

Watershed Restoration Technical Bulletin

Streamline

Vol. 6 No. 4

Editor's Notes:

This issue of Streamline, sadly, is scheduled to be the final one. I would therefore like to take this opportunity to thank all of you Streamline readers for your support, and for your ideas and words of encouragement during the five years that I've been editor of Streamline. (I am including one such letter below, as the Perspectives column for this issue.) I would also like to thank the contributors, who worked really hard to bring up-to-date articles, technical tips, and perspectives to Streamline readers. I very much enjoyed meeting some of you, and working long hours via e-mail with many others. I have greatly appreciated the continuing support of Pat Slaney, Heather Deal and Diana McPhail. Diana McPhail has created the look of Streamline since it began. I would also like to acknowledge Wendy Porter, who has helped me with some of the editing, and answered complicated grammatical questions through the years. Although the Watershed Restoration Program is no longer in existence, the work that has been accomplished in the streams and rivers of B.C. and on the ground will live on. So will the past years' publications, including Streamline, that will be invaluable references in future training and work in watershed management.

I am currently exploring the possibility of a public-private partnership to allow the continued publication of Streamline. Although the Watershed Restoration Program ceases to exist, there will be new initiatives to come in our province, some as part of The Living River Program. Many people will continue to work in watershed management throughout the province, including licensees, First Nations and stewardship groups. There is still a need for "gray" literature: short technical articles, features and case studies; and also for a forum to bounce ideas or perspectives on regulations, procedures and equipment, a convenient vehicle to announce courses, critique books, and link together professionals with technical staff and operators around the province. Some articles from Streamline have subsequently been developed for submission to scientific journals. As more stewardship groups are taking on interesting projects within stream management, these groups have valuable messages to share with one and other. This is a niche that Streamline has filled for people in B.C., and also in the Pacific Northwest. At this time we are asking you to respond by e-mail if you would be interested in continuing to receive Streamline. The bulletin we propose will not be exactly the same format that you are used to. There are opportunities to broaden focus from solely watershed restoration, expanding the subject matter and directions of interest and benefit to our readership. Perhaps there can be a more international base of authors, perhaps it will have advertising, and almost certainly it will have a subscription charge. As the role of corporations, particularly licensees, becomes more critical in watershed management, we would encourage and welcome corporate partnerships. With the continued support of our loyal readership and contributors,

we believe it will be possible to continue to produce a technical bulletin.

Please contact: streamline@axion.net with your e-mail address and full mailing address if you are interested in:

- continuing to receive Streamline
- hearing from us about our efforts to develop a Streamline partnership to continue publishing
- advertising in future issues
- discussing or proposing partnership possibilities
- suggesting new topics or directions for possible future issues

Please note that it will take some time to organize a partnership project to continue the Streamline technical bulletin, so it may be a few months before I am able to respond to all of you. Those of you that are moving or changing addresses or jobs, please advise me so that I can update the mailing list.

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Spring 2002

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Update

Editor's Note

I am always impressed with readers' astute reading of *Streamline*. In the feature article: Forest Management and Restoration on Fans, by Dave Wilford, Matt Sakals, and John Innes, in *Streamline* Vol. 6 No. 3, the table headings: "Broadcasting of sediments...." and "Channel entrenchment....." have been reversed in Figure 13. Please make a note of this in your copy.

The authors of: Murder Creek: Instream Works to Improve Fish Spawning and Rearing Habitat (*Streamline* Vol. 6, No. 3) would like to acknowledge A. Hampshire, PEng, of the McElhanney Terrace office for the contributions he made on this project. ▲

Perspective

March 12, 2002

Dear British Columbia Watershed Restoration Colleagues:

After reading the most recent issue of *Streamline* (Vol. 6, #3), I notice the posting that the publication of *Streamline* will become another victim of the provincial financial belt-tightening and subsequent cutbacks.

In my opinion, this publication has served its mission in gold medal fashion, communicating information on practical approaches for watershed restoration from forest ridge-tops to riparian corridors to river valley bottoms. It has served as an effective bridging tool linking the province together, communicating with researchers, scientists, consultants, contractors, and non-governmental organizations. The quality and quantity of the subject material covered by this publication has been truly noteworthy. The commitment by the Ministry of Forests and the Ministries of Sustainable Resource Management and Water, Land & Air Protection to publish *Streamline* needs to be commended. And all the watershed restoration practitioners who took the time to document their restoration endeavors for publication in this bulletin need special recognition.

I would like to express my sincere gratitude and pleasure in being part of the watershed restoration information exchange and technology sharing that has occurred between the Province of British Columbia and the Pacific Northwest Region of the United States Forest Service. The exchange of ideas and information sharing through conferences, workshops, and field trips over the past 5-7 years has contributed significantly to moving watershed restoration from an art form to a natural resource science-based field. And the publication of *Streamline* has been one of the primary tools used to communicate this new field of science within the province and along the West Coast of the United States.

Watershed restoration is now more than a political buzz term or catchy cocktail phrase; it has become a legitimate field in watershed management and restoration ecology. Over time, administration and political changes in governments in both the United States and Canada will swing from pro-environment to anti-environment emphasis, but achievable and effective watershed restoration programs have a place in either environment. Watershed restoration in British Columbia and in the Pacific Northwest is proving to be an important component to protecting, maintaining, and restoring resource values and natural processes in our watersheds.

Effective watershed restoration as measured by salmonid habitat recovery will take years, and in some cases a couple of decades, so watershed restoration needs to be viable as a program over time and avoid being a political or administration change casualty.

In my opinion, one of the ways for watershed restoration to remain visible and viable in British Columbia is ensure that *Streamline* continues to be a communication tool. Keep this publication going, it is worth its weight in gold. ▲

Sincerely,

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Evaluating the Performance of Channel and Fish Habitat Restoration Projects in British Columbia's Watershed Restoration Program

Andrew Wilson, Pat Slaney and Heather Deal

In 2000 and 2001, a performance evaluation was undertaken on a subset of aquatic Watershed Restoration Program projects completed between 1995 and 2000. The objectives of the evaluation were to:

1. determine the broad-scale success of instream, off-channel and fish access rehabilitation projects,
2. identify problem areas in aquatic restoration that require follow-up training or clarification, and
3. to provide a status report on the overall performance of aquatic restoration investments.

