and samples from stations downstream indicated a fauna rich in diversity again.

In late September, 1962, the chemical company discharged wastes toxic to aquatic life and a severe fish kill resulted that extended for at least 17

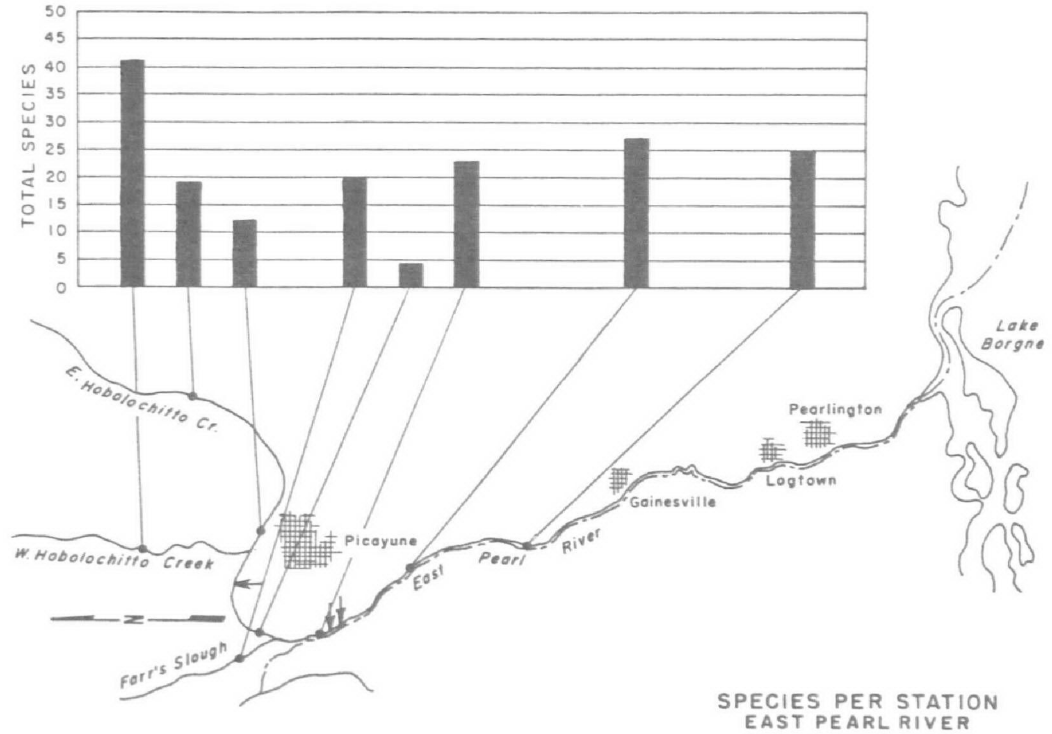

Figure 31. Species of bottom fauna per station, East Pearl River, 1962.

miles. Gar, game fish, minnows, eels, mullets, and even sturgeon were killed. Most of the bottom dwelling animals were also killed in the affected area. Where before there were four species found upstream from Picayune, none was found soon after the chemical release. At the subsequent three downstream stations, 23, 26, and 25, species were found at each station, respectively, prior to the chemical release and these included stonefly naiads, mayfly naiads, caddisfly larvae, hellgrammittes, and the more tolerant associates. After the chemical release that caused the fish kill, nine, five, and three species were found at these stations, respectively. Surviving organisms included a pulmonate snail, bloodworms, beetle larvae, tolerant damselfly and dragonfly naiads, and sludgeworms at one station. Toxic materials are considered in greater detail in Chapter VII.