

---

# The Washington Water RESOURCE

The quarterly report of the Center for Urban Water Resources Management

---

Volume 7 ❖ Number 2 ❖ Spring 1996

---

## Message from the Director

In the last issue of the newsletter, I identified the three major thrusts of the Center's research efforts for this next year. They are:

1. Understanding the physical and chemical processes that result in significant biological consequences in aquatic systems;
2. Developing cheaper, more consistent, and more useful data-collection methods for aquatic-system monitoring in urban environments; and
3. Evaluating and improving the real-world performance of our current suite of management approaches.

Each of these research directions is expressed by both current and proposed projects. Number 1 on this list, "understanding process," lies at the heart of any effective management strategy. Watershed processes are notoriously complex, and the linkages between upland land-use changes and consequent in-stream effects on biological communities can be particularly obscure. Yet it is precisely these biological effects that are motivating much of the current activity in watershed evaluation, development mitigation, and stream-channel restoration. Not all of those activities are resulting in the desired level of long-term biological function, however. This is not for lack of desire but for lack of understanding, which can be achieved only through systematic evaluation. We are developing that evaluation through our ongoing project, *Development of Stream Quality Indices*, and a proposal to determine the realistic goals of stream-restoration projects in an urban context.

The second research direction, cheap and useful data-collection methods, is being pursued through several avenues. Development of the low-cost culvert-mounted stormwater sampling is continuing with (a) an improved design for very-low-flow conditions, (b) side-by-side measurements in every Center-related project for which the sampler can be installed and its results validated by more traditional grab or automatic sampling method, and (c) outside agency testing. This third avenue, outside agency testing, is only just beginning but holds the promise of rapidly expanding the data set through which

---

*Continued on page 2*

## Water-Quality Treatment and the Frequency of "Common" Rainfall in Washington

In the last issue of this newsletter we explored the frequency of extreme rainfall events across western Washington, motivated by the rain that fell in the region between February 3rd and 9th. We recognized the close interrelationship between storm *duration*, storm *intensity*, and rainfall *frequency*: intense storms tend to be of short duration whereas storms of long duration tend to be less intense, and thus storms of increasingly longer duration for a given intensity are increasingly infrequent. These issues will arise whenever major storms occur, and they help us predict the likelihood and severity of flooding and channel erosion.

In contrast, our concerns with water quality are normally focused on frequent, *low-intensity* storms. This arises because the vast majority of the total rainfall *volume* on an annual basis is produced by rather unexceptional storms. As a first estimate we might assume that a storm's pollutant load is (at least approximately) proportional to the total volume of the storm's runoff. Because applying water-quality treatment to low discharges is always easier than treating high discharges this assumption suggests a strategy that is followed by virtually all jurisdictions: treat the low discharges up to some predetermined threshold and ignore the higher discharges, either by permitting the treatment facility to exceed design parameters (e.g., water depth in a swale becomes too great to allow for effective treatment) or by routing the high flows around the facility altogether (to protect it from potential scour).

Discriminating between "low" and "high" discharges then becomes a partly technical, partly policy issue. At minimum, we need to develop a relationship between the annual cumulative rainfall volume and the magnitude of the storm above which we are not going to attempt treatment. We then need to combine this relationship with the practical considerations of the facility size as a function of the maximum discharge anticipated. Finally, we must decide on the goals of our treatment: 20 percent of the annual load of pollutants removed? 50 percent removed? 75 percent? Of course, an overly ambitious goal may result in an overly large (and thus costly)

---

*Continued on page 3*

**MESSAGE** (from page 1)

these samplers (with a construction cost well under \$100) can be calibrated with other, less reliable and far more expensive, sampling methods. I invite all subscribers with potentially suitable monitoring projects to contact the Center for the plans to build these culvert samplers and assistance in setting them in place.

