

Large Woody Material Enhancement in Urban Streams Puget Sound, Washington: Monitoring and Adaptive Management

Prepared by



Natural Systems Design
Seattle, Washington

and



City of Redmond
Public Works Department
Natural Resources Division

May 2007

Redmond Urban Watersheds Initiative
Contribution No. 4

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EXECUTIVE SUMMARY

This study explores application of the monitoring and adaptive management approach to enhancement projects using large woody material (LWM), in small urban streams (80 to 800-acre watersheds) in the Puget Sound lowlands of western Washington.

An initial LWM stream enhancement informational survey conducted across several jurisdictions yielded only limited success. While monitoring of LWM projects is generally enthusiastically called for and endorsed, it is not clear what or how LWM project data should be gathered, how it will be used, or how it would be retrieved once an agency has collected it. Senior management needs to more consistently encourage a much better job of monitoring the outcomes of these projects.

The second phase of the study focused on seven stream enhancement projects installed in the City of Redmond between 1991 and 2004. A straightforward, objective monitoring protocol was developed and applied to determine if each project had achieved its goals. The protocol used LWM loadings and spatial distributions in undisturbed Pacific Northwest streams of similar size to Redmond's, to provide the best "reference" for comparing habitat enhancement projects – for these are the natural conditions under which local salmon species evolved.

Redmond's projects all contained significantly less LWM than the reference systems. While most Redmond projects satisfactorily achieved bed and bank stability, our success at creating instream habitat was more limited. This "under achievement" is directly related to the *inadequate hydraulic interaction* between various stream flows and the LWM. A majority of LWM volume needs to be below bankfull depth if it is to provide habitat value or energy dissipation during storm events.

Two other issues received attention: First, it appears that real stream enhancement opportunities might be missed based on "risk aversion" – *unrealistic fears* of LWM and stream flow interactions. Second, because of contract liability issues, in-house staff typically have little control over potential shortcomings in the LWM installation process.

Moving through this review it became clear that better *visual examples* of desirable stream habitat features – both, natural and constructed – could substantially benefit stream restoration planning efforts. The final phase of this study provides a solid start towards filling this need.

The most striking conclusion of this study is that hugely beneficial insights accrued to Redmond staff as a result of instituting the relatively simple and inexpensive project review and monitoring procedures described herein.

ACKNOWLEDGEMENTS

The City of Redmond Public Works Department, Natural Resources Division, is especially grateful to staff members from several adjacent jurisdictions who participated in early discussions about a project such as this, helping formulate potential study goals and approaches. Contributions from Paul Cereghino (NOAA), Kirk Lakey (WDFW), Frank Leonetti (Snohomish County), Gino Lucchetti (King County), Kit Paulson (City of Bellevue), and Chris Woelfel (City of Seattle) are particularly acknowledged.

The City of Bellevue Utilities/Environment Division, represented by Kit Paulson, funded Natural Systems Design to conduct the initial information-gathering phase of the study, generating the survey results and reference materials presented in Section Two of this report.

The Natural Systems Design study team including Alan Johnson, Mike Hrachovec, P.E., and Nick Silverman, worked closely with Redmond staff to refocus the objectives for the second and third phases of the study. They then did an outstanding job – voluntarily carrying their research considerably beyond the limited scope of the City contract. City of Redmond staff, Keith Macdonald, Ph.D. (Project Manager), Jeralyn Roetemeyer, P.E., Roger Dane, ASLA, and Peter Holte, also rose to the occasion.

The project staff are especially grateful to Natural Resources Division Managers, Jon Spangler, P.E., and Daren Baysinger, for their encouragement and financial support -- and to Dave Rhodes, Director of Redmond Public Works, for embracing the broader, long-term benefits of a study such as this.

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PREFACE

An important part of this study was to determine what constitutes “project success” for urban stream enhancement projects – and how that might be measured. Perspective is obviously an issue here. To an ecologist, “success” might mean restoration of natural functions and processes, or the return of sustainable fish populations. To an engineer, it might be the protection of infrastructure and elimination of local flooding. Achieving both goals would surely be optimal. If project success is to be measured, then an obvious key is to have well defined project goals at the outset.

