EVALUATION OF STREAMWATER QUALITY IN THE ATLANTA REGION

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REFERENCE: *Proceedings of the 1997 Georgia Water Resources Conference,* held March 20-22, 1997, at the University of Georgia, Kathryn J. Hatcher, Editor, Institute of Ecology, The University of Georgia, Athens, Georgia.

Abstract. A water-quality index (WQI) was developed from historical data for streams in the Atlanta region. The WQI was derived from percentile ranks of individual water-quality parameter values at each stream by normalizing the constituent ranks for values from all sites in the area for the period from 1990 to 1995. WQIs were developed primarily for nutrients and nutrient-related parameters, because data for metals, organics (pesticides and herbicides), biological conditions, and suspended sediment generally were unavailable. Average WQI of the individual parameter WQIs for sites in the region ranged from 0.26 (good quality) to 0.86 (poor quality), and increased downstream of known nutrient sources. Annual average site WQI decreased at most long-term monitoring sites from 1986 to 1995. Temporal trends, in part, reflect effects of a drought in the late 1980's and normal to higher-than-normal rainfall and runoff in the 1990's. For several sites, particularly in the northern part of the region where major development is ongoing, WQI increased dramatically from 1994 to 1995. Interannual WQI variability typically was less than spatial variability. Average annual site WQI for individual parameters correlated with annual hydrologic characteristics, particularly precipitation amount and water yield, reflecting the effect of dilution on individual water-quality parameter values.

INTRODUCTION

Human activities have had a profound impact on the environment. Alteration of the land surface for a variety of uses including light and heavy industry, urbanization, and suburban development have changed water pathways and induced changes to natural processes. Human activities are accompanied by sources of elements and compounds that are contributed to the landscape and receiving waters through various pathways, including atmospheric deposition, and solid and liquid waste disposal. In addition, types of contaminants and mechanisms for waste disposal are not static.

To keep pace with rapid changes in the environment, environmental managers need tools to assess impacts of their management decisions. The physical and chemical characteristics of the receiving water, whether it is ground water or surface water (streams, lakes, and reservoirs), result from an integrated basin response to all land and water decisions (*i.e.*, a land decision is a water decision).

The threat of degradation with respect to land-use change and waste disposal from previous and ongoing activities is quite high, and requires additional information about the current status of water quality in a variety of environments (*i.e.*, precipitation, soils, ground water and surface water), to effectively manage the environment. The need remains, therefore, to continually assess the status of stream ecosystems as they are impacted by resource-management decisions. As a contribution to this end, the objectives of this paper are to assess historical data for streams in the Atlanta region and to evaluate the functionality of a WQI of these data as the WQI relates to site and water-quality parameter differences among sites.

METHODOLOGY

Urban streams database

Water-quality data for urban streams were compiled from past investigations for the period 1986 to 1995. Briefly, water-quality data were obtained from the U.S. Environmental Protection Agency's STORET database system; and from reports, documents and water-quality monitoring records collected primarily by State, county and local agencies in the region. These data were augmented where possible with geology, land use, and basin characteristics from a geographic information system.

Water-quality index

A water-quality index (WQI) was calculated for each water-quality parameter value by determining the rank of a given value with respect to the distribution of water-quality parameter values for a base period. The WQI computation generally follows the guidelines of a previous study in Florida (Hand *et al.*, 1994). The WQIs were expressed as fractional percentile ranks, ranging from 0 to 1, with 0 denoting the best water quality and 1 denoting the poorest water quality. Most water-quality parameters were positively correlated with the WQI, in that high concentrations or values were associated with poor water quality, except for dissolved oxygen (DO). The DO values, expressed as percent saturation, were reversed, because high saturation of DO is viewed as beneficial and low saturation as deleterious. The distribution of water-quality parameter values for all sites and samples were evaluated for a set time period, base period from 1990 through 1995, and this distribution was used to determine the ranking of values for the historical period from 1985 through 1989. To assess the spatial and temporal variability, WQI of water-quality parameters were averaged for each site: (1) for a historical period, (2) for the base period, and (3) for each year from 1986 to 1995. In addition, an average WQI was determined for each site by averaging the individual site average WQIs.

