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Message from the Director

This issue of the Newsletter is almost entirely given over to the subject of *monitoring*, specifically evaluating the physical conditions in small to intermediate-sized streams draining suburban and urban environments of lowland Washington. There are several reasons for this emphasis:

1. The topic is timely. Many agencies have been measuring and monitoring channels for a number of years, and many more are probably going to choose, or be compelled, to begin doing so as the full consequences of Endangered Species Act listings of anadromous salmon become felt throughout the region.
2. There is interest. The City of Bellevue has been instrumental in opening a conversation over the past year between many of the institutions, and individuals, who have been monitoring aquatic systems for many years. Participation in those conversations has been substantial, both by active practitioners and by agencies without past monitoring experience who are seeking experienced guidance.
3. There is opportunity. The Center was invited into this process to help collate and evaluate the range of monitoring activities presently occurring throughout the region, emphasizing the types of streams of particular interest to our member organizations—urban and suburban systems that are large enough to have significant biological resources but small enough to be under the jurisdiction of only one or a few (local) agencies.
4. Further dialog is needed. None of us have the final word on "how to monitor," because every application is different. However, we hope to offer an approach that is sufficiently intuitive to stimulate more discussions and alternative recommendations.
5. The subject is complex, and so one issue of the Newsletter has little space for anything else! I hope you find the single-topic emphasis in this issue worthwhile.

I also hope that you have an opportunity to find your subscription renewal notice and to send it in shortly, if you haven't already. As always, feel free to contact me or the Center with any comments or questions.

Derek Booth ❖

Stream Habitat Assessment Protocols: An Evaluation of Urbanizing Watersheds in the Puget Sound Lowlands

By *Jennifer G. Scholz* (Center for Streamside Studies) and *Derek B. Booth* (Center for Urban Water Resources Management)

BACKGROUND

The physical conditions of streams are important determinants of aquatic habitat quality. These stream conditions, or *channel features*, can be used to assess the relative health of streams throughout a region. Agencies rely on these assessments in managing the state's aquatic resources. Ideally, there would be a single accurate and reproducible protocol for evaluating different streams. However, this is not the case. Different agencies employ different assessment protocols, each of which varies in its choice of the particular channel features measured and their relative importance. For this reason, these protocols yield different views of habitat quality. These protocols are not necessarily comparable, and it is therefore not possible to combine all existing data into a comprehensive database of regional stream habitat quality.

This project, initiated at the request of the City of Bellevue together with King County and Snohomish County, has the overall goal of identifying and evaluating common protocols used by local agencies to assess stream habitat conditions in western Washington. Eventually, we hope to integrate them into a final set of recommendations for use by public agencies executing stream-monitoring programs focused on the urban and urbanizing parts of western Washington. Many of the moni-

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toring protocols currently in use have been developed for other purposes or in other settings, notably the forested slopes of the adjacent mountains. Their suitability in those settings is not addressed in any way by the following discussion. However, urban lowland streams possess particular conditions, environmental stresses, and management alternatives that are not necessarily accommodated by the evaluation methods developed for wildland streams.

We have subdivided this goal into several tasks: (1) identify which channel features are commonly used by local agencies to assess stream conditions, (2) define a scale to describe the level of effort required to measure a given channel feature, (3) evaluate individual parameters as measures of stream health, (4) articulate an overall approach to stream monitoring by local agencies in urban and urbanizing areas of western Washington, and (5) recommend a set of stream-monitoring protocols that will meet the needs of agency monitoring programs across the region. To date, we have completed the first three tasks.

Our approach was to select six channel features typically monitored by local agencies in urbanizing lowland watersheds:

- channel geometry,
- stream corridor vegetation,
- channel erosion and bank stability,
- large woody debris,
- channel-bed sediment, and
- instream physical habitat elements or units.

