PRELIMINARY RESULTS

OF THE

NATIONWIDE URBAN RUNOFF PROGRAM

EXECUTIVE SUMMARY

Water Planning Division
U.S. Environmental Protection Agency
Washington, D.C. 20460

PRELIMINARY RESULTS

OF THE

NATIONWIDE URBAN RUNOFF PROGRAM

March 1, 1982

EXECUTIVE SUMMARY

WATER PLANNING DIVISION
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

DISCLAIMER

This report has been reviewed by the U.S. Environmental Protection Agency and approved for release. Approval does not signify that the contents necessarily reflect any policies or decisions of the U.S. Environmental Protection Agency or any of its offices, grantees, contractors, or subcontractors.

EXECUTIVE SUMMARY

GOALS AND OBJECTIVES OF THE NURP PROGRAM

The overall goal of NURP is to develop information that will help provide local decision makers, states, EPA, and other interested parties with a rational basis for determining whether or not urban runoff is causing water quality problems and, in the event that it is, for postulating realistic control options and developing water quality management plans, consistent with local needs, that will lead to implementation of least cost solutions. It is also hoped that this information base will be used to help make the best possible policy decision on Federal, State, and local involvement in urban stormwater runoff and its control.

As a water quality management planning effort, the primary NURP objective is to develop water quality management plans that will be appropriate, acceptable, affordable, and focused on local needs. This requires information that will allow determination of:

- The extent to which urban runoff is a contributor to water quality problems as compared to other sources and/or background loads,
- The effectiveness of control short of treatment in reducing water quality problems where they exist, and
- Whether best management practices for control of urban runoff are cost effective in comparison to alternative options.

The overall intent is to initiate programs at the local level for preventative measures for the control of pollution from urban runoff. The Water Quality Management program established demonstration projects to help facilitate this effort and to ensure that all pollution sources were being addressed in relation to the extent of their contribution of pollution. Through implementation of these locally derived programs to prevent and to control urban runoff pollution, one can minimize future high cost corrective actions.

At the national level, a primary NURP objective is to assess urban runoff on a nationwide scale and attempt to determine:

- The nature of urban runoff problems where significant problems have been identified,
- the causes of these problems (e.g., sources, transport modes, impacts),

- the severity of these problems, based on consideration of beneficial uses and water quality standards, and

- opportunities for controlling urban runoff problems, including descriptions of control measures, their effectiveness, costs, and strategies for broad-scale implementation.

Detailed NURP objectives at the national level are:

- to develop the information base required to assess urban runoff problems,

- to examine the adequacy of current dry-weather water quality standards when used to judge the significance of storm-dominated pollution problems,

- to provide technical support to related programs within EPA, other federal agencies, and program participants at the state, areawide, and local level, and

- to develop the information base required to identify, assess, and implement effective controls.

NURP PROGRAM DESIGN

A key element of the NURP program is twenty-eight prototype projects being conducted across the nation. The locations of these projects are indicated in Table 1. NURP is also closely following the urban runoff efforts of certain projects being conducted by others (e.g., USGS), and these non-NURP projects are also listed in Table 1.

Individual project work plans were designed both to respond to local issues and water quality management needs and to contribute to selected elements of the broader information base needed to address transferability and national scale perspectives. This was accomplished by active participation by EPA (at both the headquarters and regional levels) in the development of individual project work plans and the use of a matrix of overall input requirements to ensure effective representation of an array of pertinent factors including regional effects, climatological conditions, land use types, receiving water bodies, water uses and problems, and control approaches. Since project candidates were at different stages as a result of prior 208 efforts and since local match constraints precluded any individual project from completely covering all aspects of concern, the matrix approach was also used to assure that no information gaps or deficiencies would exist at the completion of all planned NURP efforts.

One of the key monitoring and evaluation tools is the project progress report (quarterly) in which each individual project sets forth its progress against the plan for the covered period, problems encountered, how overcome, resource expenditures for the reporting period and to date (and compared to plan), and specific activities proposed for the next period. Copies are reviewed and commented upon by the designated regional project officer, headquarters project officer, and consultant team member. These comments are consolidated

