NONPOINT SOURCES OF POLLUTION: THE EMERGING ISSUE IN WATER QUALITY MANAGEMENT FOR DALLAS/FORT WORTH, TEXAS

by John Promise and Charles W. Bayer

INTRODUCTION

Contrary to popular belief, oil is not the most precious liquid in all parts of Texas. The growth of the Dallas/Forth Worth area, which is the largest inland metropolitan region in the country, has been supported through man's efforts to provide clean water. The man-made lakes of North Central Texas are the sole source of drinking water for most of the area's citizens. Local government water rights are closely guarded. The lakes provide the principal water-oriented recreation opportunities in the region. They supply cooling water for the area's major electrical power plants. And the Trinity River serves as the conveyance system for the area's treated sewage. Watershed runoff affects the river as well as the lakes.

The Federal Clean Water Act, adopted in 1972 and amended in 1977, establishes as a national objective "to restore and maintain the chemical, physical, and biological integrity of the Nation's water." Under Section 208, the act establishes a nationwide planning program for working toward the national goal. Each state and designated planning area within the state must establish a continuing planning process and determine a preferred water quality management plan tailored to its unique pollution problems.

The plan must address the magnitude of pollution from all sources, ranging from sewage treatment to direct precipitation; must determine their effect on water quality; must analyze controls that could be instituted to limit pollution from the various sources; must weigh the economic, social, and environmental effects of these controls; and must select through an extensive public participation program the preferred water quality manage-

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ment plan for the region. All treatment plant permits and construction grant requests should conform to the current annual plan.

Perhaps no other water quality planning issue has caused as much confusion, consternation, and commotion nationally as that of "nonpoint" sources of pollution, and their relationship to point sources. The General Accounting Office (1976) indicated that some advanced waste treatment facilities are being financed without sufficient water quality data and planning. The study states that in many instances these facilities may not be the most effective or efficient means for achieving water quality goals. Furthermore, the EPA and the states need to obtain better water quality information and to consider all water pollution control alternatives so that the treatment methods selected will improve water quality and will result in more effective and efficient use of Federal funds.

In a study conducted for the EPA, Horowitz and Bazel (1977) recommended that

> Federal grants for Advanced Waste Treatment (AWT) should be stopped until two fundamental defects have been corrected:
>
> (1) The planning is often technically unsound, and the technical analysis specified in Section 303 (d) of PL 92-500 is ignored, oversimplified, or falsified.
>
> (2) The apparent need for AWT facilities varies greatly from state to state, and there is no uniform national policy to prevent some states getting many large AWT grants while others do not qualify for any at all.

In another report, the General Accounting Office (1977) stated that "[limited nonpoint source] controls exist and agencies developing comprehensive control plans under grants from the U.S. EPA lack sufficient resources to gather needed data—a result of past emphasis on controlling industrial and municipal point sources of water pollution."

Under the sewerage improvements program (NCTCOG, 1977), the major treatment plants in the Dallas/Fort Worth region have construction under way to attain 10/15 treatment levels, which are already much more stringent than the national requirement of secondary treatment (10/15 refers to parts per million of five-day biochemical oxygen demand and total suspended solids respectively for a 30-day average). Ninety-nine percent of the region's domestic sewage will be treated at "advanced" levels. From the results of a computer simulation model of the Trinity River, however, the state decided that even more stringent treatment levels were required. Thus in early 1977 the regulatory board of the Texas state water pollution control agency imposed 5/5/3 treatment requirements on the North Texas Municipal Water District's (NTMWD) Mesquite sewage treatment plant (5/5/3 refers to parts per million of five-day BOD, total suspended solids, and ammonia nitrogen respectively for a 30-day average).

The board at the urging of the affected local agencies did agree to schedule a special public hearing within 120 days to determine whether it should revert back to 10/15 if it was shown that 5/5/3 requirements were not necessary to restore the environmental integrity of the receiving waters or if widespread adverse economic and social impacts occurred in the region (TWQB, 1977).