Stream enhancement is not a reach-by-reach enterprise, but rather demands a more holistic, watershed perspective. An early conversation with Alan Johnson offers one experienced practitioner’s insights into successful urban stream enhancement:

*“Stream restoration isn’t really about fish habitat — it’s about **energy dissipation** and achieving a new stream channel equilibrium after adding additional stormwater runoff to our streams. Stream flow is the product of the cross-sectional area of the stream channel(A) and water velocity (V): Stream Discharge, $Q = VA$.*

“When additional stormwater is added to a stream and its discharge increases, one of three things will happen – the channel will become deeper (down-cutting, bed scour); or wider (bank erosion); or the water will flood over the stream banks (flooding). To reduce the risk of any of these three “politically undesirable” things from happening, the stream velocity needs to be decreased through the addition of instream structure to dissipate energy. That is, energy dissipation will reduce the risks of stream down-cutting, bank erosion, and flooding. If fish habitat is enhanced, it will be as a by-product of these changes that dissipate energy – a “freebie.”

*“So what is fish habitat? In the simplest of term, it reflects **hydraulic complexity**. Good fish habitat requires three things: a refuge – from both predators and high velocity flows; a source of food – based on leaf fall, organic matter, and bugs; and a place to reproduce – well-flushed, oxygenated, gravels. Most importantly, all three of these things need to be available in close proximity to the fish. This can only happen in stream reaches that experience hydraulic complexity.”*

We hope this pilot study will encourage a broader documentation and open discussion of urban stream enhancement projects. Achieving the goals of the Clean Water and Endangered Species Acts throughout the Pacific Northwest will clearly require more successful approaches to urban stream enhancement than have been accomplished to date. To benefit from this broader experience, to move us all in the “right” direction, requires better documentation and understanding of successful LWM methodologies. To be truly beneficial, we then need to share that information.

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SECTION ONE

SUMMARY OVERVIEW

Thoughtful field monitoring to measure “project success,” followed by adaptive management – the systematic application of lessons learned – is fundamental to successful achievement of the Clean Water Act goals and the protection of endangered species (WRIA 8 Steering Committee, 2005). Surprisingly, documented applications of these approaches remain scarce. This study explores the application of the monitoring and adaptive management approach to enhancement projects on small urban streams (80 to 800-acre watersheds) in the Puget Sound lowlands of western Washington.

The series of studies reported here grew out of conversations with Daren Baysinger, Environmental Compliance Manager for the City of Redmond and Alan Johnson, Natural Systems Design, Seattle, Washington. Noting that Redmond had been conducting an urban stream *water quality* monitoring (including B-IBI) program since 1995, Baysinger was seeking to incorporate more *ecological analysis* into the City’s monitoring program. Since most Puget Sound urban stream enhancement projects include installation of large woody material (LWM), Johnson suggested that monitoring the ‘effectiveness’ of LWM installation might provide the type of ecological insight Baysinger was seeking. During this same time, Keith Macdonald was representing Redmond on the Technical Advisory Committee preparing the Lake Washington-Cedar-Sammamish Watershed Salmon Conservation Plan (WRIA 8 2005). His discussions with Committee representatives from several regional and local jurisdictions confirmed a strong interest and willingness to directly participate in a LWM study such as that proposed by Johnson.

As originally conceived, the LWM study consisted of three parts. In **Phase 1**, an informational survey would be sent to jurisdictions indicating an interest in the study. This survey was to identify the ‘universe’ of local LWM projects and assemble basic data such as project size, purpose, and installation history on each jurisdiction’s projects. Five to ten LWM projects, with varying goals and reflecting different watershed settings, would then be selected for detailed analysis. **Phase 2** was to develop a practical field monitoring/data collection protocol that could be applied to each selected project to assess the ‘effectiveness’ of the LWM installation. **Phase 3** would summarize the findings of the field monitoring, LWM installation lessons learned, and where appropriate, suggest strategies to further enhance the success of future LWM projects in urban streams.

Phase 1: City of Bellevue LWM Informational Survey

In September 2004, the City of Bellevue Utilities Environment Division conducted an informational survey on the use of LWM in local urban stream restoration projects. An electronic survey form requested general project information on the types of LWM projects undertaken, their construction methods, maintenance requirements, overall

success, and total project costs. Draft versions of the survey form were circulated among all interested parties and their suggestions incorporated. The survey forms were then e-mailed it to all jurisdictions that continued to express interest in the survey.

