Washington State
Department of Transportation
Paula J. Hammond, P.E.
Secretary of Transportation

Transportation Building
310 Maple Park Avenue S.E.
P.O. Box 47300
Olympia, WA 98504-7300

360-705-7000
TTY: 1-800-833-6388
www.wsdot.wa.gov

August 9, 2010

TO: Kevin Dayton, Lorena Eng, Bart Gernhart, Julie Meredith, Keith Metcalf, Ron Paananen, Dan Sarles, Don Wagner, Don Whitehouse, Chris Christopher

FROM: J.C. Lenzi, Chief Engineer
Assistant Secretary of Engineering & Regional Operations
(360) 705-7032

SUBJECT: Project Delivery Memo #10-01, Geomorphic/Safety Guidance for the use of Large Woody Materials for Mitigation Applications in Bridge Scour Projects

Purpose and Direction

Background

To ensure proper design of Large Woody Material (LWM) structures and to address safety concerns associated with structures placed in water bodies, a steering committee was formed to look at use of LWM. The group completed a guidance document titled ***Geomorphic/Safety Guidance for the use of Large Woody Materials for Mitigation Applications in Bridge Scour Projects.*** This is the first of four large woody material guidance documents to be developed. Over the next year three additional documents will be completed. They are *Large Woody Material for Bank Stabilization*, *Large Woody Material for Low Energy Systems*, and *Large Woody Material & Safety for Engineered Log Jams*.

The purpose of this memo is to provide the technical guidance that will be followed by the agency when LWM is used in the vicinity of a bridge structure. This Guidance will be included in the Hydraulic Manual and will also be referenced in the Environmental Procedures Manual. The Geomorphic/Safety Guidance document will be presented in upcoming Project Development Engineer's monthly conference calls, the upcoming Project Engineers Conference and the Statewide Environmental Managers Meeting. It will also be incorporated into appropriate classes.

Types of Projects Affected: All bridge scour repair projects that include the installation of LWM in the vicinity of the bridge structure or bridge projects that require the use of LWM for mitigation.

Action Requested

Project Design
Projects that include the use of Large Woody Material (LWM) as mitigation for bridge scour repair will follow the guidance outlined in ***Geomorphic/Safety Guidance for the use of Large Woody Debris for Mitigation Applications in Bridge Scour Projects*** document dated **July *2010.***

Contract Ad and Award
For projects currently being advertised for bids, no changes will be required.

Construction
For projects currently under construction, no changes will be made.

Maintenance
Maintenance or repair of structures using Large Woody Material (LWM) in the vicinity of bridges will follow the guidance outlined in **Geomorphic/*Safety Guidance for the use of Large Woody Debris for Mitigation Applications in Bridge Scour Projects*** document dated **July 2010.**

Attachment: *Geomorphic/Safety Guidance for the use of Large Woody Debris for Mitigation Applications in Bridge Scour Projects*

Cc/att: Tom Baker
Jugesh Kapur
Megan White
Jeff Carpenter
Assistant State Design Engineers

Design Guidance Memo

Geomorphic/Safety Guidance for the use of Large Woody Material for Mitigation Applications in Bridge Scour Projects.

WSDOT

July 2010

Bridge scour repair is one of the most important preservation functions that WSDOT performs. These activities preserve the infrastructure, protect the public investment, ensure that the bridge functions properly for its design life, and protect the safety of the traveling public. In the simplest of terms bridge scour consists of the undermining of bridge piers, abutments and other structural components by the erosive forces of rivers. As a result, bridge scour repairs and scour countermeasures inherently involve in-water work.

Because of the vulnerability of bridge infrastructure, the incorporation of large woody material (LWM) into projects as either mitigation or functional project elements can be very challenging. Public safety concerns for recreational users also pose additional challenges to the proper utilization of LWM. This is particularly true with regard to bridges for three basic reasons.

1. Loading of LWM on bridge piers can place immense forces against the structure that can increase the likelihood of damage or failure. If a bridge is also experiencing scour problems, then these risks can mutually reinforce each others effects, dramatically increasing threat to the structure and the safety of the traveling public.
2. Bridges often present preexisting obstructions to flow such as piers, abutments, etc., that affect various aspects of flow and sediment dynamics including velocity, flow directions, and backwater effects.
3. Bridges are located at the intersection of highways and rivers often presenting the easiest way for the public to access river points such as boat ramps, fishing and swimming access, trails, etc. The public is naturally drawn to these highway/river interfaces, thus public safety concerns are heightened.