The third research direction, real-world management, represents a significant agency need and is already a significant effort for this year. We are following and assisting in a citizen-based effort in watershed assessment and planning on the Clackamas River in north-central Oregon, with the ultimate task of documenting how these activities can best be carried out at a local level, with or without state or Federal assistance. Later in this newsletter you will see the summary of our recent work on two-cell detention ponds constructed under the 1990 King County *Surface-Water Design Manual*. Finally, we have begun an intensive review of the performance of biofiltration swales, one of the most common new additions to the suite of stormwater treatment methods but one whose long-term performance is very unreliable.

A continued shortcoming of the Center's research efforts in all of these avenues is the narrowness of participation on specific projects that should have wide-ranging applicability. The reasons are understandable: when an agency's need for information is sufficiently great it will marshal the resources necessary to generate that information. Other agencies, which might also benefit from that information but whose needs are at a lower priority, see little opportunity to participate at a (reduced) level commensurate with their (reduced) level of interest. I am continuing to look for ways that a variety of agencies can join together in supporting cooperative research that will benefit all at a reduced cost for each participant. The potential applications are numerous, because the issues facing individual jurisdictions are so similar: stormwater facilities design, maintenance needs, better understanding and so better justification for imposition (or elimination) of resource-protection regulations, monitoring protocols that satisfy regulatory and informational requirements without consuming a disproportional percentage of the overall budget.

I believe that our current work on the maintenance of biofiltration swales (see the discussion under "Current Projects at the Center" later in this issue) is an obvious case in point. Currently funded in total by King County, the results are likely to have significant implications for swale maintenance and design throughout the lowlands of western Washington. We are interested in expanding the range of this project to specific swales in other jurisdictions, perhaps constructed and maintained to different standards, and involving the staff from a variety of agencies throughout the region. I encourage you to evaluate this and other equivalent projects currently before the Center as vehicles to expand your water-resource management capabilities at a fraction of the cost of a full study. Only through such activity can the Center achieve its greatest level of service to the region.

Derek Booth ❖

## Annual Report, October 18, 1996

The annual report of the Center's research projects is tentatively scheduled for October 18, 1996, at the University of Washington in conjunction with the monthly meeting of the regional stormwater section 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.

**Director:** Derek B. Booth, University of Washington

**Advisory Board:**

Joan Lee, Snohomish County, Chair  
Jim Kramer, King County  
Peter Birch, WSDOE  
Ken Canfield, Pierce County  
Bill Derry, CH2M Hill  
Damon Diessner, Bellevue  
Check Kleeberg, Seattle  
Nancy Malmgren, WEC  
Stan Miller, Spokane County  
Jacqueline Reid, Metro  
Joanne Richter, Olympia  
Matt Witecki, WSDOT  
William Wolinski, Kent

**Affiliated University of Washington faculty:**

Brian Mar (systems engineering)  
Richard Horner (water quality and wetlands)  
Steve Burges (hydrology)  
Eugene Welch (lake chemistry)  
Joel Massmann (contaminant transport)  
Dave Montgomery (hillslope and river processes)  
Carol Stein (environmental chemistry)  
David McTigue (hydrogeology)  
Kern Ewing (wetland ecology, benthic invertebrates)  
Sally Schauman (social perceptions of nature, watershed restoration)  
Marc Hershman (public policy and environmental affairs)

**RAINFALL** (from page 1)

facility-so in fact the setting of a removal goal will balance environmental protection with economic feasibility.

Although the full development of such a technical/policy decision is well beyond the scope of a simple generalized discussion, Glenn Pieritz of the Washington State Department of Ecology (360-407-6436) has produced a necessary part of the foundation of any such decision. He has analyzed rainfall data state-wide and produced a table (next column) of the 24-hour storm volumes, in inches of rain, that will capture 90 percent of the average annual precipitation volume. For the Sea-Tac rain gauge the record has been analyzed for storm-duration frequency as well as 24-hour intensity, and so for example we know for that area not only that the storms yielding 1.27 inches of rain or less in a 24-hour period account for 90 percent of the average annual precipitation, but also that such a storm is the 6-month 24-hour rainfall event. A similar analysis has not been conducted at each of the other stations, but the similarities between each of the storm-volume vs. cumulative-volume graphs suggest that this approximate frequency may be typical across most of the state and perhaps the Pacific Northwest as well.