TABLE 1. NATIONWIDE URBAN RUNOFF PROJECT LOCATIONS

NURP PROJECTS

1.	Duram, New Hampshire	NH1
2.	Lake Quinsigamond, Massachusetts	MA1
3.	Mystic River, Massachusetts	MA2
4.	Long Island, New York	NY1
5.	Lake George, New York	NY2
6.	Irondequoit Bay, New York	NY3
7.	Metro Washington, D.C.	DC1
8.	Baltimore, Maryland	MD1
9.	Myrtle Beach, South Carolina	SC1
10.	Winston-Salem, North Carolina	NC1
11.	Tampa, Florida	FL1
12.	Knoxville, Tennessee	TN1
13.	Lansing, Michigan	MI1
14.	Oakland County, Michigan	MI2
15.	Ann Arbor, Michigan	MI3
16.	Champaign-Urbana, Illinois	IL1
17.	Chicago, Illinois	IL2
18.	Milwaukee, Wisconsin	WI1
19.	Austin, Texas	TX1
20.	Little Rock, Arkansas	AR1
21.	Kansas City, Kansas	KS1
22.	Denver, Colorado	CO1
23.	Salt Lake City, Utah	UT1
24.	Rapid City, South Dakota	SD1
25.	Castro Valley, California	CA1
26.	Fresno, California	CA2
27.	Bellevue, Washington	WA1
28.	Eugene, Oregon	OR1

NON-NURP PROJECTS

29.	Minneapolis, Minnesota	MN1
30.	Des Moines, Iowa	IA1
31.	Topeka, Kansas	KS2
32.	Reno, Nevada	NV1
33.	Salem, Oregon	OR2
34.	Dallas, Texas	TX2

and returned to the individual project with requests for clarification, resolution, etc. as appropriate. Comments also include evaluation of data and its analysis, deficiency identification, and constructive comments for offices.

Ancillary oversite by others has been structured into the program. The USGS established a joint Advisory Technical Planning Committee through the interagency agreement with EPA. This joint Federal committee is made up of representatives of the USGS (Reston and Bay St. Louis offices), EPA (OWPO and ORD), the Federal Highway Administration, the Corps of Engineers, and the Soil Conservation Service. To assist this joint committee, designated nonfederal observers have been assigned, including representatives of the Chicago Metropolitan Sanitary District, Purdue University, Illinois State Water Survey, and the City Engineer of Portland, Oregon. This provides a balance of perspectives and helps assure that all concerns are represented. They meet on a regular basis, review progress, and provide recommendations which are communicated to all NURP projects. This represents a first level of peer review for NURP.

OUTPUTS TRANSFERABLE TO LOCAL GOVERNMENTS

The following are things which NURP, upon completion, will be able to provide to local and State governments and which will be useful input for the development and or implementation of the urban runoff element of water quality management plans:

A. Data base on concentrations and loads from urban runoff, with transferability factors. Given that the monitoring of urban runoff is costly and time consuming, and probably beyond the capability of most State and local governments to do effectively, the NURP data base will provide better estimates than a limited local or State program.

B. Methods of analysis which are being developed will be useful to others (especially where State and local governments do not have capability for alternate approaches). Together with the data base and appropriate local information, these will provide a basis for: 1) evaluating effects of urban nonpoint sources, and 2) comparing tradeoffs between point and nonpoint sources.

C. 28 Case Studies which will collectively provide useful information to other local non-NURP projects on: monitoring, problem identification, controls and evaluation, implementation, and institutional aspects such as financing and management.

D. Other areas will include: information on which pollutants are of more concern; conditions under which urban runoff will be of more or less concern; effectiveness and costs of management practices; and preliminary data on toxic pollutants in urban runoff.

CONCLUSIONS

It must be stressed that this is a preliminary report. A final NURP report will be published in 1983. The conclusions given below are based on data acquired between initial program start-up in 1978 through mid-1981 and analyses performed on those data by both individual NURP projects and EPA.

At this stage, data acquisition is incomplete; most of the individual projects still have active monitoring programs. Analysis and interpretation of data is even less complete, due to the inherent time lag required for laboratory analysis and entry into the data management system.

Partial data analysis has been accomplished, and preliminary conclusions have been drawn in some of the objective areas - both at the local level and the national scale. In addition, certain screening analyses have been performed making use of such data as are now available. These analyses provide a useful start to an assessment of the significance of urban runoff as a contributor to water quality problems.

While some of the preliminary (national scale) conclusions which are presented below are believed to be sound, particular analyses were performed more to illustrate approaches and procedures than to suggest actual results, and these analyses are so identified. Lack of data at this time has precluded many important areas from even being addressed as yet.

Even for those analytical conclusions which are thought to be sound, the limited data base on which they were based does not warrant suggesting that they are all scientifically substantiated at this time.

A number of local projects have drawn tentative conclusions on a variety of aspects related to the overall objectives. All are useful and informative, and thought likely to hold up under further analysis, but like the national scale activities, are based on incomplete data and have not been reviewed thoroughly enough to suggest that they are all scientifically substantiated.

NURP fully expects that the important conclusions which will ultimately be drawn at both local and national levels will be scientifically defensible. NURP is not there yet, as a careful reading of this preliminary report will confirm.