RESULTS AND DISCUSSION

Water-quality data for streams in the Atlanta region from 1986 to 1990 are relatively more abundant for nutrient related water-quality parameters (most of the components of Table 1), probably due to requirements for compliance monitoring. Most samples were collected periodically during the period at several tributary and mainstem sites of the Chattahoochee River and several of its major tributaries. In general, data for pesticides, metals, biological characteristics, and suspended sediment were relatively sparse and for most sites was nonexistent. Interpretation of the WQI for use in watershed management would be difficult for those cases having an extremely low (<100) number of observations among all sites or having an extremely low (<10) number of observations for a particular station.

Individual WQIs varied markedly and some water-quality parameters show a dilution effect, *i.e.*, high flow causes low values. At most sites, flow information was unavailable; and therefore, the water-quality data could not be normalized to remove the effects of dilution. Also, data for many of these types of constituents are not equally distributed over time or space. Sporadic measurements probably were driven by some perceived problem related to the particular stream; and therefore, bias the distribution for all streams in the area. Although data for this type of non-uniform monitoring may be inadequate for applying a WQI, these data should be used to qualify WQI results derived from other water-quality parameters. Calculation of the WQI was limited to the individual water-quality parameters in Table 1, because data for other water-quality parameters were inadequate.

Statistical distributions for most water-quality parameter values were skewed and appeared to be log normal. Although the distributions were skewed, they did not affect the calculation of WQI, which was derived from the non-parametric percentile rankings. The skewness simply indicates that most values were below the average concentrations, but at a few sites where extreme values were observed, high concentrations might pose a rather serious risk to site quality, at least on the short term.

Spatial WQI variability

The site average WQIs of long-term monitoring sites for the historical and base periods are listed in Table 2 and for the base period are shown in Figure 1. Site WQIs for the base period range from 0.26 to 0.86. The best site quality suggested by low WQIs (<0.3) occurs in the most rural areas surrounding the highly populated and industrial areas in the central part of the Atlanta Region (Figure 1). The worst site quality occurs in the most highly developed areas, which also have the highest percentage of impervious-surface area.

Site WQIs increase downstream at sites on the Chattahoochee River from Buford Dam to below Atlanta. A notable increase occurs to the site WQIs downstream of two major wastewater-treatment discharges, *i.e.*, compare the change in WQI from site 7 to site 8 in Table 2.

Table 1. Water-quality parameters used for calculating the WQI

Water-Quality Parameter
5-Day Biological Oxygen Demand
Dissolved Oxygen, percent saturation
Fecal Coliform Bacteria
Ammonium Total
Nitrite plus Nitrate Total
Orthophosphate
Specific Conductance
Total Organic Carbon
Total Phosphorus

Temporal WQI variability

The variability of individual parameter WQIs and site WQI were evaluated for seasonality and trend from 1985 to 1995. In addition, average WQIs for the historical data (1986 to 1989) were compared to the base period (1990 to 1995). Sites that had data spanning the two periods with at least four years of data were chosen for the temporal evaluation (Table 2).

Site WQIs generally were less for the base period than for the historical period (Table 2). For several of the more pristine sites such as the upper Chattahoochee River above either the Gwinnett or DeKalb County water intakes and the Etowah River at Allatoona Dam, the decrease in WQI was gradual from 1986 to 1995 (Figure 2). However, for other sites such as on Big Creek, South River or Yellow River, site average WQI decreased through 1993 and abruptly increased in either 1994 or 1995 (Figure 2), suggesting an improvement and then degradation in water quality. For many of the sites showing recent degradation, land use has been changing due to more rapid urban development than in other areas.