Aquatic restoration efforts must be effective and durable to achieve aquatic sustainability. Monitoring the performance of fish habitat rehabilitation is instructive in identifying which methods are most effective. D'Aoust and Millar (1999) reviewed six studies of instream structure durability, including Higgins and Forsgren (1986), Doyle (1991), Frissell and Nawa (1992), Metzger (1997), Roper et al. (1998) and Hartman and Miles (1995). Performance "success" varied from about 40 % (Frissell and Nawa 1992) to 86 % (Metzger 1997). The most extensive study was on seven National Forests in Oregon and Washington following 50 to 100-year winter floods of 1996 (Roper et al. 1998). On average, post-flood performance was high, with only 16 % of structures leaving sites of original placement and 75% were functioning as planned. Greater operational experience with design and construction appeared to contribute to higher success rates. However, in British Columbia similar documentation is not available on the performance of projects designed to restore fish access and off-channel areas, and there is no recent examination of current stream restoration technology. Furthermore, with the recent demise of both Forest Renewal BC and the Watershed Restoration Program, the performance evaluation provides a key wrap-up of the program and documents the legacy of the work completed.

A total of 53 instream, 32 off-channel and 18 fish access rehabilitation projects were evaluated over 2000 and 2001. Projects were selected from each of the Ministry of Water Land and Air Protection regions and represented the diversity of biogeoclimatic zones that have been worked on over the life of the Watershed Restoration Program. Evaluators were a combination of headquarters staff, regional staff and consultants. To avoid bias during data collection, the evaluation team only reviewed projects with which they had no direct involvement. Project implementers often accompanied the evaluation team on site, but their role was to provide input on the project background and objectives. Data was collected on a site-by-site basis from all restoration projects, using standardized evaluation forms. Structures and sites were evaluated qualitatively using a four-point scale (allowing for half mark increments) to determine how well site-level objectives were being achieved over the short (5-year) and long (20-year) term.

Overall, the results of the performance evaluation indicate that the Watershed Restoration Program has been very successful (Figure 1) at achieving site-level restoration objectives. Fish access restoration had the highest level of success, with 94% of projects evaluated meeting or exceeding objectives as compared with instream (81%) and off-channel (92%) projects. While the success levels were high for all three components evaluated, room for improvement for each was identified.

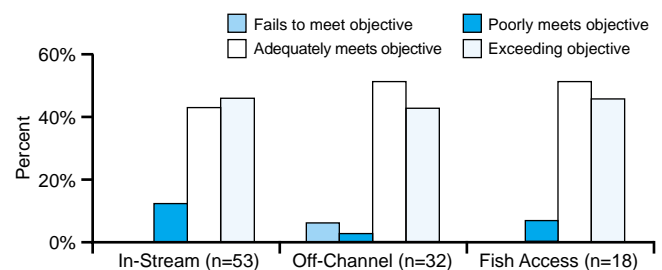


Figure 1. Overall success of in-stream, off-channel and fish-access restoration projects.

Feature

Fish Access

Three types of fish access restoration were evaluated: bridge replacement (3), culvert replacement (4), and access modification (11). Regardless of the type of fish access work, restoration success was high (Figure 2). The only project type that showed shortcomings was fish access modification. Factors affecting restoration success of fish access modification projects included use of undersized boulder material along outlet weirs and insufficient depth in outlet pools to facilitate fish passage.

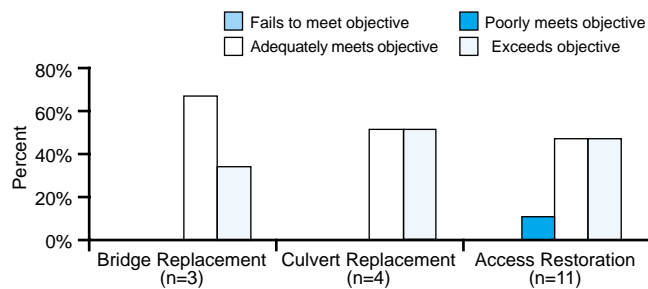


Figure 2. Overall performance of fish access modification projects broken out by type.

Because of the overall high level of success with fish access modification projects, few lessons can be learned that will improve delivery. The high level of success and extent of habitat made available for target fish species make this restoration component a very valuable tool for addressing aquatic sustainability issues. Further studies such as that of Parker (1999) examine the most appropriate method of constructing outlet weirs to aid in overcoming any potential shortfalls associated with fish access modification projects.

The off-channel performance evaluation considered both surface-fed (14) and groundwater fed (18) off-channel projects. As with fish access restoration, overall success was very high regardless of off-channel type (Figure 3). However, project failures were identified in both categories.

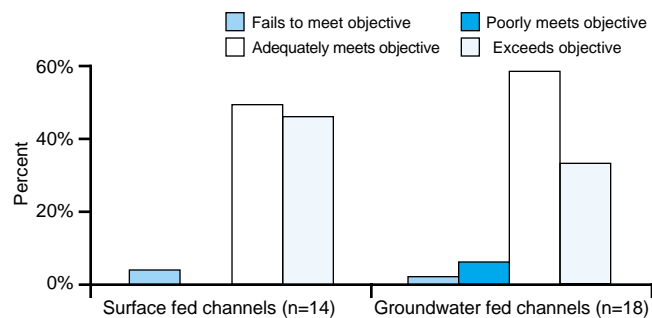


Figure 3. Overall success of side-channel projects broken out by channel type.

Failures associated with off-channel projects were either a result of intake problems (in the case of surface-fed channels), channel dewatering or channel isolation. Due to the nature of operation, surface-fed channels require routine maintenance to ensure debris does not foul intakes, and to excavate settling ponds or other sediment traps. In one occasion this routine maintenance was insufficient to prevent failure of the channel intake, leading to erosion and project failure. In other cases, large-scale flood events isolated side-channels as the mainstem river channel degraded.

Routine maintenance will continue to be an issue with side-channel projects. A lesson to be learned from this component of the performance evaluation is that long-term funding must be identified and secured to provide annual monitoring and periodic routine maintenance of these projects. Considerable investment has been made across the province to construct stable side-channel habitat, and the contribution they make to overall smolt output in salmon streams has been documented repeatedly (e.g. Cleary 2001, Decker and Foy 1998). This benefit far outweighs the cost of an annual inspection and maintenance program and must be acted on by government in combination with stakeholder groups active in watershed restoration and protection.