Consistent with the structure of the overall report, conclusions are organized in accordance with the three basic categories of loads, water quality effects, and controls.

Loads.

1. Due to the highly variable nature of urban runoff, a large data base significantly improves the confidence in any conclusions drawn. NURP's emphasis on data acquisition has, even at this interim stage, produced a data base which significantly exceeds the total pool of data on urban runoff available from other sources. Comparisons have been made with other sources which extend the utility of the NURP data base.

2. Urban runoff event mean concentrations of five pollutants analyzed to date have been demonstrated to have underlying probability distributions which are log normal. The statistical parameters (mean and coefficient of variation) have been determined for COD, suspended solids, total phosphorus, lead, and copper. Using the statistical properties of the fundamental probability distribution, it is possible to do the following:

   (a) Define urban storm runoff concentrations in a concise way, and facilitate comparisons with other sources of data.

   (b) Separate the "random" components of the variability in examining whether there are real, significant differences in urban runoff quality based on location, land use, or any of the other factors which have been suggested in the past to influence runoff quality.

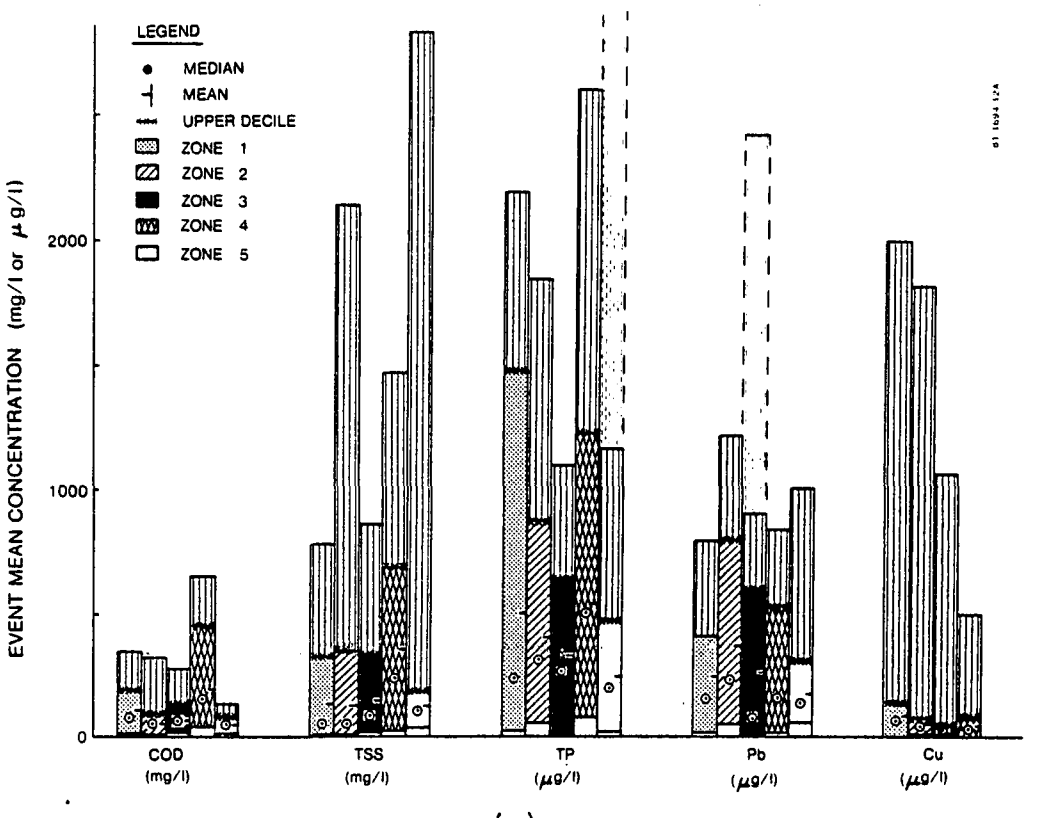
   (c) Make statements concerning the frequency with which concentrations of any particular magnitude will occur.

   (d) Interpret data from other sources which report ranges, and apply an improved perspective to such information.

