The Washington Water RESOURCE

The quarterly report of the Center for Urban Water Resources Management

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Contents

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Message from the Director

This edition of the Newsletter is arriving a bit late because of an even greater-than-normal level of activity here at the Center this last spring. Two new research projects began in earnest—"Duwamish Hydrogeologic Pathways" and the three-year study of "Urban Stream Rehabilitation"—and a third, "Environmental Indicators for Stormwater Management Programs," was recently accepted. The last is described in some detail later in this issue.

A milestone was reached this spring in the funding for the Center. As I have described here in an earlier issue of the Newsletter, the State of Washington has not provided any financial support for the operations of the Center since about 1993; the University of Washington has never provided any. In acknowledgment of this situation, several of the local governments through their stormwater management agencies—King County, Snohomish County, Spokane County, the then-independent Metro, Bellevue, and Olympia—contributed enough funds to maintain Center operations through 1996. For 1997 and despite generally tight agency budgets, seven jurisdictions (King County, Snohomish County, Spokane County, Pierce County, Kitsap County, Seattle, Everett, Olympia, and Kent) have committed not only enough funds to cover the year's anticipated operational needs but also enough *additional* funds to support a summer internship. This year, that internship is addressing one of the most commonly articulated needs of these agencies: how to maintain stormwater facilities, particularly water-quality facilities such as biofiltration swales and wetponds (and their *de facto* counterparts, road ditches), in a manner that is cost-effective and that achieves acceptable (if not optimal) treatment performance. This summer we will be compiling and evaluating regional and national maintenance practices and conducting an extensive literature review through the University's computerized databases for relevant publications and research on this topic.

Out of that effort I hope to achieve another milestone for the Center. Since I began here in 1995, one of the most commonly articulated goals for the Center has been to coordinate research of broad interest to our sponsoring

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Annual Report of Research, October 17, 1997

The annual report of the Center's research projects is scheduled for the morning of October 17, 1997, at the University of Washington in conjunction with the monthly meeting of the regional stormwater managers' committee of the American Public Works Association. More details will be forthcoming to all subscribers in the next issue of the newsletter.

The Washington Water Resource is the quarterly publication of the Center for Urban Water Resources Management at the Department of Civil Engineering, University of Washington, Box 352700, Seattle, WA 98195.

MESSAGE (from page 1)

members but with costs too great for any one jurisdiction to carry alone. We have yet to achieve that goal completely, despite several projects that have attracted a wide range of interest (but no additional support!) beyond the initial agency that funded them. This upcoming effort on facility maintenance, however, seems poised to change this trend. The Center's Advisory Board includes several members who have articulated a strong interest in supporting a full investigation based on the outcomes of this summer's investigation, one jurisdiction (King County) has already committed significant seed money for a full effort, and the effort is in good time for inclusion in the 1998 and 1999 budgets of government agencies. Will we be successful? I am optimistic, in the belief that such an effort is in the best long-term financial (as well as water-quality) interests of the region.

Additional support for Center activities this spring also arrived from a new source. The Center for Streamside Studies, another interdisciplinary research center based in the colleges of Forestry and Fisheries, made support available for graduate students and selected three of our research assistants here for spring quarter funding—Jennifer Leavitt, working on environmental indicators in the Clackamas River watershed; Chris Konrad, beginning our work on urban stream rehabilitation; and Greg Mazer, continuing his work on vegetative conditions and requirements in biofiltration swales. This support is gratefully acknowledged.

In addition to these various research-related activities, our increasing level of activity and some major initiatives at the University of Washington are presenting both opportunities and constraints for the way in which the Center for Urban Water Resources Management operates. Since late 1995, the Center has been run by a 1/3-time director (myself), with administrative support for publications and the Newsletter generously provided by Stephanie Strom in Engineering Professional Programs. Research projects have been carried out by a combination of myself, other faculty in departments all over campus, and graduate research assistants. The Center has been very successful in attracting new grants, which paradoxically is both the mark of a "successful" research organization and a force mandating future changes, because within the next year we will likely exceed the ability of this rather modest organizational structure to manage the workload effectively.