Although this analysis is invaluable, one additional assumption (or substantially more information) is required before a clearly defined water-quality treatment plan can be implemented with certainty. The annual percentage of rainfall volume that is treated may not correspond to the annual percentage of runoff pollutants treated, because measured concentrations of pollutants tend to increase with increasing discharge. Thus we may design a facility to treat 90 percent of the runoff volume, and perhaps remove as much as 75 percent of the targeted pollutants within that water volume, resulting in a naive expectation of  $(0.90 \times 0.75) = 68$  percent pollutant reduction. Yet if the remaining 10 percent of the annual flow, perhaps generated by only a few large runoff events, contains a pollutant concentration that is many times greater than the smaller runoff events, then the annual reduction of pollutants could be substantially less than 68 percent. For example, Steven Butkus, a past graduate student at the University of Washington, showed that the daily average concentration of phosphorus in Issaquah Creek increased by 5 to as much as 50 times over "normal" levels during storm events during the winter of 1986-1987.

The consequences of this uncertainty may be irrelevant to a chosen design standard, because that standard may need to be determined as much by physical or economic constraints as by desired treatment standards. Where long-term estimation or reduction of pollutant loads are required, however, resolving this issue will become unavoidable. ❖

STATION	MEAN ANNUAL PPT. (INCHES)	"90 %" 24- HOUR PPT. (INCHES)
<b>Puget Lowland:</b>		
Bellingham	35.82	1.23
Sedro Woolley	46.97	1.41
Port Townsend	19.13	0.76
Sea-Tac	38.10	1.27
Tacoma	36.92	1.12
Olympia	50.68	1.65
Centralia	45.94	1.40
Vancouver	38.87	1.28
<b>Pacific Coast:</b>		
Aberdeen	83.12	2.25
Long Beach	80.89	2.04
Forks	117.83	3.13
<b>W. Columbia Plateau:</b>		
Moses Lake	7.89	0.54
Chelan	10.44	0.76
Yakima	8.16	0.72
<b>Eastern Washington:</b>		
Cle Elum	22.17	1.2
Wenatchee	8.93	0.8
Walla Walla	19.5	0.94
Spokane	16.04	0.7

## Cooperative Project Opportunities

As described in detail in the Fall 1995 newsletter and discussed on page 2 of this issue, the Center will seek opportunities to execute research projects most efficiently through multiple sponsors. In many cases, the study being supported by one agency will yield results of benefit to other agencies as well, with little or no additional cost. Subsequent participants thus may be able to join these projects for substantially less than full cost, benefiting from their own staff's involvement and (in the case of field-oriented studies) the inclusion of additional sites of particular interest. Please refer to the inserts to the Fall newsletter or contact the Center for more information on the following projects:

- Maintenance of failed biofiltration swales
- Runoff reduction using soil amendments
- Modular pavement systems for parking areas: water quantity and water quality performance ❖

## Current Projects at the Center

### 1. MAINTENANCE OF FILTER BERMS IN DETENTION PONDS

Since the last newsletter, fieldwork and most of the analyses for our evaluation of 2-cell detention ponds have been completed. This project was commissioned by King County and carried out as part of the King County Surface Water Management Division's Best Management Practices Evaluation Program by Karen Billica, a graduate student in Landscape Architecture and professional geotechnical engineer.

King County has required stormwater detention ponds since the early 1970's. Historically, the primary function of detention ponds has been to control stormwater runoff quantity. Most of the existing ponds in King County built since the 1970's are single-celled detention ponds, also called "dry ponds" because they were designed to drain completely between storm events.