Because the WQI is derived from the ranking of water-quality parameter values, the WQI is affected by dilution. The WQI for most water-quality parameters and for the site averages was highest in summer and fall when water discharge typically is the lowest. Likewise, on a longer term, average WQI for most sites was highest during the drought years of the mid 1980's and decreased under more normal to wet conditions in the 1990's. Dilution may have caused the trend of improving water quality. At those sites for which the WQI increased, the water quality has clearly been adversely impacted by basin changes in recent years. Because the WQI was changing throughout the study period, the intra-annual variation for individual years should be much more pronounced.

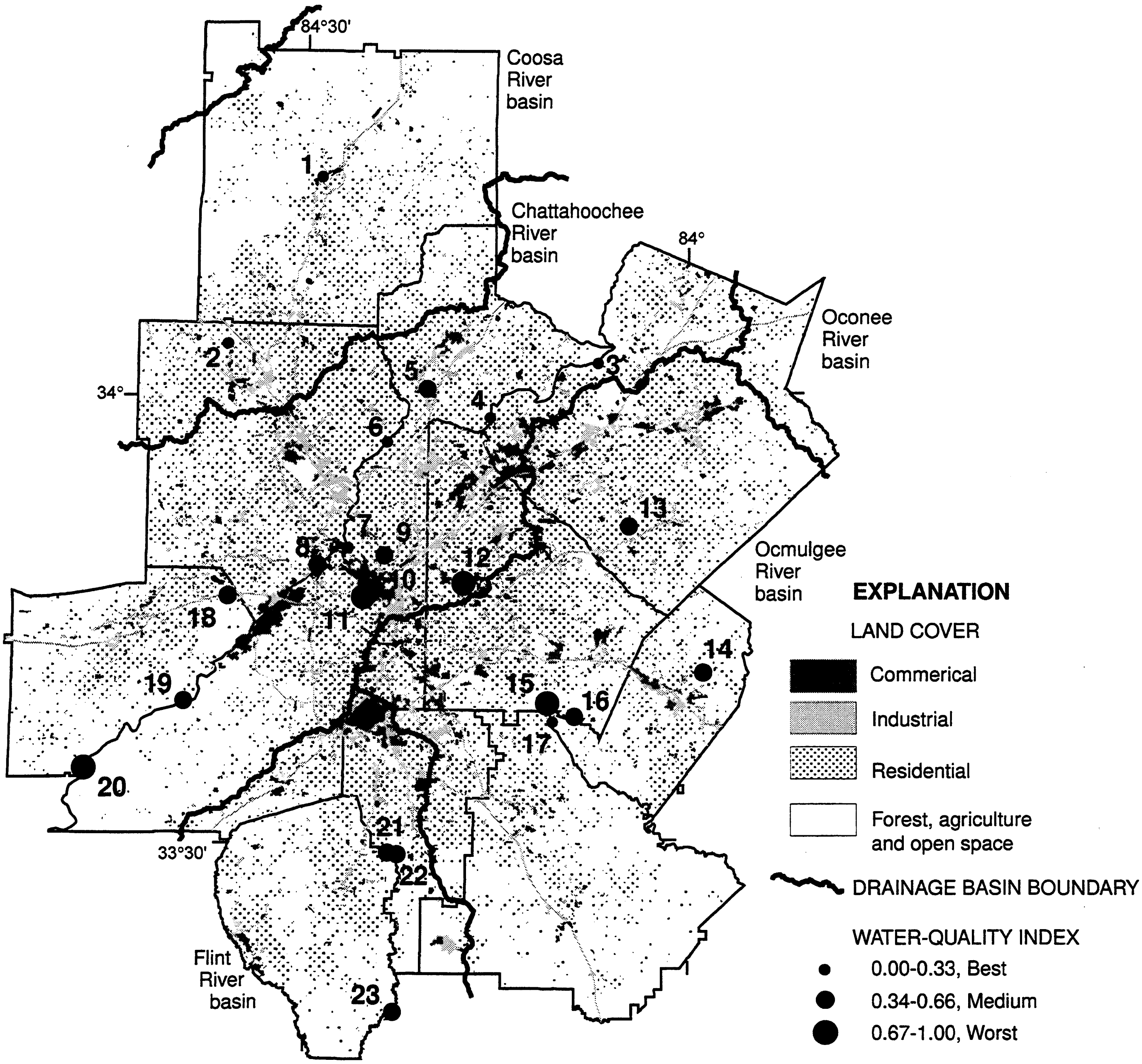

Figure 1. Spatial distribution of site average Water-Quality Indexes for long-term stream monitoring sites in the Atlanta region for the 1990 to 1995 base period. The number next to each symbol refers to the location in Table 2.