As summarized by Promise et al. (1977), the major treatment plant operators (including the NTMWD; the Trinity River Authority; and the cities of Dallas, Fort Worth, and Garland) and the North Central Texas Council of Governments formulated a position statement saying that before effluent requirements involving removal of pollutants beyond the 96% level were adopted, the following factors should be evaluated:

1) The results of the "208" area-wide planning process now under way
2) The results that will be achieved by advanced wastewater treatment plants now under construction
3) The cost effectiveness of more advanced treatment requirements
4) Alternative pollution abatement techniques.

After receiving the testimony of the treatment plant operators, NCT-COG, and their consultants, the state board decided to rescind the 5/5/3 treatment requirements for the NTMWD's Mesquite plant partly because of the large incremental cost and the uncertainty of any notable benefits. Perhaps of greatest significance, the state's decision not to pursue 5/5/3 allows the local governments of North Central Texas to assess more fully the complete range of pollution sources and problems, and cooperatively to determine the preferred water quality management strategy to achieve a cleaner Trinity River.

DISCUSSION OF RECENT RESEARCH FINDINGS

The first overall assessment of urban and rural nonpoint sources of water pollution in the Dallas/Fort Worth region and their relationship to loadings at treatment works was conducted as part of the areawide planning program during 1977 (Hydroscience 1977).

Sources contributing to water quality within a given watershed may consist of all or part of the following categories: urban and rural watershed runoff, point source treatment works discharge, and in-stream processes (sediments, biota, etc.). Also, for a given subwatershed, upstream sources may be important. As is shown in figure 1, many of the lakes in the planning area receive the majority of their watershed runoff from outside the

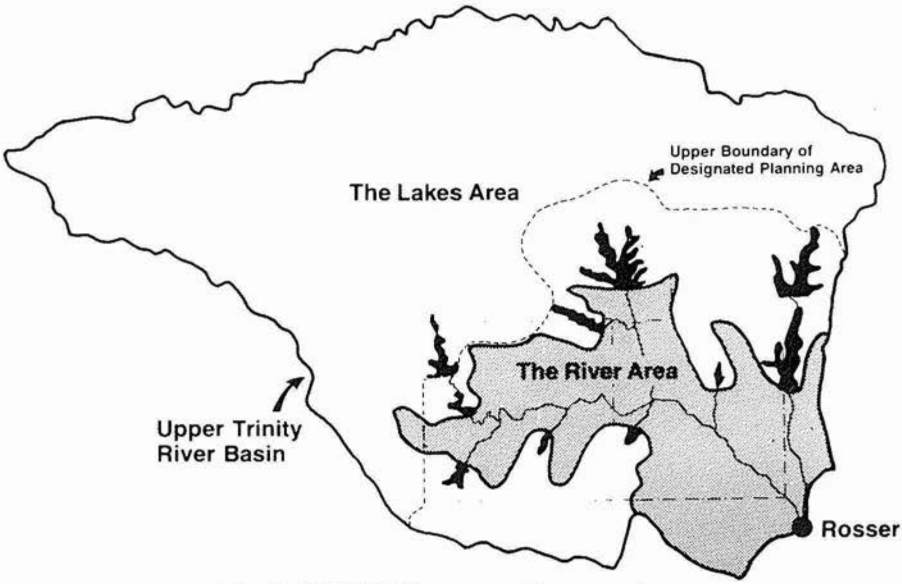

FIG. 1. NCTCOG DESIGNATED PLANNING AREA

planning area. The quality and quantity of each of these categories of water and waste material varies significantly throughout the year, as does the actual impact on stream or lake waters. For example, during winter months with relatively cold temperatures and higher flows, the organic load of a stream may not affect the dissolved oxygen content as severely as it does during the low-flow high-temperature late summer period.

