SUMMARY OF EMERGENT URBAN STORMWATER THEMES

Conference Held August 19-24, 2001, Snowmass Village, Colorado

Ben Urbonas, P.E.
Urban Drainage and Flood Control District; Denver, Colorado

Jonathan E. Jones, P.E.
Wright Water Engineers, Inc.; Denver, Colorado

ABSTRACT

This paper summarizes and synthesizes, from the authors' perspective, the key themes and observations that emerged during the August 19-24, 2001 conference held in Snowmass, Colorado entitled: *Linking Stormwater BMP Designs and Performance to Receiving Water Impact Mitigation.* The objective of the conference was to discuss and debate what we know and do not know about the linkages between BMP designs and their performance and their ability to mitigate receiving water impacts of urbanization.

INTRODUCTION

This paper summarizes the key themes and observations that emerged during the August 19-24, 2001 conference held in Snowmass, Colorado entitled: *Linking Stormwater BMP Designs and Performance to Receiving Water Impact Mitigation.* In addition, a summary of the paper-by-paper highlights is presented in a separate paper under *Session VIII – Closing Session*, titled "Summary of Presentations at the August, 2001 Conference" to help the reader navigate through the wealth of material included in all of the papers and discussions.

The conference was co-sponsored by a number of organizations. All are listed in the Acknowledgements portion of these proceedings. We express our sincerest gratitude for their generosity, without which this gathering would not have occurred.

The conference was organized by the Urban Water Resources Research Council (Council) of the Environment and Water Resources Institute (EWRI), an institute operating under the charter of the American Society of Civil Engineers (ASCE). The objective of the conference was to discuss and debate what we know and do not know about the linkages between BMP designs and their performance and their ability to mitigate receiving water impacts of urbanization.

What follows is the authors' own interpretation and synthesis of the key themes that emerged during the presentations and discussions that followed. The observations herein are those of the authors and may reflect their perspective and interpretations. The reader is encouraged to study each paper and the recorded discussions that followed to develop their own understanding of the topics and perspectives of the original authors.

HISTORICAL PERSPECTIVES

The Foreword to these Proceedings lists a series of 14 Engineering Foundation Conferences prior to the one held in August, 2001 that were organized by the Council since 1968. The 2001 conference illustrates the advances in the topic of stormwater management and its interaction with receiving waters. It is striking to note that the Council identified much of today's knowledge and many topics of concern as being important as long ago as 1968. The short list that follows summarizes what emerged from some of these earlier conferences regarding the topics that were judged at them as needing further study and research:

1974 Sources of pollutants in urban runoff (i.e., precursor to the Nationwide Urban Runoff Program, NURP).

Incompatibilities between objectives of urban flood control and water quality.

Design factors for treatment of urban runoff.

Expanded data collection program.

1978 Relationships of urban runoff to channel evolution.

Improving local stormwater management for multiple purposes.

Relationships of stream corridors to water quality.

1982 Detention facility effectiveness as a function of design characteristics.

Stormwater pollutant removals as a function of design parameters.

1986 Field performance data to evaluate BMPs.

Information on BMP failures to avoid repeating mistakes.

Emphasis on quality should not replace emphasis on quantity controls. Both are needed.

1989 Rehabilitation technology for urban streams.

Performance evaluations of treatment devices (i.e., BMPs).

Effects of infiltration of runoff on groundwater and soils.

Consult the list in the *Foreword* for full references for the above list.

It is clear that many questions raised at these earlier conferences have been addressed. As a result, we have much more knowledge, as the 2001 conference papers reveal, about effects of urbanization on urban receiving systems, their geomorphology and biology, and various measures on mitigating impacts. This information did not appear overnight and is the result of the persistent and creative work of many scientists, engineers and other professionals. The Engineering Foundation Conferences helped to shape the direction in the development of the required knowledge. At the same time, bear in mind that there are more questions that need to be answered and much knowledge that needs to be developed before we have confidence about what systems of controls and technologies will provide the benefits we seek in our urban waters, including what is feasible and what may be wishful thinking. The workshop reports found in these Proceedings provide some guidance on what areas of knowledge may still need to be developed.