The division between those off-channel projects adequately meeting restoration objectives versus those exceeding objectives was due to issues of finishing quality. Some projects appeared to have been built to specification, without thorough consideration for the life history or habitat requirements of the target fish species. Projects that exceeded objectives tended to have emphasized secondary habitat features associated with juvenile rearing. This included placement of loose rip rap toes along the margins of side channels, aggressive planting and seeding of channel banks, and the placement of quality large woody debris in key habitat areas such as deep pools. The potential benefit of the secondary habitat features on smolt output was not determined but could be considerable given the low incremental cost of adding these features to side channel habitats.

As off-channel projects mature and fully revegetate, additional maintenance may be required to manage beaver colonization. While there was little evidence of colonization or damage resulting from beavers at the time of this evaluation, it may change over time. To counter these concerns, novel approaches for low maintenance beaver management such as those presented by Finnigan and Slaney (2002) will need to be employed.

Instream

When considered at the project level, instream restoration was found to be highly successful, with no projects failing to address restoration objectives and only 13% poorly addressing objectives (Figure 1). However when considered at the site level, the results indicate that across all projects, 19% of sites poorly met or failed to meet objectives over the short-term (5-year) and this increased to 32% when performance was projected over a longer (20-year) period (Figure 4).

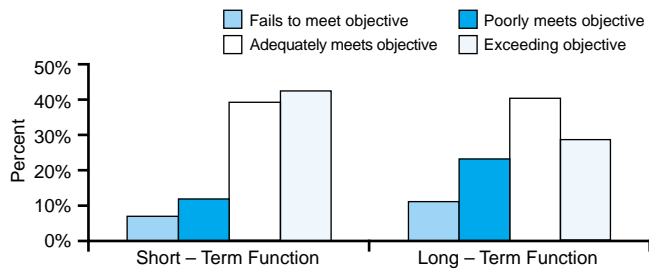


Figure 4. Function of in-stream structures over short (5-year) and long (20-year) time frames (n=552).

The decreased performance of instream restoration structures over longer time periods is a cause for concern for watershed restoration planners and practitioners. Instream restoration structures are installed with the objective that they will provide habitat or channel structure benefits for at least a 20-year period (Slaney and Martin 1997) following installation. However, this target is not being met given the results of this performance evaluation.

Several independent variables were analyzed to determine what factors might be responsible for decreasing the projected long-term performance of instream restoration structures. Previous studies (e.g. Roper et al. 1998) identified flood flows, structure location in the channel and watershed magnitude as key variables affecting the success of instream watershed restoration efforts. Findings for the Watershed Restoration Program for instream structures followed a similar pattern, although there were some differences.

Instream structure performance was found to vary by structure type. Habitat structures that tended to have a higher percentage of success included boulder clusters and lateral large woody debris jams. Structures that tended to have lower success included sill logs and pool-riffle reconstruction (Figure 5). Full channel spanning structures tended to perform less well than either laterally placed structures or structures placed in the channel as observed in the USDA Forest Service studies (Figure 6). This finding was partly due to the improper placement of full spanning structures or installation in watersheds or reaches with unfavourable

geomorphic conditions (e.g. unconsolidated streambanks). Issues with riffle-pool reconstruction included in-filling of pools with bedload sediment, outflanking and displacement of riffle crests.

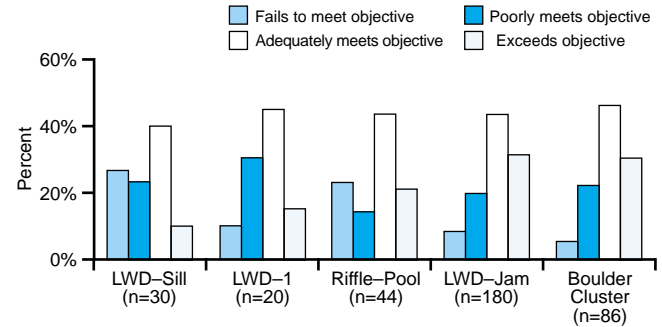


Figure 5. Long-term (20-year) function of in-stream, restoration projects broken out by structure type.

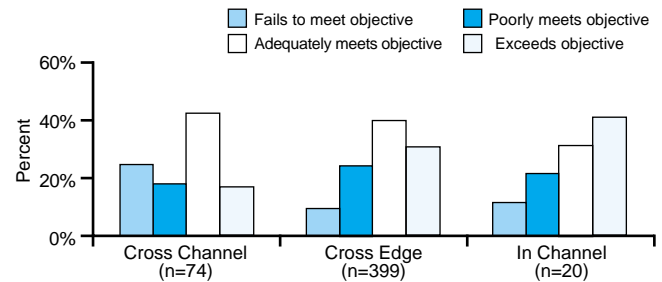


Figure 6. Long-term (20-year) function of in-stream, restoration projects broken out by channel placement.

Post-construction flood history greatly influenced structure performance. The majority of watersheds that the Watershed Restoration Program has been actively involved with have not been subjected to large-scale (e.g. greater than 20-year return period) post-construction floods. In those incidences where very large magnitude floods have occurred, structure performance was observed to be poor (Figure 7). This finding parallels that of studies conducted throughout the Pacific Northwest following regional flooding in the mid-1990s (Roper et al. 1998). While the percentage of structures failing to achieve site objectives was high for those watersheds experiencing a greater than 20 year return interval flood event, it should be cautioned that this is based largely on the results of a single project in Martin Creek. In this one instance, the 50-year flood design capacity of the project was exceeded during a 100-year return interval flood that occurred in the summer of 2001 in isolated areas throughout the north east corner of the province.