Elements of the University have also begun to acknowledge the value of our historic focus on urban-related watershed and stream issues. The Center for Streamside Studies, traditionally focused on forestland issues, is undergoing a major review and is likely to seek a geographically and thematically broader mandate. Our Center is recognized as one of the major places on campus where urban and suburban watershed research occurs, and so a number of conversations have occurred between faculty members, directors, and administrators about ways in which our work could be integrated more effectively with other efforts. At this time, a suite of alternative organizational structures has not been fully defined, but the Center's Advisory Board will be holding a half-day retreat on July 3 to set a direction for our current and future emphases, growth, and organization. I hope to have much more complete news for the next edition of the Newsletter, but in the interim if you have any questions or thoughts on these changes please feel free to contact me or any of the Advisory Board members directly.

Derek Booth ❖

Maintenance of Failed Biofiltration Swales

Biofiltration is a process whereby pollutants are removed from stormwater runoff by passage through channels having a dense cover of grasses and/or wetland plants. Maximum reported treatment efficiencies for fully vegetated bioswales average 60%-90% removal of total suspended solids, 40%-75% removal of less soluble forms of metal contaminants, and 10%-30% removal of phosphorus. Herbaceous cover is considered to be well correlated with treatment efficiency (termed bioswale 'success').

Over one hundred bioswales have been constructed in King County, Washington, to treat runoff associated with residential, commercial, and light industrial development. In a recent survey of 33 of these swales by John Koon, only 28% were found to be in 'good' condition (high herbaceous cover throughout the swale). Wide fluctuations in water level and soil moisture, erosion and structural damage due to high flow velocity, excessive shade, and poor bioswale installation have been often mentioned as the most common causes of low vegetation survival and hence bioswale failure in King County.

As described in the Fall 1995 Newsletter upon the initiation of this project, the goal of our study was to develop a field-usable checklist to identify non-functioning swales based on channelization or lack of adequate vegetative contact, determine the cause(s) of that lack of function, and specify any and all solutions amenable to a "maintenance" scale of action. The work has been divided into two discrete sections: physically, what are the conditions of erosion and sediment transport in swales that render these facilities more or less susceptible to channelization and gullying; and biologically, what are the environmental conditions that favor or inhibit the growth of grass? We anticipated that, for many swales, failure was inevitable because erosive conditions would exist so long as grass growth was anything less than perfect. We also anticipated that the attention paid to the "engineering" aspects of biofiltration swales–cross sectional area, slope, length, etc.–might not capture the full range of "biological" aspects (particularly soil conditions, shading, and moisture availability) that are in fact necessary for long-term vegatation survival.

Work on this project is still in progress, but several outcomes are beginning to emerge. There are characteristic "types" of failures that are readily observable in swales, at varying degrees of severity, and they form the basis for a simple field classification. We find a very strong correlation between the failure type and the physical conditions in the swale, particularly the *overall longitudinal gradient*–swales with a slope of about 3% or greater are very difficult to maintain in any but a partly or fully eroded state. Our experience with swale retrofitting last summer suggests that there is nothing particularly exotic or difficult about constructing a swale that can maintain a stable form, so long as the overall site gradients are amenable to low to moderate (<3%) longitudinal gradients. We will be further investigating geotextiles as a way to extend this gradient range where site conditions, particularly in a retrofitting situation, mandate steeper slopes.

Vegetative conditions, however, appear to be more complex. That portion of the overall study, being conducted by Greg Mazer, has three objectives:

- Test the hypothesis that excessive inter- and intra-seasonal water level fluctuation is a major cause of low bioswale vegetation stem density and cover;
- Assess the relative tolerance of five species considered appropriate for biofiltration to different inundation regimes; and
- Refine the recommendations for bioswale construction and retrofit.