KEY THEMES AND OBSERVATIONS THAT EMERGED

The subject of the Snowmass conference, namely, discovering what we know about various BMP designs and performance and the linkages to their ability to mitigate the receiving water impacts caused by urbanization, is critically important. In the United States alone, billions of dollars will be spent in the near future to implement BMPs, supposedly to protect our receiving waters, their physical (i.e., geomorphic), biological (i.e., aquatic life and its habitat) and bio-chemical (i.e., water quality) integrity. Unfortunately, the conference revealed that our knowledge in this area is still limited. Many major and complex questions still need to be answered and addressed. Answering them with any degree of certainty is not going to be easy, will be expensive and will take a considerable amount of time. Not answering these questions will be much more expensive as this nation launches a massive stormwater BMP deployment over the next ten years and beyond.

The following is a summary of the authors' own perception of the most prominent themes and issues that emerged at the conference:

1. There are sufficient data and studies to clearly demonstrate that urbanization changes the quantity and quality of surface runoff and groundwater reaching receiving waters, including changes in the rates, volumes, frequency, physical characteristics and quality of the surface water runoff, which result in impacts to the physical, chemical and biological nature of receiving waters. Conference papers addressed the following changes associated with urbanization:

   A. Changes in Hydrology

      1) Increased runoff rates and volumes
      2) Increased frequency of runoff
      3) Changes in dry weather flow rates
      4) Changes in groundwater levels and hydrology
      5) Increased wet weather flow rates
      6) Increased "flashiness" of flows

   B. Changes in Stormwater Runoff Quality

      1) Constituent concentrations and loads
      2) Water toxicity
      3) Temperature
      4) Suspended and settleable solids concentrations and loads
      5) Litter, debris and floatables
      6) Pathogens
      7) Oxygen demand and availability during dry and wet weather periods

8) Impacts on attainment of designated uses under state and federal water quality classifications and standards

C. Geomorphic Changes

1) Degradation and aggradation of streambeds
2) Widening and deepening of streams
3) Accelerated stream bank erosion
4) Sediment deposition in streams, rivers, lakes and estuaries
5) Changes in stream meander patterns, movement and dynamics

D. Changes in the Biological Systems

1) Aquatic species diversity and numbers
2) Biological integrity (as measured by various indices)
3) Aquatic habitat
4) Eutrophication potential
5) Shade-providing vegetation cover along streams

2. The above-listed changes can vary tremendously from region-to-region and site-to-site. For example, in semi-arid and arid regions, urbanization creates base flows and very large increases in runoff events. Left unchecked, waterways respond with severe degradation and widening. When checked, the increased runoff can create new and expanded riparian areas and wetlands where dry channels previously existed. By contrast, in water-rich watersheds, urbanization can increase the numbers of runoff events while reducing base flows, both having resultant negative consequences.

3. There have been several reported efforts to compile information on the effects of urbanization and impacts on receiving water. Many of these studies, although good to excellent in their own right, did not follow consistent protocols or attempted to couple data from various sources to develop linkages between observed effects and impacts. Unfortunately, the various reports which demonstrate declining biological indices (such as drops in macroinvertebrate richness, diversity and density) between upstream and downstream reaches of an urban area have not, in general, tied the degradation to the parameters *specific to the effects of urbanization.*

4. There have been only few attempts to link the performance of stormwater BMPs with their ability to mitigate the observed impacts of urbanization. Although these excellent studies looked at catchments with retention basins, extended detention basins, vegetated buffers and swales to mitigate the impacts of urbanization on aquatic biota, they did not attempt to link specific BMP design parameters (e.g., various types, surface areas, and capture volumes relative to local mean runoff volume, release rates, etc.) to their effectiveness. None of the studies so far looked at entire systems of municipal BMPs that thoroughly cover the watershed and operate simultaneously.

5. Many past efforts to investigate linkages between BMPs and their ability to mitigate the effects of urbanization have been excellent in what they pursued and the knowledge they generated at each study location. On the other hand, they did not involve a broad cross-section of the scientific and engineering

community; were limited in scope; were focused on only few areas of the United States; and were limited in the parameters evaluated and documented. It is imperative to develop a consensus on the techniques to use in such studies, the parameters and information to collect that will be of most use and on how the findings may apply to different geographic, meteorological, and urban settings. In addition, the scarcity of these types of studies makes it premature at this time to extrapolate conclusions beyond the few sites investigated

6. The underlying statutory language in the 1972 Federal Clean Water Act (Public Law 92-500) and the 1987 Clean Water Act Reauthorization is profoundly important and has become the ultimate "driver" for urban runoff management. Indeed, phrases from these laws, such as "fishable/swimmable," "restore and maintain the chemical, physical and biological integrity of the nation's waters," "it is the national goal that, whenever attainable, an interim goal which provides for the protection and propagation of fish and recreation shall be attained" and stormwater runoff impacts will be mitigated "to the maximum extent practicable (MEP)" set very high goals for all stormwater program managers to pursue.