Instream structure performance varied with stream magnitude, but not in a linear fashion as has been the case with earlier investigations in the Pacific Northwest. Previous studies have determined that

Feature

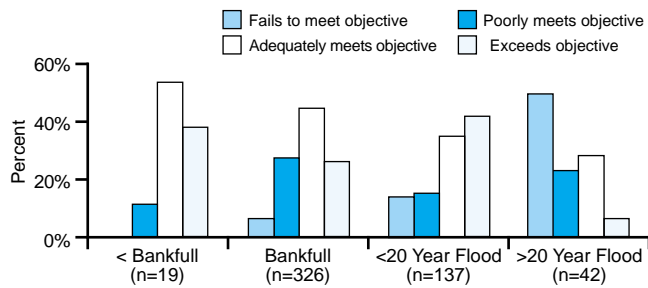


Figure 7. Long-term (20-year) function of in-stream, restoration projects broken out by post-construction flood history.

structure performance decreased with increasing stream order or magnitude (e.g. Roper et al. 1998). However, this study identified a modal or humped distribution, with a higher percentage of structures meeting or exceeding performance objectives in the medium sized watersheds (Figure 8). The lower success in small magnitude streams probably reflects the difficulty of undertaking instream restoration in steeper headwater streams or small channels located on alluvial fans.

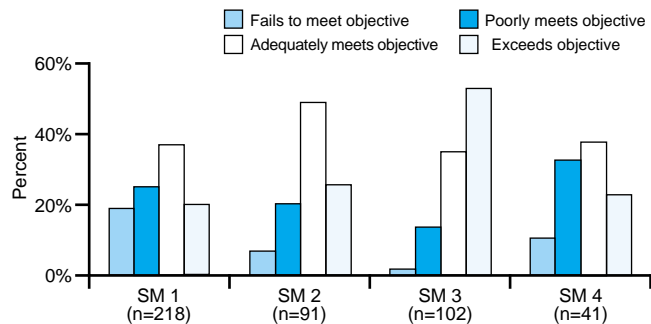


Figure 8. Long-term (20-year) function of in-stream, restoration projects broken out by stream magnitude (SM1=1-20, SM2=21-40, SM3=41-100, SM4>100).

Recommendations

The 2000 and 2001 performance evaluation of instream, off-channel and fish access restoration projects identified more than successes and failures of the Watershed Restoration Program. Examining the results and outcomes of many projects around the province allowed for the synthesis of a number of recommendations that must be considered to improve the delivery of restoration programs in the future.

1. All restoration components evaluated had high levels of success and are best used in combination with each other to best achieve resource restoration and sustainability objectives.
2. Fish access rehabilitation projects need to consider the implication of culvert water velocities when sizing rip rap to be placed in outlet weirs.

3. A formalized annual inspection and maintenance program for off-channel restoration projects must be developed to ensure that the benefit gained from these projects are not impaired.
4. Secondary habitat requirements of target species must be taken into account when constructing off-channel projects. The incremental cost of adding quality large woody debris to deep pools, aggressively planting and seeding banks and loosely placing rip rap along channel margins is likely a marginal cost relative to the sizeable benefit gained.
5. Caution must be used when selecting channel-spanning structures for instream restoration. Geomorphic and hydrologic factors in watersheds, reaches and sites must be taken into consideration when planning to use these types of restoration structures. Although these types of stream features may be prevalent in old-growth templates, they are likely transitory in nature and as such are not the best option for providing habitat over a 20-year period.
6. Avoid pursuing instream restoration in steep headwater streams and on alluvial fans. Where restoration is a requirement to achieve sustainability and restoration objectives, consider watershed processes and take into account the dynamic nature of the surroundings.
7. Continue to explore new methods and approaches to watershed restoration. Program success has been gained through a process of evolution and adaptation as more and better information on watershed processes and restoration has become available. This must continue if future restoration programs are to continually improve and achieve restoration and sustainability criteria.
8. Maintain a technical bulletin (such as Streamline) to disseminate advances in watershed restoration technology to planners and practitioners. Without publications such as this one, adaptive management and evolution are compromised.

Conclusions

The Watershed Restoration Program has invested considerable time and effort since its inception to restore and protect fish habitat and water quality adversely affected by pre-1994 forest harvesting. Although the program is coming to a close in March 2002, this study has highlighted the legacy of successful instream, off-channel and fish passage restoration projects it will leave behind all across the province. All British Columbians are the beneficiaries of this legacy, as the fishery and aquatic resource belongs to all of us. This

study identifies issues that, once addressed, will improve future restoration, mitigation and compensation efforts. However, the most valuable output is the indication of the overall success of the Watershed Restoration Program. Thus, an integrated, watershed- and science-based restoration program or strategy is a sound approach to addressing aquatic resource sustainability issues, provided it is directed at clearly stated objectives.

The success of the Watershed Restoration Program can be largely attributed to a willingness to learn from the past while working for the future. Mentors, partners and collaborative efforts combined to deliver a program that we can all be proud of as we have worked towards the restoration of physical and biological processes in watersheds across the province. The commitment of many individuals and groups to the aquatic resources of this province has given hope that we will overcome setbacks and have abundant fish and water quality for subsequent generations to enjoy. While the Watershed Restoration Program fades, other programs, groups and individuals must continue to ensure that the aquatic resources of British Columbia are restored and protected for the benefit of future generations.

Acknowledgements

This performance evaluation was made possible by the assistance of many dedicated volunteers and professionals. Jaclyn Cleary in particular assisted in data collection and entry, and Ray Pillipow provided field and GIS technical support. Others who lent assistance include: Mike Feduk, Sherri McPherson, Bruce Usher, Tanis Douglas, Phil Epp, Duane Wells, George Smith, Bill Rublee, Herb Tepper, Cory Legebokow, Terry Anderson, Mike Ramsay, Trevor Andrews, Brendan Anderson, John McInnes, Jeff Lough, Chris Broster, Dan Bate, Dave Heller and others.