We identified the parameters normally used to measure each of these features, through a compilation of existing monitoring protocols from public agencies around the region. We then determined the relative institutional "level of effort" required to measure each of those parameters:

1 = Rapid, low cost, but only likely to generate either qualitative or imprecise quantitative data. Level 1 measures are single snapshot evaluations and typically have modest utility because they can reliably offer only a coarse discrimination of aquatic-system quality or health. However, they may be useful in evaluating gross conditions ("good" vs. "bad"), and they are suitable for a wide range of volunteers with only minimal training.

2 = Nominal equipment, relatively rapid, and likely to generate reproducible (but coarse) quantitative results. These techniques require trained volunteers or professionals. At this level of effort, measures can be useful to classify a stream or reach, or to characterize conditions relative to some reference condition. As such, they can be used for both one-time and continuous monitoring programs, but most parameters will require substantial change for any difference to be detected.

3 = Similar requirements and applications as Level 2 but requiring more time and training in order to yield more precise results; discrimination of trends should be commensurately improved.

Finally, we evaluated the relative merit of these parameters in answering three common management questions that depend on characterizing the health of streams in urbanizing watersheds:

1) Can the parameter/method effectively describe current watershed conditions?
2) Can the parameter/method effectively identify trends in watershed condition?
3) Can the parameter/method effectively prioritize planned efforts at stream restoration or rehabilitation efforts?

The next section defines the channel features evaluated and discusses our basis for identifying the most (and least) effective measures.

RESULTS

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1. Channel Geometry

Channel geometry describes the physical structure of a stream channel. Several different parameters are currently used by local agencies to measure this channel feature. These include wetted width, bankfull width and depth, flood-prone width, and gradient. Bankfull channel dimensions, particularly bankfull width, is the most effective measure of channel geometry for the following reasons:

- Documented channel changes can be very useful in trend analysis. For example, cross section data can be used to identify changes in channel geomorphology over time (Leopold, 1973; Booth, 1997; Booth and Henshaw, in press) with almost no risk of subjective mis-interpretation. Bankfull channel dimensions can be measured more rapidly than full cross sections, but recognizing change in the former (bankfull channel dimensions) requires a greater magnitude of channel change than for cross sections.
- These measurements help evaluate current conditions and prioritize streams for rehabilitation by showing the relative deviation of channel geometry from anticipated undisturbed conditions (Dunne and Leopold, 1979; Booth and Jackson, 1997). Restoration projects can use this information to directly improve stream habitat and provide some information needed to characterize current conditions.
- Bankfull width and depth measurements can be measured quickly and require limited equipment. However, experience is necessary to identify bankfull conditions consistently because a variety of indicators are needed to identify it reliably (Williams, 1978), and some uncertainty in reported bankfull channel dimensions is almost inescapable (Johnson and Heil, 1996).

By comparison, other measurements are not as effective in characterizing the physical dimensions of the channel. For example, wetted width measurements vary with rising and falling stage, and this parameter may change by a factor of two or more in the course of a single day. Thus although useful for certain fisheries applications, it is not reliable for trend analysis and does not provide information needed to prioritize restoration projects.

2. Stream Corridor Vegetation

Stream corridor vegetation describes the amount of area above and adjacent to the stream (the riparian corridor) occupied by vegetation. The City of Bellevue and King County currently use several parameters to characterize vegetation within the stream corridor. These include shade percentage, ground cover, shrub layer, and canopy. Numerous studies have demonstrated a close correlation between intact riparian corridor and good instream conditions (*e.g.*, Steedman, 1988; May, 1996; Horner and others, 1996) in both agricultural and urbanizing environments, and so this feature has particularly high utility. Shade percentage and canopy measurements collected using a spherical densiometer have greater precision and replicability than unaided visual estimates because they provide a calibrated means of measuring vegetation within the stream corridor. For this reason, use of this instrument is standard in forest practices (Lemmon, 1957). Characterization of riparian vegetation using this parameter can be readily used to accurately describe both current conditions and long-term trends within the stream corridor. However, use of a densiometer does require some training and may be too time consuming for some field applications (such as those where the majority of riparian shade has been removed naturally or through management activities).

