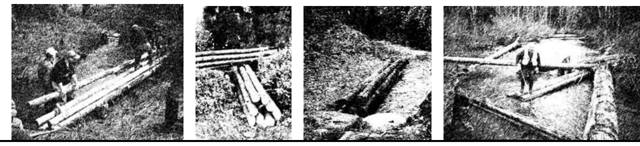
ELWd Systems

division of *Forest Concepts, LLC*



Innovative Wood Materials for Habitat Enhancement and Watershed Restoration

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Technical Background

ELWd® Engineered Woody Debris Jam Structures for Small Rivers and Streams

"Removing Barriers to Installing Large Functional LWD by Volunteer and Conservation Crews"

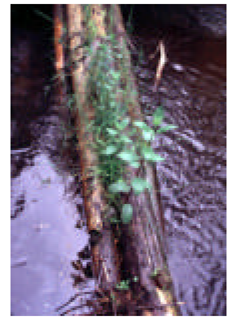
(rev.) December 18, 2001

Depletion and loss of functional large woody debris from streams and rivers of the Pacific Northwest is identified as a contributor to the decline in salmonid populations. Salmon, bull trout, steelhead and other fish are dependent on large woody debris (LWD) and channel morphology resulting from the presence of LWD for many of their in-stream habitat needs. LWD provides cover and shelter from predators, stimulates the formation of pools and calm waters, and aids in gravel sorting to provide spawning beds. Historic LWD density in the coastal streams of the Pacific Northwest is approximately one functional LWD key piece per channel width and one wood complex per 7-10 channel widths. Natural restoration of in stream wood abundance will take decades or centuries in highly degraded systems, particularly those that are just now receiving riparian zone plantings. An ecological engineering approach that is being widely practiced is to import and place functional LWD in streams as a bridging solution. Placed LWD provides habitat, hydraulic and geomorphic benefits in the short term until natural delivery occurs due to channel migration, tree death and wind throw. It is expected that placed LWD will decay to provide fine organic matter and otherwise blend into the natural environment as riparian protection and silvicultural solutions begin to take hold. Unfortunately, functional LWD is difficult to procure in the quantities required, and is very expensive to transport and place due to its weight. The object of this paper is to introduce an engineered log jam structure that is easy to transport and install by citizen volunteer and conservation crews.

A citizen volunteer crew installed this engineered log jam in the North Fork Newaukum Creek near Enumclaw, WA on June 25, 2001.

The photograph at left was taken on December 15, 2001 during a high water event. Water flowing over the first pole scours a pool under the structure. Water flowing past the angled downstream pole is redirected away from the bank toward midstream.

ELWd® Structures



ELWd® (pronounced "el-wood") structures are designed according to the Appreciative Design method (Dooley and Fridley 1996) to accommodate readily available wood materials, low-tech manufacturing methods, and work-crew-based installation. The launch-product in 1998 was a large hollow log structure that replicates the form and function of native remnant large woody debris (Dooley et al. 2000). Recent ELWd® structure products include stump and nurse log replacements for wetland and lake margin restoration. The newest ELWd® products are a series of engineered woody debris jams uniquely scaled for streams with 10 – 60 feet bank-full width.

Technical features of all ELWd® structures include a high organic surface area, structural integrity in an all round-wood product, and size proportional to channel width and flow depth. ELWd® structures have been installed to provide a number of different functionalities including: scour pool formation, complex cover features, bank protection, flow routing, sediment storage and high flow refuge. ELWd® structures are now proven to be an effective alternative to solid LWD that enables volunteer and conservation crews to install large amounts of functional LWD with only hand tools.

ELWd® structures were developed by the ELWd Systems division of Forest Concepts, LLC. ELWd Systems is a Washington company whose founders emphasize the development of new products from small diameter timber for use in habitat enhancement and watershed restoration. Manufacture of engineered LWD provides new markets for forest landowners, supports silvicultural and forest health thinning programs, and provides jobs for rural and timber-dependent communities. More information on engineered LWD and project reports are on the Company web site www.elwdsystems.com .

DESIGN OF ENGINEERED WOOD DEBRIS JAMS

Background

Abbe, et. al. (1993) found that most large woody debris accumulations, or log jams, could be characterized as one of three types. Bar apex jams tend to be associated with a single key member that is oriented with the flow and having the root-wad upstream (Abbe and Montgomery 1996). Apex jams accumulate woody and fine debris around the root wad, thus locally slowing the current and resulting in gravel and sand deposit along the key member. A gravel bar is formed over time, burying the bole of the key member and further anchoring the accumulation. Bar apex jams result in formation of a crescent pool upstream of the jam and a deposition island along and downstream of the key member. Over time, stable apex jams lead to formation of vegetated islands.