References

- Cleary, J.S. 2001. Increasing coho productivity in the Chilliwack River watershed. *Streamline*. 6(1): 1-7.
- D'Aoust S.G. and R.G. Millar. 1999. Large woody debris fish habitat structure performance and ballasting requirements. Watershed Restoration Management Report No. 8, Ministry of Environment Lands and Parks and Ministry of Forests.
- Decker, A.S. and M. Foy. 1998. The contribution of restored off-channel habitat to smolt production in the Coquitlam River. *Streamline*. 4(3): 22-24.
- Doyle, J.E. 1991. A report on large woody debris management. Mt. Baker-Snoqualmie National Forest. 43p.
- Finnigan, R. and P. Slaney. 2002. Baffling beavers for fish access at off-channel rehabilitation projects. *Streamline*. 6(3): 18-19.
- Frissell, C.A. and R.K. Nawa. 1992. Incidence and causes of physical failure of artificial habitat structures in streams of western Oregon and Washington. *North American Journal of Fisheries Management*. 12:182-197.
- Hartman, G.F. and M. Miles. 1995. Evaluation of fish habitat improvement projects in BC and recommendations on the development of guidelines for future work. BC Ministry of Environment Lands and Parks. 39p.
- Higgins, B. and H. Forsgren. 1986. Monitoring and evaluation of Mt. Hood National Forest stream habitat improvement and rehabilitation projects. Mt. Hood National Forest. 56p.
- Metzger R. 1997. Stream habitat changes and the effectiveness of instream structures. *In* Assessment of the effects of the 1996 flood on the Siuslaw National Forest. Ed. H. Plumley. USDA Siuslaw National Forest.
- Parker, M. 1999. A discussion of fish passage at culverts in the Cariboo region, British Columbia. *Streamline*. 4(2): 9-12.
- Roper, B.B., D. Konhoff, D. Heller and K. Wieman. 1998. Durability of Pacific Northwest instream structures following floods. *North American Journal of Fisheries Management*. 18: 686-693.
- Slaney, P.A. and A.D. Martin. 1997. Planning fish habitat rehabilitation: linking to habitat protection. Chapter 1 *in* P. A. Slaney and D. Zalkodas [eds.] Fish habitat rehabilitation procedures. Province of B. C., Ministry of Environment, Lands, and Parks, and Ministry of Forests. Watershed Restoration Technical Circular No. 9: 341p.

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Feature

The Legacy of WRP

Donna J. Underhill

The Watershed Restoration Program (WRP) was established in 1994 as a provincial initiative under Forest Renewal BC to restore the productive capacity of forest, fisheries and aquatic resources that had been adversely affected by past forest-harvest practices. It came into effect at about the same time as the Forest Practices Code.

The Code was generated largely because of two independent audits done by Tripp consultants from 1993-94, the first commissioned by Ministry of Environment, Lands and Parks, and the second by Ministry of Forests. Both audits caused a strong public response and demand for changes. The reports had similar results, showing many slope failures, about 2/3 from landslides and 1/3 from gully over-loading failures. The landslides and failures resulted in torrents and other damage to fish-bearing streams (Tripp, 1994). It was also evident that many culverts were undersized for flood capacity. The decay of stump roots on overloaded road fills were identified as a primary cause of torrents and landslides. There was no streamside protection in the Interior, and only on the Coast after 1988. On the Coast, the Coastal Fish Forestry guidelines were established in 1988 to control forest harvesting close to streams. Finally in 1995, the Forest Practices Code began to protect streams from disruptive forestry practices.

Past forest-harvest practices had negatively affected water quality, fish stock productivity, and habitat of anadromous and resident fish. Often the many roads required for log transport caused the problems. They resulted in changes to flow and drainage patterns in existing waterbodies. Sometimes, it was a lack of understanding that caused problems, as during the 1960's and 1970's logging was to the edge of the streams, then the streams were "cleaned up", removing logs and trees from streams. Fish passage at road culverts has been a long-standing concern, but the extent of the use of the small tributaries and off-channel refuges by juvenile fish was not well understood. Without intervention and proper deactivation, the old roads often fail at the drainage crossings or saturated side-casts. Logging also caused greater sediment delivery to streams, in part from old roads and in part from the landslides and gully failures. Early forest practices favoured natural restocking of trees, resulting in a dominance of deciduous trees. This promoted the beaver activities, such as damming, on small streams

and ponds that are utilized by the fish species. A lack of streamside protection decimated many of the riparian zones, which we now understand to be of key importance to fish habitat and, thus, survival.

Logging was not the only threat to fish habitat. Agricultural practices and urban development caused damage to streams too. In the early years, WRP was focussed on trying to fix the problems caused by logging. This focus has broadened during the duration of the program, and now the program works with the agriculture industry and is also involved in watershed development issues. The goals for watershed restoration have changed as the years progressed to reflect less on seasonal employment, forest rehabilitation requirements and more on aquatic resources, stewardship, and environmental awareness.

With the exception of transition projects, since 1999 the goals of the WRP have been to:

- restore and protect fisheries and aquatic resources in key watersheds throughout the province,
- increase knowledge information and tools for restoration and management of watersheds, and
- provide opportunities for community-based employment, training and stewardship.

As the Watershed Restoration Program will no longer exist by the time you read this it seems like a good time to review the legacy of the projects that were initiated and completed under the WRP. The program has been very successful in mitigating many problems that were caused by past forestry practices. In order to give a balanced retrospective, it is also useful to look in general terms at problems that could have been avoided. As is often the case with retrospectives, hindsight is twenty-twenty. To research this summary, I spoke about the lessons learned with a number of people that have been involved in watershed restoration throughout the province including consultants, engineers, foresters, biologists, licensees, representatives from government agencies, WRP staff and former staff. As environmental regulation moves toward a results-based program, many concerns are being expressed about whether watershed restoration will still occur and whether existing projects will continue to be monitored and maintained in a proper adaptive-management model. There has been a move towards stewardship and sustainability, and in the best

of all worlds, this will be borne out in results-based environmental management. Once again concerns were raised that the information that has been learned through the process of watershed restoration should be made available and proactively shared with those who will be in the decision-making roles. There is a famous quote, credited to George Santayana, that gives us this warning: "Those who do not remember the past are condemned to repeat it."

When the WRP was initiated, the idea of stream restoration was new. There were not many projects in Canada to look to, and few staff members had experience in this field. Most consulting firms had little or no experience in this type of work and experienced crews were not available. Now there have been approximately 2000 people trained in watershed restoration work by the WRP and cooperative programs offered through the Forestry Continuing Studies Network. Those who have been trained include consultants and professionals, as well as displaced forest workers and First Nations' crews. The BC Advisory Team was established as a mentor program, linking people who had been involved in WRP for years with those who were planning WRP projects, often in geographically isolated communities. The US Forest Service had begun watershed restoration a decade prior to our program in BC. A technical exchange was established with them, and each year there was a formal sharing of information where a team from Washington and Oregon would come to BC and advise our technical staff on specific problems for restoration. In addition there were five technical exchanges between the US staff and those individuals that were conducting watershed restoration in BC. Notes and abstracts from the US/BC Technical Exchanges were highlighted in Streamline (Vol. 1-1; Vol. 2-4; Vol. 4-2; Vol. 5-2; and Vol. 6-1). One of the most important legacies of the WRP is the human resource of well-trained people.