Canopy estimates made using several percentage classes (*e.g.*, 0-25%, 25-50%, etc.) are adequate for many applications. These measurements can be performed readily in the field with fair replicability and limited training. However, unaided estimates of percent canopy are prone to some observer error and are less precise than measurements made with a densiometer, and so they will not be nearly as sensitive to changes over time.

3. Channel Erosion and Bank Stability

Channel erosion and bank stability describe the health of the stream bank by characterizing the amount of bank erosion present and the relative stability of the bank. Local agencies describe bank erosion and bank stability by direct characterization of erosion and constructed bank hardening. Measuring bank erosion, particularly in urban areas, is a critical parameter for assessing channel health and for guiding rehabilitation. It provides “snapshot” information, useful in some types of trend analyses (*e.g.*, mass wasting, instream sedimentation), and requires little equipment or basic training to measure. We recommend using methods of verbal ranking and photographic record as this information requires minimal effort, generally describes current conditions, is useful for some level of trend analysis, identifies the need for habitat restoration, and has a high benefit-to-cost ratio. Established channel-assessment methods (*e.g.*, Galli, 1996a, b) typically divide the observed range of bank (in)stability into about four distinct categories of descriptive conditions, which appears to be a useful and replicable degree of detail.

In contrast, identifying the length and location of an erosional zone, by plotting it on a map or by associating it with a habitat unit, can increase the precision of the original measurements but requires substantially more training and more field time. The utility of such measurements is uncertain—for example, channel erosion features were precisely located along nearly all reaches of the King County lowland streams covered by the Basin Reconnaissance Program (King County, 1987). Yet in virtually every case, these data were used simply to indicate those reaches, in aggregate, that showed a relatively high degree of erosion. The specific sites themselves were never resurveyed, and the detailed description of their location or character have never been used for either current assessment or subsequent remediation.

4. Large Woody Debris

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Large woody debris (LWD) is used as a general indicator of watershed condition in forested (and once-forested) watersheds. Low levels of LWD can reduce the number of pools, pool quality, gravel and organic debris levels, and habitat complexity (Bisson et al. 1987; Grette 1985; Harris 1987; Bilby and Bisson 1992). Good correlation has been demonstrated between the degree of watershed urbanization and the number of instream LWD pieces in urbanizing Pacific Northwest channels (May, 1996; Horner and others, 1996; Booth and others, 1996). Parameters used by local agencies to measure woody debris include the length and diameter of the LWD, length and diameter of small woody debris (SWD), location and stability of logs, percentage of wood covering and creating pools, rootwad diameter, and dimensions of LWD jams.

The parameters and methods used by local agencies to measure LWD generally provide useful information on current conditions, can be used in trend analyses, are useful in prioritizing restoration projects, and have a high benefit-to-cost ratio. Similarly, they all require some training to collect accurate field measurements. We recommend that specific minimum diameter and length criteria be used in counting LWD because they appear to improve accuracy and replicability while requiring little additional training. There are, however, no absolute minimum size criteria for LWD; agencies contemplating cooperative data collection need to agree to a common standard. A minimum diameter of 10 inches (25 cm) is a common criterion in the published literature. For example, Bilby and Ward (1989) do not report any stable LWD less than this size; Montgomery and others (1995), citing Swanson and others (1976), use this as their minimum diameter for LWD; and Oregon Department of Forestry (1995) does not allow logs of lesser diameter for its rehabilitation projects.

The minimum *length* of LWD, however, has less agreement. Bilby (1984) suggests that any piece shorter than 5 m may be unstable; Bilby and Ward (1989) counted none shorter than 4.5 m in their study; Montgomery and others (1995) counted any piece longer than 1 m; Oregon Department of Forestry (1995) requires a length double to that of the bankfull width. A minimum length of 10 feet (3 m), in combination with the minimum diameter criterion of 10 inches (25 cm), is probably a defensible, appropriate, and easily remembered standard to use where none other has been agreed upon. However, restoration projects must consider stream size in determining the specific length and diameter of replacement LWD, and a monitoring program focusing on large rivers might elect to use minimum size criteria different from those suggested here.