Table 2. Site water-quality indices averaged for the historical period (1986 to 1989), present period (1990 to 1995), and total for long-term monitoring sites in the Atlanta region [data from U.S. Environmental Protection Agency STORET data base; site numbers refer to locations on Figure 1; —, no available data]

Site number	Location	Site Water-Quality Index		
		Historical	Present	Total
1	Etowah River at Allatoona Dam above Cartersville	0.31	0.26	0.27
2	Proctor Creek at Baker Road near Kennesaw	—	.29	.29
3	Chattahoochee River at Gwinnett County Water Intake	.31	.27	.29
4	Chattahoochee River at Dekalb County Water Intake	.30	.28	.29
5	Big Creek at Roswell Water Intake	.60	.51	.55
6	Chattahoochee River at Cobb County Water Intake	.42	.33	.37
7	Chattahoochee River near Atlanta	.43	.33	.38
8	Chattahoochee River at I-285 Upstream of Proctor Creek	.74	.53	.63
9	Peachtree Creek at Northside Drive at Atlanta	.70	.62	.64
10	Proctor Creek Tributary at Bankhead Welding	.69	—	.69
11	Proctor Creek at Bankhead Welding	.77	—	.77
12	South Fork Peachtree Creek Tributary at Scott Boulevard at Decatur	—	.81	.81
13	Yellow River at Killian Hill Road	.65	.54	.57
14	Yellow River at Conyers Water Intake	.60	.51	.55
15	South River near Lithonia	.72	.67	.69
16	South River at Klondike Road near Lithonia	.74	.66	.70
17	Mountain Creek at Panola Mountain State Park	—	.25	.25
18	Sweetwater Creek near Austell	.48	.42	.44
19	Chattahoochee River near Fairburn	.84	.63	.73
20	Chattahoochee River at Capps Ferry Road near Rico	.86	.68	.72
21	Flint River at State Route 54 near Fayetteville	.70	.51	.60
22	Flint River at Ackert Road near Inman	.62	.44	.52
23	Flint River Between Fayetteville and Lovejoy	.59	.46	.52

SUMMARY AND CONCLUSIONS

A water-quality index (WQI) was developed from historical data from 1986 to 1995 for streams in the Atlanta region. The WQI was derived from percentile ranks of individual water-quality parameter values at each stream by normalizing the constituent ranks for values from all sites in the area for the period from 1990 to 1995. Data for pesticides, metals, biological characteristics, and suspended sediment were relatively sparse and for most sites nonexistent. Therefore, WQIs were developed primarily for nutrients and nutrient related water-quality parameters. Average WQI of the individual water-quality parameter WQIs for sites in the region ranged from 0.26 (good quality) to 0.86 (poor quality), and increased downstream of known nutrient sources. Annual average site WQI decreased at most long-term monitoring sites from 1986 to 1995. WQIs, in part, were affected by dilution as evidenced by seasonal correlation with highest values during summer and fall low flow periods and highest annual averages associated with the drought years in the mid 1980's. For several sites, particularly in the northern part of the region where major development is ongoing, WQI increased dramatically from 1994 to 1995. Interannual WQI variability typically was less than spatial variability. Average annual site WQI for individual water-quality parameters correlated with annual hydrologic characteristics, particularly precipitation amount and water yield, reflecting the effect of dilution on individual water-quality parameter values.

