WATERSHED EVALUATION REQUIREMENTS TO MANAGE GROWTH-DRIVEN WATER QUALITY IMPACTS

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Abstract. A watershed evaluation was conducted by a metro Atlanta utility to examine water quality impacts attributable to an advanced wastewater treatment facility. A biological assessment and computer model were used to assess effects resulting from the effluent and those from other sources. A watershed management alternatives analysis was developed from the results of the assessment and model. The project led to the identification of actions needed to reduce phosphorus loadings in order to preserve water quality.

INTRODUCTION

The metro Atlanta area has experienced rapid growth during the last several decades. This growth has placed significant demands on local utilities to provide additional water and wastewater services and also has put stress on receiving waters to meet water supply demands and provide assimilative capacity for wastewater disposal. Primary concerns associated with rapid development in suburban areas have included degradation of streams as a result of increased runoff, increased sediment loads, encroachment of development into riparian areas of stream channels, and the cumulative impact of increased nutrient loading on downstream reservoirs. In response to concerns about stream impacts from new development and cumulative downstream nutrient impacts from new development, the Georgia Environmental Protection Division (EPD) of the Department of Natural Resources (DNR) recently required local utilities to conduct watershed evaluations (monitoring and model development) in service areas requiring expanded wastewater treatment capacity as a prerequisite to increasing their treatment capacity.

The Cobb County Water System (CCWS) in northwest metro Atlanta operates the Noonday Creek Water Reclamation Facility (WRF), which is a 12-mgd advanced treatment plant. This WRF discharges to Noonday Creek, which flows into the Little River Embayment of Lake Allatoona, a Corps of Engineers reservoir on the Etowah River. A recent diagnostic feasibility study report for Lake Allatoona (A. L. Burruss Institute, 1992-93) indicated potential problems with eutrophication in the lake as a whole and specifically indicated that the Little River Embayment is eutrophic.

In order to allow continued expansion at the Noonday Creek WRF, EPD required CCWS to conduct a watershed study that included the following tasks: review existing water quality data for Lake Allatoona and its embayments and tributaries; evaluate the impacts of the Noonday Creek WRF and other discharges, as well as the impacts of stormwater runoff on the fish and macroinvertebrate populations in the Noonday Creek watershed; analyze the impacts of nutrient loads from the Noonday Creek WRF on the Little River Embayment; develop and evaluate management strategies for watershed protection and water quality improvement; and summarize the findings of the biological study, eutrophication analysis, and watershed management strategies analysis.

BIOLOGICAL ASSESSMENT AND WATER QUALITY

To assess the impacts from point and nonpoint sources on the biota in Noonday Creek, a biological sampling program was developed using rapid bioassessment protocols (RBP) developed by the EPD and the US EPA. (Plafkin et al., 1989). The study area is depicted in Figure 1.

Approach

The RBP constitutes an integrated approach for comparing habitat (e.g., physical and structural) and biological measures of community structure (metrics) in an affected environment with empirically defined reference condition metrics in an unaffected environment. The RBP benthic community metrics are based on very general structural and

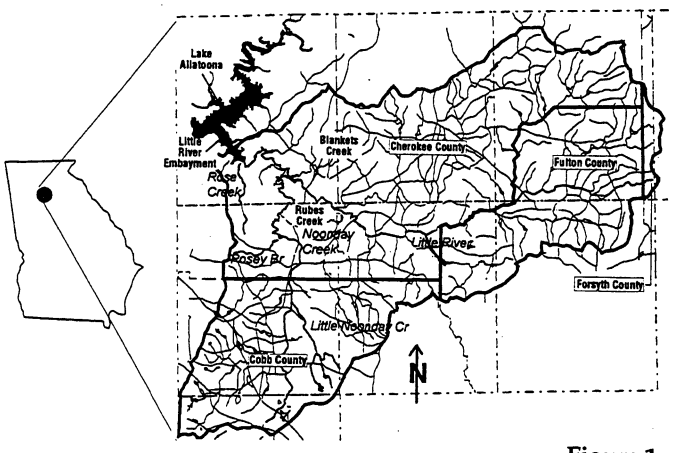

Figure 1
Location of Facility and Sampling Sites

trophic relationships that are applied nationally. The primary fish assessment method was Karr's index of biotic integrity (IBI) (Karr et al., 1986).