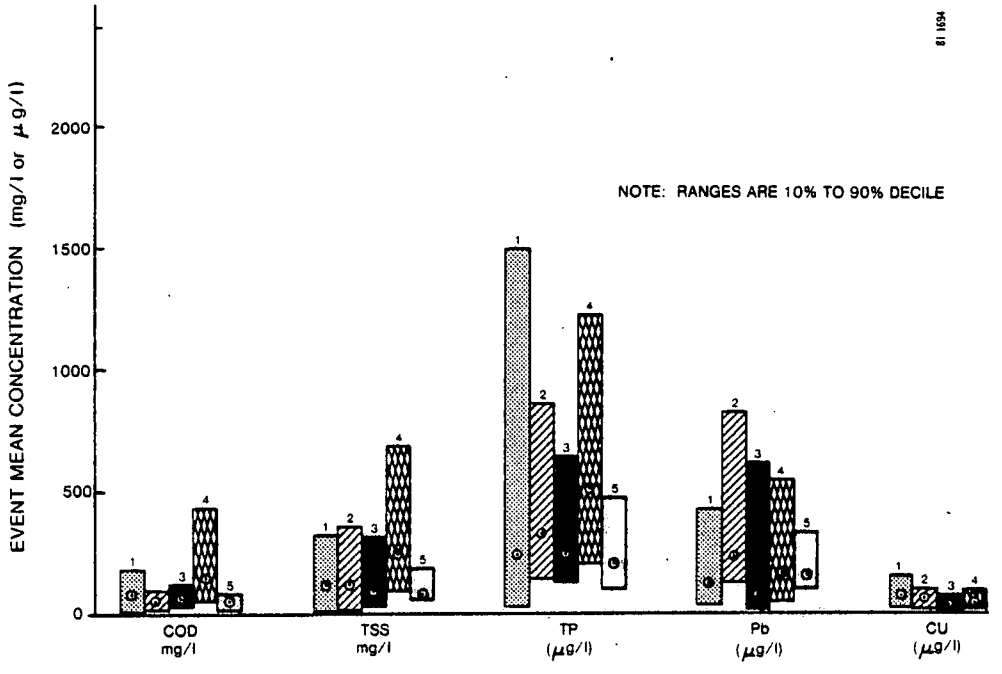
   (e) Examine water quality impacts and evaluate such effects in terms of potential for significant threats to beneficial use.

   Some misleading conclusions that might be drawn with respect to contaminant concentrations in urban runoff are illustrated in Figure 1. In Figure 1(a) the total NURP pilot data set statistics are presented by zone, or geographic region. Indicated are the maximum likelihood estimators for the mean, the median (the best indicator of central tendency), and the upper decile (that portion represented by only the upper ten percent of the events). In Figure 1(b) the same data sets are reproduced with the lower decile (that portion represented by the lower ten percent of the events), which is of little interest insofar as water quality management is concerned, and the upper decile (a range of relatively rare occurrence) omitted. Although the copper data most dramatically illustrate the result, all constituents examined indicate the misleading impression that simple range statements can give. If one focuses on the median values, the change in perception of concentration magnitudes is even more striking.

   Figure 2 provides an illustrative example of the rationale which will be employed by NURP to evaluate the extent to which pollutants discharged by intermittent, variable urban runoff events may impair assigned beneficial uses of receiving waters. Applying the analysis methods adopted