The remaining parameters used by local agencies include length and diameter of "small" woody debris, location and stability of logs, percentage of wood covering and creating pools, rootwad diameter, and dimensions of LWD jams. Measuring these parameters may be useful for specific fish-habitat assessments, but, in general, are too detailed and require more training than is necessary to assess LWD in urbanizing watersheds.

5. Channel-Bed Sediment

Although channel-bed sediment is critical to the physical and biological functioning of stream channels, most of the commonly measured parameters are not suitable for use in the type of monitoring program we are considering. In part this is due to the difficulty in generating certain types of reliable, replicable data for this channel feature and in part because there are few reliable correlations between channel-bed sediment and overall stream condition.

The most common parameter, point counts of the substrate, is useful only if measurements are made in equivalent locations along a stream and between streams, namely on upstream sides of point bars at low flow or in uniform channel-spanning riffles where no point bars are present (Reid and Dunne, 1996; Kondolf, 1997). Measuring this parameter therefore requires modest training. More importantly, *interpreting* the resulting data generally requires experience in sediment analysis that is beyond the scope of this evaluation. Variability in the channel gradient, source area, season of measurement, and history of recent high flows all can affect the measured values of this parameter without any corresponding influence from watershed disturbance. In a study where channel conditions and sampling locations were reasonably consistent across a number of Puget Lowland streams, however, a good correlation between substrate size and high-quality biological conditions was reported by May (1996).

Embeddedness can also be a useful monitoring parameter because it can be measured with moderate precision and clearly affects certain elements of channel health, particularly the viability of benthic animals and incubating salmon eggs. However, it does not provide an unambiguous characterization because different streams can have very different sediment characteristics as a consequence of different gradients and source areas. Thus a snapshot characterization of embeddedness might show if a channel had a suitable substrate for biota but would *not* necessarily demonstrate that the cause of poor conditions was from human disturbance. MacDonald and others (1991, p. 124) note that "Embeddedness has shown promise, but the immediate need for a monitoring technique has resulted in widespread use and adaptation before cobble embeddedness could be adequately field-tested and validated." Change in this parameter over time may guide protection or rehabilitation strategies, although Burns and Reis (1989) judged that five consecutive years of embeddedness data were necessary to evaluate trends in a mining district in Idaho. Galli (1996a,b) groups embeddedness fractions (% fines on the bed surface) into four categories (0-25%, 25-50%, etc.), but does not report the sensitivity of these groupings to changes in the channel or the watershed. Local observations suggest that channels can fully span the range from 0 to 100 percent embeddedness and that the differences are well correlated both with human disturbance of the watershed and with biological utilization of the stream channel (May, 1996; Wydzga, 1997). However, we have no data

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on the rate at which such changes can occur and thus no basis to judge the predictive value of this parameter.

Other parameters on this table yield data with limited application in assessing urbanizing watersheds. Problems with these parameters are listed below:

- Sediment sizes vary markedly between different morphologic units (e.g. between pools and riffles). Characterization of the substrate without reference to the morphology of the channel will not provide replicable or comparable data, and so it will not be useable for establishing conditions or trends. If such data are needed, the point-counting method of Wolman (1954) is well-established and is relatively quick and easy. Kondolf (1997) emphasizes that the various alternative methods of sampling, such as single-grain measurements or “zig-zag” sampling across and down a reach of channel (Bevenger and King, 1995) yield non-reproducible results with little or no predictive value.
- Use of visual substrate classifications is an unnecessary loss of accuracy (Chapman and McLeod, 1987; MacDonald and others, 1991). For surface-sediment sampling, the pebble-count method of Wolman (1954) has good statistical replicability for only a modest expenditure of additional time.
- More detailed characterization of “substrate” requires not only the measurement of the surface sediment but also, for gravel-bedded channels, that of the sediment below the upper layer of (usually coarser) gravel. Such subsurface measurements are even more time-consuming, although with care they are useful in characterizing habitat suitability given the overall size distribution of the gravel and the percentage of void-filling fine sediment. However, the techniques available to make such measurements (Platts and others, 1983; Church and others, 1987) are beyond the scope of this evaluation.

