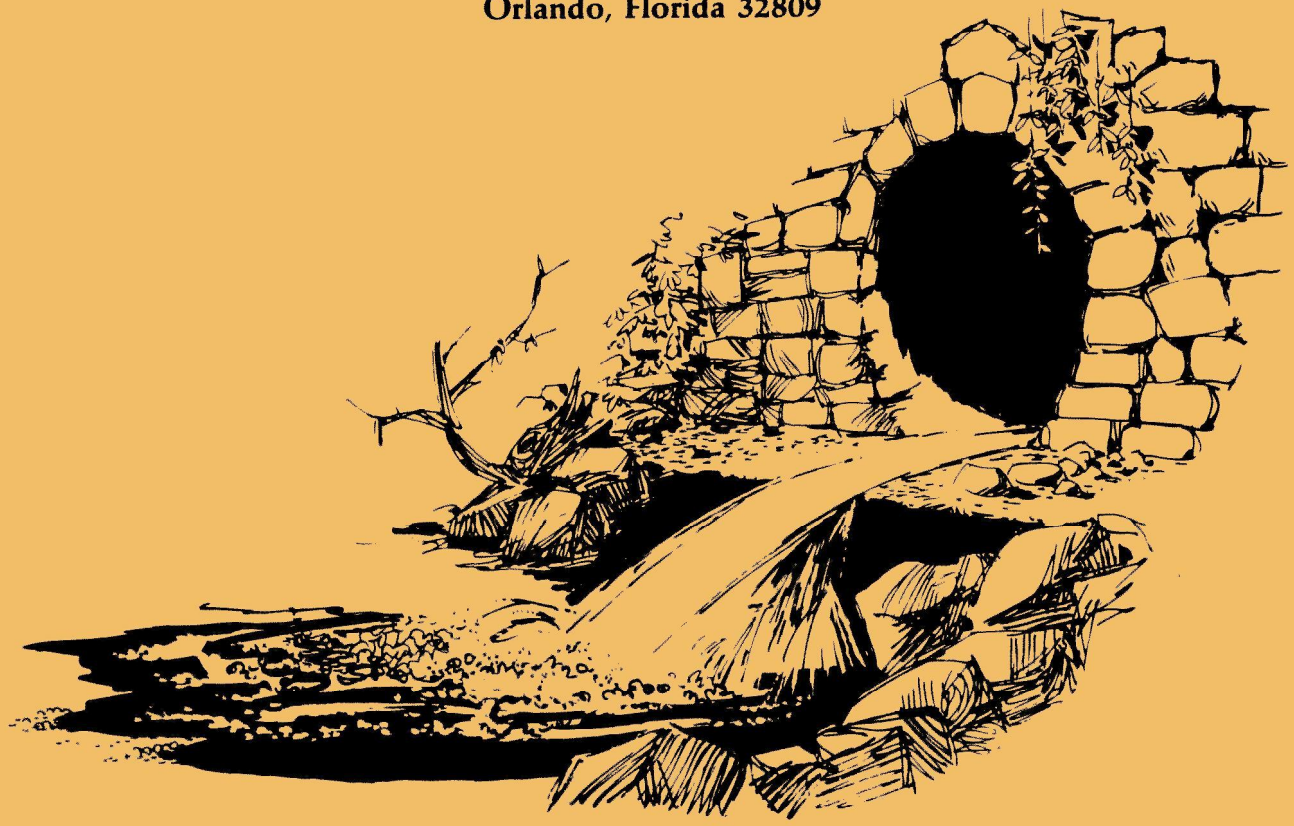
Abstracts For

Urban Stormwater and Combined Sewer Overflow

Impact on Receiving Water Bodies

November 26-28, 1979

Holiday Inn
6515 International Drive
Orlando, Florida 32809



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SESSION ONE
Monday, November 26, 1979
9:00 - 10:00

URBAN RUNOFF RECEIVING WATER IMPACTS: PROGRAM OVERVIEW AND RESEARCH NEEDS

by

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ABSTRACT

Receiving water impacts are a major national concern. We are spending huge sums of money on secondary treatment plants, meanwhile major culprits, stormwater and combined sewer overflows, are still uncontrolled. To attain the goals set forth in PL 92-500 and PL 95-217 of abating pollution and achieving water quality standards in an economical and efficient manner those analyzing, planning and designing controls must have a thorough understanding of the impact of pollutants on receiving waters. Receiving water impacts are the bottom line justification for funding countermeasure campaigns and the passage of abatement legislation. This conference will provide a forum for the attendees to acquire first hand knowledge of the state-of-the-art and to consider ongoing and recently completed research.

Data on the environmental impacts of urban stormwater and combined sewer overflow are being gathered by projects of the Storm and Combined Sewer Program (SCSP) of the Municipal Environmental Research Laboratory (MERL) as a first step in developing control needs and a methodology to quantify pollutant stress and evaluate the impact in relation to receiving water standards and desired uses. This paper will contain a brief history of our receiving water impact projects, an overview of recently completed and ongoing projects. The projects will be briefly described including project objectives and an outline of significant results to date. Also, future Program needs will be discussed and areas in which we anticipate concentrating our efforts will be outlined.

SESSION TWO
Monday, November 26, 1979
10:30 - 12 noon

AN ASSESSMENT OF THE IMPACT OF URBAN DRAINAGE ON EUTHROPHICATION-RELATED WATER QUALITY IN URBAN LAKES

by

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ABSTRACT

The conversion of rural lands to urban area is often accompanied by a significant increase in the total amount of phosphorus and nitrogen derived per unit area of a waterbody's watershed. For rural lands phosphorus without livestock, export coefficients typically range from 0.005 to 0.5 g $P/m^2/yr$, while in urban areas the typical export coefficient is 0.1 g $P/m^2/yr$. A significant part of this difference is due to the much greater water yield per unit area of watershed in urban areas compared to rural areas.