The objectives of the biological sampling program were to document water quality conditions in Noonday Creek using a biological assessment method; identify watershed effects on water quality in Noonday Creek; identify differences, if any, in water quality above and below the Noonday Creek WRF outfall; and assess the biotic integrity of Noonday Creek. The biological sampling program included an assessment of the benthic macroinvertebrate and fish community structure at five stations in Noonday Creek and a comparison of results to a reference station.

Station Selection

Six sampling locations were established: five in the Noonday Creek system and one in Stamp Creek. Stations 1 and 2, located above the Noonday Creek WRF, exhibit typical urban-industrial and urban-residential disturbance and land use for the watershed area, but are not affected by discharges from the Noonday Creek WRF. Stations 3 through 5 were located downstream of the WRF and are potentially affected by its discharge. Station 6, the reference station, was located on Stamp Creek in the Pine Log Mountain Wildlife Management Area in a mostly undeveloped watershed. Benthic macroinvertebrates were collected at each station and fish were collected at four of the stations. In situ water quality measurements were made and habitat conditions were qualitatively evaluated (EPD, 1995) at each station.

Summary

Based on the evaluation of the physical conditions and habitats, many areas of Noonday Creek had distinctly similar bank structure and morphology due to channelization and development in the watershed. Primary features of all Noonday Creek stations were siltation from erosion in the watershed and unstable bottom substrates. The Stamp Creek habitat, markedly different from that of Noonday Creek, represents expected conditions for streams in the middle reaches of the Etowah River watershed since it was not channelized or dredged. Also, the bottom substrates were more diverse.

No discernible difference was observed in the benthic community structure above and below the Noonday Creek WRF based on an evaluation of ecological parameters of habitat quality and community structure. A comparison of sensitive species abundance that was based on biotic integrity tolerance values indicated that at least 30 more sensitive species were collected in Stamp Creek. In addition, selective elimination of Ephemeroptera, Plecoptera, and Tricoptera (EPT) below the WRF outfall and enhancement of replacement species was not observed. However, the EPT were reduced at all stations in Noonday Creek compared to Stamp Creek, demonstrating that nonpoint source pollutants in the watershed had a greater effect on water quality than did the WRF. Although the macroinvertebrate RBP index did not show a decreased biotic integrity below the WRF, the IBI used in evaluating the fish data exhibited a longitudinal response pattern and reduced IBI score at Station 3 during the spring and fall sampling seasons.

While IBI values indicate water quality degradation below the WRF, water quality effects of the WRF outfall could not be separated from potential influences on biotic integrity from Little Noonday Creek, which enters Noonday Creek between Stations 2 and 3. Nonpoint source degradation and channel alteration affecting fish community structure were pervasive throughout Noonday Creek. Characterization of physical habitat and water quality parameters at Station 1, located between Stations 2 and 3, indicates that the Little Noonday Creek inflow elevates water temperatures in upper Noonday Creek and contributes a substantial sediment load from surrounding developed areas.

The biological data do not conclusively indicate that the Noonday Creek WRF has a detrimental impact on Noonday Creek. A comprehensive evaluation of habitat, benthos, and fisheries data suggests that habitat deterioration and siltation are the dominant influences on the observed communities in the creek.

WATER QUALITY MODEL

The Lake Allatoona report (A. L. Burruss Institute, 1992-93) indicated that P was the limiting nutrient. This study focused on estimating P loads, both nonpoint and point, to the Little River Embayment as described in the following sections. To investigate the impact of modifications to the existing loading scenario (expansions to existing wastewater treatment facilities, changes in land use, etc.), a model that represents the relationship between nutrient loads on the trophic state of the Little River Embayment was necessary. The resulting trophic state of the water body could then be predicted from the change in nutrient loadings (both point and nonpoint).

EUTROMOD, a watershed and lake modeling spreadsheet, was selected to estimate the impacts of nutrient (P) loads on the Little River Embayment. EUTROMOD was developed by Ken Reckhow and Miranda Henning at Duke University and is available through the North American Lake Management Society. This model applies land use information, point source information, and lake characteristics to calculate nutrient loading and various trophic state parameters.