6. Instream Physical Habitat—Pools, Riffles, and Other Habitat Units

Characterizing <u>instream physical habitat</u> has a long history in forested watersheds of the Pacific Northwest. This approach is intuitively well founded—if one of our primary interests is the ability of the channel to support aquatic organisms, what better way to assess that “ability” than to measure the features of the channel directly associated with biological use? (An even more obvious question—Why not measure the biology directly?—is entirely compatible with the physical monitoring approach being discussed here and should be included, in some fashion, in any agency’s overall stream-health-evaluation program.)

Two factors limit the utility of direct measures of channel habitat features. Although both researchers and field personnel have articulated these limitations for over a decade, the consequences of those limitations have not been consistently reflected in many monitoring programs:

1. The measurement or characterization of such features is imprecise and subject to substantial observer error. Although this is true of nearly all monitoring parameters, the magnitude of typical errors associated with habitat-unit inventories renders most such data inappropriate for between-stream or time-trend comparisons.
2. In-channel physical habitat features do not necessarily respond rapidly to human disturbance, and so even if a measurable change in such a monitoring parameter can be documented it may come far too late, if at all, to trigger an effective management response.

Both of these limitations have been the subject of an extensive, recent literature review and analysis (Poole and others, 1997). Their conclusion is particularly germane to our current evaluation:

> “Habitat-unit classification was not designed to quantify or monitor aquatic habitat. At the level necessary for use as a stream habitat monitoring tool, the method is not precise, suffers from poor repeatability, cannot be precisely described or accurately transferred among investigators, can be insensitive to important human land-use activities, is affected by stream characteristics that vary naturally and frequently, and is not based on direct, quantitative measurements of the physical characteristics of interest. Relying on habitat-unit classification as a basis for time-trend monitoring is time-consuming, expensive, and ill-advised.” (Poole and others, 1997, p. 894)

They base their conclusions in part on the work of four studies that specifically investigated observer bias (Platts and others, 1983; Hankin and Reeves, 1988; Ralph and others, 1991; Roper and Scarnecchia, 1995). For example, Roper and Scarnecchia (1995) found that five days of standardized training were *in*sufficient to produce consistent results among different observers when a full range of habitat units (nine, in their study) was used. Even if high precision could be achieved, a variety of researchers have noted the relative insensitivity of habitat units to land-use changes or other human impacts (Warren and others, 1987; MacDonald and others, 1991; Ralph and others, 1994). We therefore anticipate that most such efforts will combine the unfortunate attributes of large time commitments, non-repeatable results, and limited predictive or management utility.

Despite the generally poor record for habitat assessment in monitoring programs, we recognize the underlying conceptual basis for including some aspect of these channel features among the list of monitoring parameters. Useful results are most likely where the number of habitat categories is small. Roper and Scarnecchia (1995) reported complete agreement among their multiple observers for only 25 percent of the classified units, using their full set of nine categories. In contrast, their observers achieved a more useful 75-percent agreement when only three units were being discriminated (pools, riffles, and glides).

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We recommend focusing on pools, because they show a crude but consistently inverse correlation with human watershed disturbance across a wide range of landscape types (*e.g.*, Booth, 1990; Peterson and others, 1992; Galli, 1996a; May, 1996).

We recommend measuring pool width and depth over any alternative parameters because they provide adequate assessment of current conditions and require only moderate training. In addition, these measurements can be quickly collected and they require little field equipment (see also Robison and Kaufman, 1994).