Urban runoff typically contains appreciable quantities of both soluble ortho P and particulate forms of P. Studies have been conducted to evaluate the amounts of available forms of phosphorus present in typical urban stormwater drainage for several municipalities located across the U.S. It has been found that on the order of 10 to 30 percent of the particulate phosphorus present in urban stormwater drainage would likely become available to affect algal growth in a lake or stream. As a result of these findings, the focal point of the control of nitrogen and phosporus from urban stormwater sources should be directed toward the soluble orthophosphate component. Most stormwater drainage control programs are directed toward control of particulate matter. Such programs are likely to have limited impact on eutrophication-related water quality in urban lakes, since only a small part of the particulate phosphorus will likely become available to stimulate aquatic plant growth in the waterbody.

The OECD (Organization for Economic Cooperation and Development) eutrophication modeling study which included about 40 water-bodies across the U.S. and 200 waterbodies in Western Europe, North America, Japan, Australia, etc., has shown that the phosphorus load normalized by waterbody mean depth and hydraulic retention time is correlated to the planktonic algal chlorophyll concentration, planktonic algal-related water clarity and hypolimnetic oxygen depletion rate. The results of the OECD study provide the tools necessary to quantitatively assess what water quality improvement can be achieved as the result of various nutrient control efforts.

THE EFFECT OF URBAN STORMWATER RUNOFF ON THE WATER QUALITY OF LAKE JACKSON, FLORIDA

by

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ABSTRACT

Lake Jackson, Leon County, Florida, a depression of approximately 4800 acres, is a north Florida lake of conflicting water quality. In contrast to the northern portions of the lake, which have been found to possess excellent water quality, the southern portions are consistently characterized by significantly poorer water quality. Investigations into this problem have discovered that the reduction in the water quality in the southern sections is a direct result of increased "urbanization" in that area. Extensive field research and data analysis of the water quality of the southern watersheds of Lake Jackson, in particular the urban watershed of Meginniss Arm, have concluded that the magnitude of the pollutional loading of that area was due to stormwater runoff. Analyses of the runoff of Meginniss Arm have revealed high concentrations of suspended solids, dissolved nutrients, heavy metal particulates, and petro-chemicals. In response to the serious state of water quality in this area of the lake, the Florida Department of Environmental Regulations in association with the United States Environmental Protection Agency have proposed to construct and maintain a bio-filtration system in the urban watershed of Meginniss Arm to restrict the pollutional loading.

One of the pollutants mentioned in the analyses of the urban stormwater runoff was petro-chemicals. Lake Jackson affords an area for a very interesting study of the loading of hydrocarbons into the lake. There are two watersheds in Lake Jackson, which are similar in size, topography, and geology (Ox-Bottom Creek in the northern section and Meginniss Arm in the southern section). These two watersheds are very dissimilar in land usage: Ox-Bottom Creek is primarily forested-agricultural with little mechanical activity; Meginniss Arm, in contrast, is highly urbanized with two shopping malls. The analyses of the stormwater runoff from these two areas will enable comparisons of the concentrations and possible sources of hydrocarbons, both biogenic and anthropogenic, that enter Lake Jackson. Rainfall, dust, sediment, and lake water samples will be examined to determine other possible sources and sinks for hydrocarbons in the lake.

A COMPARISON OF STORM-RELATED MATERIALS LOADING TO TWO GLACIAL LAKES FROM URBAN, WETLAND, AND AGRICULTURAL SOURCES

by

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ABSTRACT

Comprehensive watershed and in-lake studies have been conducted for two glacial lakes located in the Lake Michigan drainage system. These studies have shown that >97% of the total-N and >85% of the total-P received by these lakes annually in runoff is discharged during 10-12 weeks in the spring. During that interval, large differences in storm-related nutrient loading were measured from urban, wetland, and agricultural watersheds. Separating runoff due to melt of the snow pack from that due to rain events, it was found that storm-related discharge from the urban area studied was 0.289 kg total-P and 1.239 kg total-N ha^{-1} of watershed. Rain induced runoff from marshes in the same drainage basin transported 0.019 kg total-P and 0.545 kg total-N ha^{-1} of catchment. Rainfall in the same amount caused runoff from agricultural land of 0.091 kg total-P and 4.579 kg total-N ha^{-1}. Algae of both lakes were phosphorus limited; nitrogen was present in excess. Using constants from Nicholls-Dillon relationships in the literature regarding phosphorus, phytoplankton biomass, and secchi disk transparencies, the urban input of phosphorus ha^{-1} of drainage was sufficient to bring 0.44 ha-m of lake water to undersirable algal bloom status. Similarly, marsh input ha^{-1} would bring an estimated 0.03 ha-m into bloom. By the same calculation, storm-related agricultural runoff would result in 0.14 ha-m of lake water becoming undersirably rich in algae. Knowing the number of hectares in these types of catchment and the volume available in a particular lake for phytoplankton production, decisions regarding cost-effective treatment of storm-related discharge can be made.

SESSION THREE
Monday, November 26, 1979
1:30 - 3:00

IMPACT OF STORMWATER RUNOFF ON A FLORIDA LAKE ECOSYSTEM: EFFECTS ON WATER QUALITY AND BIOTA

by

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ABSTRACT

A study of external nutrient loadings to the Lake Conway ecosystem, an interconnected series of three lakes located in Orange County, Florida, showed that both nitrogen (2.6g-N/m^2-yr) and phosphorus (0.22 gP/m^2-yr) inputs were within the range of loadings that leads to mesotrophic conditions. The major external sources of both elements were atmospheric inputs, stormwater runoff and subsurface seepage. Experimental evidence indicated that phosphorus became a limiting factor in the lakes briefly during the spring and summer of 1977. A dynamic hydrologic-phosphorus model demonstrated the relative magnitudes of nutrient loadings from external sources and those from internal nutrient cycling by the macrophyte communities and sediments in this subtropical lake ecosystem.