In order to ensure stability and safety of engineered log jams and other LWM structures, WSDOT has developed the following parameters for design and permitting of complex in-stream structures incorporating LWM. While their primary intent is as guidelines for siting and structure design they also help define parameters for permit conditions, and for carrying out due diligence with regard to public safety concerns expressed by some recreational river users.

General Guidance

Reach assessments are highly encouraged to identify preferred locations for LWM placement.

At minimum, the following locations and conditions should be discouraged or avoided:

- Channels that have a history and/or a near-future likelihood of material torrents and other mass wasting activity.
- Locations immediately above permanent culverts or bridges unless LWM is incorporated and designed as a protective project element.
- Locations within or under culverts or bridges.
- Confined channels where the valley floor width is less than twice the bankfull width
- Alluvial; streams with a gradient of more than 2 %
- Non-alluvial streams with a gradient of more than 4%
- Apex Bar log jams should not be constructed in proximity to bridges, particularly upstream of bridges.

LWM structures should be designed within the following parameters.

Design Life

Because LWM and ELJ structures are intended to function over a long project life, design flows equivalent to the 100-year recurrence flood are recommended.

Stability and Anchoring

Structures should be designed with limited flow-through characteristics by including an impermeable core to prevent "straining". Straining is a phenomenon by which swift water flowing through a LWM structure tends to draw floating objects toward and into it. The more dense the core of the structure the less this tends to occur.

Protrusion of LWM structures should not exceed 25 percent of the channel cross section.

In bank-based placements, at least 2/3 of the stem length shall be keyed into the bank to resist rotation, with adequate overburden and anchoring to overcome buoyancy and drag.

LWM structures are subjected to a combination of hydrodynamic, frictional and gravitational forces that act either on the LWM or on its anchors. The principle forces acting on the structure and its anchors are:

- Vertical buoyancy force acting on the LWM and transferred to its anchors.
- Horizontal fluid drag force acting on the LWM and transferred to the anchors
- Horizontal fluid drag force acting directly on the anchors.
- Vertical lift force acting directly on the anchors.
- Immersed weight of the anchor (if boulders are used as anchors).
- Frictional forces at the base of the anchor which resist sliding (if boulders are used as anchors) or being pulled out (if pilings are used as anchors).

Where possible, redundant anchoring systems should be used. Examples of this include combining pilings or anchors with bank overburden partially burying the LWM in the bank. Regardless of the type of anchoring systems used, woody material should be designed with safety factor of at least 2, where the safety factor is defined as the ratio of the resisting forces divided by the driving forces (itemized above).

There are numerous guidance documents dealing with the stability analysis equations for estimating these forces. A succinct description of applicable equations and their use can be found in Doust, S.G. and Millar, R.G, 1999. Large Woody Debris Fish Habitat Structure Performance and Ballasting Requirements.

Other useful guidance documents are listed in the Appendix A of this memorandum.

For waters known to be used by recreational boaters or swimmers:

- LWM structures should not be constructed in confined channels.
- LWM structures should be placed where there is good visibility of the structure from upstream.
- LWM structures should not be constructed in channels that do not allow for circumnavigation or locations such as gravel bars to allow landing to avoid the structures.
- Larger LWM structures should not be placed on the outside of a meander bend where the tortuosity of the bend is less than 3 ($Rc/W<3$), where R_C is the radius of curvature of the meander and W is the upstream channel top width.
- Larger LWM structures should not be constructed in close proximity to boat ramps

For Jurisdictional Floodways

Because of their size and strong hydraulic effects, large LWM structures (such as ELJ's) should not be placed in "Zero Rise" jurisdictional floodways in such a manner as to violate local floodplain ordinances. These floodways are chiefly located in urban areas. If it is not practicable to obtain variances from Zero Rise stipulations, smaller structures that have less backwater effect (such as log toes, crib walls etc.) should be considered in lieu of larger ones in these areas.

Appendix A: Design Guidance References

1983 Keller, E. A. and A. MacDonald. 1983. **Large Organic Debris and Anadramous Fish Habitat in the Coastal Redwood Environment: The Hydrologic System**. California Water Resources Center, University of California, Davis, Technical completion report.

1986 Lisle, T. E. 1986. **Effects of woody debris on anadramous salmonid habitat, Prince of Wales Island, southeast Alaska**. North American Journal of Fisheries Management 6: 538-550.

1990 Robison, E. G. and R. L. Beschta. 1990. **Characteristics of coarse woody debris for several coastal streams of southwest Alaska**. Can. J. Fish. Aquatic. Sci. 47: 1684-1693.

1992 Frissel, C.A. & Nawa, R.K. 1992. **Incidence and causes of physical failure of artificial habitat structures in streams of western Oregon and Washington**. North American Journal of Fisheries Management, vol. 12, pp. 182–97.