As is illustrated in figure 2, runoff pollutant loads can be assessed on an "annual" basis (Level 1), a "per storm" basis (Level 2) or a "variation within a storm" basis (Level 3). Of these three levels of detail, generally only the first two are appropriate for an initial assessment; they were the levels addressed during the 1977-78 NCTCOG planning cycle. Level 3 assessments are generally appropriate for more detailed design studies and when extensive data on a wide variety of individual storms are available.

To determine the level of analytical detail required, one must consider the size of the area and the length of time over which the anticipated impacts on water quality are expected to occur. A Level 1 assessment is appropriate for the factors that are expected to have distributed effects on an annual or seasonal basis. Examples of these effects would include eutrophication caused by high levels of nutrients in runoff or the long-term buildup of a toxic substance in the receiving water bodies. A Level 1 analysis is also appropriate for comparisons between annual runoff loads and annual loads discharged from point sources such as treatment plants.

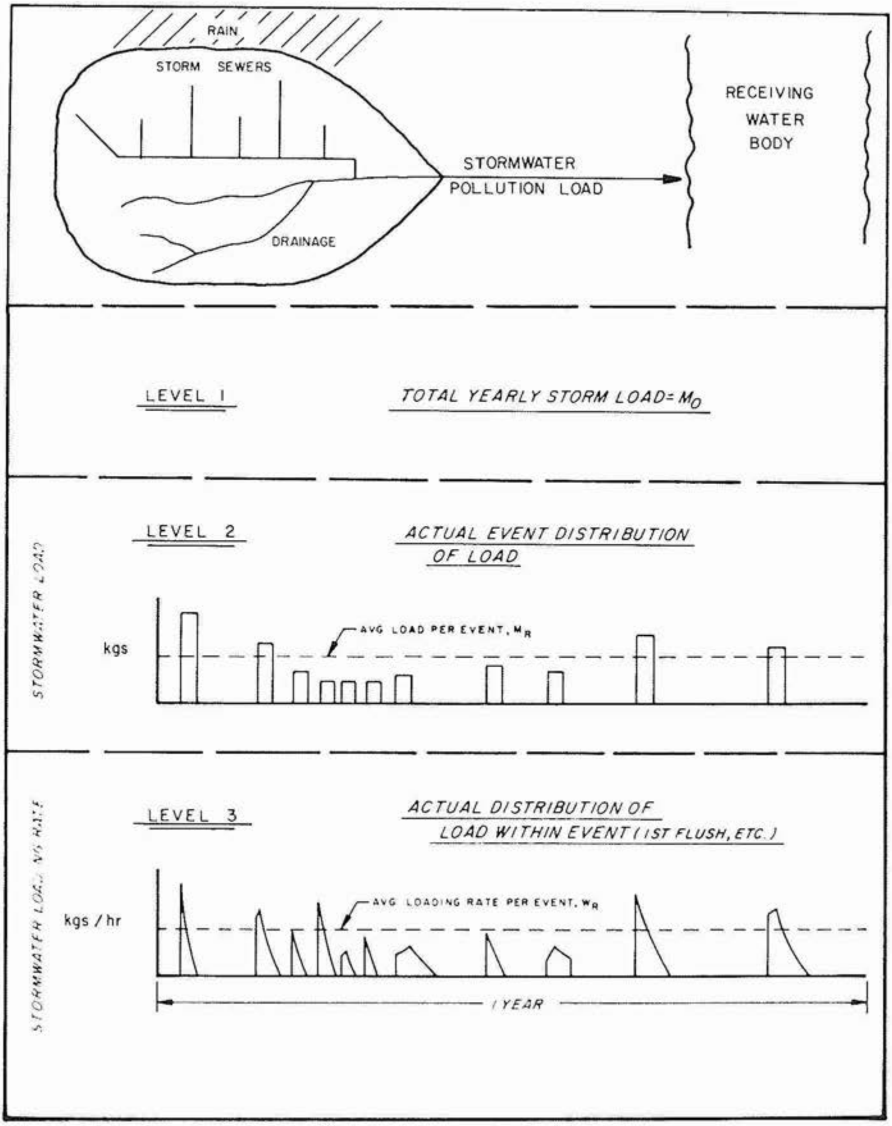

FIG. 2. LEVELS OF DETAIL IN STORMWATER LOAD CHARACTERIZATION (adapted from Hydroscience, 1977)