Multivariate analysis of water quality data by discriminant analysis showed differences among the three lakes of the Conway system. Seasonal trends in several water quality indicators varied concomitantly with changes in external nutrient loadings, especially with those from residental stormwater runoff. Those lakes that had a proportionately larger share of phosphorus loadings from stormwater runoff showed a degradation in water quality. Strong linear relationships were found between watershed area to lake area ratio and stormwater phosphorus loadings (r^2=0.98); stormwater phosphorus loadings and Secchi disk transparency (r^2=0.98) and chlorophyll a and total zooplankton numbers (r^2=0.96). These findings indicate a direct impact of stormwater runoff on water quality and subsequently on changes in the lakes biota.

THE DISTRIBUTION OF SEDIMENTS AND PARTICULATE CONTAMINANTS FROM COMBINED SEWER AND STORM DRAIN OVERFLOWS IN SEATTLE'S NEARSHORE WATERS

by

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** Department of Civil Engineering, University of Washington, Seattle

ABSTRACT

The distributions of particulates and the associated contaminants emanating from combined sewer outfalls and storm drains in Lake Washington were examined. In a preliminary study sediment samples were collected by SCUBA divers from the area of greatest apparent contamination at each of 29 outfalls. The sample content of organics, heavy metals, oils and greases, and pesticides was used to select stations for more intensive study. At each of those sites quality and quantity analyses of the overflows provided loading estimates for the wastewater particulates entering the nearshore waters. Light transmissions measurements of storm-induced wastewater plumes helped to define the nature of plume dispersion and its area of significant influence. Organic carbon and heavy metals analyses of settling particulates and surface sediments near the outfalls supplied further detail and confirmation of the fate of the wastewater particulates. Later in the program, Dr. Thom will discuss the response of infaunal communities to seasonal variations in wastewater discharge.

THE ECOLOGICAL EFFECTS OF URBAN RUNOFF ON STREAM COMMUNITIES

by

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ABSTRACT

A literature review of the ecological effects of urban runoff on streams indicates a dearth of principles for evaluating the impact of urban runoff or any pollutant on streams and a serious lack of studies that determine urban runoff impacts on communities of stream ecosystems. The uniqueness of urban runoff impacts results from the nature of pollutant input to streams --large magnitude variation/stochastic occurrence. Most stormwater research has been directed towards determining runoff quantity and quality including the fates of specific pollutants such as heavy metals, nutrients, salts, toxic substances, and bacteria. Demonstration of the impacts of these materials on stream communities is necessary to justify costs of managing stormwater effects.

Several approaches for analyzing ecosystems are suggested, such as stream community analysis and biogeochemical cycling of elements (carbon, nitrogen, phosphorus). Three published case studes of stream ecological impacts typify the effects of urban runoff inputs resulting in a hypothesis that large scale variations and instabilities of stream pollutant input and concentration would result in greater impact to stream communities than steady inputs. This concept is discussed and applied to urban runoff analysis and management.

SESSION FOUR
Monday, November 26, 1979
3:30 - 5:30

ANALYSIS OF RECEIVING STREAM IMPACTS ON THE MILWAUKEE RIVER

by

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ABSTRACT

The Milwaukee Metropolitan area contains approximately 15,000 acres of combined sewers which discharge to the three rivers of the area or directly to Lake Michigan. As part of the Facilities Planning efforts of the Milwaukee Metropolitan Sewerage District and research for EPA's Storm and Combined Sewer Section, extensive monitoring and modeling efforts were performed to quantify the receiving water impacts of the combined sewers.

Over 100 overflow points within the combined system were modeled using the EPA SWMM model and Corps of Engineers STORM model. The output of these models was used to load Harper's receiving water model. Major difficulties in modeling the river systems were the variable influence of Lake Michigan in the lower reaches. The relatively clean, high DO and lower temperature lake inflows could not be easily quanitified because of the dependence of the inflows on wind speed, direction, lake level and other variable factors. Final model calibration using a linearly decreasing flux was found to match the continuous DO data generated during two years of record.

The Milwaukee river exhibits tremendous DO sags in the lower reaches of the river following runoff events. The modeling tasks of the CSO project could not duplicate these sags using the instream concentrations found in the monitoring program. Extensive field monitoring was then conducted to quantify the source and mechanism of these sags. After numerous investigations, the bottom sediments in the lower reaches were found to be the source of the rapid DO declines. The mechanism was related to the scouring action of submerged combined sewer outfalls.

In order to model the response of the river to discharge events, the receiving water model was modified to include an expression which would predict the extent and duration of the scour action from the submerged outfalls. Long term simulations of DO and other parameters were calibrated and verified using the response of the river to a multitude of rainfall events.

The use of this model network in the evaluation of alternatives for abating combined sewer overflows produced magnitudes of DO and fecal coliform impacts for each alternative using 20 years of rainfall record. The results for the following alternatives are presented.

* existing conditions
* partial separation
* complete separation
* out-of-basin (storage-conveyance-treatment)
* end-of-pipe (EOP)
* 100% CSO removal

Discussions of how these results were quantified including the model development will be discussed. The cost-benefits analyses that were used to satisfy the EPA PG-61 requirements will also be detailed to provide the reader with a methodology that has been successfully applied and approved in the Milwaukee area.

URBAN STORMWATER IMPACTS ON RECEIVING STREAMS IN NORTH CAROLINA

by

E. Ryland Brown and Ross S. Green
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Division of Environmental Management
North Carolina Department of Natural Resources
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ABSTRACT

Studies were conducted in North Carolina by the Division of Environmental Management as part of the statewide 208 program to determine the extent of water quality degradation in streams receiving urban stormwater runoff. Selected streams were monitored in three of the larger urban areas within the state; Asheville, Raleigh, and Winston-Salem. The monitoring program involved physical/chemical sampling under both high (storm) and low streamflow conditions. Parameters sampled include pH, temperature D.O., BOD_5, COD, fecal coliforms, ammonia-nitrogen, total Kjeldahl nitrogen, nitrite plus nitrate nitrogen, total phosphorus, iron, mercury, lead, zinc, copper, chromium, manganese, cadmium, nickel and suspended solids. Biological sampling of aquatic benthic macroinvertebrates was conducted concurrently to further document water quality conditions.