However, substantial observer variability, seasonal variability in flow, and variability caused by instream objects such as boulders or LWD (MacDonald and others, 1991; Myers and Sherman, 1997; Poole and others, 1997) make measuring and interpreting pool habitat problematic. Accordingly, monitoring pools is often not terribly useful for the specific tasks being evaluated in this report and so their overall value is modest at best.

Habitat types other than pools do *not* appear to be suitable for use in the type of monitoring program we are considering. This is primarily because of the difficulty and expense in generating reliable, replicable data for these other habitat parameters, as much or more so than with pools. Information gathered during assessment of other channel features (e.g., channel geometry) can probably generate equivalent information with much greater reliability and greater insight into the *cause* of physical-habitat change (MacDonald and others, 1991; Poole and others, 1997).

SUMMARY

Although there is general agreement that the physical conditions of streams are important determinants of aquatic habitat quality, there is little agreement on the best way to measure or to characterize those physical conditions. Even though many agencies and volunteer groups are collecting tremendous amounts of stream-condition data, the region cannot assess comprehensively the status of its aquatic systems. This problem is compounded in urban and urbanizing areas because most of the monitoring protocols currently in use have been developed for other purposes or in other settings, notably the forested slopes of the adjacent mountains.

Based on this evaluation, we see a limited set of monitoring tasks appropriate to a rapid, low-cost effort ("Level 1" in the tables below), although the benefits of enhanced stewardship by involving volunteer monitoring far exceed any concerns about data imprecision at this level of effort. The measurements that are suggested by our analysis are as follows:

Summary of Recommended "Level 1" Measurements

PARAMETER	METHOD OF MEASUREMENT
Canopy	Visual estimate of canopy cover, expressed as a percentage range (*e.g.*, 0–25%, 25–50%, 50–75%, 75–100%) at a site or along a reach
Bank erosion and bank hardening	Written entries on a data sheet describing the erosion or hardening, together with map location, approximate length, and representative photographs
Large Woody Debris; minimum length > 10' (3 m) and minimum Diameter > 10" (25 cm)	Tally of the number of pieces in the channel in a specified length or reach of stream.

This is a much shorter list than even the most low-effort monitoring plan typically includes, and we emphasize that there may be a number of reasons why an expanded list might be appropriate. If, however, the intended purpose is simply to provide useful information for guiding management decisions, we see little evidence that additional tasks executed at the lowest level of effort will produce any useable results.

At a greater level of effort ("Level 2," requiring trained volunteers or professionals but minimal equipment and modest field time) the range of recommended tasks is much greater and includes many of the activities that normally constitute many agencies' "stream monitoring program." However, some commonly executed tasks are absent from this recommendation. Those tasks require an even greater level of effort in order to produce reliable results, or else there is no evidence that *any* level of effort applied to them can achieve practical guidance for our three management questions in the urban environment.

Because of the number and range of tasks included here, not all will be appropriate for a given monitoring effort. Therefore, a clear articulation of the goals of the monitoring effort must *precede* any choice of parameters to measure, or the results will almost certainly be inefficient at best and misleading at worst.

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Summary of Recommended "Levels 1 and 2" Measurements

PARAMETER	METHOD OF MEASUREMENT
Gradient	Several alternative methods are available, with the use of hand-held equipment generally adequate
Shade/canopy	Gridded mirror (densiometer) used to measure the percent shade, or visual estimate of canopy cover
Bank erosion and bank hardening	Written entries on a data sheet describing the erosion or hardening, together with map location, approximate length, and representative photographs
Large Woody Debris; minimum length > 10' (3 m) and minimum Diameter > 10" (25 cm)	Tally of the number of pieces in the channel in a specified length or reach of stream; include four numerical zones used to identify the location within the stream channel
Substrate composition	"Point and count" method with 100 randomly selected grains from upstream side of point bar or channel-spanning riffle
Pools (specify minimum depth for inclusion)	Tally and measurement of the number of pools in a specified length or reach of stream, using residual depth and wetted channel width to define size

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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.