By the end of February 2005, despite several direct requests and follow-up, only one agency had responded to the information requests. **SECTION TWO** of this report summarizes the findings of this effort. Table 1 provides a bulleted list the key findings – and a list of recommendations to improve future project monitoring. The foremost conclusion of the survey was that while monitoring of LWM projects is generally enthusiastically called for and endorsed, it is not clear what or how LWM project data should be gathered, how it will be used, or how it would be retrieved once an agency has collected it.

As one participant noted, *“The bottom line remains that if we’re investing thousands – maybe millions – of dollars in LWM stream enhancement projects, we certainly need to be doing a much better job of monitoring their outcomes. Not to mention looking at their cost effectiveness!”*

Phase 1A: LWM Reference Materials

In addition to the survey data mentioned above, a compilation of reference materials focused on the form, function, and installation of LWM in small-forested stream systems was prepared. A bibliography of these materials is provided in **SECTION TWO**. A CD containing this information is included at the back of this report.

Phase 2: LWM Monitoring Methodology & Results

As the City of Redmond chose to fund the remainder of this study, the study focus narrowed to stream projects within the City of Redmond in which LWM was a key component. In August 2005, six Redmond Public Works/Natural Resources LWM stream projects across the City (a seventh project was added in August 2006) were field reviewed to:

- Document the use of LWM in each project.
- Provide examples of the range of effectiveness of LWM installations.
- Recommend guidelines for designing and constructing future LWM installations to increase their overall effectiveness.

Two major assumptions underlie this phase of the study. First, experience indicates that understanding the functions and processes operating in undisturbed natural systems provides the best template for habitat protection and enhancement (e.g., Spence et al. 1996; Riley 1998). Thus documenting LWM form and function in undisturbed small forested stream systems provides our best opportunity to enhance urban stream

Table 1. Collecting LWM Project Data

FINDINGS

- The survey forms were relatively simple to complete: Redmond staff spent a total of 12 hours documenting 13 stream projects involving LWM installation.
- The low response to the survey reflects a general low priority for completing the LWM project survey within the context of regularly scheduled workload.
- Most jurisdictions lack an established infrastructure to readily locate and summarize LWM project data. Locating pertinent information often involves searching through paper records held by individual project managers.
- LWM projects are often on time critical pathways tied to capital improvement project (CIP) budgets and schedules. The focus is on LWM project design and construction with little attention given to monitoring.
- When LWM work is part of a larger CIP project, it is often difficult to isolate real project costs. In-house and volunteer contributions are rarely accounted for.
- When LWM project data are required – even by permitting agencies – it is not clear what data should be collected nor how that data will be used once collected. Insights on the effectiveness of various designs, construction methods, materials, or project costs are not investigated.

RECOMMENDATIONS

- To be meaningful, management must make LWM project monitoring a priority within staff budgets, work plans, and schedules. Monitoring must include a timeline in which it is to be completed.
- Guidance should be provided on what to track and how to begin LWM project effectiveness monitoring. For example:
 1. What were the purpose and goals of the LWM project?
 2. What was done and why?
 3. How effective was the LWM project at meeting its goals?
 4. Is the project making a difference, and if so, to what?
 5. If identified as a project goal, did the LWM project result in improved instream habitat?
- A watershed plan can provide a framework for collecting LWM information and ensuring more reliable retrieval of the data.

restoration practice. Second, monitoring LWM project outcomes over time is our only objective way to learn how to improve design and installation methods. If projects reveal what Alan Johnson refers to as “*unexpected results*,” it provides a unique opportunity for us to learn how things might be done differently. It is with this perspective that staff of Redmond’s Natural Resources Division chose to share their personal project experiences with others.

Table 2. Redmond LWM Stream Enhancement Projects

FINDINGS

- The central role of LWM in maintaining stream stability and creating instream habitat is well established. As such, the addition of LWM is commonly required in federal, state, and local permits for projects that impact aquatic environments.
- LWM loadings and spatial distributions in undisturbed Pacific Northwest streams of similar size to Redmond's, provide the best "reference" for comparing habitat enhancement projects – for these are the natural conditions under which salmonids evolved.
- Seven Redmond stream restoration and enhancement projects (installed 1991-2004) were reviewed. All contained significantly less LWM than the "reference" systems (<25th percentile for wood volume).
- Most LWM was installed to provide bed and bank stability – which was reliably achieved on a majority of projects.
- *Largely due to a lack of hydraulic interaction*, little of the installed LWM directly created or maintained instream habitat. Instream cover was limited at all sites; small shallow pools provided little instream refuge; only half the sites had a balance of fast and slow moving water habitat.
- LWM was predominantly installed as single pieces. This limits instream hydraulic diversity and reduces the accumulation of small woody material needed for habitat complexity and cover.
- While LWM with attached rootwads was more common than in "reference" systems, it provided only limited instream habitat.