7. Some researchers suggest that even a small amount of urbanization (i.e., less than 10% impervious cover) can cause changes in the existing biological characteristics of the affected stream, irrespective of how much on-site mitigation is used. If this is the case, some degree of biological change is inevitable when urbanization and other land-use changes occur. Many participants noted that stopping urbanization, or reducing the impervious cover in a watershed below the so-called incipient impact levels, is not feasible.

8. Some communities have recently implemented "zero" impact policies for stormwater, despite the fact that evidence now shows that such programs are an oxymoron. Conference participants reflected on this in the wrap-up discussion session and virtually all agreed that zero (sometimes called "deminimus") impact regulations and policies are impractical and ignore the fact that growth is inevitable.

9. The issue of how much change in urban streams is acceptable was discussed. Many observed that it is not practical to have biological metrics in urbanized streams that compare to ones found in streams located in undeveloped or pristine watersheds. In response to urbanization, some amount of change is inevitable. Such change should be planned for and stream classifications and standards to reflect urban conditions should be developed.

10. Various presenters addressed the question of whether some BMPs can protect (or enhance, in the case of degraded streams) receiving water integrity, including aquatic life. Although opinions varied in this regard, the recent findings of case studies and research (see papers by Horner, Spooner, Shaver, Cave, Lloyd, Bicknell, Chocat, Lawrence, Roesner and others) indicate that comprehensive use of certain types of BMPs (e.g., retention ponds or extended detention basins, in combination with minimizing impervious area directly connectives techniques, housing density controls, etc.) appears to reduce, but not prevent, adverse impacts from new development. The conclusion was that their use could also assist, at least in part, with the recovery of degraded water bodies. There was a general consensus that:

- A multi-layered or "treatment train" approach may be most helpful.
- It is essential to properly select, size and construct the BMPs to be used and to observe and maintain the ones in use.
- Enhancing stream channel stability and providing in-stream aquatic habitat improvements in urban and urbanizing areas is extremely important to complement traditional BMPs such as retention and detention ponds.
- Control of pollutants at their source (i.e., paper by Clark, Pitt and others regarding product substitution) is an important element of non-structural BMPs needed to protect water quality and aquatic species.

11. Bledsoe's paper demonstrates that it is not possible to relate stream channel stability and behavior to the amount of impervious area in a watershed. The system responses to urbanization are far too complex to rely on only one metric. Although it is feasible to project the direction and nature of change (i.e., stream enlargement, etc.), it is not feasible to quantify the magnitude or rate of change.

12. Research by Horner and others also emphasized the essential need to look closely at circumstances found in individual watersheds. For example, in the Puget Sound (Pacific Northwest) area, Horner found that the scattered use of extended detention basins, in combination with vegetated buffers and swales, in the study watershed tended to reduce, but not eliminate, the impacts of urbanization on the macroinvertebrate species. There was little evidence to suggest, however, that their use improved the Coho Salmon/Greenback trout ratios when compared to pristine watershed streams.

13. Many speakers indicated that when properly integrated into the urban landscape, BMPs provide important multi-purpose benefits and can become important community assets. In addition, cases were illustrated of successful use of the "blue-green" concept in urban stormwater management, through which communities protect natural drainage corridors using a network of parks and riparian/natural buffers ("green" areas) in conjunction with streams, rivers and lakes ("blue" areas).

14. The broad class of measures (i.e., BMPs) referred to as "low impact development" (LID), or, alternatively, as "better site design," "minimizing directly connected impervious area" or others, are valuable and should be utilized when feasible. However, the effectiveness of such measures has not yet been adequately quantified and some expressed concern about their potential to promote widespread soil contamination. This points to a high-priority research need for this concept's application under real-world settings. There was a general feeling that the techniques associated with LID are best used in conjunction with other stormwater management measures, such as larger downstream facilities that can capture, treat and slowly release the stormwater runoff that is not, or may not be in the future, intercepted by LID-type facilities in the watershed.