Maximum water level fluctuation down the length of eight swales and in their upstream retention/detention ponds is being monitored weekly for six weeks during the winter (January to February), spring (April-May), and summer (July-August) using crest-stage gauges at 15 m spacing. In addition, inundation duration is being calculated 10 m from the swale inlet by use of a newly developed instrument, the Inundation Sensor and Integrator.

More intensive examination of species response to inundation–period fluctuation occurred via greenhouse research began in March 1997. Individuals belonging to four turfgrass and one graminaceous hydrophyte were separated by species in 2.9 L pots. Each species was exposed to three treatments simulating a wide range of water level fluctuation over two 14-day cycles. Plant conditions for two species (*F. arundinaceae and A. geniculatus*) were assessed during the 7th and 14th day of each cycle. Physiological response to treatments were monitored. Above-ground biomass was gauged by comparing weights of oven-dried replicates at experiment outset and termination, and from these data were determined relative growth rates.

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Germination has also been monitored under conditions simulating those found during bioswale seeding (minus the effect of actively flowing water). Treatments include water regimes nearly identical to those described above (inundation at 2-4 cm depth). Germination rates are determined by recording seeds germinated divided by total seeds sown twice per week for six weeks. Seedling survival is also being monitored.

The results of these experiments to date are intriguing. Mature grasses for all species were not inhibited by flooding for long durations; indeed, those individuals generally acquired more biomass than the non-inundated controls. Field work also has shown that wintertime intra-seasonal water level fluctuation is NOT related to bioswale success–episodic inundation of mature established grasses do not result in their die-off. In contrast, the germination experiments are suggesting that conditions during this period of initial establishment are *quite* critical. Too much water, or too little water, is sufficient to inhibit growth or prevent it altogether. The implications of these findings, if confirmed, are clear and significant–bioswale vegetation is particularly limited during establishment, and the attention paid to irrigation and/or inundation immediately following seeding may have very long-term consequences for the performance of the swales. ❖

Evaluation of Environmental Indicators for Stormwater Management

Introduction

The Center was notified last month that we were the successful applicant in a national grant competition for evaluating the utility of a recent EPA-sponsored publication, *Environmental Indicators to Assess Stormwater Control Programs and Practices* (R. A. Claytor and W. E. Brown, Center for Watershed Protection, July 1996). This $297,000 project will be conducted over the next two years in conjunction with King County Water and Land Resources Division, our co-applicant on this proposal. Through this work, we hope to improve our ability to recognize development-related changes to aquatic systems and to improve our communication of those conditions to decision-makers and the public.

Environmental indicators (EIs), by many names, have been used historically to characterize the condition of natural aquatic systems. Quantitative measures of water chemistry, once popular as the sole determinant of "quality," slowly have given way to a broader suite of parameters that can characterize the range of physical, chemical, and biological conditions of an aquatic system.

Yet there is tremendous variability in the choice of, and use of, environmental indicators. Some of this variability is the result of regulatory mandates—if contaminant concentrations are the basis for determining compliance, counting invertebrate populations are unlikely to be strongly supported by regulatory agencies. The variability also results from inescapable, and entirely appropriate, differences in the types of aquatic systems being evaluated, the nature of the human disturbance being evaluated, the climatic region in which the evaluation is occurring, and the financial and technical resources available to the investigator or the investigating agency. There is no set of "ideal" environmental indicators, and there are no fully "representative" environmental-indicator projects: only instructive examples, which can demonstrate intelligent applications in relatively common settings.

Research Objective of the Proposal

The substantial ongoing efforts at stormwater management here in the Pacific Northwest are not fully integrated with efforts elsewhere in the United States. Regional differences in data-collection methods have evolved, some for fully justifiable reasons but some merely as a result of happenstance. Thus, for example, the genuine applicability of a plausibly "universal" set of temperate-latitude environmental indicators is in part unknown. Some of the published indicators are quite similar or identical to those in use here, and all are reasonable direct or indirect measures of aquatic-system conditions. But we recognize several remaining questions:

Do regional differences in aquatic systems require modification or abandonment of particular indicators?