Level 2 analyses include a more thorough investigation of the distribution of the pollution loads among storms. At this level of assessment, the number of storms is counted, and the frequency with which various magnitudes of loadings can be expected is estimated. This approach is particularly useful for the estimation of loading values that are associated with individual storms, such as elevated BOD levels and resulting dissolved oxygen depressions in the receiving body of water (Hydroscience, 1977).

The Level 1 assessment presented in the working paper (Hydroscience, 1977) was based upon data that were readily available in early 1977 from local reports and national literature. All values were subject to change and many were expected to be modified to varying degrees as a result of continuing data collection and analysis. Four major pollutants for which sufficient data were available were five-day biochemical oxygen demand (BOD), total nitrogen (N), total phosphorus (P), and sediment (Sed). In this terminology, the word "pollutant" was used in a general sense, simply meaning some material that was added to the water.

The designated planning area was divided into major watersheds ("presentation areas" as shown in figure 3), several of which contribute pollutants to the major lakes (including Lakes Worth, Benbrook, Arlington, Mountain Creek, Grapevine, Lewisville, Lavon, and Ray Hubbard),

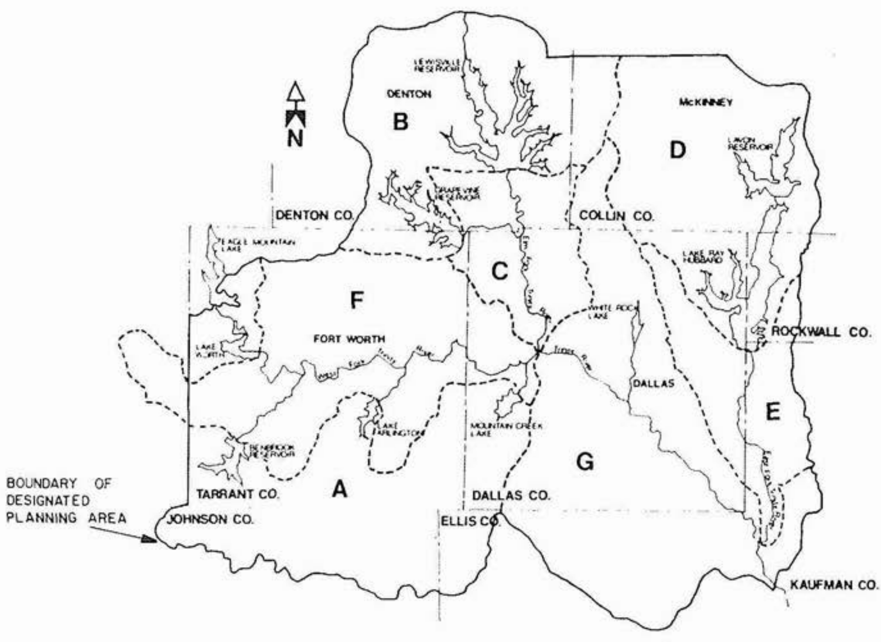

FIG. 3. WATERSHED PRESENTATION AREAS

and four of which contribute pollutants to the major river sections (the Elm Fork, East Fork, West Fork, and main stem of the Trinity River).

Point sources

Municipal wastewater treatment plants are the only significant point sources of BOD and nutrients to public waterways in the planning area. Approximately 95% of these pollutants is discharged into the river sections downstream from the major lakes.