15. Papers were presented regarding stream (and other water body) classifications, criteria and standards. One by Herricks provided a review of bioassessments and biocriteria. He cautioned that the commonly utilized numeric standards are

often not meaningful for episodic, wet weather events, where exposure conditions vary dramatically between events and even within a given event.

16. Swietlik's paper (and presentation) asserted that the existing water quality regulatory framework focused on beneficial use classifications and accompanying numeric standards, lends itself to urban stormwater management, and provided the classification systems in Maine and Ohio as good examples for acknowledging the differences and limitations of urban streams. The discussion that followed raised many practical points about the difficulty of determining what is actually achievable in a given urban receiving water.

17. Several speakers argued that there is a need for better hydrologic analysis, criteria and design for small, frequently occurring storms (those that are smaller than the two-year return period) to protect channel stability and habitat. A case was made that these smaller events from urban and urbanizing areas can destabilize streams and modify aquatic habitat. Traditional multi-frequency detention requirements often do not address these smaller storms.

18. Conference participants agreed that the term "BMP" is now used too broadly and is too all encompassing. It has lost its meaning and specificity. Virtually every activity related to stormwater runoff and receiving water management is now characterized as a "BMP," whether it involves product substitution, product restrictions, street sweeping, ponds, swales, public education, fish habitat enhancement activities or others. More specificity is essential. For example, it would help if these practices were broken down into the following categories:

    - Public education and involvement (PEI).
    - Land development practices (LDPs), such as incorporation of minimized directly connected impervious area, use of swales instead of curbs-and-gutters, vegetated buffer strips, riparian buffer zone preservation, etc.
    - Stormwater treatment facilities (STFs), such as retention ponds, extended detention basins, ponds, wetland basins, filters, bio-retention basins with discharging underdrains, etc.
    - Infiltration practices (IP), such as infiltration basins, bio-retention basins, infiltration pits at downspouts, etc.
    - Chemical reduction & substitution (CR&S), such as implementing pesticide use/restrictions based on longevity, solubility, partition coefficient, etc.

19. The training and educating of regulators, municipal staff and politicians has to be a priority. Such training needs to aim at dispelling myths about what works and does not work to help these individuals understand that one set of practices may not solve all problems and that solving all "problems" may not be feasible.

20. There was much discussion about long-term "sustainability." The needs for properly funded and staffed local stormwater management organizations, clear ownership of facilities, and the essential need for guaranteed long-term facility operation and maintenance are often ignored. BMPs have to be viewed similarly to what is needed for sustaining a wastewater treatment plant, city street, park or any other infrastructure element of an urban area.

21. It was observed by the participants that there is enormous variability in the use, and non-use, of BMPs and their implementation nationally. This is the case for both the construction and post-construction phases of urbanization. Some communities have rigorous design criteria manuals and watershed master plans; others have virtually nothing along these lines. BMPs are routinely used in some areas, and are hard to find in others.

22. BMPs are often chosen from a "laundry list" provided by a state agency, municipality or from a variety of proprietary products, without regard for their effectiveness in mitigating impacts of urbanization on the receiving waters they should be protecting. Funding, monitoring, maintenance, and community involvement also vary dramatically from locale-to-locale. Such variability increases the difficulty of linking the effectiveness in of the use of BMPs to their ability to mitigate the receiving water impacts.

23. The international papers presented provide much hope for the future, as they demonstrate that a sophisticated mixture of land use planning, construction controls and post-construction BMPs can be remarkably effective at protecting receiving water integrity and public enjoyment of water resources.

CONCLUDING REMARKS

Clearly, the entire subject of what we know and do not know about the ability of various BMPs and their designs is an emerging topic. Much work has been done on trying to answer this simple question, but much more research work still needs to occur before we can recommend, with confidence, which BMPs to use and how to design them in order to mitigate specific impacts of urbanization in a given watershed. Although the conference focused primarily on streams and rivers, other receiving waters must be addressed, as well.

Nevertheless, there is a consensus emerging by the top professionals in this field that urbanization does have very significant impacts on our gulches, streams, rivers, lakes, wetland and estuaries. The changes in hydrology that result from urbanization appear to have the greatest impact on the receiving waters. These changes tend to destabilize waterways, accelerate erosion and sedimentation, destroy or significantly modify aquatic habitat, fill in lakes and estuaries with sediment, affect water quality, etc.