Land use area was estimated using land cover maps and map files based on LANDSAT Thematic Mapper Satellite Imagery. The land cover classification, which was performed by ERDAS, Inc., and the Georgia DNR, included 15 classes. For this study, the 15 classes were reduced to seven broad land use categories: forest, wetland, agriculture, fallow, low-density urban, high-density urban, and water. Forest land covers the majority of the study area (74 percent). At 15 percent and 9 percent of the total land use, respectively, agriculture and urban land are the 2 next largest land use categories. The remaining categories (wetland, fallow, and water) each account for 1 percent or less. Future land use was estimated using future land use maps and other documents obtained from the planning departments of Cherokee, Cobb, Fulton, and Forsyth Counties.

Point source discharges from treatment facilities and estimated septic tank loadings are required EUTROMOD input. Nine facilities were identified within the study area, including the Noonday Creek WRF and other municipal discharges. A conservative estimate of septic tank loadings was applied since limited information was available.

WATERSHED MANAGEMENT ALTERNATIVES ANALYSIS

A watershed management alternatives analysis was conducted to investigate the impacts of various nutrient loading scenarios on the Little River Embayment. The analysis addressed current and future land use conditions, permitted concentrations and loading scenarios, the impacts of expansions of the Noonday Creek WRF, and the impacts of watershed-wide runoff controls on new urban development. Cases investigated included the following:

Current land use conditions

Case 1: Actual monthly average flow and P concentration

Case 2: Current permitted flow and P concentration

Future land use conditions

Case 3: Expansion flow (20 mgd) and current permitted P concentration

Case 4: Expansion flow (20 mgd) and current permitted P loading

Case 5: Expansion flow (20 mgd) and current permitted P concentration with new development controls

Case 6: Expansion flow (20 mgd) and current permitted P loading with new development controls

Assessment of Current Conditions

Current nutrient loading from nonpoint sources was calculated for each land use category using an export coefficient (expressed as a mass loading for an area over time) for that land use category and the area of that land use category. Total flows and average monthly actual and permitted P loadings from the treatment facilities were estimated and entered into the model for current point source loading. Values for the export coefficients in EUTROMOD were estimated from a literature search of several studies conducted by the North Carolina Department of Environmental Management (NCDEM, 1993) for the *Neuse River Basinwide Water Quality Management Plan*. These export coefficients were used in EUTROMOD since these were well documented and assessed as appropriate for the Upper Piedmont area.

EUTROMOD predictions using the export coefficient method (for current land use conditions and using actual monthly average flow and P concentrations) were compared to the findings in the Lake Allatoona report. This comparison indicates that the model provides a reasonable tool and slightly higher (conservative) estimates of P loadings and concentrations and other trophic parameters.

Assessment of Future Conditions

The assessment of future conditions involved the application of future land use conditions and the expansion of the Noonday Creek WRF to 20 mgd (with no reduction in effluent P concentrations or nonpoint source controls). EUTROMOD predicts a P loading and concentration for the future permitted scenario that are approximately double those of the current permitted condition. This future scenario is unlikely to occur since CCWS, if allowed to expand to 20 mgd, would reduce effluent P concentrations to the level of the current permitted loading or lower. In addition, CCWS amended the Cobb County Erosion and Sedimentation Control Ordinance in 1995 to meet the minimum requirements of the State of Georgia and is in the process of strengthening the enforcement of this ordinance. This will probably result in the establishment of new development controls within Cobb County.

ANALYSIS OF RESULTS

Based on current land use conditions and actual monthly average flow and P loadings from wastewater treatment facilities estimated from discharge monitoring reports from January 1995 to September 1995, P loading is approximately 35,000 kg/yr (Case 1). The model predicts a resulting P concentration from this loading of 0.06 mg/L, a resulting chlorophyll *a* concentration of 17.7 ug/L, and a secchi depth of 0.74 m. Applying current permitted conditions in the model (Case 2) results in a P loading of approximately 40,000 kg/yr with a predicted P concentration of 0.07 mg/L, a chlorophyll *a* concentration of 18.7 ug/L, and a secchi depth of 0.71 m.

Applying future land use conditions with the expansion of the Noonday Creek WRF to 20 mgd at the current permitted P concentration (Case 3) results in a P loading and concentration that are approximately double those of the current permitted conditions (approximately 84,483 kg/yr and 0.119 mg/L, respectively). EUTROMOD predicts a chlorophyll *a* concentration of 28 ug/L and a secchi depth of 0.57 m for this loading.