In the 1975-76 period, referred to as "Condition 1," point sources contributed approximately the following pollutant loads within the entire Dallas/Fort Worth designated planning area:

BOD_5	=	18.6	million kg/yr
N	=	10.1	"
P	=	3.8	"
Sed	=	20.9	"

Treatment plant improvements were recommended and updated by NCTCOG (1977 and 1978). The improvements will result in major treatment plants achieving 10/15 treatment levels, and should reduce the BOD and sediment discharges to approximately the following levels:

BOD_5	=	4.1	million kg/yr
Sed	=	4.1	"

These improvements, referred to as "Condition 2," will represent a decrease in BOD and sediment from point sources of 78% and 80%, respectively, of the 1975-76 point source loadings levels (Hydroscience, 1977). As discussed previously, considerable activity was undertaken during 1977 regarding a possible "Condition 3," which involved reductions to 5/5/3 levels.

Urban watershed runoff

Analysis of twenty-four years of hourly rainfall records for the rain gauge at Dallas Love Field indicated that the planning area receives an average of approximately 86 storms per year, of which approximately 26 occur during the nominally "dry" summer period of June, July, August, and September. On an annual average basis, approximately 35% of the rain falling on urban areas within the planning area becomes direct runoff and is a major determiner of water quality in the lakes and streams.

On the basis of local data and data in national literature, the following pollutant loading factors for urban stormwater were used in the initial assessment:

BOD_5	=	10.0 mg/l
N	=	2.5 "
P	=	0.5 "
Sed	=	608.0 "

Using these loading rates, the following annual average pollutant loads were estimated for urban stormwater runoff in the entire planning area:

BOD	=	5.9 million kg/yr
N	=	1.5 "
P	=	0.3 "
Sed	=	357.0 "

Rural watershed runoff

Land which is used for agriculture generally introduces a larger amount of pollutants to rural runoff than does the same amount of grassland. Available local and national data were used to estimate the loading rates for grassland and cropland for the presentation areas as shown in table 1. Areas A, B, C, and F are located primarily within the Grand Prairie and East Cross Timbers resource areas, and Areas D, E, and G are located within the Blackland Prairie resource area.

TABLE 1

ESTIMATED RURAL LOADING RATES FOR THE PLANNING AREA

Pollutant	Grassland ($kg/km^2/yr$)	Cropland ($kg/km^2/yr$)
PRESENTATION AREAS A,B,C,F		
BOD_5	1,100	2,600
N	100	300
P	11	33
Sediment	55,000	1,100,000
PRESENTATION AREAS D, E, G		
BOD_5	1,100	2,600
N	193	579
P	15	45
Sediment	77,000	1,540,000

The annual rural mass loading for the planning area was then estimated for the four pollutants as follows:

BOD

Grassland = 4.8 million kg/yr
Cropland = 5.1 million kg/yr

Nitrogen

Grassland = 600 thousand kg/yr
Cropland = 910 thousand kg/yr

Phosphorus

Grassland = 55 thousand kg/yr
Cropland = 79 thousand kg/yr

Sediment

Grassland = 280 million kg/yr
Cropland = 2.7 billion kg/yr

Nearly all of the sediment from outside the planning area and in the lakes area is retained in the lakes, and therefore does not directly affect the river watersheds.

Background levels

From local data, preliminary estimates can be made of the approximate levels of pollutant loading that would exist in the absence of all human activity in the planning area. These background loads can be summarized as follows:

BOD_5 = 7 million kg/yr
N = 610 thousand kg/yr
P = 61 thousand kg/yr
Sed = 350 million kg/yr

Comparisons among sources

From the calculations presented so far, it is possible to compare the major sources of BOD_5, nitrogen, phosphorus, and sediment. Five major sources are included in this comparison: point sources, urban stormwater, grassland, cropland, and sources outside the planning area. A summary of the total pollutant loads and of the approximate percentages contributed by each source is presented in table 2.