RECOMMENDATIONS

- More closely approximating LWM loading and spatial characteristics of the "reference" stream systems would improve stream bed, bank, *and habitat quality*.
- Install LWM to hydraulically interact over a much wider range of stream flows (e.g., minimum flow to 10-year flows). Increased hydraulic interaction will dissipate stream energy to provide additional pool formation, and cover by collecting small woody debris.
- Increase the amount of wood that provides instream cover. LWM installed with a majority of its volume above bankfull depth provides very little habitat value or energy dissipation during storm events.
- Rather than single pieces, LWM installed in accumulations of three or more pieces will increase instream hydraulic diversity, scour pools, and cover.
- Limit placement of rock in areas where the goal is to create habitat. Allow plunge pools to form on the downstream side of sill logs and the outside of bends.
- An objective monitoring/review protocol is essential for determining if project goals have been achieved.

A summary describing the general study approach, detailed methodology, study results, and conclusions for this second phase of the study is contained in **SECTION THREE**. The combined field survey data and available project background information were combined to generate individual summaries for each Redmond LWM project. These summaries include: project goals, tabulated LWM evaluation and habitat data, watershed/project maps, and an illustrated narrative summary that describes the role of LWM in the project and opportunities for project enhancement. Individual project summaries are included as *Appendices B through I*, at the back of *Section Three*.

Once the individual LWM project analyses were completed, Natural Systems Design prepared a summary that also included general guidance for enhancing LWM use in future projects. A bulleted summary of key findings from this second phase of the study is presented in Table 2, along with recommendations for enhancing future LWM stream projects.

Phase 3: Using LWM in Stream Projects — Are We Hitting the Mark?

As we moved through the review of Redmond’s stream enhancement projects, it became clear that useful and specific guidance for better project planning is limited. While literature descriptions of desired stream habitat features are common, there are few *visual examples* to illustrate these desired features. Perhaps the “under achievement” of some urban stream enhancement projects partly reflects this lack of examples illustrating the “desired results.” Specifically, what is good instream habitat? How will we know it when we see it? From a design perspective, are we sure we know where we’re going?

With these questions in mind, a document providing *visual examples* of various regional, instream habitats, both natural and constructed, was desired. The resulting document, entitled “*Using Large Woody Material in Stream Projects: Are We Hitting the Mark*” is included as **SECTION FOUR** of this report. While this final phase of Redmond’s study could be a ‘stand alone’ document – and we think it will prove useful to many stream restoration practitioners – Redmond staff believe that it gains greater meaning when presented in the context of the complete monitoring and adaptive management study.

The report addresses the issues of: What is instream habitat? How are complex habitats formed? What is a “successful” restoration project? Specifically, the illustrations included focus on:

- The complexity of natural streams and habitat features
- Constructed habitat features that *don’t* match the complexity of natural systems
- Constructed habitat features that *match* the desired complexity.

A summary of the ‘lessons learned,’ presented at the back of the report, is included here in Table 3.

Table 3. Installing Better LWM Projects

LESSONS LEARNED

- Instream habitat is not “one size fits all.” All aquatic species have adapted to a specific set of hydraulic conditions i.e., water depths and velocities. If those conditions do not exist, then habitat for that species does not exist.
- The focus for enhancement projects should be on stream hydraulics, not habitat. Most instream habitat elements are the by-product of hydraulics. If stream flows and structural elements – boulders, LWM, or installed structures – do not interact hydraulically, viable habitats will not be created nor maintained.
- The presence of LWM does not imply that habitat will automatically occur. Hydraulic interaction is required for structural elements to be successful in creating viable habitats.
- Many projects have not enhanced stream habitats. Projects that contain too little LWM, where the LWM is not adequately in contact with flows, or where the LWM are single pieces widely spaced along the stream channel, generate minimal hydraulic diversity and consequently provide minimal habitat benefits.
- Both large and small woody material play critical roles in creating ecologically functional stream habitats.
- Natural stream systems provide our best templates for designing stream enhancement projects. Structures that emulate natural stream conditions have the highest chance for success. Projects that fail to emulate natural stream functions and processes usually provide little significant habitat benefits.
- More creative and natural use of LWM can function to both stabilize stream banks and provide real habitat benefits. Change the focus to creating habitat projects that stabilize the bank rather than bank stabilization projects with some habitat.
- Projects will only succeed when the practitioner – when selecting and placing structures – incorporates an understanding of how the various structures will likely respond to different levels of flow.
- Without objective project monitoring or review, it is difficult to know which practices are effective in achieving restoration goals. A much higher priority is needed for gathering and disseminating data on stream restoration methods, and most importantly, the resulting outcomes.