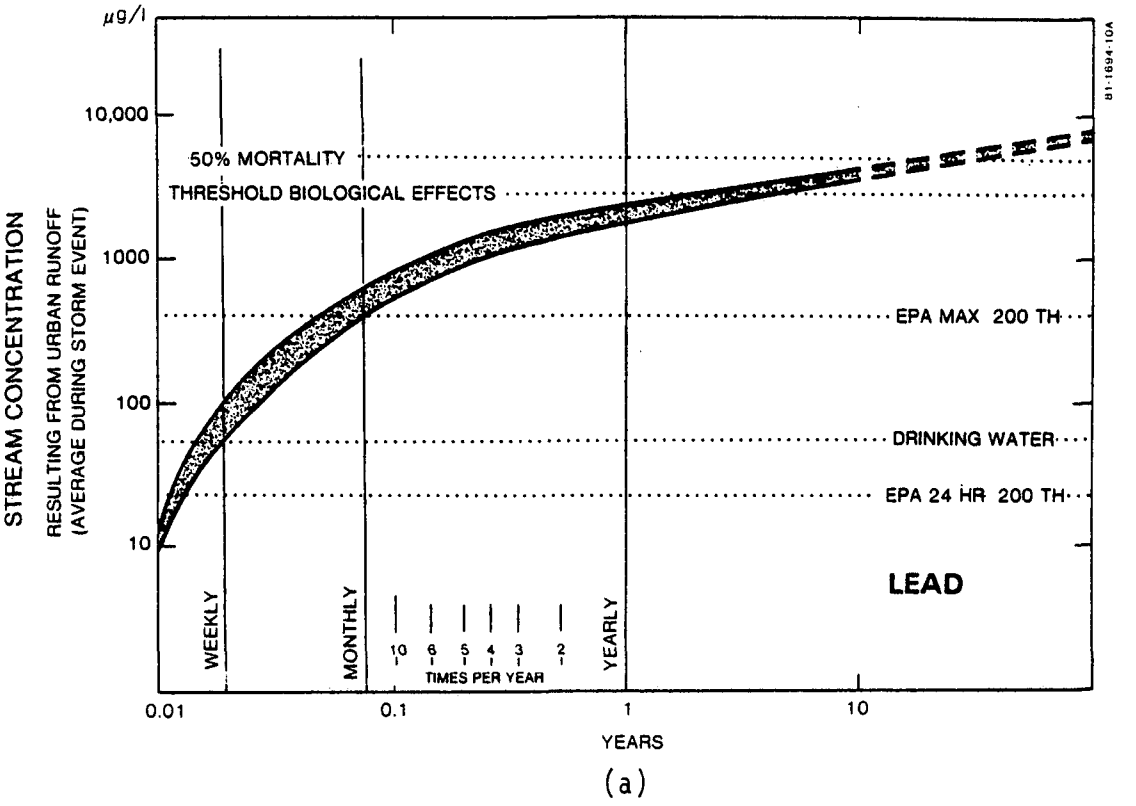


(a)

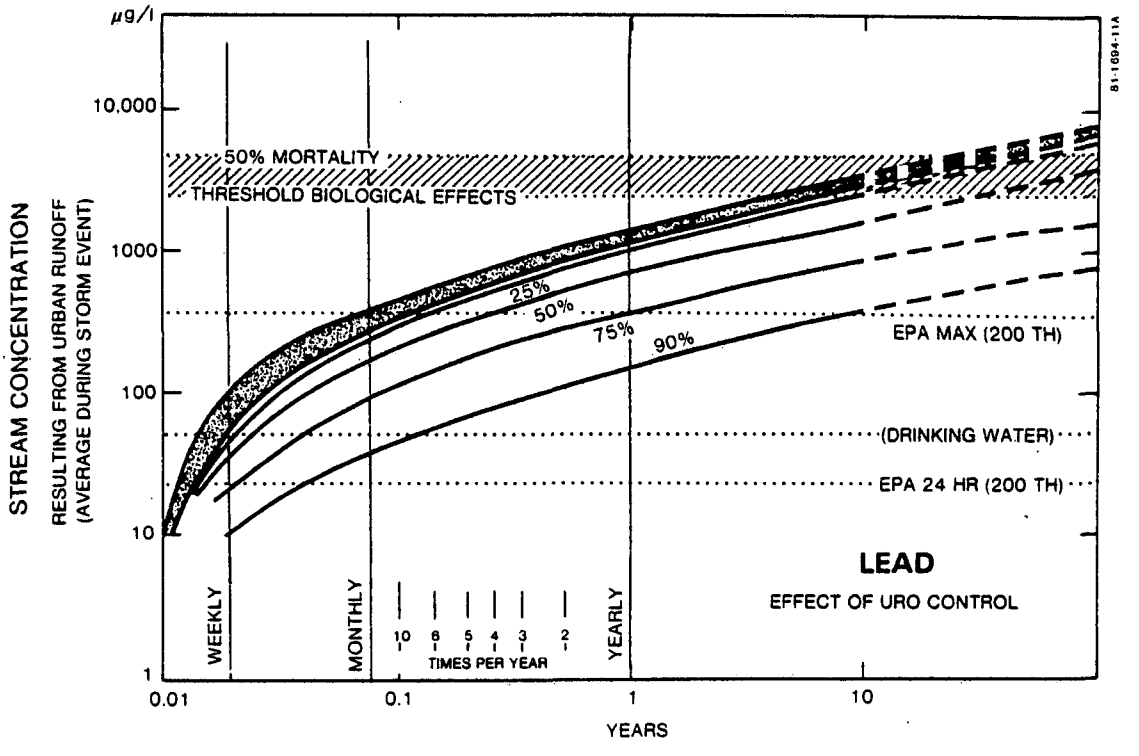


(b)

Figure 1. Event Mean Concentration Statistics for NURP Pilot Data Set (824 site events) by Geographic Zone



(a)



(b)

Figure 2. Mean Recurrence Intervals for Lead Concentrations

by the NURP program to the statistical characteristics of pollutants in urban runoff developed from monitoring data acquired by the 28 individual NURP projects, estimates can be made of the frequency with which various concentration levels in the water body will occur as a long term average. This concentration/frequency distribution (see Figure 2-a) is compared with various receiving water target concentrations, for example those that relate to the specific beneficial use of the water body, or those which reflect specific criteria or different degrees of use impairment. The procedure may be extended to illustrate the benefit to be expected in terms of water use for different degrees of control of urban runoff (see Figure 2-b).