Figures 4, 5, and 6 show the relative magnitudes of point and nonpoint sources of BOD on an annual basis for each of the seven major lake and river watersheds (presentation areas) for the three BOD conditions. These

TABLE 2

ESTIMATED SOURCES OF ANNUAL POLLUTANT LOADS FOR THE PLANNING AREA

	Approximate Total Load (million kg/yr)	Point Source	Urban Stormwater	Grassland	Cropland	From Outside Planning Area
BOD_5, Condition 1	47	39%	12%	10%	11%	28%
BOD_5, Condition 2	33	12%	18%	15%	16%	39%
Nitrogen	15	68%	10%	4%	6%	12%
Phosphorus	4.4	87%	7%	1%	2%	3%
Sediment	6,800	0.3%	5%	4%	39.7%	51%

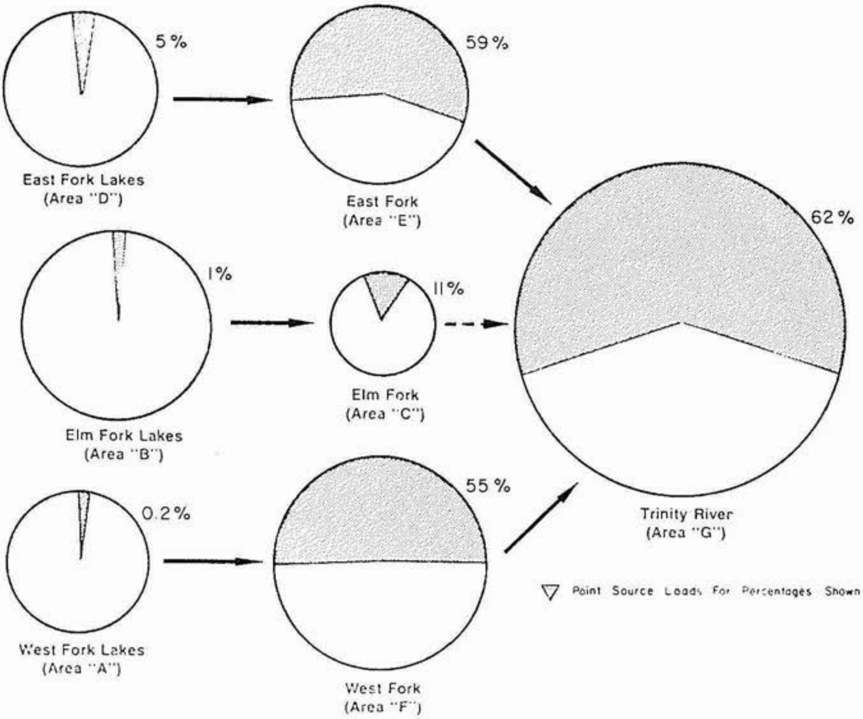

FIG. 4. FIVE-DAY BIOCHEMICAL OXYGEN DEMAND LOAD COMPARISONS for nonpoint sources and Condition 1 point sources (adapted from Hydroscience, 1977)

illustrations present: 1) the relative magnitude of five-day BOD loads entering or being generated within each presentation area as indicated by the size of the circle; 2) the percentage of nonpoint source load entering and or being generated within each presentation area; and 3) the percentage of point source load entering or being generated within each presentation area. In these calculations, we have allowed for the decay of some of the BOD_5 in each presentation area.

As is shown in figure 4, point sources were the major contributors of BOD in three of the river watersheds (E, F, and G) on an annual basis, whereas watershed runoff was the major annual contributor in the remaining four areas. The recommended sewerage improvements currently under construction (10/15 treatment) will greatly reduce the amount of point source BOD discharged to the river areas (figure 5). Figure 6 represents the estimated annual loading values under the state-proposed 5/5/3 treatment. It is clear that very little improvement in the total BOD load could be expected from the additional treatment.