In Asheville, a stream draining a mixed land use urban area was studied. In the Raleigh area, three streams were monitored, including one that drains a highly impervious watershed comprised primarily of a shopping center.

The most intensive sampling was conducted in the Winston-Salem area. In this locality, streams draining both residential and Central Business District watersheds were monitored to investigate water quality characteristics associated with these different land use types. For comparison purposes, control stations upstream of urban inputs were also monitored.

All of the urban streams were found to exhibit extensive water quality problems. Physical/chemical sampling consistently revealed high pollutant concentrations for several parameters under high flow conditions. Notable problematic parameters included suspended solids, lead, and some nutrients. Several parameters were found to frequently be present in high concentrations under low flow conditions also. Variations in pollutant concentrations from the different land use types were also observed.

The Division of Environmental Management's biological monitoring group has developed an index of the macroinvertebrate organisms found in North Carolina streams. As part of this index, each taxa is rated according to its ability to withstand pollutional stressed conditions. All of the urban streams monitored were found to be extensively biologically degraded. Populations of Diptera and Oligochaeta, pollution-tolerant organisms, averaged over 90% of the existing fauna. In contrast, control station population percentages of these organisms were a maximum of 15% of the fauna in the mountain stream, and 35% in Piedmont streams. Many intolerant groups were not just reduced in numbers in the urban streams, they were usually completely absent.

These studies have shown that, under present conditions, almost all urban streams will be unable to meet the 1983 water quality goals. The Division of Environmental Management is currently finalizing guidelines for a study to be centered in the Winston-Salem area to evaluate management techniques aimed at reducing these documented water quality problems. This three year project is in conjunction with the Environmental Protection Agency's National Urban Runoff Program.

DISSOLVED OXYGEN IMPACT FROM URBAN STORM RUNOFF

by

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ABSTRACT

One hundred and four water quality monitoring sites in and downstream of urban areas throughout the country were considered for inclusion in this study. These were screened from over 1000 monitors maintained by federal and state agencies such as the U.S. Geological Survey, Environmental Protection Agency (EPA), Ohio River Valley Sanitation Commission and Wisconsin Department of Natural Resources. Daily data were obtained and processed for 83 of the 104 candidate sites. Of the 83 monitors considered, 42 percent or roughly one monitor in three of the 104 candidates demonstrated a 60 percent or greater probability of a higher than average DO deficit occurring at times of higher-than-average streamflow or on days with rainfall. This result was obtained by considering daily data for entire water years. Not all years at any given station exhibited a 60 percent probability. One to three years out of five is typical. DO levels fell to less than 75 percent saturation at most of the sites where 60 percent or greater probability existed. Levels of 5 mg/l or less were not uncommon.

Detailed hourly data analysis was made at 22 of the sites with high correlation between flow and DO deficit. Typically, at times of steady low flow the DO fluctuates widely on a daily cycle. These cyclic changes range from 1 to 7 mg/l. When a storm event occurs and the flow increases, the diurnal cycle disappears. The minimum DO drops from 1 to 1.5 mg/l below the minimum values observed during steady flows and remains constant there for periods ranging from one to five days. As the flow event subsides, the DO level resumes its cyclic behavior. Of the 22 monitors examined on an hourly basis, 11 would not meet a 5.0-mg/l DO standard. Six of the 11 would not meet the EPA-suggested 2.0-mg/l-for-four-hour standard. Streeter-Phelps analysis indicated that two additional monitor sites at which hourly data were examined would not have met the EPA standard had they been properly located. An additional two sites at which hourly data could not be obtained would also not have met the EPA standard.

THE IMPACT OF COMBINED SEWER OVERFLOWS ON THE DISSOLVED OXYGEN CONCENTRATION OF A SMALL STREAM

by

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ABSTRACT

The paper discusses the impact of combined sewer overflows on the dissolved oxygen concentration of a small stream. The different oxygen consumption processes in the receiving stream have been studied at 4 consecutive stations during and after the passage of the discharged volume of stormwater and untreated sewage. Two different effects on the DO-concentration were observed in the stream:

1. An immediate effect caused by degradation of the soluble BOD-fraction in the polluted watervolume.
2. A delayed effect caused by degradation of the adsorbed colloidal and outsetting particulate matter.

ad 1. This effect is caused by the degradation in the water-body and by direct absorption by the animals (invertebrates) in the bottom. The deoxygenation constant K_1 in the water volume is about 0.15 days^{-1}, but the total deoxygenation constant K_r for the whole stream is about 0.55 days^{-1}, which indicates the importance of the degradation in the bottom.

ad 2. After passage of the discharged polluted volume there is an effect on the DO-concentration in the stream, which is attributable to adsorption of colloidal organic matter at the bottom. The delayed degradation may increase the respiration of the bottom in certain stations by 100%. This delayed effect may last 12-24 hours after the stormwater passage.

The investigation shows that due to the delayed effect, the oxygen consumption is spread over a long period compared to the passage time of the polluted volume. The importance of this depends among other things on the reaeration of the stream.

SESSION FIVE
Tuesday, November 27, 1979
8:30 - 10:00

IMPACTS OF INTERMITTENT URBAN DISCHARGES ON RECEIVING WATERS

by

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ABSTRACT

The paper will present an illustration of the impacts of CSO discharges on bathing beach areas of New York City. The illustration will also define the treatment required and the costs for controlling water quality. A unique statistical analysis used in the project will be discussed.

The proposed paper will be divided into two segments.

Segment #1 - will discuss an analysis of coliform distribution in New York Harbor. The paper will present calculated and observed time variable coliform distributions over several storm events for the major water bodies that make up New York Harbor. Data and calculations will be presented for different size rainfalls and for different Hudson River flows. This segment of the paper will conclude with economic data on the cost of controlling coliform levels at selected beach locations in New York Harbor. Therefore, loads, fate and effects of storm water associated coliform distributions will be discussed.

Segment #2 - will address the fate and effect of intermittent discharges of toxics. In particular, information from data in the Trinity River, will be employed to calculate partition coefficients and equivalent removal rates for Cd, Cu, and other metals. Comparable calculations for the equivalent removal of Lindane, DDE, DDT and several other organic toxics will also be provided. This will be a discussion of fate of toxics.