What subset of the environmental indicators can be feasibly measured by a local jurisdiction over the long term? Can that subset provide a representative picture of aquatic conditions?

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EVALUATION (from page 4)

- Which of the environmental indicators are sufficiently responsive to human disturbance of the watershed that useful results will appear within a period that is meaningful from a management perspective?
- In aggregate, do the environmental indicators paint a representative picture of an aquatic ecosystem?

The objective of this proposal is to answer these questions.

Research Approach

We believe that any comprehensive evaluation of environmental indicators must proceed on two scales. Most obviously and most specifically, how accurately does a particular type of monitoring activity characterize the environmental parameter being measured? A measured indicator that can produce a high degree of accuracy in a research setting may require an overly time-consuming level of effort as part of a municipality's stormwater management effort, or it may be dependent on a poorly understood chain of physical or chemical processes that does not translate well to new climatic regions, or it may be subject to unacceptably high observer bias, or it may be so sensitive to the vagaries of storm and weather patterns that many years of data collection are required to demonstrate a trend. This is the *indicator-specific scale* of evaluation.

At least as important, however, is a larger, *integrated scale*. Our overriding goal is to characterize aquatic-system health as broadly yet as efficiently as possible: can a carefully chosen set of individual environmental indicators "add up" (either figuratively or literally) to a clear picture of aquatic-system health? Is their more than one such set, suited to different environmental or institutional settings, that can each produce such an integrated picture?

Research Activities

1. Choose a limited set of EIs for detailed evaluation

In our judgment, the full set of published EIs is unlikely to be used by most jurisdictions. Some are particularly costly, some are duplicative, and some produce results that are only marginally useful to "typical" stormwater-management activities. Therefore, the first task of this project is to identify a selected number of EIs that are most likely to be useful *and* feasible, both individually and as an integrated set, in a jurisdictional setting. We intend to evaluate the following proposed indicators, placing particular emphasis on the cost, required duration, and applicability of the indicators for evaluating stormwater management programs:

ENVIRONMENTAL INDICATOR (from Claytor and Brown, 1996)	USE IN THIS PROJECT: 1 = all sites 2 = limited sites 3 = omit
Water quality pollutant parameters	1
Toxicity testing	2
Modeled NPS loads	1
Exceedence frequency of WQ standards	1
Sediment contamination	2
Human health criteria	3
Stream widening and downcutting	1
Physical habitat quality monitoring	1
Reduced dry-weather flows	3
Increased flooding frequency	1
Stream temperature	1
Fish assemblage	1
Trends in macroinvertebrate diversity and quantity	1
Single species indicator	1
Composite indicators	1
Other biological indicators	3
Public attitude surveys	3
Industrial/commercial pollution prevention	3
Public involvement groups	1
User perception	3
Illicit hookup surveys	2
Number of BMPs installed, inspected, and maintained	2
Permitting and compliance	3
Growth and development	1
BMP performance monitoring	3
Industrial site compliance monitoring	3

2. Use the strict protocols in the EI document at selected large-development monitoring sites to compare results with preexisting monitoring data.

Several large-scale development projects in King County have been collecting aquatic-system data for many years. Three in particular (with development areas of 400-700 acres each) have well-established monitoring programs in place with as much as eight years of pre-existing data collected under a variety of protocols. This represents a unique opportunity to test the performance of the selected set of EIs against data sets with far

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greater resources of duration and funding than this project has available.

3. *Target 1-3 new developments with fall 1997 construction dates for limited-set EI measurements*.

To supplement EI evaluation at the three large-development sites, we propose establishing new monitoring efforts at one to three new developments with anticipated clearing and construction mid- to late 1997. Those developments will be chosen to lie in otherwise undeveloped headwater areas and to affect at least several tens of acres of the watershed area. At this scale of development, stormwater controls are imposed at a somewhat lower level of effectiveness than for the very large developments, and thus we will be able to assess BMP effectiveness across a *range* of management efforts. In this phase of the study the ability of the EIs to provide rapid assessment of aquatic health will be emphasized, with the review of BMP effectiveness assessed later in the project.