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Fundamentals of Urban Surface Water Management

October 1999
Design and Retrofit of Culverts for Fish Passage in the Northwest

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STREAM HABITAT ASSESSMENT PROTOCOLS (from page 8)

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Current Projects at the Center

- Stream Temperature Survey (see Fall 1998 Newsletter): Our next step in this project, scheduled for next month, is to compile all watershed-scale land-cover percentages for each measurement site.
- Rehabilitation-Project Database (see Fall 1998 Newsletter): Some of the agencies who contributed to this database are still finalizing their entries; we expect to post the document on our web site as soon as it is complete.
- LANDSAT Land Cover Interpretation: This project is close to completion, with classified 1991 and 1998 LANDSAT images now undergoing error-checking. The 7 categories are:
  1. intense urban
  2. urban grass
  3. urban forest
  4. coniferous forest
  5. deciduous forest
  6. grass/pasture
  7. open water.

Preliminary comparisons with orthophotos suggest that our accuracy rates on a pixel-by-pixel basis (30 m on a side) will be 85-95%. Application will be virtually instantaneous on any watershed area identified in a GIS. We will be releasing the layers in Arc-compatible format, together with preliminary "percent impervious" estimates for each of the seven categories, as soon as the work is complete.

- Urban Stream Rehabilitation in the Pacific Northwest (see description in the Summer 1998 issue of the Newsletter)
- Puget Lowland Urban Corridor Geology and Geologic Hazards (see description in the Summer 1998 issue of the Newsletter). In cooperation with the U. S. Geological Survey, we held a 2-day workshop at the University on February 24–25, with over 200 people in attendance.
- Road-ditch and water-quality BMP maintenance (see Winter 1998 Newsletter)
- Issaquah Creek sediment budget (see description in the Fall 1997 issue of the Newsletter)
- UPD monitoring (see description in the Fall 1997 issue of the Newsletter)
- Watershed Academy (see Winter 1998 Newsletter): This joint week-long course of the Center for Streamside Studies and the Center for Urban Water Resources Management has been renewed by the U. S. Environmental Protection Agency for at least another offering in September 1999. ❖

Brief Research Notes

- The Report by the Technical Advisory Committee on Capture of Surface Water by Wells (Hydraulic Continuity) has been released in draft form. It can be downloaded from the Department of Ecology's web site at <www.wa.gov/ecology/wr/plan/hc.html>.
- As summarized in the April–June 1998 issue of the Newsletter of the North Carolina Sedimentation Control Commission, "Field monitoring recently conducted by researchers in the University of Texas-Austin College of Engineering found the median percentage of total suspended solids (TSS) removal attributable to filtration by geotextile silt fences to be zero." The complete reference of the report is:

  Barrett, M. E., and others, 1995, An evaluation of the use and effectiveness of temporary sediment control: Technical Report CRWR 261 of the Center for Research in Water Resources, University of Texas at Austin, Austin, TX.
- The U. S. Geological Survey has recently released the report, "Water-quality assessment of the Puget Sound basin, Washington—environmental setting and its implications for water quality and aquatic biota" (W. W. Staubitz and others, 1997, Water-Resources Investigations Report 97-4013). From the abstract:

  "This report describes the natural and human factors that affect water quality in the basin and includes an overview of the physiography, geology, soils, surface- and ground-water hydrology, land use, instream habitat, and the aquatic ecosystem. The report also provides an overview of existing water-quality conditions and summarizes the results of selected water-quality studies of the basin. This information indicates that the quality of fresh water in the Puget Sound Basin is generally good, although in agricultural and urban areas, surface water is degraded in places by fecal-coliform bacteria, and nitrate at undesirable levels is found in some aquifers. Toxic materials from terrestrial sources also discharge to Puget Sound and accumulate in bottom sediments, and the physical hydrology, water temperature, and biologic integrity of many streams have been degraded to varying degrees by logging in the upper forested watersheds and by agricultural and urban development in the lower watersheds." ❖

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