Bar top jams form from the deposit of large woody debris on top of an existing gravel bar as flood flows ebb (Abbe and Montgomery 1996). In subsequent lower flood flows, additional large woody and fine organic debris accumulate giving rise to an organic island.

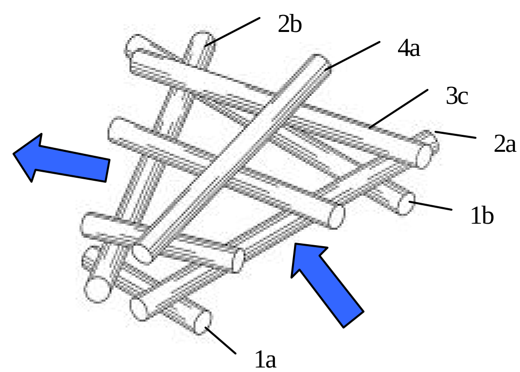
Meander jams (Abbe and Montgomery 1996) form on the upstream end of point bars on the inside of meanders through flood deposition of multiple key members and subsequent accumulation of additional wood that racks up on the key members. As the channel migrates, meander jams form hard points along the bank thus reducing bank erosion. Abbe notes that the key members in meander jams tend to be aligned parallel with the flow of the channel.

Slaney, Finnigan and Millar (1997) refined methods for constructing boulder and log-jam complexes in rivers of British Columbia. Their lateral log jams provide armor for eroding banks, trigger formation of scour pools, and provide complex cover for fish. The Slaney jams are typically constructed from large logs, root wads and boulders with the aid of heavy lifting machinery. The jams are generally solid against the flow much in the nature of rock barb deflectors (The Federal Interagency Stream Restoration Working Group 1998), bendway weirs (Evans and Kinney 2000), and similar structures. A variation on the structure acts to collect woody debris flowing in the channel such that a larger debris complex forms over time.

The ELWd® Conceptual Solutions

ELWd® structures are intended to work in concert with other riparian and channel interventions to jump-start habitat and water quality improvements. ELWd® structures provide a bridging solution that has immediate positive impact, yet decays into the natural environment as other long-term components of the enhancement and protection effort begin to function.

Concept ELWd® structures were designed to capitalize on the insights of Abbe, Slaney and others. The structure shown is not simply a stack of crossing logs but is engineered on sound hydraulic principles. It is known that water crossing a log or similar object will flow away from the log at right angles to the longitudinal axis of the log, regardless of the angle of incidence of the water. It is also known that sediments and gravels will accumulate in the lee of flow obstructions. These principles are used advantageously to direct stream flow within and around the ELWd® lateral jam structure shown at right and apex jam below right.



We will use the sketch at the right to explain the hydraulic principles. With the stream flow moving from the lower right toward the upper left, and the bank on the right, one can visualize some features of flow management. Two base poles (1a, 1b) are oriented parallel with the flow. One pole (1b) is fairly long along the bank to provide a stable base and act as a toe log to protect the bank from scour. Another short pole (1a) is located mid-channel as a base and keel for upper layers of the structure. The bank log (1b) is typically anchored to the bank with hand-driven cable anchors. The bank log defines the channel edge. Neither base pole is intended to provide hydraulic function.

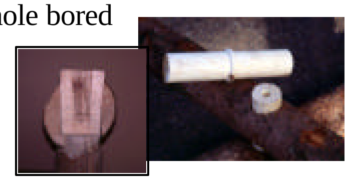
The second layer of poles (2a, 2b) is situated to trigger a plunge pool under the structure and route exit flow back toward the channel center. At very low flows, the entire current flows under poles 2a and 2b. This maximizes fish passage and provides quiet water in the pool that forms under the structure in higher flows. As the flow depth increases, water strikes the 2a pole and is driven downward under the structure. Increasing depth that overflows the 2a pole will create a turbulent zone under the structure digging a substantial plunge pool. As the flow exits the structure it passes across the 2b pole where it is redirected to the left and away from the bank. This redirection of the flow helps reduce the risk of a whirlpool forming below the structure that might erode the bank. It is important to note that we encourage substantial flow through the structure rather than forcing the water around it as would be the case with a rock barb or flow deflector. The third layer (3a, 3b, 3c) (with only 3c identified) act as vanes in extreme flows to help reduce turbulence around the jam. The third layer typically only includes two poles, but a third one may be added as shown to wider structures. In most cases the fourth layer provides ballast only.

A typical ELWd® lateral jam structure would include a total of four or five layers, each with a carefully determined hydraulic role. The photo at right also shows a set of jackstraw poles that are loosely stuck through the structure to increase complexity and provide strainers for floating woody debris. The prototype structure is scaled for a stream with approximately 30 foot bank-full width and three feet bank-full depth.