4. *Use the strict protocols in Claytor and Brown (1996) at selected preestablished long-term monitoring sites to compare results using different methods*.

This task is a key element of this project and will continue through both years of the study. It is the vehicle to explore whether EIs can capture the elusive concept of "watershed health." Historically, different indicators have been advocated for such a role. Chemical measures were popular during the 1970s and 1980s; recently, biological metrics (such as the B-IBI) have received expanded interest. Biological measures *are* attractive: organisms integrate environmental stresses in a way that no discrete set of measurements can, and in many instances the interest in "aquatic health" is almost precisely equivalent to public and agency concern about the status of the resident biota. Yet the range of utility for any single-focus metric, even this one, is limited because its discriminating power is not uniform across the range of aquatic systems found in urban and suburban settings. For example, moderately and highly degraded streams may both have the same level of biological activity (*i.e.* poor) but still function at very different levels in other ways. This project will therefore *use*, but not overly *emphasize*, biological indicators: they are part of any credible tool box, but even their value may have limits.

5. *Compare EI effectiveness with other (existing) environmental monitoring methods for characterizing watershed conditions*.

The EPA-supported effort on Environmental Indicators is but one of many efforts being conducted nation-wide on environmental indicators. One such effort in the Pacific Northwest, King County's Basin Management Evaluation Program, a significant source of preexisting data that will be compared and supplemented by this proposal. Another, the "Stream Quality Indices" project funded by the Washington State Department of Ecology has been active here at the Center for Urban Water Resources Management for the past three years (see the Winter 1997 Newsletter).

Regardless of the outcome of the present EPA effort to develop and to evaluate environmental indicators, we judge it unlikely that all of the locally and regionally developed protocols, nationwide, will be abandoned in favor of a single consistent standard anytime soon. We welcome the present variety, however, and find it highly instructive: each project reflects the interests and biases of the investigators, and the demands and limitations of the site and region. There are lessons to be learned from each of them, and so we intend to conduct a systematic evaluation of the recently developed environmental indicators in (or relevant to) the Pacific Northwest, a task which of necessity has already begun. ❖

Current Projects at the Center

- Maintenance of Failed Biofiltration Swales (see accompanying article, this Newsletter)
- Stormwater Environmental Indicators (see accompanying article, this Newsletter)
- Infiltrative Parking Lot Surfaces: The first-year report of this project is now available from the Center; see the accompanying summary in this Newsletter under "New Publications."
- Soil Amendments to Improve Infiltration (see Summer 1995 Newsletter). A full-scale field test of the hydrologic, economic, and aesthetic effects of soil amendments is being conducted in the city of Redmond; more information will be forthcoming in a subsequent issue of the Newsletter.
- Eastgate Water-Quality Pond Performance: The goal of this project was to determine the pollutant removal efficiencies for two wet ponds receiving stormwater runoff from a commercial area in the Eastgate area in Bellevue. The constituents of interest are total suspended solids, total phosphorous, soluble reactive phosphorous, biologically available phosphorous, and heavy metals; the receiving water body is Phantom Lake (which subsequently drains into Lake Sammamish), for which potential water-quality degradation has been a long-standing concern.

  Throughout the winter of 1996-1997, Karen Comings (Graduate Research Assistant here at the Center) collected storm-event water samples from the inlet and outlet of each pond and had them analyzed by the King County Metro Water Quality Laboratory. Flow data also has been collected continuously at each sample site and downloaded on a periodic basis.

  Currently, six months' worth of stormwater sampling has been completed together with several baseflow samples. The concentration data for the collected samples has been received from the Metro lab and compiled into summary tables. The hydrologic data that were recorded on–site have also be compiled into spreadsheets. Using this information, preliminary calculations of loading and removal efficiencies have been made for each constituent for both ponds. A summary of these preliminary findings has been presented to both the City of Bellevue and the Lake Sammamish Technical Committee.