3. It will be possible, when additional data have been analyzed, to develop quantitative expressions which will express differences in urban runoff quality as a function of factors such as land use, geographical location, season of the year, etc. The procedure adopted (examining subpopulations) appears to provide a viable technique for so doing. Indications of regional, seasonal, and land use effects presented in Chapter 5, should be considered tentative, because the data base for performing such comparisons is still sparse. NURP expects, however, that some of the differences suggested will be confirmed. For example, Denver and other locations with similar geography will, because of climate and soil characteristics, continue to exhibit higher concentrations of suspended solids and other contaminants closely associated with them.

4. About one-half of the substances on EPA's priority pollutant list sometimes occur in urban runoff. Heavy metals (especially lead, zinc, and copper) are much more prevalent than organic priority pollutants. Some of the metals are present often enough and in high enough concentrations as to be considered threats to beneficial uses.

5. Organic priority pollutants appear to be generally present only in certain urban runoff discharges. Where present, and the beneficial use is potable water supply, there is a significant concern. Stream dilution and other mitigating factors may prevent any real problem from developing, but communities with water supply intakes in close proximity to urban runoff discharges are encouraged to check for the relatively limited number of pertinent priority pollutants which have been detected in urban runoff.

6. Total suspended solids concentrations in urban runoff from available NURP data appear to be lower in general than suggested by other studies.

Water Quality Effects.
Conclusions on the receiving water impacts of urban runoff will be presented for each designated beneficial use for which it is believed that urban runoff

will have a negative effect on water quality sufficient to cause impairment or denial of the use.

Fresh water aquatic life.

1. The effect of oxygen demanding substances in urban runoff on dissolved oxygen levels in receiving water has not been examined yet. This analysis will be done when sufficient data become available.

2. The potential for suspended solids to have a significant deleterious effect has not yet been assessed. Thus analysis will be done when sufficient data are available.

3. Organic priority pollutants do not appear to pose a general threat to fresh water aquatic life. This is based upon the limited available data on the frequency with which they are found in urban runoff discharges and the measured end of pipe concentrations relative to published toxic criteria.

4. At this time heavy metals appear to be the urban runoff contaminants that have the greatest potential for impacts on the aquatic life beneficial use. This conclusion is based on the fact that a number of heavy metals are consistently found in urban runoff in high concentrations relative to suggested toxic limits.

5. It appears reasonable to conclude that some degree of impairment of this benefical use is probably common in many water bodies which receive urban runoff. With some exceptions, however, the degree of any impairment that exists does not appear to be of sufficient magnitude to generate serious local concern. This conclusion is based on the following:

   - The screening analysis suggests that local conditions can be expected where the magnitude and frequency of intermittent concentrations of some metals would have adverse effects. Conversely, there will be local conditions where adverse effects are very unlikely or extremely rare occurrences. The governing local circumstances are storm flow characteristics and average rainfall intensity, both of which vary with geographic locality.

   - Absence of evidence from NURP projects confirming impairment of this beneficial use which is considered significant at the local level. Bellevue, Washington, with a high degree of local awareness and interest in protecting a fishery, has concluded that chemical constituents in urban runoff create no problem for their sport fishery. Glen Ellyn (NIPC) documents high metals concentrations which undoubtedly strongly influence the

nature of the fishery which is present, but local opinion does not characterize this as a problem, i.e., local residents do not consider the degree of use impairment to be significant.

- In an EPA examination of over 10,000 fish kills that occurred from 1970 to 1979, only 265 were attributed to runoff of any kind, and less than one-half of that number were associated with urban runoff.

6. Indications to date do not provide any basis for believing that a denial of this benefical use is a widespread, general occurrence.

Marine aquatic life.

1. Adverse effects of urban runoff in marine waters will be a highly specific local situation. It is not a beneficial use generally threatened by urban runoff, though specific instances where it is impaired or denied can be of significant local and even regional importance.

2. A significant impact of urban runoff on shellfish harvesting has been well documented by the Long Island, New York NURP project.

3. Coliform organisms present in urban runoff are the primary pollutant indicator of concern.

Recreation.

1. Pollutants in urban runoff which pose the most significant threat to this beneficial use are pathogenic organisms (as possibly indicated by the presence of coliform bacteria), nutrients (particularly phosphorus), and suspended solids.

2. Coliform bacteria are present at high levels in urban runoff and affect all types of water bodies -- streams, lakes, bays, estuaries, and oceans. Whether the potential for use impairment is realized depends principally upon physical factors such as the location of the discharge relative to swimming areas and the degree of dilution and dispersal. In this sense, actual use impairment will be a local condition. This problem has been identified by a number of projects; however, data are not yet available for characterizing the extent and severity of use impairment.