The province was divided into the following WRP regions: Vancouver Island, Lower Mainland, Southern Interior, Kootenay, Cariboo, Skeena, and Omineca-Peace. Funding and personnel to accomplish watershed restoration projects came from a variety of sources including Forest Renewal BC, Ministry of Forests, Ministry of Environment (and most recently the Ministries of Water, Land, and Air Protection and Sustainable Resource Management), Stakeholder, and Stewardship groups, First Nations, Fisheries and Oceans Canada, Fisheries Renewal BC, and private landowners.

Another legacy of WRP is a plethora of assessments, and projects, which are listed in the Fisheries Project Registry http://www.canbcdw.pac.dfo-mpo.gc.ca/fpr/Qf_Welcome.asp. The assessments were done and

then refined, mistakes were made, and adaptive solutions were developed. Many of these assessments will provide benchmarks for future work towards sustainability and biodiversity in watersheds.

WRP has recaptured, rehabilitated, and constructed at least 750 kilometres of fish habitat that was unavailable because of former logging practices (Zaldokas, 1998, 1999; Underhill, 2000, Cleary and Underhill, 2001). Off-channel and side-channel projects have been constructed to provide fish habitat that may have been there historically, but was not there in 1994 when the program began. Much of this work was off-setting or mitigation because the mainstem impacts could not be restored. Hundreds of large-scale projects to replace lost channel-structuring elements were carried out to restore the amount and quality of fish habitat. Providing fish access through properly installed culverts, bridges, and cross-ditches has been a success story. Experimental introduction of nutrients to streams have been very successful in replicating the food sources of fry that were historically provided by salmon carcasses. Many natural drainage patterns have been re-established and water quality has been improved. Riparian and streambank functions have been restored to pre-logging conditions through bioengineering and silvicultural modifications in many situations. Most of these aquatic projects are listed in the annual compendium (see references above). Road deactivation, which really was one of the major components of the overall Forest Renewal BC program has resulted in far less sediment entering many systems, thereby improving water quality and fish habitat.

Throughout the Watershed Restoration Program there have been lessons learned and the success of the program has been to communicate these lessons and make the changes that are required to adapt the solutions to be more effective. In outlining the lessons learned, I have tried to provide examples. Some examples are from very successful projects, while some of the other examples may reflect projects that did not meet their objectives

Lessons Learned

1.) Approach Restoration in a Whole Watershed Context

At the beginning of watershed restoration in BC and elsewhere, much effort initially went into instream structures. There are stories of instream projects that were completely in-filled with sediment by the year following construction. There were situations where there was a debris-torrent or stream avulsion problem after the construction of the structures. Sometimes

Feature

structures were completely blown out. This lesson was first learned by studying the US Forest Service experience.

Approximately three years ago, there was an extensive planning process to prioritize the watersheds that most needed work, where fish stocks were at risk, and where the work could be done in a feasible manner. These resulting Resource Management Plans were developed in each region, identifying high priority projects based on factors such as the likelihood of success, existing investment, community water sources and social/cultural importance. The results were published in the Watershed Restoration Program Planning and Priority Setting for the next Five Years – Phase 3 Watershed Level Planning (Chatwin et al., 2000). At this time, Forest Renewal BC set a program goal of restoring 20% of high priority watersheds by the year 2004. Restoration works within those “target” watersheds have been proceeding until Mar. 31, 2002.

Often when there is a specific problem, for example a stream avulsion, a consulting firm is hired to fix the problem. Now we know that some large watersheds probably cannot be “fixed”, but the initial response has generally not been: “we can’t fix this problem.” A Ministry employee, on the other hand, who has been involved in many problems and many watersheds, may be able to see the whole picture and be able to provide a larger perspective to a licensee. Examples of the problems encountered by not approaching the watershed as a whole were seen in early projects in some of the very steep watersheds located on the coast. As the gradient of the stream drops, sediments are deposited. These streams were often used by coho and early spawning steelhead, and their habitat was restricted or of poor quality where the channel braids out and dewater. Efforts were made in the early days to solve the problem by removing the sediment in the channels. But there was so much material in the system above, that the sediment re-entered the system. The works completed did not generally result in harm to fish, however the project objectives were not met. Perhaps the decision should have been made initially to fix these watersheds from the top-down, first addressing the cause of sediment production, rather than approaching site-specific problems lower in the stream, or river. The moral of the story might be to not work in unstable systems, or to work on the margins looking for off-channel opportunities.

A good example of approaching restoration in a whole watershed context would be the Kennedy Flats Watershed Restoration Program, in the Clayoquot Sound near Tofino. This project combines road

deactivation, restoration at road crossings and extensive instream habitat restoration work. It is a jointly managed project involving a management team composed of members of Interfor (the lead proponent), MOF, MELP. Many partners also played important roles in the project, including the Tla-o-qui-aht First Nations and the Uclulelet First Nations, the Thornton Creek Enhancement Society, the Tofino Salmon Enhancement Society, the IWA, and MacMillan Bloedel. Prescriptions specified construction of about 1900 cross ditches, and removal of approximately 900 bridges or culverts, of which, over 400 were estimated to be on fish-bearing watercourses. Instream work involved removing, rearranging, and anchoring wood debris to restore channel capacity and increase scour. Some problems were encountered when streams were over-cleaned initially. Cover habitat was also enhanced, and added in the riparian zone for wildlife. Work started at the upstream reaches of the creeks and proceeded downstream. This was also found to ensure access was maintained for both road and stream work.

Processes are complicated, however, and monitoring work in the Kennedy watershed indicated that there were some problems with clearing the upper reaches first during 1996. The studies concluded that clearing the upper reaches first allowed amore rapid transfer of the water downstream, causing increased flooding of infrastructure and riparian zones, and potential instability of jams in untreated lower reaches. Thus, in 1997, the methodology was modified and, while work continued from the upstream end, the entire lower section was also treated concurrently.

Strong Project Management

Project management is very important to the overall success of the project. Generally the projects have been managed by a variety of personnel including consultants, WRP staff, licensees, staff from stakeholder groups or stewardship groups, First Nations managers.