With the publication of its 1990 *Surface Water Design Manual*, King County introduced the requirement for the construction of two-cell dry detention ponds rather than single-celled dry detention ponds for the temporary storage of surface water runoff. The two-cell pond design was intended to add water quality benefits to the primary function of controlling runoff quantity.

The two-cell dry detention facilities consist of a pond divided into two cells by a quarry spall and washed gravel filter berm. The berm design is intended to increase water residence time in the first cell by several hours, to help induce the settlement of larger sediment particles and pollutants which could then be cleaned out periodically from the first cell without necessitating cleaning out the entire pond.

As more of these two-cell facilities have been constructed since 1990 and observed during operation, County personnel have found that the quarry spall and gravel filter berms separating the two cells are prone to clogging by fine-grained sediment. Clogged filter berms affect the function of detention ponds because as water becomes impounded in the first cell, the live storage volume of the pond decreases which limits the water quantity benefits of the facilities. Attempts to deal with the clogged berms have resulted in increased maintenance costs, as the typical solution to the problem has been excavation and replacement with gravel and/or quarry spalls free of fine-grained sediment.

These observed problems associated with the clogged berms motivated this study. The first objective was to develop recommendations on how to maintain clogged berms, including rapid evaluation methods and maintenance actions. The second objective was to develop recommendations for avoiding future problems with berms through altered design, including an analysis of the likely benefits of berms.

#### Preliminary Conclusions:

- Despite the published design standards in the 1990 *Design Manual*, berm construction varies widely from site to site and commonly does not follow the requirements, particularly the need for a washed gravel core of the proper grain size.

- The primary mechanism by which berms reduce downstream sediment loads is by stilling of the flow in the upstream cell, increasing residence time and permitting more of the sediment load to deposit out of a greater percentage of the flow. Although short-circuiting of the first cell is probably more likely in berms with only a limited-width permeable "window" than with a full-width permeable construction, this phenomenon also depends on the details of the berm geometry and was beyond the scope of this study.
- Based on limited field measurements, detention ponds appear to reduce sediment loads by about one-third in most cases and perhaps as much as 50 percent or more in unusual cases. We saw no systematic differences between the removal efficiencies of one-cell and two-cell ponds. The disproportionate contribution of very large storms (which entirely submerge the berm) and the effects of resuspension during large events were beyond the scope of this study but would obviously reduce these reduction efficiencies.
- If active filtration of stormwater through the core of the berm *does* occur, the berm sediment will clog long before quantitatively significant amounts of sediment have been removed.
- Because filter berms are designed to allow water carrying sediment to pass through them, they may clog in time even if constructed according to the *Design Manual* specifications. Only those berms that are (incorrectly) constructed solely of quarry spalls appear entirely immune from clogging. With a correctly sized washed gravel core, however, the time to clogging may be many years unless the pond has a high organic load (algae or waterfowl droppings).
- The net contribution of sediment passing through a detention pond is low relative to the load from the watershed as a whole, once grading and construction in the contributing basin is complete. Thus removal efficiencies of about 30 percent, applied to relatively insignificant initial sediment loads, suggest that both berm design and berm maintenance should neither compromise the primary function of two-cell detention ponds, namely water quantity control through maximizing available live storage, nor engender high cost.
- Failing berms are most cost-effectively identified by observing differences in water levels across the two cells within 2-5 days of the last significant rainfall. The appropriate weather conditions to make such an evaluation are likely to occur at least ten or more times per year in western Washington.
- Clogged berms are most cost-effectively maintained by excavating a "window" five to ten feet wide down to within six inches of the base of the first cell. The raw faces of the cut should be armored with quarry spalls. Backfilling with quarry spalls may be desired for aesthetics or access but is not required for adequate function.