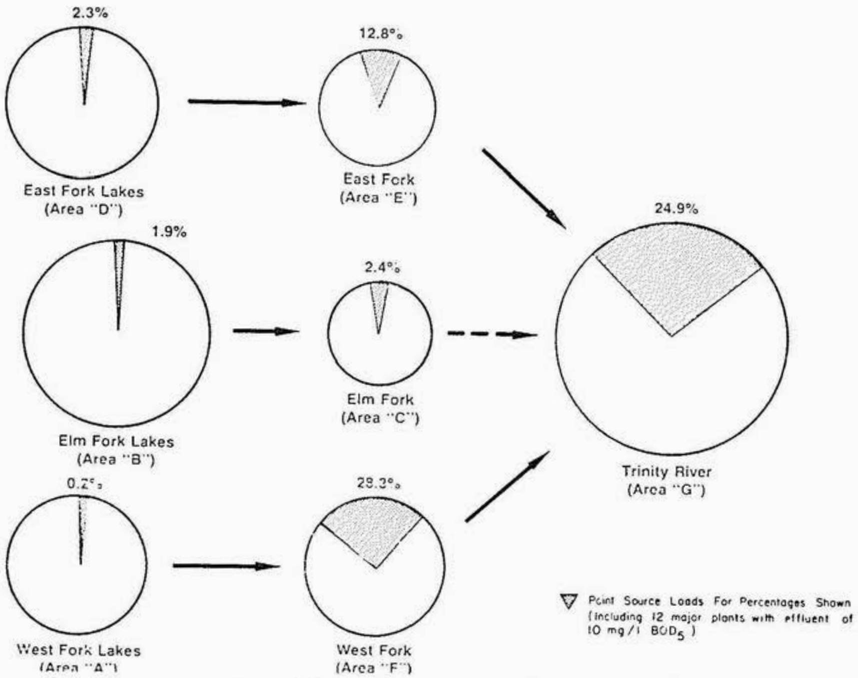

FIG. 5. FIVE-DAY BIOCHEMICAL OXYGEN DEMAND LOAD COMPARISONS for nonpoint sources and Condition 2 point sources (adapted from Hydroscience, 1977)

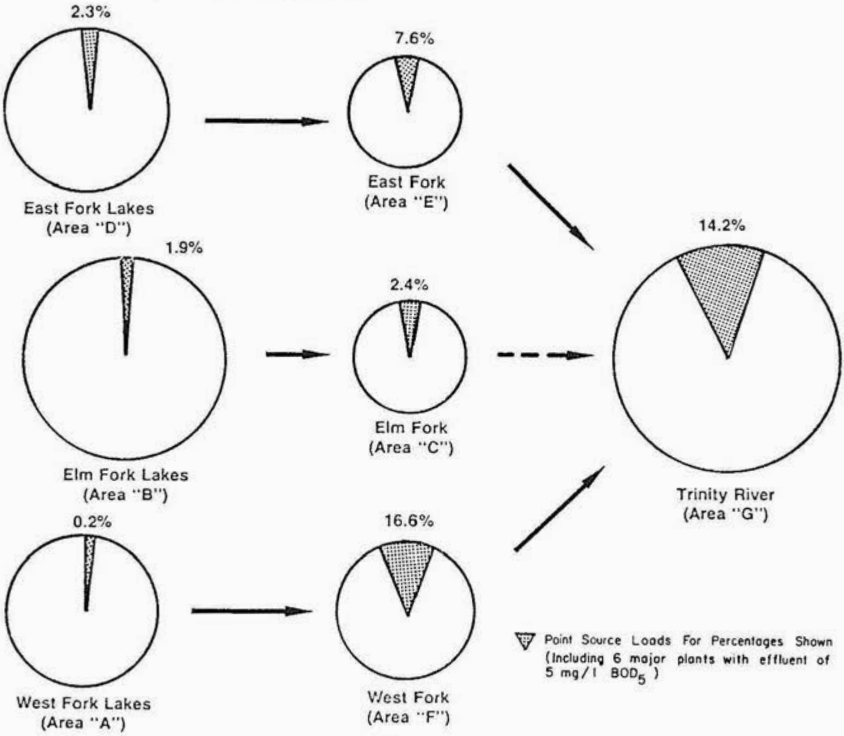

FIG. 6. FIVE-DAY BIOCHEMICAL OXYGEN DEMAND LOAD COMPARISONS for nonpoint sources and Condition 3 point sources (adapted from Hydroscience, 1977)