1995 Gippel, C.J. 1995. **Environmental hydraulics of large woody debris in streams and rivers**. Journal of Environmental Engineering, vol. 121, no. 5, pp. 338–95.

1995 Oregon. 1995. ***A Guide to placing large wood in streams***. Salem, OR: Oregon Dept. of Forestry

1995 Fetherston, L. K., R. L. Naiman, R. L. Bilby. 1995. **Large woody debris, physical process, and riparian forest development in montane river networks of the Pacific Northwest**. Geomorphology 13: 133-144.

1996 Booth, D.B., D.R. Montgomery, and J.Bethel. 1996. **Large woody debris in urban streams of the Pacific Northwest**: *in* Roesner, L.A., ed., Effects of watershed development and management on aquatic ecosystems: Engineering Foundation Conference, Proceedings,

1996 House, R. 1996. **An evaluation of stream restoration structures in a coastal Oregon stream 1981–1993**. North American Journal of Fisheries Management 16:272–281.

1997 Cederholm, C. J., R. E. Bilby, P. A. Bisson, T. W. Bumstead, B. R. Fransen, W. J. Scarlett, and J. W. Ward. 1997. **Response of juvenile coho salmon and steelhead to placement of large woody debris in a coastal Washington stream**. North American Journal of F

1998 Hilderbrand, R. H., A. D. Lindy, C. A. Dolloff and K. L. Harpster. 1998. **Design considerations for large woody debris placement in stream enhancement projects**. North American Journal of Fisheries Management. 18(1): 161-167.

1999 Doust,S.G., Millar, R.G, 1999. **Large Woody Debris Fish Habitat Structure Performance and Ballasting Requirements,** Watershed restoration management Report No. 8 Department of Civil Engineering, The University of British Columbia

1999 Drury, T., Petroff, C., Abbe, T B, Montgomery, D. R., and Pess, G. R., **Evaluation of engineered log jams as a soft bank stabilization technique: North Fork Stillaguamish River, Washington**, Proceedings of the ASCE conference on Stream Restora-

tion, 1999.

1999 Perkins, S.J. 1999. **Geomorphic feasibility report for large woody debris placement in the middle Green River, Washington**. Prepared for Jones & Stokes Associates, Inc. and U.S. Army Corps of Engineers, Seattle District. Perkins Geosciences, Seattle, WA. 29

2001 Shields, F. D., Jr., Morin, N. and Cooper, C. M. 2001. **Design of large woody debris structures for channel rehabilitation.** In U. S. Subcommittee on Sedimentation. Proceedings of the Federal Interagency Sedimentation Conferences, 1947 to 2001, Seventh Con

2001 Brooks, A. P. and Abbe, T. B. and Jansen, J. D. and Taylor, M. and Gippel, C. J. 2001. **Putting the wood back into our rivers: an experiment in river rehabilitation**. In, Rutherfurd, I. and Sheldon, F. and Brierley, G. and Kenyon, C., Eds. Third Australian

2001 Castro, J. & Sampson, R. 2001. **Incorporation of large wood into engineering structures**. Natural Resource Conservation Service Engineering Technical Note no. 15, U.S. Department of Agriculture, Boise, ID, 14 pp.

2002 Tim B. Abbe and David R. Montgomery. 2002. **Patterns and processes of wood debris accumulation in the Queets river basin, Washington**. Department of Earth and Space Sciences, University of Washington, Seattle, WA 98195, USA

2003 Washington State Department of Fish and Wildlife. 2003. **Integrated Streambank Protection Guidelines**. Aquatic Habitat Guidelines Program. P. 6-31-6-38.

2003 Shields, F. D., Jr. 2003. **Large Wood as a Restoration Tool: I Fought the Law and the Law Won**. Proceedings of the Streams Channel Protection and Restoration Conference, 2003. P. 35-39.

2003 John M. Faustini, Julia A. Jones. 2003. **Influence of large woody debris on channel morphology and dynamics in steep, boulder-rich mountain streams, western Cascades, Oregon**. Geomorphology 51 (2003) 187–205

2004 Saldi-Caromile, K., K. Bates, P. Skidmore, J. Barenti, D. Pineo. 2004. **Stream Habitat Restoration Guidelines: Final Draft**. Co-published by the Washington Departments of Fish and Wildlife and Ecology and the U.S. Fish and Wildlife Service. Olympia, Washing

2006 Abbe, T. (Herrera Environmental Consultants, Inc.), 2006. **Conceptual Design Guidelines: Application of Engineered Logjams**. Prepared for Scottish Environmental Protection Agency, Galashiels, United Kingdom