---

*Continued on page 5*

**CURRENT PROJECTS** (from page 4)**2. OTHER ACTIVE PROJECTS**

- **Maintenance of Failed Biofiltration Swales (Winter 1996-Summer 1997):** Described in the Fall 1995 Newsletter, this project is evaluating the variety of mechanisms by which many (in some areas, *most*) grassy swales fail to establish or maintain an adequate vegetative cover. Greg Mazer (graduate student) and Kern Ewing (faculty) in the Department of Urban Horticulture are investigating the proper match of plant types and environmental conditions through a combination of field tests and greenhouse propagation, focusing on the stresses imposed by the oscillation between very wet wintertime conditions and very dry summertime conditions. The other primary mode of swale failure, erosion due to high flows, is obviously related to the establishment of a thick vegetative cover but will be investigated in its own right in the winter of 1997. Although the focus of this project is presently on the design and maintenance standards of King County, the project's primary sponsor, this project has obvious opportunities for other jurisdictions to cooperate in the evaluation of their particular design and maintenance issues at a substantially reduced cost (see *Cooperative Project Opportunities* elsewhere in this newsletter).
- **Modeling the Hydrologic Response of Lawns on Till with and without Soil Amendments (completed Spring 1996):** Tim Kurtz, a graduate student in Civil Engineering under the direction of Stephen Burges (faculty), has just completed an effort to calibrate the HSPF (Hydrologic Simulation Program-Fortran) rainfall-runoff model to a highly simplified field-scale experiment, namely the soil amendment plots described in the Summer 1995 newsletter and more fully in Publication K7. He found that the various levels and characteristics of subsurface storage that are represented in the HSPF model do not have definitive field analogs, and that the modeled drainage pathways between them are not borne out by field measurements of groundwater levels and subsurface runoff. As a result, modeled runoff compared poorly with measured runoff even after calibration. These results were particularly surprising because the physical system of the plots was designed to be simple and uniform, with well-mixed soil at a uniform surface gradient, even vegetation cover, and a known infiltration rate (equal to zero) out the bottom of the soil column. The implications for the application of HSPF to larger and more complex systems are significant, and suggest that accurate and robust rainfall-runoff modeling may require a more physically based model that does not yet exist in its entirety (see Publication J4 for one such example).

Other active projects at the Center include:

- **Storm Water Monitoring in the Lower Duwamish River Watershed** (see Spring 1995 newsletter)
- **Soil Amendments to Improve Infiltration** (see Summer 1995 Newsletter)
- **Lakemont Boulevard Construction Oversight** (see Fall 1995 Newsletter)
- **EPA Watershed Restoration Training** (see Fall 1995 Newsletter)

- **Improvement of Runoff Quality and Quantity from Road Shoulders** (see Winter 1996 Newsletter)
- **Infiltrative Parking Lot Surfaces** (see Winter 1996 Newsletter)
- **Development of Stream Quality Indices** (see Winter 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 6.

- **Clean water is not enough:** by James R. Karr, 1995, 9 p.

This analysis of existing laws and policies addressing surface water concludes that water resources continue to decline in this country because four realities are inadequately acknowledged: (1) water resources, especially their biological components, are in steep decline; (2) degradation stems from more than chemical contamination; (3) long-term success in protecting water resources requires biological criteria; and (4) the legal and regulatory framework in place today does not respond appropriately to continued degradation. Karr calls for laws and programs that explicitly acknowledge the *biological* significance and importance of water-resource protection, and that do not rely on narrow chemical criteria to determine whether or not "success" has been achieved. Price = \$2.25 (E12; originally published in *Illahee*, v. 11)

- **Modeling and monitoring to predict spatial and temporal hydrologic characteristics in small catchments:** by Wigmosta, M. S., Burges, S. J., and Meena, J. M., 1994, 223 p.