3. Water bodies particularly susceptible to recreational use impairment by nutrients are lakes. In the cases where at least some information is presently available (Lake Quinsigamond, Irondequoit Bay, Lake Austin, Lake George) it is apparent that the degree of beneficial use impairment varies widely, as does the significance of the urban runoff contribution. Detailed

analysis which will permit establishing the relative significance of urban runoff compared with other sources is not available at this time except for Lake Quinsigamond but can be expected to be very site specific. At Lake Quinsigamond urban runoff was found to be a significant source of the critical nutrient phosphorus, such that a proposed water quality management plan will include the objective of reducing urban runoff loads. By contrast, very preliminary indications are that nutrients in urban runoff are not causing any appreciable negative impact on Lake Austin and controls do not appear warranted, pending results of analysis of long term effects.

4. Adverse impacts on recreational use caused by suspended solids have not yet been evaluated.

Public water supply.

1. Ground water aquifers do not appear to be threatened by pollutants in urban runoff caused to percolate through the ground. This finding is based on only one NURP project (Long Island) which has specifically examined this issue and must be considered in that light.

2. Lakes and impoundments that receive urban runoff and also serve as water supply sources are being addressed in NURP, but at this time results available are too limited to warrant drawing preliminary conclusions of a general nature.

3. Rivers or streams which serve directly as water supply sources with intakes in close proximity to urban runoff discharges are probably rare nationwide, but some do exist. From information and preliminary analysis developed to date, it is inferred that, where water supply intakes are in close proximity to urban stormwater discharges, a serious enough potential for adverse impacts exists that careful examination of the situation is prudent. The principal contaminants of concern suggested by preliminary results include heavy metals, a limited number of the organic priority pollutants, and coliform bacteria. Although the potential problem is present, there are mitigating factors which reduce the likelihood that a problem situation will actually exist at any given location. The present status of our analysis does not warrant any firm conclusions to be drawn with regard to the prevalence of actual problem situations of this type. However, based on the fact that local factors can significantly reduce the potential, and the belief that relatively few water supply intakes exist at stream locations dominated by urban runoff, NURP believes that any problems that do exist will be limited rather than widespread occurrences.

Control effectiveness.

1. Some detention basins are quite effective at reducing pollutant concentrations in urban runoff, with reductions on the order of 90 percent or better reported. High removals of suspended solids and heavy metals, especially copper, are noted, with somewhat lower removal efficiences for phosphorus and chemical oxygen demand.

2. Other NURP project detention basins do not appear to be performing very well in terms of reducing effluent concentrations and may not be capable of providing a significant water quality improvement. The performance of some is quite variable, being fairly good for some storm events (~ 50 percent reduction) and quite poor for others. Some detention basins are consistently poor performers.

3. The design features of detention basins play a very important role in their performance in terms of reducing pollutant concentrations. Data suggest that basins designed to merely control water quantity (drainage) problems may not function well in water quality terms. The installation of an arbitrary detention basin could even exacerbate water quality problems. As more NURP project data become available, it will be possible to make definitive recommendations on detention basin design for water quality improvement.

4. Street sweeping is effective for its original purpose, but it does not appear to be universally effective in reducing urban runoff pollution. Only one project out of six has been able to show any water quality improvement as a result of even very intensive (daily) street sweeping.

5. The effectiveness of street sweeping as a water quality BMP should be measured in terms of actual pollutant reduction in the runoff, not determined theoretically from estimates of pounds removed from street surfaces obtained from examination of street sweeper hopper contents, pounds remaining on the street surface, etc.

6. Data are insufficient to allow firm projections to be made as to those conditions under which street sweeping might be able to provide a water quality improvement, but preliminary indications are that it might be limited to semi-arid parts of the country with pronounced wet and dry seasons.

7. Data indicate that under certain conditions street sweeping may actually increase urban runoff pollutant levels, but this conclusion must be considered highly speculative until more data become available. A possible mechanism is that sweeping can break up larger particles making them available for washoff by smaller, less intense storms with less runoff volume for dilution. At its conclusion NURP will be able to make definitive statements in this regard.

8. Recharge Basins appear to offer promise as effective and economical BMP's for reducing urban runoff pollution to surface waters, without creating a threat of adverse impact on ground waters. This conclusion is tentative, and is based on preliminary data from monitoring efforts on one device, and screening analyses to examine applicability. Applicability can be expected to vary on the basis of site-specific conditions such as soil percolation rates, depth to water table, topography, proximity to water supply wells, and the like. Preliminary indications are, however, that recharge basins could have relatively broad applicability.