The effects part of this segment will employ dose response data for Cd to illustrate calculations of mortality of an organism due to a storm load. The effect part of the paper will present a procedure for calculations. In situ data are not available to test the calculation procedure. The issues of concern in rational evaluation of effects will be identified in a quantitative manner.

THE RESPONSE OF GREAT LAKE ESTUARIES TO STORMWATER RUNOFF

by

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ABSTRACT

Glacial rebound of the northern shore of Lake Erie has resulted in drowned rivermouths of southern shore tributaries. Transport of material through these estuaries depends not only on river stage but also lake stage. This paper describes studies carried out in two Lake Erie tributaries during high and low flow conditions. It also examines the effect of localized urban runoff on one of the estuaries.

Three separate studies of water chemistry in the lower Maumee River, an estuarine river section, were conducted by the Toledo Metropolitan Council of Governments, the Buffalo District Corps of Engineers, and others, during 1974 and 1975. Base flow river conditions and the resultant estuary chemical variations were measured during the summer of 1974. Winter storm runoff effects were measured during January and February, 1975. Additional sampling and analysis was conducted during the summer of 1975, giving a fairly complete record of water chemistry variability.

Winter storm runoff was also measured in the estuary of the Cuyahoga River, with simultaneous river and estuary sampling over the hydrograph for selected pollutants.

This paper outlines the problems and complexities of chemical measurements of water quality in estuarine systems of the Great Lakes during varying hydrologic conditions. The studies in the Maumee River point out the importance of sampling program design, and the difficulty in evaluating the transport of pollutants through such estuarine systems. The summer studies were conducted by TMACOG as part of an evaluation of in situ water quality, as effected by a number of waste discharges from the Toledo area. The winter storm runoff measurements, made simultaneously at both an upstream riverine station and a downstream estuary station were designed to evaluate whether the mass transport being carried out into the basin was passing through the estuary and out into the lake. The question of an increase or decrease in mass transport was also considered, to evaluate scouring and depositional mechanisms in the estuary.

The results of the Maumee estuary measurements were compared with the Cuyahoga estuary in Cleveland, where similar sampling of river and estuary transport was carried out for the same storm periods.

WATER QUALITY AND URBAN RUNOFF IN SELECTED CANAL COMMUNITIES ALONG THE TEXAS COAST

by

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**Professor of Civil Engineering
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ABSTRACT

Water and runoff samples from seven waterfront communities in the Galveston Bay area were collected and analyzed in order to evaluate causes of canal water quality problems. Until present, community design has been based on optimum utilization of land area with little or no regard toward the effect of development on water quality. The primary cause of water quality problems in these communities appears to be urban runoff.

Samples of canal waters were collected over a five-month period and analyzed for nutrients, oxygen demand, pesticides, and hydrological variables, including Rhodamine dye concentrations. In general, canal waters exerted BOD_5 values of 2-10 mg/l with no problems associated with toxic substances. Evaluation of domestic wastewater data from centralized treatment facilities indicates that these wastewater streams are not major sources of pollution loading.

Runoff samples were collected from three rainfall-runoff events and were found to contain signficant amounts of carbonaceous material. Also, the possibility of canal sediment resuspension by point discharge of runoff was investigated using a canal model. The two-year frequency rainfall event for the Galveston area was found to produce significant resuspension of high BOD_5 benthic sediments. These data were applied using the modified Streeter-Phelps equations for estuarine dissolved oxygen analysis and were found to fit actual conditions with reasonable accuracy.

SESSION SIX
Tuesday, November 27, 1979
10:30 - 12 noon

THE RESPONSE OF INFAUNAL COMMUNITIES TO SEASONAL VARIATIONS IN WASTE WATER DISCHARGE

by
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ABSTRACT

Certain aspects of the structure of macroinfaunal communities in the subtidal sediments adjacent to an intertidal combined sewage overflow were studied. The impact of this ephemeral source of raw waste water and street runoff on the communities was evaluated using samples taken after periods of high (April) and low (August) frequency of discharge. In April, the community nearest the overflow was characterized by a high number of individuals, low number of taxa, a low species diversity, a high abundance of the polychaeta Capitella capitata, and a high relative number of polychaetes. Subsurface deposit feeding species dominated the community. Infaunal abundance was markedly low in the region immediately beyond the area of acute impact. Diversity and number of taxa were highest at the sites furthest (i.e. > 1000 m) from the overflow. Bivalve molluscs were in relatively high abundance, and carnivores, surface deposit feeding and subsurface deposit feeding species were approximately equally abundant at these sites.

The samples in August showed similar trends relative to the overflow in number of individuals, number of taxa, species diversity and community composition by phyla and feeding type. However, differences among all sites in these parameters were less pronounced during this period. Capitella capitata was not in low abundance, and the loptostracan crustacea Nebalia pugettensis was in highest abundance at the site nearest the overflow.

A cluster analysis of the communities indicated that the communities closest to shore and northward from the overflow were most altered. The communities at the sites nearest the overflow appear to be primarily affected by intense scouring and deposition, whereas those communities further away appear to respond largely to input of organic debris. The decreased frequency of overflows in August may be responsible for the relative decrease in differences among the communities at all distances from the overflow.

PRODUCTIVITY RESPONSES OF LAKE EOLA WATER TO URBAN RUNOFF

by

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ABSTRACT

Lake Eola is a land-locked lake located in downtown Orlando, Florida. Its surface area is approximately 27.0 acres (11.0 Ha) and water depth is 2 to 3 feet (0.6 to 0.9 meters) near the shore area and 22 feet (6.7 meters) toward the center. The lake directly drains 85 acres (34.4 Ha) of impervious land and 56 acres (22.7 Ha) of pervious land from commercial and residential areas. Currently there are coarse screening devices (1½ inch opening) on inlet storm drains which are called grass catchers.