Initial evidence was presented which showed that BMPs (i.e., treatment devices) that can capture small storm runoff events reduce the small sediment fractions and release the captured waters slowly (and/or infiltrate the runoff) can have a mitigating effect on urbanization. However, it is becoming apparent that it will not be possible (let alone practical) to totally eliminate the impacts of urbanization on streams and smaller rivers, and that we do not have any information on what may be possible for larger rivers. Clearly, there is a need for a national effort to fund research that will help fill in our lack of knowledge about this topic. The ongoing deployment of BMPs in the United States demands that this happen soon, before billions of dollars of new infrastructure is in place that provides little protection of our nation's waters.

URBAN WATERSHED TRENDS: LOOKING OVER THE DIVIDE

Stuart G. Walesh, PhD, PE
Consultant and Author
3006 Towne Commons Drive, Valparaiso, IN 46385-2979

ABSTRACT

Described here are threats and opportunities facing the urban water field. Awareness of and action on these is in the best interests of water professionals, employers, professions and society. The paper urges more diligence in applying the state-of-the-art, guarding against software misuse, adopting a holistic approach to watershed development, and rejecting price-based selection when clients need consulting services.

INTRODUCTION

Our Attraction to Water

What brought you into the water field? Regardless of your particular profession, why is water part of it? My childhood home was across the highway from Lake Michigan. From as early as I can remember, mother would walk me across that highway to the beach. We went to where a small creek flowed into the lake. There I "built" channels, levees, dams, and reservoirs. Upon arriving at college, I discovered that a degree in civil engineering would enable me to continue to "play" with water and get paid for it. A water career resulted. I suspect many water professionals have similar stories. We love this "stuff!" We feel pride and satisfaction in the results of our work. And we are fortunate. Someone said, "find a life's work you love and you'll never work another day in your life."

Possible Down Side

But there is a possible down side. Because of our zeal, we tend to keep our nose to the grindstone; to focus on current water issues and projects. As a result, we may fail to look up, around, ahead and behind. As individual professionals and as a profession, we may miss opportunities and be unaware of threats. It's like working on a watershed planning project and focusing exclusively on that watershed. While the watershed may be hydrologically independent, it is environmentally, economically, and politically interdependent with other watersheds.

Premise and Purpose

We, in our professional work as in our watershed projects, need to, every now and then, look over the divide. This paper's premise is that occasional "looking over the divide" will serve the best interests of individual water professionals, their employers, our professions, and society. The purpose of this paper is to provide some thoughts on what we might see over the divide; threats and opportunities facing the urban water field. A few future-oriented thoughts are presented in this paper with the hope of stimulating many more. The view over the divide is revealing. It may encourage thinking and suggest actions through which we can build on strengths, reduce threats, seize opportunities and more effectively manage our urban watersheds.

Being invited to offer this keynote address is an honor and a valued opportunity. Water resources, especially urban issues and projects, have been a part of my work for over 30 years. Knowledge, experience and biases have been acquired during that period. Preparing for this presentation caused me to reflect on my knowledge and experience and review my biases. I appreciate that opportunity. Edward Albee, the American playwright, said "I write to find out what I'm thinking." By writing and otherwise preparing this paper, I've more thoroughly discovered what I really think about urban water management and related topics. Please hear me out; consider my view of what lies over the divide. Agreement is not my goal; stimulation is.

REINVENTING THE WHEEL

Someone said "inventing the wheel was easy; the clever part was putting four of them together." We do too much wheel reinventing and wheel putting together in urban water management.

An Example: Rediscovering the Watershed

Take the watershed itself. About five to ten years ago there seemed to be a rash of conferences about the "new" concept of approaching water resources planning and management on a watershed basis. My initial reaction was to somewhat egotistically think that many of us had already "invented" the watershed approach in the 1970's. That was the decade when watershed based hydrologic-hydraulic models exploded and began to be used to assess the impact of urban development. Tools were now available to facilitate comprehensive watershed planning.

But then I recalled the pioneering work over 80 years ago on the 400 square mile Miami (Ohio) River watershed. This effort, which was led by engineer and educator Arthur Morgan and would evolve into the Miami Conservancy District, "...was the first time [in the U.S.] that plans would be made for an entire river valley in a comprehensive and thorough fashion." Incidentally, the plan for the Miami River watershed was the first in the U.S. to use "dry reservoirs" (Leuba, 1971).