  Although the results appear promising, statistical evaluations of the data set need to be performed and quality control needs to be verified. The data are also being more closely examined for the possibility of seasonal and/or monthly patterns in the removal rates. A final report on this effort is anticipated in late summer or early fall of this year.

- Puget Lowland Urban Corridor Geology and Geologic Hazards: The U. S. Geological Survey has embarked on an ambitious, multi-year project to create geologic maps along the Portland-Seattle-Bellingham urban corridor where such information is currently outdated or absent altogether. Derek Booth and Kathy Troost, a professional geologist and also graduate student in Geological Sciences at the University of Washington are working with the USGS in the Seattle-Tacoma area to address the following problems through this effort:

  1. GROUNDWATER: What is the nature and likely continuity of aquifers beneath the lowland surface, particularly those deep aquifers that are currently known only from sporadic and widely spaced penetration by deep wells?

  2. VOLCANIC HAZARDS: What is the distribution of recent volcanic deposits from Mount Rainier in the central lowland? Likely deposits have been identified as far southwest as Burien, on the coast of Puget Sound just south of Seattle, and along the entire Green River valley walls from Puyallup north almost to Lake Washington, but their age and distribution are unknown. A scant 5,700 years ago, for example, the Osceola Mudflow descended the flanks of Mount Rainier and traveled to within 15 km of the Seattle city limits.

  3. CRUSTAL STRUCTURE AND QUATERNARY DEFORMATION: Deformation of young geologic strata across the Lowland has been recognized for decades, but in the absence of absolute age control or even reliable stratigraphic correlation, neither a regional pattern nor a history of deformation can be determined. What *are* the patterns of uplift and deformation of these deposits? What are the ages of the deposits involved, and what are the spatial and temporal patterns to the nature and intensity of deformation? What are the ages of the youngest materials involved? How does this deformation relate to the network of demonstrable and hypothesized faults that cut

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PROFESSIONAL ENGINEERING PRACTICE LIAISON (PEPL) Program

The PEPL (PROFESSIONAL ENGINEERING PRACTICE LIAISON) Program, in cooperation with the Center for Urban Water Resources Management, offers a continuing education program in urban water resources management.

As part of the benefits extended to supporters of the Center for Urban Water Resources Management, member organizations submitting five or more registrations for the same course may deduct $30 per registration for a 1-day course, $35 for 1.5-day, $45 for a 2-day course, $50 for a 2.5-day course, and $60 for a 3-day course.

For further information on the *Urban Surface Water Management Continuing Education Program* or on any of the courses on the next page, please contact:

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PROJECTS (from page 7)

across the lowland, passing near or directly beneath several of the major population centers of Washington State?

- Boeing Creek Reestablishment: As part of a senior project in Geological Sciences, Joan Blainey has conducted biweekly stream surveys of Boeing Creek, a small channel in the city of Shoreline, north King County, that was completely buried by many feet of sediment during the New Year's storm this last winter. She has been able to document some of the rates and processes by which lowland stream channels incise and evolve into a more-or-less stable form, using this unique opportunity provided by an otherwise quite catastrophic and damaging event.
- Hydrogeologic Pathways, Duwamish Corridor (see Fall 1996 Newsletter; collection of existing subsurface data and integration into conceptual geologic framework has begun)
- Urban Stream Rehabilitation in the Pacific Northwest (see Summer 1996 Newsletter)
- Lakemont Boulevard Construction Oversight (see Fall 1995 Newsletter)
- Environmental Benchmarks in Citizen-Based Watershed Planning (see Summer 1996 Newsletter) ❖

New Publications Available Through the Center

To order these or any other publications, or to receive a complete listing of available titles, contact the Center's publication distribution service using the order form on page 11.