The most important lesson here confirms the theme of Alan Johnson’s conversation early in the project and highlighted in the Preface – urban stream enhancement isn’t about installing something that “looks like fish habitat.” Rather it is about encouraging and shaping the hydraulic interactions between LWM and stream flows. This approach can reduce bed and bank erosion, helping to stabilize the stream channel and manage

potential sediment flux issues. Highly functional instream habitat is mostly generated as a “by-product” of the creation and enhancement of hydraulic complexity within the stream channel at various flows.

The goal is to move away from projects designed *principally* to stabilize stream beds and banks – instead develop *habitat projects* that also function to more naturally stabilize the channel bed and banks.

Moving Forward With Adaptive Management

The primary goal of this study was to identify procedures for designing and constructing LWM structures that achieve project goals while accounting for risk, cost, construction constraints, and geomorphic stream types. The significant lessons the City of Redmond learned from this study include:

1. The unexpected difficulty in retrieving records describing local stream projects that incorporated LWM. While monitoring LWM projects is generally enthusiastically called for and endorsed, it is not clear what or how LWM project data should be gathered, how it will be used, or how it would be retrieved once an agency has collected it.
2. To be effective, greater quantities of wood (both numbers of pieces and total wood volumes) are needed in Redmond’s projects. Multiple pieces of LWM should be installed in more diverse orientations relative to the active stream channel.
3. While most Redmond projects satisfactorily achieved bed and bank stability, our success at creating instream habitat was more limited. This “under achievement” is directly related to the inadequate hydraulic interaction between various stream flows and the LWM. Much of the wood in Redmond’s projects was installed parallel with, or set into, the channel banks where there was little opportunity for hydraulic interaction. Other LWM was installed too high on the channel banks, or too far from the actively-flowing channel, to allow frequent hydraulic interaction.
4. A very significant issue is the “risk aversion” of project designers, installers, and project management staff involved in enhancement projects. Keith Macdonald recalls advice received some years ago when he was planning the installation of LWM (in another jurisdiction): “*Be sure to install the LWM so that it doesn’t interfere with stream flows in any way. What about installing root wads in alcoves along the bank?*” Clearly there was concern about LWM slowing stream flows, causing backwater effects and increased flooding. Yet in this case, the site was an open floodplain set aside for habitat enhancement – much could have been done to add hydraulic and habitat complexity with only the smallest risk of any negative consequences. This issue deserves more aggressive research for it

presently appears that real stream enhancement opportunities might be missed based on *unrealistic fears* of LWM and stream flow interactions.

5. Because stream enhancement projects are often part of much larger CIP projects, they are often designed/installed by designers/contractors with minimal appropriate experience. Detailed project specifications and construction drawings are rarely adequate for stream enhancement work; last minute decisions inevitably depend on personal experience. Because of contract liability issues, Redmond's in-house staff often have little control over potential shortcomings in the installation process.
6. Finally – and perhaps the most striking – are the hugely beneficial insights that Redmond staff gained from instituting these relatively simple project review and monitoring procedures. This study strongly confirms that simple, repeatable field measurements can be used to gain considerable project insight with modest effort. The insights provided by such a review are essential for determining if a project has achieved its desired goals. Applying similar approaches to stream enhancement projects in other jurisdictions can only lead to substantial improvements in future regional urban stream restoration practice.

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May 3, 2005

To: Kit Paulson
City of Bellevue
FROM: Alan Johnson
Re: Results of Large Woody Material Informational Survey

BACKGROUND

In September 2004, the City of Bellevue contracted with Natural Systems Design for an informational survey on the use of large woody material (LWM) in local stream restoration projects. Staff in several local governmental agencies agreed to personally participate in the survey and to distribute the survey to other entities that constructed LWM projects. The survey requested general information on the types of projects, construction methods, maintenance requirements, overall success, and total cost of past LWM projects (Appendix A). This information was to provide insight for further investigation to develop specific guidelines for designing and constructing LWM projects. Participating agencies included the cities of Bellevue, Redmond, Seattle, and King County.

