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Project Summary

Development of Methods to Define Water Quality Effects of Urban Runoff

John L. Mancini

Because the costs of treating combined sewer overflows and urban runoff nationwide are extremely high, methods are needed for quantitatively evaluating the impacts of these discharges on the receiving water. This report summarizes an investigation of methods for developing wet weather water quality criteria that could form part of the basis for wet weather standards. The wet weather criteria could ultimately be used for measuring the benefits of treating combined sewer overflows and urban runoff.

This project considers short-term water quality impacts that occur during or shortly after a storm event. Examples of short-term impacts are dissolved oxygen depressions resulting from rapid oxidation of contaminants, or a fish kill caused by short-term increases in toxic substances in the receiving water. The nature and degree of the impacts depend on characteristics of the event such as the runoff volume, duration, and concentration of contaminants, and the dilution provided by the receiving water. This dilution in turn depends on the scale of the total river width, the joint occurrence of storm discharges from urban areas, and the stream flow in the receiving waters.

This project describes methods for defining the effects of time-variable concentrations on organism mortality and considers the carryover effects between storms as a result of varying instream contaminant concentrations during dry weather. The methods presented for evaluating the effects of exposure to time-variable concentrations can be used to define wet weather water quality criteria.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Nationwide programs to control discharges from combined sewers and the runoff from separately sewered urban areas can require capital costs ranging from tens to hundreds of billions of dollars, with associated operating costs of hundreds of millions of dollars annually. Methods must therefore be available for quantitatively evaluating the impacts of these discharges on receiving waters so that benefits can be estimated and compared to the very substantial costs involved. One method that indirectly assesses receiving water benefits uses local water quality standards. These standards consider economic and social impacts along with water quality criteria defined by the beneficial water use to be protected. This report describes methods that can be used to develop wet weather water criteria that could be the basis for wet weather standards. The wet weather criteria could ultimately be used to measure the benefits of treating combined sewer overflow (CSO) and urban runoff.

Two types of water quality problems are normally associated with the discharges from combined sewers and urban runoff: short-term and long-term effects. The first problem involves the rapid, short-term changes in water quality that occur during and shortly after a storm event. The nature and degree of these impacts depend on the characteristics of the storm event such as runoff volume, duration, and contaminant concentration, and the dilution available in the receiving water. Examples of the short-term impacts are dissolved oxygen depressions resulting from rapid oxidation of contaminants or a fish kill caused by short-term increases in a toxic substance in the receiving water.

The magnitude of water quality impacts from urban stormwater discharges is defined partly by the dilution available in the receiving water. This dilution depends on the scale of the total river width, by the joint occurrence of storm discharges from urban areas, and the stream flow in the receiving waters. The project describes methods for defining the effects of time-variable concentrations on organism mortality and considers the carryover effects between storms as a result of varying instream contaminant concentrations during dry weather.

In addition to having short-term negative impacts, combined sewer oveflows and urban runoff can also contribute to longer-term water quality degradation. The long-term impacts are caused by the contaminants associated with the suspended solids in the receiving water. In this context, long-term impacts may also be associated with both dissolved and particulate nutrients. The long-term impacts can include mass loading to receiving waters accumulated over long periods of time. Examples of long-term impacts are bottom oxygen demand of accumulated sediments or the biological accumulation of toxic substances as a result of leaching from sediments or uptake by benthic organisms. In the former example for dissolved oxygen, the critical water quality impact is usually associated with the normal low-flow, high-temperature summer periods. For both of these examples and for all other long-term effects, the effectiveness of control actions can be measured by comparing mass loadings from the various sources. Conventional analysis techniques such as steady-state modeling can then be used to estimate water quality improvement and benefits. This report addresses the latter situation and does not consider water quality problems associated with bottom scour of sediment.

Approach

A technique was developed to calculate for each event the probability distribution of the mean instream contaminant concentration. Example calculations are presented in the report for various regions of the country. These calculations used pollutant loading information from the EPA Urban Rainfall-Runoff-Quality Data Base and appropriate information on regional stream flows and rainfall statistics. The calculation results consider a number of ratios of urban drainage area to stream drainage area.

Techniques were developed for calculating distributions of event mean stream concentrations for lead, copper, and ultimate oxygen demand. These three contaminants were used to illustrate one method of determining locations where water quality problems could occur from CSO or urban runoff discharges. Results were determined for stream-to-urban-drainage-area ratios ranging from 1 to 1,000. The lower drainage area ratio (1) represents undiluted CSO and/or urban runoff. The calculated instream concentrations were plotted against drainage area ratio for a constant probability. This transformation was used to determine the median, expected mean, and 90% probability levels.

Graphs were prepared to determine (1) the percentage of rainfall events that would produce instream contaminant concentrations exceeding water quality criteria, and (2) the drainage area ratio for which water quality criteria will not be violated for a given percentage of time during periods of rainfall.

Findings

The findings of the project can be summarized as follows:

- A method has been developed that uses existing data from classical bioassay tests to calculate the effects exposing aquatic organisms such as fish to time-variable concentrations of toxicants. The procedure calculates the equivalent dosage and can define the equivalent mortality dosage. This procedure can be used to define water quality criteria for time-variable, event-related phenomena such as those associated with urban discharges.
- The procedure for calculating equivalent dosage has been tested using several sets of data collected independently.
- A method has also been developed to define how fish respond to the low dissolved oxygen levels that occur on the short-time scales associated with stormwater discharges.
- A calculation procedure has been developed to calculate the statistical distribution of instream concentrations of contaminants. The calculation combines statistics on rainfall and runoff, stream flow, concentrations in streams, and concentrations in CSO and/or urban runoff.
- The methods for calculating wet weather criteria and the statistics of instream concentrations can be combined to define locations where water quality problems are likely to occur as a result of storm-related discharges from urban areas.
- Judgments on the extent of water quality problems associated with CSO and urban runoff discharges depend to a large extent on the water quality criteria that are used. If generalized water quality criteria (usually employed for continuous discharges) are considered, CSO and urban runoff can produce water quality problems under most circumstances. If criteria are developed that consider the short duration of storm events and the relatively large interval between storms, water quality problems associated with CSO and urban runoff appear to be significantly reduced.

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John L. Mancini is with Manhattan College, Bronx, NY 10471.
***Douglas Ammon** is the EPA Project Officer (see below).*
The complete report, entitled "Development of Methods to Define Water Quality Effects of Urban Runoff," (Order No. PB 84-122 928; Cost: $16.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Municipal Environmental Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268

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