GENERAL DISCUSSION

In summary, the possibility of having water quality problems caused by urban runoff varies in type and degree. Whether or not a problem may truly exist is strongly influenced by a variety of local, site-specific characteristics. These include:

- Local climatology and hydrology;
- Type of water body which is the principal recipient of urban runoff;
- The particular beneficial use desired; and
- Local attitudes, resources, values -- especially values as applied specifically to individual water bodies in an area.

The NURP screening analysis to date suggests that there are a lot of places where urban runoff is unlikely to result in problems (quantifiable problems reflected in standards violations or use impairment). The same screening analysis also suggests that there should be a significant number of locations where urban runoff could theoretically result in the occurrence of a quantifiable problem. Some "possibilities of problem situations" would have to be discounted on the basis of the actual beneficial uses. For example, "problems" based on drinking water standards not being met would be problems only if the receiving water is actually used as a drinking water source. Local attitudes or alternatives could further reduce a theoretical or potential problem to the category of no problem from a practical standpoint.

NURP is unable, at this time, to estimate the probable relative distribution of sites in the nation which fall into the above alternate categories. Its analysis efforts are continuing to try to make this determination. At this time, however, NURP is not highly optimistic about its ability to be able to make a credible generalization of this type. However, some rather sweeping generalizations that will be true more often than not are offered. The water quality impact of urban runoff will be greatest in small urban impoundments, especially those with no other influent flows. Aside from possible nearshore effects, the water quality impact of urban runoff will diminish with impoundment size and, consequently, so should the potential for occurrence of water quality problems. Similarly, the water quality impacts of urban runoff will be greatest in small streams, especially those that headwater in the

urban area. As stream flow and size increase, the potential for water quality impacts caused by urban runoff should decrease as should problem potential. Furthermore, in this regard, swiftly flowing streams should be less vulnerable than more sluggish ones. Bays and estuaries are so complex that even such rather simplistic generalizations as the foregoing are difficult to justify and the same is true of the near-coastal oceans.

There are plateau and threshold effects for many pollutants that influence their impact on a given receiving water and, consequently, the strategy for their control. As an example, consider the case where the level of a toxic substance is four times the LC-50 value for a species of fish associated with the desired beneficial use. If urban runoff is the only source of the toxicant, and if the implementation of a given control measure results in a 50 percent reduction in loads, the money spent would have been wasted insofar as attainment of the designed beneficial use is concerned. To be sure, pounds of pollutants would have been removed at a (perhaps) cost-effective rate of so many dollars per pound, but there would still be none of the sought-after fish in the water and, consequently, the desired beneficial use would still be denied. Similarly, the removal of a contaminant that is at such low levels that it is not interfering with a designated beneficial use, simply because the substance is present in urban runoff, results in the incurrence of costs but produces no benefit because the beneficial use was not being impaired in the first place.

While the tools are available for conducting cost-effectiveness analyses and the procedures are rather straightforward, NURP is not so fortunate in the area of benefit-cost analysis. Damage theory and utility cost tools exist, but their application is far from straightforward and is subjective at best. The Agency is currently attempting to remedy this situation, and successful approaches, if found, will be applied by NURP.

Because of the local nature of water quality problems in terms of existence and cause, and because in many cases much more attractive approaches than control of urban runoff will be available for addressing problems where they are found to truly exist, it does not appear desirable to adopt a universal requirement for urban runoff control or treatment.

Urban runoff does appear to contribute significantly to certain water quality problems in certain areas (there are a number of well-documented cases in the NURP program), and there are situations where control of urban runoff is the only realistic action that is available to address the problem. However, the practicality of being able to solve some problems will be constrained in some cases by technological limitations, in some cases by costs, and in some cases by physical site constraints. Some examples of such constraints include:

> Technological. Situations which require very high degrees of removal of a pollutant may prove to be beyond the performance capabilities of control measures available. Example: Suspended forms of a contaminant lend themselves to removal whereas, if the soluble component is a substantial fraction of the total, control measures may not be able to reduce the total load sufficiently to achieve desired effects.

Cost. The cost associated with reducing the overall load of a pollutant from an entire urban area could prove to be prohibitive, even though relatively cost effective when applied in restricted areas. Usually, the overall urban runoff load must be addressed if the "problem" is to be successfully attacked. However, it may provide real benefit to apply efficient, cost effective controls serving only limited areas where it can be done conveniently.

Physical Site Constraints. Even where efficient, cost-effective controls may be available for reduction of the specific pollutants contributing to a particular problem, the physical space to implement them may not be obtainable. For example, Central Business Districts may be a significant pollutant source, but provide little opportunity for control.