The purpose of this study was to develop a methodology for predicting the internal hydrologic processes in small catchments as well as the integrated outflow from them. Simple hydrologic monitoring and field mapping were conducted in a forested catchment on Novelty Hill and in the Klahanie development on the East Lake Sammamish Plateau, both in King County. Streamflow, precipitation, and shallow water table levels were monitored for several years in both catchments. A continuous hydrologic model was developed to simulate explicitly the flux rates and spatial distributions of evapotranspiration, Horton and saturation overland flow, return flow, and subsurface flow. The model was calibrated using several years of data and then validated over an additional rainy season; simulation of storm peaks and water-table levels were good but storm volumes were somewhat overpredicted. In the Klahanie development, the so-called "pervious" areas covered 71 percent of the catchment and contributed a surprisingly high 60 percent of the total runoff volume, primarily as a result of the thinness of the soil column that remains after site development. Price = \$34.00 (J4; University of Washington, Department of Civil Engineering, Water Resources Series Technical Report No. 137)

- **Urbanization and the natural drainage system—Impacts, solutions, and prognoses:** by Derek B. Booth, 1991, 26 p.

*Continued on page 7*

### Publications Order Form:

Check desired publication(s) listed below and mail or fax this form to Engineering Professional Programs. Please include payment and shipping address.

Engineering Professional Programs  
3201 Fremont Ave. North  
Seattle, WA 98103-8866  
Phone: (206) 543-5539  
Fax: (206) 543-2352

- Clean water is not enough (E12)** Price = \$2.25
- Modeling and monitoring to predict spatial and temporal hydrologic characteristics in small catchments (J4)**  
Price = \$34.00
- Urbanization and the natural drainage system—Impacts, solutions, and prognoses (K4)** Price = \$20.00
- Hydrologic response of residential-scale lawns on till containing various amounts of compost amendment (K7)**  
Price = \$22.00
- An examination of stormwater detention and infiltration at the scale of an individual residence in the Sammamish plateau of King County, Washington (K8)** Price = \$16.00
- Annotated Bibliography: Impervious Surface Reduction (K9)** Price = \$4.50
- Please send a list of current publications available through the Center for Urban Water Resources Management (no cost)

**TOTAL PAYMENT AMOUNT:** \$ \_\_\_\_\_ (minimum order \$5.00)

### Payment Method:

- Check or money order enclosed payable to **University of Washington**
- VISA     MasterCard    Expiration Date \_\_\_\_\_  
Card # \_\_\_\_\_  
Print name as it appears on card \_\_\_\_\_

### Send to:

Name \_\_\_\_\_  
Organization \_\_\_\_\_  
Mailing Address \_\_\_\_\_  
City \_\_\_\_\_ State \_\_\_\_\_ Zip Code \_\_\_\_\_  
Telephone \_\_\_\_\_ Fax \_\_\_\_\_ E-mail \_\_\_\_\_

9CE-CWM62

**PUBLICATIONS** (from page 5)

This paper presents an overview of the physical effects of urban development on aquatic systems, primarily as a result of the increases in peak discharges, flow durations, the frequency of channel-disrupting flows, and loss of riparian corridor. Some of the expressions of watershed urbanization on channel form are discussed, together with the limitations of the common methods of reducing the hydrologic consequences of development. Price = \$20.00 (K4; originally published in *The Northwest Environmental Journal*)

- **Hydrologic response of residential-scale lawns on till containing various amounts of compost amendment:** by Kolsti, K. E., Burges, S. J., and Jensen, B. W., 1995, 144 p.

Test plots were constructed at the University of Washington to examine the hydrologic effects of various forms of compost amendments on till soils. Instrumentation of surface and subsurface runoff collectors, piezometers, and rainfall showed the relative effects of different proportions and types of soil amendments on the infiltration capacity of the lawns. With adequate amounts of fine compost, surface runoff amounts were reduced by 30 to 47 percent relative to the untreated plots, suggesting a promising strategy for basin-wide mitigation of stormwater problems. Price = \$22.00 (K7; University of Washington, Department of Civil Engineering, Water Resources Series Technical Report No. 147)

- **An examination of stormwater detention and infiltration at the scale of an individual residence in the Sammamish plateau of King County, Washington:** by Conrad, C. P., Burges, S. J., and Jensen, B. W., 1995, 105 p.