FINDINGS

A major and very surprising result of this survey was the nearly complete lack of response to the request for information. When the survey was initially discussed and developed, participants generally expressed considerable interest in the information that was to be collected. By the end of February 2005, following several direct requests and follow-up, only one participant had responded to the information requests.

Staff of the participating agencies were contacted for follow-up discussions to gain insight to the low completion rate. The first question explored was whether the data input forms were simply too long and complicated to complete. The form was developed to minimize the time required to

complete. Staff of the agencies involved in the study had initially reviewed the survey form; their comments and suggestions were incorporated into the form prior to initiating the survey. The sole participant completing the forms provided the requested information for 13 projects. When queried about the time commitment for this effort, they reported that the entire effort required approximately 12 hours divided among three people.

The discussions identified that the low response, as to be expected, was attributed to a variety of reasons. The reasons most cited were a low agency priority for completing the survey, difficulty in retrieving the data, and a difference in focus between construction and monitoring staff. A main contributor to the low completion rate appears to be the low priority of the survey within the context of the participants' regularly scheduled workload. While support for the concept was expressed, this type of project follow-up is generally not a scheduled or budgeted staff work item. If and when project follow-up happens, it occurs between other commitments. A common response was that because of busy schedules, holidays, and other job demands, this survey was a low priority among more pressing agency projects with time-critical pathways and budgets. It appears in general, this type of project follow-up and record keeping is not high priority in staff work plans. Therefore, the infrastructure is not established for staff to spend time locating the information and completing the survey for historical projects.

Given the recent emphasis on restoration of stream habitat, it seems a contradiction that project follow-up and evaluation is a low priority. The focus of many LWM projects, from the beginning, is on design and construction with little effort towards monitoring. These projects are often on time-critical pathways tied to capital improvement project (CIP) budgets and spending timelines. Completing CIPs is a high priority, especially for engineering staff; monitoring is often the responsibility of other staff. This often leads to discontinuities between project designs vs. construction vs. follow-up of project effectiveness.

A second surprising finding was that for projects containing restoration or habitat elements, most agencies lack a systematic data recording/retrieval process to obtain the information requested by the LWM survey. Reasons for difficulties in retrieving the data include:

- Project managers within the same agency often have different recordkeeping and archiving techniques with no central style or location for project information.
- LWM stream projects were often part of larger CIP projects. As such, the details of LWM are contained within construction and/or other group files. It can be challenging to access and identify the various cost components from information tracked and approved in different groups. It can be difficult to isolate indirect costs such as staff/equipment mobilization and site access when these costs are included in CIP project budgets rather than a separate LWM work component.
- It was difficult or impossible to retroactively retrieve the data. If the project information was not collected immediately at the conclusion of a project, it becomes very difficult to retrieve at a later date.
- It was unclear how to access historical information on past projects when there was no plan established to collect this information prior to construction. A project name or number and possibly a project manager's name may be required to locate the requested information. While recent project information may be computerized, most is not—finding the data then requires searching paper records. The success of a paper search often depends on contacting the best-qualified or long-term employee (e.g., project manager or other lead staff) and hoping they can recall details of the project. If the project manager or staff cannot be located, it rapidly becomes, as one respondent called it, a “painful” search as to who might have the records and where they might be.
- The reporting requirements for internal projects (i.e., departmental) are often different than those for contracted projects. While certain checklists are required for contracted work, the same work completed by agency crews may be exempt from the same reporting requirements. In other situations where internal and external reporting requirements are similar, the documentation requirements for internal projects are much less rigorous than those for contracted projects.
- LWM/stream enhancement and restoration projects frequently use volunteer help for tasks such as planting. The skill and role of volunteers or the source of vegetation for replanting can vary widely from project to project. For example, some projects may use salvaged on-site plant material versus purchasing established nursery stock. While the

plant list may read the same, there are large cost differences between the two approaches. This may skew the associated total project cost information.

- When project-monitoring data was required, it was unclear how permitting agencies use the data when it is collected and delivered. The focus of most monitoring is on required permit parameters that typically center on environmental effects. Insights on the effectiveness of various designs or construction methods, materials or project costs were not investigated.