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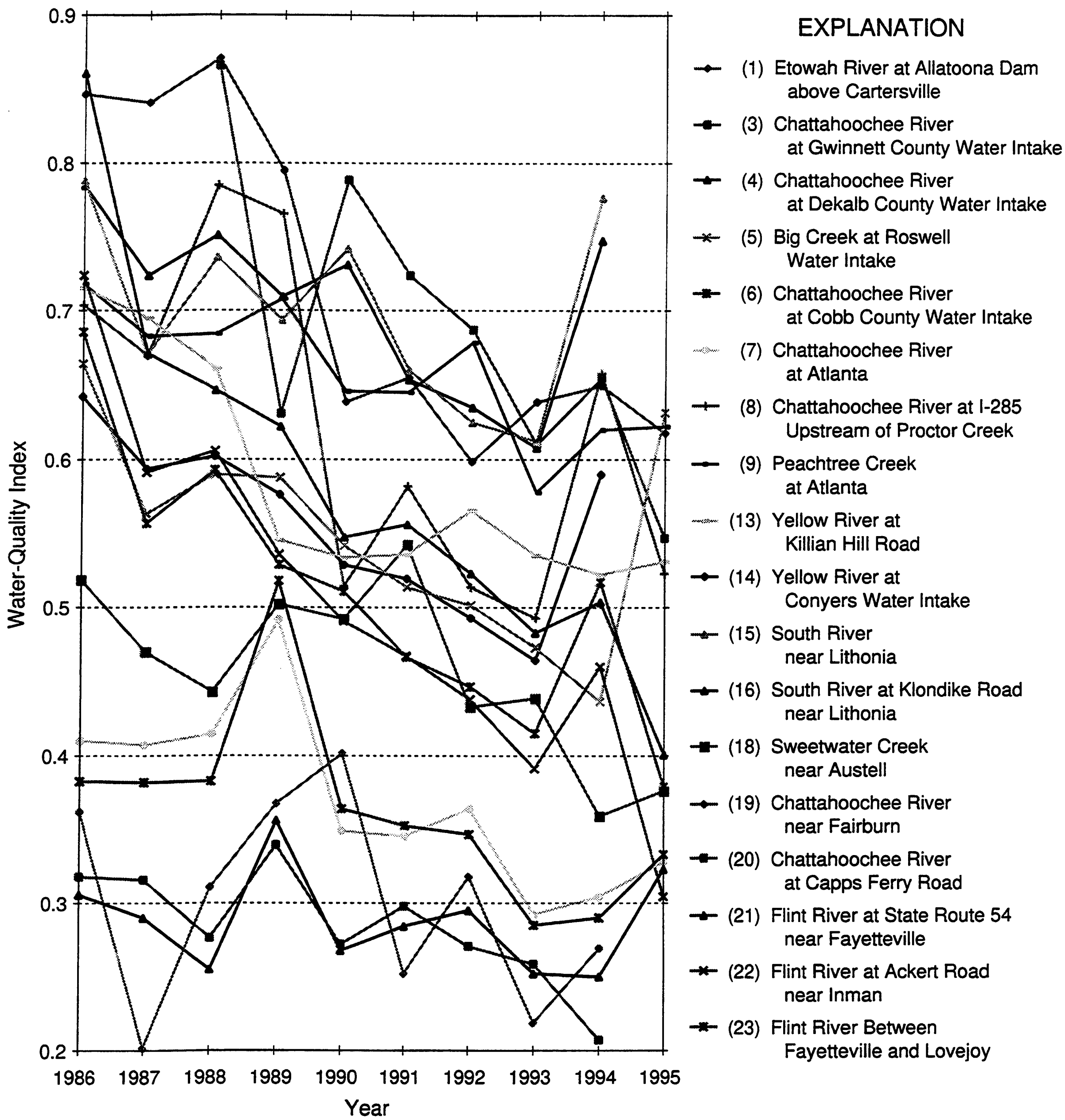

Figure 2. Temporal variations of the annnual average Water-Quality Index for long-term stream monitoring sites in the Atlanta region from 1986 to 1995.