Since the initial nonpoint source assessment (Hydroscience, 1977), the NCTCOG watershed sampling program for 1977 reveals that the concentrations used to represent the planning area were reasonably accurate (see table 3). Further analysis of sampling results and reapplication of the calculation procedures are currently under way.

CONCLUSIONS

The "208" planning process provided the impetus for local governments and state and federal agencies to determine the most cost-effective means to achieve the goals of the Clean Water Act. It has become apparent that continued expenditures for more advanced treatment at sewage treatment plants may not achieve the desired goals, nor may they be the most cost-effective means. This paper should not be construed as pitting point sources of pollution against nonpoint sources. Rather it is an attempt to show that we must consider all the cause-and-effect relationships concerning water quality within our streams and rivers in order to determine the

TABLE 3

COMPARISON OF AVERAGE RUNOFF POLLUTANT CONCENTRATIONS

POLLUTANTS	Common National Range mg/l	Rate Used in "Nonpoint Sources" mg/l	Average of 1977 Sampling mg/l
BOD_5			
Urban	2.0 to 50.0	10.0	12.0
Rural	1.0 to 30.0	12.0	6.0
Nitrogen			
Urban	1.0 to 4.0	2.5	2.8
Rural	0.4 to 30.0	1.6	2.1
Phosphorus			
Urban	0.1 to 1.0	0.5	0.9
Rural	.002 to 2.0	0.15	0.3
Total suspended solids			
Urban	50.0 to 1200.	608.0	663.0
Rural	100.0 to 25,000	6000.0*	337.0**

* Sediment

** Total suspended solids

best solution to any problems that may arise. By attempting to determine priorities on a rational basis and by establishing a procedure adequate to test proposed solutions, the Annual Plan (NCTCOG, 1978) serves as a framework for the Dallas/Fort Worth Area to achieve and maintain the goals of the Clean Water Act.

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REFERENCES CITED

GOVERNMENT ACCOUNTING OFFICE, 1976. "Better Data Collection and Planning is Needed to Justify Advanced Waste Treatment Construction." Report to the Congress by Comptroller General of the United States, CED-77-12.

———, 1977. "National Water Quality Goals Cannot Be Attained Without More Attention to Pollution From Diffused or 'Nonpoint' Sources." Report to the Congress by the Comptroller General of the United States, CED-78-6.

HOROWITZ, J. and L. BAZEL, 1977. "An Analysis of Planning for Advanced Wastewater Treatment (AWT)." Final Report to the U.S. EPA by Vertex Corporation.

HYDROSCIENCE, 1977. *Nonpoint Sources: An Assessment of Pollutant Loadings to Lakes and Rivers in North Central Texas*. Prepared for the North Central Texas Council of Governments.

NORTH CENTRAL TEXAS COUNCIL OF GOVERNMENTS, 1977. *The 1977 Annual Water Quality Management Plan*, vol. I.

NORTH CENTRAL TEXAS COUNCIL OF GOVERNMENTS, 1978. *The 1978 Annual Water Quality Management Plan*, vol. I.

PROMISE, J., H. J. VESELKA, and J. RAGSDALE, 1977. "Are Treatment Plants Enough? A Dallas/Fort Worth Perspective on the National Clean Water Goals." Paper presented to the Tri-Sectional Fall Meeting of the American Society of Civil Engineers, Albuquerque, New Mexico, October 6-8.

TEXAS WATER QUALITY BOARD, 1977. Hearing Notice. Texas Register 2(35): 1726.