- Urbanization of Aquatic Systems—Degradation Thresholds, Stormwater Detention, and the Limits of Mitigation, by Derek B. Booth and C. Rhett Jackson

Urban development imposes a variety of watershed changes that profoundly affect runoff processes and the downstream surface-water aquatic system. Attention is generally given to *channel changes*: the stream channel itself is the object of interest and also, typically, the focus of any subsequent restoration or rehabilitation efforts. Yet that stream channel, commonly draining up to many square kilometers, is largely a product of its upland watershed. The net effect of *upland changes*, occurring across the land surface of the contributing headwater catchments, is at least as important in determining overall stream function, degradation, and rehabilitation potential. To understand the potentially degrading effects of urban development and the potential for mitigation, both areas–upland and riparian–must be considered in turn.

A variety of physical data from lowland streams in western Washington display the onset of readily observable aquatic-system degradation at a remarkably consistent level of development, typically about ten percent *effective* impervious area in a watershed (that fraction of a wa-

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tershed where the impervious area drains directly to a watercourse or stream channel). Even lower levels of urban development cause significant degradation in sensitive water bodies and a reduced, but less well quantified, level of function throughout the system as a whole. Our approach to this problem draws on both field data and hydrologic simulation results from a variety of lowland watersheds in western Washington. We have relied on field data to display overall trends in stream-channel changes; hydrologic simulations have been no less invaluable to improve our understanding of the likely physical processes that underlie those observed changes.

Although an analysis of urban-induced channel changes would be complete without any discussion of mitigation, we have elected to include here an investigation into the most common of mitigation efforts, stormwater detention. Stormwater detention is a particularly widespread application that promises substantive improvements, but all-too-often it fails to achieve even the most limited of objectives. Using continuous hydrologic modeling we have evaluated detention ponds designed by conventional event methodologies, and our findings demonstrate serious deficiencies in actual pond performance when compared to their design goals. Even with best efforts at mitigation, the sheer magnitude of development activities falling below a level of regulatory concern suggest that increased resource loss will invariably accompany development of a watershed. Without a better understanding of the critical processes that lead to degradation, some downstream aquatic-system damage is probably inevitable without limiting the extent of watershed development itself.

Price = $4.75 (K18)

- The University of Washington Permeable Pavement Demonstration Project—Background and First-Year Field Results, by Derek B. Booth, Jennifer Leavitt, and Kim Peterson

From the introduction:

Wherever grasslands and forest are replaced by rooftops and roads, the movement of water across the landscape is radically altered. Some of these changes are intentional, and they render the land more useful for the purpose for which it has been altered. Yet some of the changes are unintended and can have severe consequences. Flooding, channel erosion, landsliding, and destruction of aquatic habitat are some of the unanticipated changes that can also result from these alterations, recognized by many decades of studies because of the loss of both lives and property that sometimes result. With urbanization, stream channels expand catastrophically to consume adjacent land never before affected by either flooding or erosion, sediment inundates low-lying areas seemingly far away from active channels, stormwater facilities are overwhelmed by frequent flows far beyond their design capabilities, and populations of aquatic organisms are decimated.

Nearly all of these problems result from one underlying cause: loss of the water-retaining function of the soil in the urban landscape. This loss may be literal, in that the loose upper layers of the soil are stripped away to pro-

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1997–1998 Professional Engineering Practice Liaison (PEPL) Courses

September 9, 11, and 16
Basics of Project Management for Design Professionals

September 18, 23, 25, 30 and October 2
Effective Writing for Technical Professionals

September 23 and 24
Alternative On-Site Stormwater Management Techniques

October 24 and 25
Seismic Hazard Analysis for Constructed Facility Sites

December 3 and 4
Design and Retrofit of Culverts in the Northwest for Fish Passage

December 11 and 12
Stormwater Treatment by Media Filtration

January 14 and 15, 1998
Fundamentals of Urban Surface Water Management

March 25 and 26, 1998
Biofiltration for Stormwater Runoff Quality Enhancement

June 10 and 11, 1998
Infiltration Facilities for Stormwater Quality Control

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vide a better foundation for roads and buildings. The loss may also be functional, if the soil remains but precipitation is denied access to it by paving or rooftops. In either case, a stormwater runoff reservoir of tremendous volume is removed from the stormwater runoff system; water that may have lingered in this reservoir for a few hours or a few days or many weeks now flows rapidly across the land surface and arrives at the stream channel in short, concentrated bursts of high discharge.