We expect a scour pool to form under the structure. Further, we expect a gravel deposition zone to occur downstream of the bank toe log and around the keel pole. A gravel deposition zone may form upstream of the structure if it sufficiently blocks the channel to back up a pool of water. It will be important to monitor installations to validate or dispute the scour and deposition assumptions.

Structural Materials

ELWd® debris jam structures are all wood. There are three structural components – poles, spars, and wedges. Poles are scaled to the stream being improved, and to sizes that can be handled by an installation crew. Wooden connectors that we call "spars" are used to pin crossing poles together. While our normal ELWd® hollow log structures use spars with a long barrel section, spars used in debris jams have only a locating ring separating the two tenon sections.



Spars provide an all-wood structural connector between crossing poles. The hole bored through each pole is tapered so that a solid mortise and tenon joint is created as a wedge is driven into each end of a connecting spar. Round wooden mortise and tenon joints enable the structure to flex and adjust to hydraulic loads as well as changes in streambed form.

In most installations, an ELWd® debris jam structure can be designed to be self-ballasting, and located to take advantage of natural current breaks. The photo at right shows a structure that is ten feet wide and approximately three feet tall. The top pole primarily provides additional weight to the structure. The design allows additional materials to be placed on the structure as ballast, potentially including one or more conventional ELWd® structures. A conventional twelve foot ELWd® structure filled with ballast cobble would add at least 1,000 pounds of weight to the debris jam. Yet, the entire structure can still be assembled and installed by hand crews.

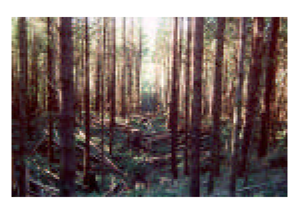
If anchoring is required by regulatory authorities or designers, only the bank toe pole needs to be anchored in most instances. The bank toe pole most likely would be tied to the bank with 2-4 drive anchors such as the Duckbill™ No. 88 or MantaRay™ anchors from EarthAnchor Company. By anchoring only the bank pole, the rest of the structure is free to flex or even float up in extreme events. Such movement is typical of natural debris jams that are keyed to remnant logs or standing trees on a stream bank.

Over a period of many years, an ELWd® debris jam structure will lose strength due to natural decay of the poles and connectors. However, during its functional life a structure will accumulate additional woody material from the stream and knit into a relatively stable and long-lived debris jam. In the event of a major flood or at the end-of-life for the structure the remnant pieces will become part of the small organic debris flux in the watershed system. Round wood components ensure that any debris blends with other organic debris in the system.

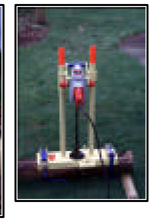
ELWd® Manufacturing and Installation Advantages

ELWd® structures use small-diameter timber poles to manufacture large functional habitat and watershed restoration structures. Structure properties are easily scaled for streams from 10 – 60 feet bank-full width. The smallest structures are manufactured from poles approximately four inches in diameter. Large structures are manufactured from poles five to eight inches in diameter. All components are designed to be transported and installed by hand crews comprised of conservation workers or citizen-volunteers.

ELWd® woody debris jam structures typically include eight to twelve poles.



- ELWd® pole material is readily available from forest thinning projects. The required diameter is common in early commercial thinning of managed forests and from fuel reduction thinnings.

- Once poles are cut to length, they can be drilled and made into kit form by hand crews using lightweight power tools. A typical in-field production crew is 4-5 persons. The minimum production crew is two persons.

- ELWd® structure kits are delivered to project sites via self-loading log trucks. Kits are staged at the project site for assembly and installation by hand crews. Assembly crews can typically assemble ELWd® structures with only small sledges and pry bars.

It is possible for the same crew to do the logging, kit manufacture and installation – particularly if they are experienced in timber and natural resource work. Our experience has been to manufacture the kits at or near the wood source. However, all pole work can be done at the project site if space is available.

Conclusions

During the summer of 2001, the first four engineered log jams from ELWd Systems were installed in the North Fork of Newaukum Creek near Enumclaw, WA. Manufacturing was accomplished by hand crews with low-tech equipment. A crew of citizen volunteers was able to carry the components from a staging area to the stream and assemble several ELWd® structures in just a few hours. The summer experience confirms the viability of our design for ease of manufacture and installation.

The fall rain season has produced rainfall at least fifty percent above normal, and a number of rain-on-snow events. To-date the engineered log jams have performed exactly as expected. Flow through the structures is as anticipated. Scour and deposition of gravel is dramatically improving what was previously a plane bed channel. Fine organic debris is accumulating on the structures, thus delaying its movement through the system.

Long term performance and structural life will be determined over the next several years. However, ELWd® structures with similar sized poles and all-wood joinery have successfully performed in Western Washington streams since 1998.

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