Lake Eola is a focal point for the City of Orlando and is visited by many tourists for its aesthetic appeal. No swimming, motor boating, or fishing is allowed. The lake was drained down exposing 40% of the bottom and approximately 4 feet of mud was removed in 1972-1973. However, input nutrients, organics and other compounds from street stormwater runoff have not been effectively managed. Five years later, excess fish and algae have to be removed periodically and the water quality of Lake Eola is again questioned.

A research project sponsored by the U.S. Environmental Protection Agency, the Florida State Department of Environmental Regulation and the City of Orlando is currently underway to determine the lake impacts of pollutants in stormwater runoff and to develop a methodology for determining optimal combinations of stormwater management methods.

Periodical water samples are being collected from the lake for various stormwater events. Changes in water quality parameters with time through each storm event are documented. Parameters analyzed include alkalinity, hardness, solids, BOD_5, TOC, Nitrogen, Phosphorus, and heavy metals for particulate and dissolved fractions. Analytical methods followed Standard Methods for the examination of water and wastewater and EPA's Methods for Chemical Analysis of Water and Wastewater. Heavy metals including, Zn, Cd, As, Ni, Cu, Fe, Pb, and Cr are being analyzed using a plasma spectrometer, SMI SpectrospanIII. Loading rates from nutrients and heavy metals released to Lake Eola due to stormwater runoff are analyzed, and lake impacts are evaluated.

Algal bioassay studies are performed to investigate stormwater impacts on Algal productivity. Periodical water samples are being collected from various locations in the lake, mixed and filtered for limiting nutrient studies using various concentrations of N, P, and Fe.

Unialgal species of Selenastrum, Cholorella and indigenous species are used and changes in chlorophyll "a" and biomass are measured. Initial results indicate that phosphorus or nitrogen can be limiting at sometimes of the year. However, the ratio of P:N can be more important than actual concentration of phosphorus and nitrogen separately. Maximum standing crop seem to occur at N:P ration of 15-20:1.

Also, similar bioassays are performed on a mixture of stormwater, coagulated stormwater and lake water at different ratios. Higher concentrations of stormwater would inhibit algal productivity and smaller ratios would significantly increase productivity. Additionally, no increase in productivity is observed when coagulated runoff water is used. These experiments can be used as useful tools to facilitate stormwater management decisions.

WATER QUALITY AND BIOLOGICAL EFFECTS OF URBAN RUNOFF ON COYOTE CREEK

by

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ABSTRACT

This preliminary report presents the initial results and conclusions from the EPA-sponsored demonstration study of the water quality and biological effects of urban runoff on Coyote Creek, near San Jose, California. This first phase included investigating various field procedures that would be most sensitive in evaluating water, sediment and biological changes in the creek as it passed through the urban area. The procedures identified as most promising are currently being used in additional Coyote Creek studies.

The report describes the characteristics of urban runoff affecting the creek, sources of urban runoff pollutants, effects of urban runoff and potential controls for urban runoff. Local urban runoff characterization information is summarized, based on a previous EPA sponsored demonstration project in the area (Demonstration of Non-Point Pollution Abatement Through Improved Street Cleaning Practices-EPA grant No. S-804432, Pitt 1979) and from the local "208" study (Metcalf and Eddy 1978). Sources of urban runoff pollutants in the study area are being investigated as an important part of the field activities of the project and include sampling runoff from many source areas (such as street surfaces, parking lots, landscaped areas, rooftops and rain).

Various short- and long-term biological sampling techniques were used to evaluate the fish, benthic macroinvertebrate and attached algae conditions at many stations in the creek, above and within the urban area.

Creekwater and sediment samples were also obtained and analyzed for a broad list of parameters. In most cases, very pronounced gradients of these creek quality indicators were observed, with the urbanized portion of the creek being significantly degraded. Current additional monitoring is being conducted to identify the urban runoff control goals necessary to improve creek quality to adequate levels.

SESSION SEVEN
Tuesday, November 27, 1979
1:20 - 3:00

NATIONWIDE ASSESSMENT OF URBAN STORMWATER IMPACTS ON RECEIVING WATER BODIES

by

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ABSTRACT

Urban stormwater runoff has been recognized in recent years as a potential major contributor of pollution to receiving water bodies. Assessment of urban stormwater runoff pollutant quantities and characteristics have been made for several areas throughout the United States, the most ambitious being the Environmental Protection Agency's 208 Areawide Wastewater Management Planning Program. Price tags for abating urban stormwater pollution (though elimination or reduction of discharges) range in the billions of dollars. Projections of high costs have forced a look beyond abatement of discharges to the receiving water bodies for insight as to what are the impacts, where are they, and are they significant?

First-year results of a nationwide search for documented case studies of impacts of urban runoff receiving waters indicate that well-documented cases are scarce. Impacts previously attributed to urban stormwater runoff may be point source impacts in disguise, or they may be masked by greater contributions from other sources. In some cases they are offset by hydrological, biological, or geological attributes of the receiving water body.

The lack of documentation and clear definition of urban stormwater impacts makes the task of assessing importance of this pollution source even more difficult. Efforts to address this aspect include relating sources of pollutants and pollutant types to receiving water characteristics and effects on desired water uses. Characteristics such as stream or lake bed hydraulics, present and potential water uses, established stream standards, ecological data and water quality information are being summarized for the documented cases to determine how the urban runoff pollutants might behave or react in the receiving water and what potential use they might affect most adversely. Results of these analyses are to be used as a basis for devising simple criteria for analyzing an urban area to determine whether a potential impact does or would occur.

STATISTICS OF ADVECTIVE DISPERSIVE SYSTEM RESPONSE TO RUNOFF

by

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ABSTRACT

An analysis is presented for the mean and variance of a one dimensional advective dispersive system that is subjected to random inputs of runoff. Analytical solutions are available for which the mass input is represented as a Poisson process of delta functions. The effects of event to event variability of runoff mass discharges are included in the formulation as are the random times between overflows. The method of solution evaluates the overlapping effects in the receiving water due to the persistence of discharged mass. Both conservative, first order reactants, and sequentially reacting substances are considered.