Traditionally, this problem has been addressed by replacing the lost functions of the soil reservoir with an excavated "detention pond." Yet this strategy has proven to be surprisingly ineffective. The primary reason is one of *scale*–the volume of water retention in the soil that is lost, typically several inches to nearly a foot of depth over the to-be-developed area, is replaced by only a few tenths of an inch. This represents a reduction in "reservoir" volume of perhaps 90 percent or more, and so there should be little surprise that substantial downstream consequences result. Most detention ponds, unless designed to truly extraordinary (and thus no less costly) standards, are of limited or virtually no effectiveness. In addition to this fundamental shortcoming, the stormwater-management strategy of holding all water in a facility removed from the developed area itself yields two additional problems: stormwater-facility construction and maintenance are distressingly erratic, with striking divergence between design targets and post-construction in-the-ground performance; and a surprisingly high fraction of a developed area does not drain through stormwater facilities at all, because regulatory thresholds typically allow much of the development in a watershed to occur without any runoff mitigation at all (see accompanying publication K18).

> *"Water belongs in the soil. This principle is supported by the fundamental way landscapes maintain themselves, and by decades of experience in thousands of documented field installations. But it is astonishingly unrecognized in stormwater management conventions in large areas of the country." (Ferguson, 1995)*

Our study of permeable pavements has evolved from a growing recognition of the limitations of traditional stormwater management. To keep water in the soil we must allow access of water to that soil across much of the landscape, developed as well as undeveloped. This will not be practical everywhere, but where previously undeveloped land is being consumed most rapidly, and thus previously high-quality aquatic resources are being threatened most immediately, the opportunities are particularly great.

Based on the perceived values of stormwater infiltration and the scattered examples of promising yet ill-tested applications of permeable pavements in the Pacific Northwest, the Permeable Pavement Demonstration Project was initiated. It has three elements:

1. *Review existing information* on the types and characteristics of permeable pavements, to provide simple and readily accessible information to potential users of these systems;
2. *Construct and make operational a well-instrumented full-scale test site* where parking occurs regularly and that permits evaluation of the durability, infiltratability, and water-quality benefits of a representative sampling of permeable pavement systems; and
3. *Evaluate the long-term performance* of these systems.

This publication documents our efforts on the first two elements of this overall project.

Price = $5.00 (K19)

- Wetlands and Urbanization–Implications for the Future (final report of the Puget Sound Wetlands and Stormwater Management Research Program), edited by Amanda L. Azous and Richard R. Horner, 1997

The Puget Sound Wetlands and Stormwater Management Research program was a regional research effort intended to define the impacts of urbanization on wetlands. The wetlands chosen for the study were representative of those found in the Puget Sound lowlands and most likely to be impacted by urban development. The program's goal was to employ the research results to improve the management of both urban wetland resources and stormwater. The first section of this report defines the issues facing the program at its inception, summarizes the state of knowledge on these issues existing at the beginning and in the early stages of the program, and concludes by outlining the general experimental design of the study. Subsequent sections and chapters are as follows:

SECTION 2: DESCRIPTIVE ECOLOGY OF FRESHWATER WETLANDS IN THE CENTRAL PUGET SOUND BASIN

- Morphology and hydrology

Continued on page 11

PUBLICATIONS (from page 10)

- Water quality and soils
- Palustrine wetland vegetation
- Macroinvertebrate distribution, abundance, and habitat use
- Bird distribution, abundance, and habitat use
- Small mammal distribution, abundance, and habitat use

SECTION 3: FUNCTIONAL ASPECTS OF FRESHWATER WETLANDS IN THE CENTRAL PUGET SOUND BASIN

- Effects of watershed development on hydrology
- Effects of watershed development on water quality
- Hydrologic requirements of common Pacific Northwest wetland plant species
- Emergent macroinvertebrate communities in relation to watershed development
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