The management of WRP projects has improved significantly throughout the WRP history as the project managers gained experience. The most successful projects were managed well and were impeccably organized from the assessment and the design process, through permitting, organizing materials and crews. They were carefully supervised through implementation, and all work was monitored. Commitment of the project manager and crews has been identified as very important by many WRP staff. The good projects often have a very keen and organized project manager, and often is a person that lives close to the site, so that they can go back and

check it frequently. This informal monitoring allows for quick and adaptive solutions to improve the project. Monitoring, even in an informal manner, over the period of years is the best way to learn the management skills required. If a contractor goes back to the site to re-visit, they will learn.

Two of the very important aspects of managing watershed restoration projects have been a collaborative approach and clearly stated objectives. The collaborative approach must start during the referral process. It is necessary to work closely with all landowners and stakeholders involved along the stream, and to work as a team with the crews that are constructing structures, installing culverts, or providing bioengineering to the project. Open communication was found to be key. Managers that rushed or ignored the referral process caused major problems for the program. Ignoring an upstream landowner's concerns could jeopardize the project.

With the possibility that the future of watershed restoration may move to results-based implementation, there is a concern that the commitment to careful management of existing restoration projects will not be a priority and there may be much less aquatic rehabilitation. Of course, the financial bottom-line will be the major objective for licensees, which has not been the case to date, with most WRP projects. The objectives for the past few years have been more focussed towards restoring, creating or enhancing fish habitat. Results-based implementation could result in expecting a variety of groups, with third-party delivery, to provide watershed restoration. In the past, when WRP teams were given a lot of leeway, and not provided with adequate training and communication lines, the projects were not done well. As an example, some of the projects carried out under "Delivery 2K," a hands-off project management project piloted in Region 1, achieved lower success than projects carried out with more direction. Yet, the need for forest product certification will continue to ensure some effort is placed on watershed sustainability.

An example of a well-managed project was the San Juan watershed where private forest companies and agencies cooperated in the restoration because of the deterioration of the San Juan River. Although initiated by a court action, this restoration was managed jointly under the San Juan Watershed Agreement, which provided for a Management Committee and a Steering Committee. The agreement was signed on August 1, 1995, and terminated on December 31, 2001. The Management Committee consisted of an Assistant Deputy Minister from MELP, the MOF District

Manager, the Chief of Habitat Policy Unit for Fisheries and Oceans Canada (FOC) and the Chief forester from both MacMillan Bloedel Ltd. and TimberWest Forest Ltd. The steering committee also involved Pacheedaht Band, Sooke Renfrew Forestry Society, San Juan Enhancement Society, Cowichan Lake Forest Coop, Renfrew Community Association and the International Woodworkers Association (IWA Union). The San Juan watershed is huge, 665 km². This project initially came about as a result of a large fine that was levied against one of the forestry companies.

A coordinator, Bud Iverson, was hired in October 1995, to work for committees, and consulting biologists that were hired in managing this huge project. Detailed assessments and prescriptions were developed for hillside restoration and road deactivation during 1997 and 1998. Terrain mapping was used to map gullies, slides and soil stability and to provide recommendations for treatments where feasible. A report was prepared and used to determine areas of priority for action, and a number of landslide rehabilitation projects were initiated. Hydrometric stations collected data. Stream restoration and enhancement activities were planned and completed on tributaries. Many of these involved the addition of large woody debris (LWD) to the streams. Bioengineering was an important component of the upslope activities. These activities were detailed in *Streamline* (Iverson and Epps, Vol. 3, No.4). The riparian zone was enhanced and the detailed work and follow-up work was described in *Streamline* (Muller and Muller, Vol. 4, No.1).



Figure 1. An example of some of the areas chosen for road deactivation in the San Juan watershed.

Anecdotal stories that demonstrated poor management involved roads that were deactivated, then reactivated in order to extract timber. Another problem that occurred early in the history of watershed restoration

Feature

involved a project that initially called for groundwater test pits, monitoring, etc. prior to choosing the site and installing fairly major instream works. There were many referrals required, but the protocol was not followed and a “let’s just get it done” mentality set in. As a result the project was installed prior to the proposed data collection and monitoring. The project site that was chosen was poor, the geomorphological risks were high, and in the end, the proponent was required to remove the project. Although fish were probably not harmed by this poor management, it no doubt led to mistrust and misappropriation of funding.

A problem that has faced managers on a project basis, the watershed basin, regional basis, and even program basis was the setting of clear goals and objectives. In the introduction I mentioned that the objectives/goals of WRP had changed through the years. Initially one of the goals was related to forest resources. At least 50 percent of hillslope projects, as a conservative estimate, were likely driven by non-water/fish objectives during those first five years. This did reflect the very broad range of the initial goals of Forest Renewal BC, and did not always mesh clearly with the aquatic goals of the Watershed Restoration Program. As a result restoration of forest resources were removed from the program goals in 1999. Upslope work could still be carried out, but only in areas where fish and aquatic resources were effected.

Information Management/Monitoring of Projects

A lack of monitoring programs and project success became evident as more and more projects were implemented. This became problematic for the WRP and Forest Renewal BC because there were a lack of statistics regarding the work that occurred. When I was researching this article, I was unable to determine the number of kilometres of road that have been deactivated.

In the beginning WRP projects were constructed to meet specific objectives, however money was not always allowed in the funding for ongoing monitoring and adaptive maintenance. WRP practitioners suggested that it would have been useful to set up some of the WRP projects purely as experiments. As many of the projects were quite experimental in the first place, it led to projects being considered “failures” if the objectives were not met. If they had been purely experimental, then research objectives would have been met, and perhaps surprising results would have occurred in teaching us other lessons. Also in the beginning, the information was not as easily shared between ministries, and with all people that were doing watershed restoration. This has improved as the program matured and the knowledge base expanded.

Another suggestion was that, perhaps when the program was established, there should have been approximately one million dollars that was put into a trust fund or investment fund, and now, years later, the interest from the initial investment could have been used to support ongoing monitoring and maintenance.

Sometimes in our restoration program, we did take a chance and try something that wasn’t tried and tested. This approach often resulted in a gain of knowledge that could be applied to other systems. An example of a great project that did have a novel approach was the instream work in Colt Creek (Figure 2). There had been long-standing instream issues with this creek, and the road that had been developed along the corridor. The restoration work involved very large-scale tree revetments (up to thirty trees in a structure). These have stood up well, and met objectives very well. Monitoring of this project concurs with some of the research that has been coming from the US studies and their conclusion is to the “go big”.