The solutions have certain unexpected properties. In particular, the normalized variance of BOD and DO are symmetric about the discharge point, whereas the means of the concentration are not. This is explained in terms of the effects of advection and dispersion of flucuations. The analytical solutions are compared to simulated results using an observed hourly rainfall sequence. The results indicate that the within event variability is not significant, if the receiving water dispersion is large enough. It is also pointed out that treatment devices such as retention basins which remove a certain average fraction of the overflowing mass are less effective in removing variance in the receiving water. This phenomena is of importance in the evaluation of the probable benefit of runoff treatment.

CONTINUOUS RECEIVING WATER QUALITY MODELING FOR URBAN STORMWATER MANAGEMENT

by

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ABSTRACT

A simplified continous receiving water quality model has been developed to permit preliminary planning and screening of areawide urban wastewater treatment alternatives, in terms of frequency of water quality violations and more traditional approaches such as dissolved oxygen profiles. The model name is Level III-Receiving.

It simulates the hypothetical reponse of the stream or tidal river system to the separate and combined effects of waste inputs from: 1) upstream sources, 2) dry weather urban sources, and 3) wet weather urban sources. The total hours of runoff-producing rainfall throughout a year are separated into storm events by defining a minimum interevent time. For a given storm event, the runoff and pollutant loads are summed and critical dissolved oxygen concentrations are estimated as a function of several hydrodynamic and biochemical parameters. Alternative control strategies are evaluated in terms of relative impacts by determining the probability of occurrence of water quality violations. Model output includes the downstream dissolved oxygen sag curves computed per each event, and the dissolved oxygen profile computed at a user-specified location downstream for all simulated events. An application to the Des Moines River at Des Moines, Iowa, has been made.

POTENTIAL OF STORMWATER IMPACTS BASED ON CAMPARATIVE ANALYSIS OF WET AND DRY WEATHER POLLUTANT LOADING

by

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ABSTRACT

Recent work indicates that urban runoff and combined sewer overflows can be significant contributors to the trace contaminant input to urban receiving waters. For example, a 1975 National Academy of Science Study estimates that on a global basis, 2 to 8 percent of the petroleum hydrocarbons entering the ocean is from urban runoff. This paper summarizes much of the stormwater characterization data for trace contaminants and several conventional parameters, such as BOD_5 and COD. Comparisons are made among loadings and concentrations from urban runoff, combined sewer overflows and secondary treatment plant effluents. Finally, the significance of each contaminant is identified based on loading potentials or, whenever possible, based on toxicity to aquatic organisms.

SESSION EIGHT
Tuesday, November 27, 1979
3:30 - 5:00

THE USE OF RECEIVING WATER QUALITY MODELS IN URBAN RUNOFF POLLUTION ABATEMENT: APPLICATION TO MARGINAL BENEFIT - MARGINAL COST ANALYSIS

by

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ABSTRACT

Urban storm runoff has been determined by a number of investigations to be a significant portion of the water pollution problem and abatement of this source has been recognized as a necessary consideration in achieving the national water quality goals of PL 92-500. However, due to the highly irregular nature of the runoff phenomenon, abatement measures that address this problem tend to be very expensive. Thus, in the EPA construction grants program great importance has been placed on careful planning demonstrating the cost-effectiveness of proposed projects (Program Guidance Memorandum 61).

The benefits of runoff pollution abatement measures must be evaluated in terms of projected receiving water quality conditions relative to some defined quality standards. There is considerable experience in the establishment of water quality standards and resultant effluent limitations for non-transient municipal and industrial discharges, generally through the use of mathematical models. Generally, these models are applied against a "design" receiving water hydrologic regime (for instance, 10-year, 7-day low flow) and effluent limitations selected which will meet the desired water quality standards. This steady-state analysis assumes a toleration of water quality contravention from the discharge of a low frequency corresponding to the designated low flow.

This approach is not wholly adequate to analysis of the problem posed by intermittent storm runoff discharges. These analyses require alternate modeling approaches and a restatement of pertinent standards to reflect the short-term high variability of the storm runoff event.

Using ongoing studies of combined sewer systems in Rochester, New York and Washington, D.C., as case studies, a procedure is presented for the application of receiving water analyses in urban runoff planning. The studies in both areas have included the development of water quality models based on familiar concepts of mass balance and calibrated against detailed field surveys and laboratory experiments.

In the Rochester study, steady state models of dissolved oxygen in the Genesee and fecal coliform concentrations in the Rochester Embayment of Lake Ontario are used to project receiving water conditions under dry-weather loads and an envelope of expected impacts of the combined sewer overflows under various system configurations. A time-variable model of Rock Creek and the Potomac and Anacostia Rivers has been used to project transient fecal coliform nutrient and dissolved oxygen concentrations resulting from overflows from the District of Columbia sewer system.

In an analysis of marginal costs and marginal benefits associated with various combined sewer overflow abatement alternatives, a series of model runs are made to project the impact of various waste discharges from the alternate system configurations on the receiving waters under several hydrologic regimes and ambient temperatures. The conjoint probabilities of the receiving water conditions and storm loads are determined on the basis of historical records and used to project the expected water quality under the alternative system configurations. These projections can be quantified as water quality improvements in terms of expected degree of contravention of stream standards with regards to frequency, duration, areal extent and peak concentration. On the basis of this analysis of project cost estimates drawn from generalized cost curves, marginal costs and benefits can be displayed graphically for each alternative.

The analysis of the Syracuse, New York, Rochester, New York and the District of Columbia combined sewer facilities planning activities are discussed relative to this marginal cost-marginal benefit approach as case studies.

COMBINED SEWER OVERFLOW IMPACTS ON URBAN LAKE AND ASSOCIATED ABATEMENT METHODOLOGY

by

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and John M. Karanik
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ABSTRACT

A general methodology is presented for the evaluation of the impact and abatement of combined sewer overflows on receiving waters. It was developed from experience with Onondaga Lake, an urban lake in Central New York that receives major combined sewer overflows from the City of Syracuse via two tributary streams.

Field investigations of the combined sewer system and the receiving water must first be undertaken.