On-site residential detention and infiltration systems can restore some of the hydrologic characteristics of a forested basin even after development has occurred. A detention system requires about 20 mm of storage, with a minimum 5 mm per day release rate, to maintain pre-development low-flow conditions. A minimum of 100 mm (4 inches) of storage with a 5 mm/day release rate is needed to control peak flow rates and durations to a more representative level, although the release rate still exceeds expected runoff rates from an equivalent forested area. Domestic use and summertime irrigation can also be supplied by storage of rainfall; in the winter, about 20-days' supply is advisable, and for irrigation about 250 mm storage over the area to be irrigated is needed. Two on-site infiltration systems were monitored during the winter of 1994-1995 and eliminated all surface discharge from their associated impervious area during that period. Price = \$16.00 (K8; University of Washington, Department of Civil Engineering, Water Resources Series Technical Report No. 148)

- **Annotated Bibliography: Impervious Surface Reduction:** City of Olympia, 1996, 18 p.

This bibliography was compiled for the "Impervious Surface Reduction Research Symposium," sponsored by the City of Olympia at The Evergreen State College on March 29, 1996. Over 60 documents are cited and briefly summarized, covering such topics as roads and parking lots, alternative surfaces, public involvement and education, costs and benefits, policies and regulations, and watershed assessment methods. Price = \$4.50 (K9) ♦

**Additional Newsletter Recipients?**

Your subscription to this newsletter can include multiple recipients in the same organization, if this is more convenient for you than circulating a single copy. Please mail or fax your list of additional recipients to:

Engineering Professional Programs

3201 Fremont Ave. North

Seattle, WA 98103-8866

Phone: (206) 543-5539

Fax: (206) 543-2352

E-mail: uw-epp@engr.washington.edu

Please add the following people to the *Washington Water Resource* mailing list:

**Current Subscriber** \_\_\_\_\_

**Organization** \_\_\_\_\_



Name \_\_\_\_\_

Organization \_\_\_\_\_

Address \_\_\_\_\_

City/St/Zip \_\_\_\_\_



Name \_\_\_\_\_

Organization \_\_\_\_\_

Address \_\_\_\_\_

City/St/Zip \_\_\_\_\_



Name \_\_\_\_\_

Organization \_\_\_\_\_

Address \_\_\_\_\_

City/St/Zip \_\_\_\_\_

## Professional Engineering Practice Liaison (PEPL) Courses

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 course, \$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 listed below, please contact:

Dr. Ronald E. Bucknam  
UW - PEPL Program, Box 352700  
Seattle, WA 98195-2700  
phone: (206) 543-1178  
fax: (206) 685-3836

### 1996-97 PROFESSIONAL ENGINEERING PRACTICE LIAISON (PEPL) Courses

October 9 and 10	Construction Site Erosion and Pollution Control
October 29, 30 and 31	Basic Stream Habitat Modifications for Salmon and Trout
December 11 and 12	Fundamentals of Urban Surface Water Management
January 15 and 16, 1997	Geology and Geomorphology of Stream Channels
March 5 and 6	Hydrologic Modeling and Design of Retention/Detention Facilities
April 16 and 17	Storm and Surface Water Monitoring
May 14 and 15	Design and Retrofit of Culverts in the Northwest for Fish Passage

The Washington Water Resource  
Center for Urban Water Resources  
Department of Civil Engineering  
University of Washington, Box 352700  
Seattle, WA 98195-2700

First Class Mail  
U.S. Postage  
PAID  
Seattle, WA  
Permit No. 62

09-9623 / 123