The foremost conclusion of this initial survey was that while monitoring of LWM projects is generally enthusiastically called for and endorsed, it was not clear how the data would be used, how to gather it, or how to retrieve once an agency has it.

RECOMMENDATIONS

We offer the following recommendations to improve the monitoring associated with LWM use in stream restoration projects:

1. Management must make monitoring a priority within staff budget, work plans and timelines. Furthermore, this type of monitoring should include a designated timeline in which it is to be completed.
2. There should be guidance on what to track and how to begin effectiveness monitoring. This would include:
 - i. What were the purpose and goals of the project?
 - ii. What was done and why?
 - iii. How effective was the project?
 - iv. Is the project making a difference?
 - v. If a goal, did the project result in improved habitat for fish?
3. A watershed plan could serve as the basis for work plans to collect LWM information and ensure the retrieval of the data.

4. To broaden the understanding of all staff a glossary, guidance, and/or training could be used to help identify and collect critical information. For example: How many logs ordered? How many structures and what kinds? How do you count pieces of LWM (does a “W” weir count as a single log, or as 4 logs?) What is most important: the number of pieces or the number of structures?

Increasing the priority of monitoring within agencies, followed by improvements in data organization and retrieval is critical. As noted by one participant:

“The bottom line remains that if we're investing thousands—maybe millions—of dollars in LWM/stream enhancement projects, we certainly need to be doing a much better job of monitoring their outcomes. Not to mention looking at their cost effectiveness!”

APPENDIX A. Large woody material project survey form.

Large Woody Material (LWM) Project Review

Project Contact: _____ Phone: _____ E-mail: _____

Project Name: _____ Stream: _____ WRIA No.: _____

Project Sponsor: _____ When Was Project Constructed: _____

Project Cost: Total _____ Design _____ Construction _____

If only part of project, estimated costs for LWM: Design _____ Construction _____

Approximate Time to Complete: Design (including pen _____ Construction _____

Predominate Land Use Adjacent/Upstream of Project:

Forest Field/Pasture Agriculture Grass/Lawn

Commercial Industrial Residential

Watershed Area Upstream of Project (acre): _____ Estimated Percent Impervious A _____

Project Length (ft): _____ Average Channel Width (ft) in Project Area: _____

Channel Gradient (%): _____ Estimated Maximum Water Depth (ft) Since Project In: _____

Are stream flow data (e.g. summer base flow, bankfull [1.5 year], 10 yr, 100 yr) available Yes No

Is the project in a fish bearing str Yes No

If yes, fish species utilizing proje _____

Are project plans availat Yes No Are there post-project plans (as- Yes No

Was project constructed as design Yes No If not, why? _____

Has the project required any adjustments/rep Yes No If yes, briefly describe: _____

Is there pre-/post monitoring data for the pr No If yes, what Physical

Pre-Project Biological

Post Project Other

Are photos of the project available No If yes: Pre-Project Constructio Post Project

What were the objectives for the

Project: Primary: _____

Secondary: _____

LWM: Habitat Improve Bank/Bed Stabilit Flow Director Other

Primary Secondar Primary Secondar Primary Secondar

Number of Pieces of LWM Installed in Proje _____

Size of LWM (Approx. Range): Length (ft): _____ Diameter (i _____

Primary LWM Placement Me Machine Hand Combinator If machine placed, ho Excavator Helicopter Other

Method for Anchoring LWM

Primary:

Secondary:

The hydraulic interaction of the majority of the installed LWM with the stream is:

- Seldom (installed above most st
- Occasional (some interaction at moderate/high
- Frequent (interacts over wide rang
- Continuous (interacts at al

Overall, is the LWM fulfilling its design Yes No If no, desc

Is the LWM providing unintended habitat Yes No If yes, desc

Is the LWM creating unintended habitat Yes No If yes, desc

Is installed LWM stable (i.e. remained Yes No Installed)? Estimated percent of installed LWM

Generally, was LWM installed Non-deformable (i.e., does not move) Deformable (i.e., some movement) Combination

Overall, in general terms, the outcome/performance of the Very Satisfactory Somewhat Satisfactory Not Satisfactory

If less than satisfactory, what could have been done differently to increase

Any additional comments/information:

LARGE WOODY MATERIAL (LWM) IN SMALL FORESTED STREAM SYSTEMS

REFERENCE MATERIALS COMPILED BY

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NOVEMBER 2004

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