The field work includes flow measurement and water-quality sampling of the sewer overflows and the receiving waters during several different storms. Use of a computerized data bank has been found virtually essential for the storage and manipulation of the large quantity of data resulting from the sampling and analysis.

Mathematical modeling of the receiving water is undertaken to evaluate water quality as a function of pollutant load; the storm sewer system is modeled to determine the quantities of pollutants discharged during storms of various recurrence intervals. Prior to the modeling effort, analysis of local rainfall records is necessary to develop the classical intensity-duration-frequency relationships. After assessing the water-quality impact of dry-weather pollutants from wastewater treatment plants and other sources, the results of the two models can be combined to express the reduction in stormwater pollutants needed to achieve a particular water-quality objective as a function of storm frequency or storm recurrence interval.

Abatement alternatives, and their respective costs, for the reduction of pollutants from wet-weather sources, particularly combined sewer overflows, are next investigated. Using engineering judgment of the most effective and economic abatement measures, a relationship is then developed between abatement cost and storm frequency for each of several water-quality criteria or standards. From the cost-benefit relationships thus developed, a graphical determination can be made of the "general optimum solution" (GOS) for reduction or treatment of combined sewer overflows.

It is recognized that the quality of the receiving water resulting from the GOS may not be acceptable to the general public or regulatory agencies. In that case, a decision to provide greater (or lesser) pollution abatement will be based upon social or political considerations, but the governmental body making the decision will be cognizant of its economic implications.

In the study for Onondaga County, New York, from which the methodology was developed, 35 overflows from the combined sewers of the City of Syracuse, which serve an area of about eight square miles, were monitored for a period of one year. Onondaga Lake, the principal receiving water, is approximately four and one-half square miles in surface area; it was sampled at tne surface locations, each at two distinct depths, for the period of influence of each of six storms. The Storm Water Management Model (SWMM) was applied to the City's sewer system. A 27-segment, three-dimensional, dynamic water-quality model with capability of predicting enteric bacteria, dissolved oxygen, nutrients, and toxic materials, was developed.

From the models, it was determined that the impact of CSO's on dissolved-oxygen concentrations in Onondaga Lake will not be critical after tertiary treatment facilities for dry-weather wastewaters are placed in operation; a maximum DO deficit of 2.8 milligrams per liter was predicted for a 10-year, two-hour storm. Combined sewer overflow contributions of phosphorus will be negligible in comparison to those from other sources.

In an average rainfall year, 38 violations of the fecal coliform standard will occur in the area of the lake intended for contact recreation.

If abatement of CSO pollution were to follow the "optimum general solution" of this methodology, there would still be 13 annual violations, ten of which persists for about three days, more extensive CSO abatement will be required if the projected recreational usage of Onondaga Lake is to be realized.

A WATER QUALITY PLANNING METHODOLOGY FOR URBAN AREAS

by

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ABSTRACT

The Environmental Protection Agency's (EPA) 1978 Needs Survey reported that an estimated $36 billion is required to construct necessary municipal wastewater treatment facilities. Additionally, $26 billion is required to control pollution from combined sewer overflow, and $46 billion is required to control urban stormwater runoff. In light of the current trend toward reduced taxes, local funds for water quality projects will become more limited. Moreover, the public should demand that such projects demonstrate perceptible improvements in water quality and are required for the protection of the intended beneficial use of the receiving water. Further, the most cost-effective pollution control alternatives should be used. Without this assurance, required pollution abatement projects may well go unfunded.

Based upon information gained in the performance of the EPA's 1978 Needs Survey, a two-phase approach to water quality planning is presented that determines the most cost-effective mix of control alternatives and their impacts on the receiving water. This approach is general in nature but is oriented toward combined sewer overflow (CSO) areas and the requirements of EPA's Program Requirements Memorandum, PRM No. 75-34.

Phase I is an initial assessment designed to answer the following questions:

1. What is the intended beneficial use of the receiving water? POLITICAL
2. What water quality goals or criteria are required to ensure this use?
3. Based on the goals, is there a water quality problem?
4. Can CSO, urban runoff, or domestic wastewater abatement techniques solve the problem, and what degree of controls is required?
5. If the problem can be solved, what controls, in general, are the most cost effective, and what is the nature of the tradeoffs between cost, degree of control, and receiving water quality?
6. Considering these tradeoffs, are changes in the water quality goals, or in the desired beneficial use for the receiving water indicated?

This two-phase approach is designed to achieve water quality goals established to protect a given beneficial use of the receiving water. Rather than a fixed limit, such as a minimum dissolved oxygen standard, statistical water quality responses are used as the goals. Examples from the EPA's 1978 Needs Survey illustrate this point.

Phase I involves the use of a simple, continuous receiving water quality model and the Heaney-Nix economic optimization procedure. The model, the Continuous Stormwater Pollution Simulation System (CSPSS), incorporates the pertinent features of an urban area and its receiving water. A very brief description of CSPSS is given. The economic optimization is performed using estimated areawide production functions for a first-cut analysis of the costs required for various levels of pollution abatement. The water quality model uses these relationships to produce cost-water quality relationships that can be used to guide planners as to the desirability of various pollution abatement projects. Studies from areas with CSO's are presented.

If the results of the Phase I analysis indicate that there are water quality problems that can be corrected with affordable solutions, the detailed analysis of Phase II is required. This phase considers, in much greater detail, the area's hydrology, combined sewer system hydraulics, nonpoint and point source pollutants, and the receiving water quality response, thus requiring more sophisticated data and models.

The product of the Phase II analysis is a description of the optimal mix of control alternatives, the total plan costs, and the receiving water quality response due to the plan. The description of the alternatives includes the level of effort required, the area to which the alternative applies, the expected pollutant reduction due to the alternative, and the cost of the alternative.

In summary, this two-phase approach can result in substantial monetary savings by obtaining economically optimal solutions. Use of this methodology also explicitly evaluates the benefits or improvements in water quality as a result of the project. These features satisfy EPA planning requirements and should assure the public that their tax dollars are wisely spent.