Expanding the Noonday Creek WRF to 20 mgd with a reduction of the P concentration to a level that remains within the current permitted loading (Case 4) reduces the future loading to approximately 73,000 kg/yr. Applying new development controls with the 20-mgd expansion and current permitted concentration scenario (Case 5) reduces predicted P loading to approximately 61,000 kg/yr. For simulation of new development controls, the application of unspecified best management practices (BMPs) was assumed, providing estimated P and nitrogen (N) loading reductions of 60 and 40 percent, respectively. These percentages were derived from findings of the Mountain Island Lake Watershed Study (May, 1991). These removal rates were selected to be representative of a combination of BMPs. Under the current permitted loading scenario with the 20-mgd expansion and new development controls (Case 6), loading is reduced to approximately 50,000 kg/yr.

New development controls were applied to new urban land use in all four counties in the study area for Cases 5 and 6. If new development controls were applied only in Cobb County, the resulting predicted P loadings are increased by approximately 17,000 kg/yr. For Cases 5 and 6, predicted N and P loadings are then approximately 78,712 kg/yr and 66,957 kg/yr, respectively. Therefore, implementation of

new development controls in all four counties is important for nonpoint source pollution control, since urban growth is occurring throughout the Little River Embayment watershed. Buildout capacity of the Noonday Creek WRF is 24 mgd. At this discharge flow, the facility would remain within the current permitted P loading with a permit limit of 0.5 mg/L.

Trophic State Parameters

According to the Lake Allatoona report (A. L. Burruss Institute, 1992-93), the Little River Embayment is strongly eutrophic; its chlorophyll *a* concentrations were generally twice as high as those at the dam pool. Since chlorophyll *a* is considered to be proportional to the concentration of algal biomass, it is the most common measure used in eutrophication studies. Since lake embayments tend to have higher nutrient concentrations and chlorophyll *a* densities than the main body portions of the lake, the Little River Embayment was compared with other embayments of the Lake Allatoona watershed in this study. In comparing trophic state parameters of selected embayment areas of the lake, they more closely resembled each other than corresponding parameters at the dam pool.

CONCLUSIONS

The evaluation of biological and habitat conditions in Noonday Creek and the watershed nutrient analysis and anticipated basin development indicated that actions are required to mitigate future nutrient impacts. Findings of the study regarding biological and habitat conditions in Noonday Creek indicated that the effects of erosion and impervious areas in the watershed are the primary factors contributing to degraded water quality.

The watershed nutrient model using future conditions showed that P loading will significantly increase in the future without targeted control actions. Based on future land use at buildout (from planning projections) and anticipated increases in wastewater discharge at the Noonday Creek WRF, P loading to the Little River Embayment will approximately double without further P controls. The loading analysis for the future may underestimate potential point source contributions from other parts of the watershed, since future increases in point source discharges other than the Noonday WRF were not estimated.

Nutrient Loading

While eutrophication concerns have been identified for the Little River Embayment in the Lake Allatoona report (A. L. Burruss Institute, 1992-93) , key eutrophication indicators for the embayment appear only slightly degraded in comparison to other (even relatively unimpacted) embayments. The watershed nutrient analyses have examined loadings from the entire Little River watershed area. Although the watershed includes four counties, CCWS has control over the point and nonpoint source loadings from only the Cobb County portion. CCWS proposes to implement nonpoint source controls and reduce the Noonday Creek WRF effluent P loading, anticipating that these actions will reduce the total P loading from Cobb County. Some of these controls include the following tasks:

- Develop a BMP Manual and implement a surface-water quality monitoring program in the Noonday Creek basin.
- Require formal approval of erosion control measures on individual projects by a certified erosion control inspector.
- Acquire key floodplain/wetland areas as perpetual sediment control buffers.
- Coordinate with other County departments in the development of erosion control strategies.
- Establish regional detention pond(s) and increase the undisturbed buffer from 25 to 50 feet.
- Establish and populate GIS database layers for floodplain information and stormwater management facilities.
- Incorporate the use of infrared aerial photography into the stormwater management program.
- Evaluate a wetlands enhancement/banking program.
- Examine the use of zoning restrictions to reduce water quality impacts.
- Encourage municipalities within the basin to participate in increased control efforts.

The goal of these actions is to reduce overall P loadings to the Little River Embayment in efforts to maintain water quality.

It should be noted that certain components of this study, primarily dealing with future land use, are currently being reevaluated.

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