Program Coordination and Financial Management

In the beginning the WRP was given the direction to have region-by-region coordination. In retrospect, starting with central coordination may have been wise,



Figure 2. Very large tree revetments in Colt Creek have successfully met project objectives.

as re-inventing the program sometimes led to the spinning of wheels. Sometimes the work had been done successfully in another region, or even in the same region by a different ministry, and the information could have been shared. Sometimes the Ministry of Forests and Ministry of Environment worked hand in hand, other times it was more difficult.

The financial management based almost entirely on a budget, which must be spent or lost by fiscal year-end leads to much waste in government budgetting. We are dealing with biological systems that have their own patterns. For the first few years, it seemed incredibly difficult to “roll the projects out” each spring, as the budget process dragged into summer. Sometimes projects would optimally be accomplished in April and May, but the money is never available, because budgets

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The 2002 Interior Watershed Conference was held in Kamloops on March 13 and 14, 2002. There were more than 300 participants at this event which was coordinated by the Forest Continuing Studies Network. The theme was Watersheds: We're In This Together. The two keynote speakers both spoke eloquently on this topic. Concurrent sessions focussed on:

- Successful Partnering for Watershed Restoration
- Range and Agriculture and its effect on Water Quality
- Watershed Plans, Monitoring and Evaluation
- Restoring and Management of Fish and Wildlife Habitat
- Computer Models in Forest Management
- Research and Science in Watersheds



Alan Thorne, winner of the 2002 Interior Watershed Award.

Congratulations to Alan Thorne, the winner of the 2002 Interior Watershed Award.

Dave Nordquist, Natural Resources Manager, and Greg Witzky, Fisheries Manager with the Adams Lake Indian Band, nominated Alan for this prize. Al was introduced by Dave Nordquist. Al graduated from the University of New Brunswick in 1990 with a Bachelor of Science in Forest Engineering. Since then, Al has worked for International Forest Products Ltd. both on the coast and for the last 9 years at Adams Lake Lumber. His experience includes layout and development planning for watershed restoration. Dave Nordquist attributed Al's success to the collaborative spirit that he brought to all meetings. He has managed the Adams Lake IFPA program. Al lives with his wife and two children in Chase. ▲

Keynote Presentations

A Pragmatic Approach to Watersheds and Water Quality

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Research based results of watershed conditions, ground water, and shade's effects on stream temperature and other water quality conditions were summarized through five active research studies. The first study involved research on the effects of temperature on running water. This is important because there is an optimum temperature above which salmon populations do not do well. It concluded that stream shade is an important factor in decreasing water heating. It demonstrated that water depth, surface area, time and rate of discharge were also important to the temperature of the running water.

The second study involved the temperature response to thermal environment. The implications are that the thermal environment has an influence on stream temperature. It found that air temperature increases with a decrease in elevation, and so does the stream temperature.

In the third study, remote sensing and Geographic Information Systems were used to assess changes in stream morphology and vegetation. This combination of GPS and GIS technology is an excellent tool for time change analysis using large scale imaging to determine for instance, the length of thalweg and right and left streambanks, or the sinuosity of the stream.

In the Meadow Creek Study, the streambank is sloughing. The study looked at the effects of different grazing strategies and wintertime hydrologic events on this creek. It demonstrated that season-long grazing was detrimental to streambanks and associated with high degrees of bank sloughing. Properly managed grazing (timing and fencing) gave results that were similar to non-grazed control areas. The forces of nature during hydrologically active over-winter months were significant. When the ice floes occur, drainage-wide erosion was high regardless of treatment.

Stream temperature related to sub-surface waterflow was the topic of the fifth study. The sub-surface waters were controlled through a head-ditch system. The irrigation water was introduced to the streamwater through the head ditch, resulting in cooler stream temperatures and more flow later in the season during

periods of low water. This study demonstrated that irrigation is not always bad, in fact, it can improve the water temperature situation if it is managed to flow through the soil.

Stating that it is better to get the water into the ground, and have it flow through the ground to the stream can summarize the results of these studies. The temperature of water entering the system is tied to infiltration rates and upland range and forestry conditions.

The essence of beneficial release is:

- 1) **Timing of Flow:** Water infiltration into a system can take the top off floods, and increase the amount of water that is available during drought because it is stored underground, thereby not evaporating as quickly.
- 2) **Quality of Flow:** If water is added to the system and flows across the ground it warms and can evaporate, or it can carry soil and debris to the soil causing erosion. If the water infiltrates through the layers of soil and rock, the kinetic energy is removed from the water. Nutrients are added to the soil profile, often benefiting plants that grow above. In comparison, if this same water flows straight into the stream system it can cause eutrophication. Infiltration also removes fecal coliforms, pathogens and other bacteria that are potentially added to a stream system from range or agricultural land use. If the water transfers through the soil, it ameliorates the water temperature.

All of these studies have been brought together because they all demonstrated the theme of this Conference – Watersheds: We're in this together. A couple of stories about the viewpoints that children have of our watersheds demonstrate that we need to work together on education. The importance of outreach and extension programs in ensuring the stewardship of our watersheds cannot be underestimated. That is where you make contact between research and the person on the ground. It is important to involve landowners, and their families, in the proper management of rangeland and forested land.

“If you want people to have a land ethic, they have to be able to afford it.” said Dr. John Buckhouse. ▲



Stewardship of Water in a Crowded and Changing World. How do we achieve ethical conservation and management of water and watersheds?

J. P. (Hamish) Kimmins

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The enthusiasm with which we press our search for evidence of water on other planets stands in stark contrast to the profligate manner in which we use and treat water on earth. While we recognize the absolute necessity for water for life as we know it, we are generally poor stewards of earthly water. This is not unique to water. We similarly mistreat our global atmosphere, soils, forests and aquatic and terrestrial animals.

What are the origins of this lack of stewardship, and what are some possible solutions?

The human population increased by a factor of six over the past 200 years. It doubled to more than 6 billion over the past 40 years, and it is expected to increase by another 3-5 billion in the next 100 years. This has put enormous pressure on the world's water resources, especially in climates that favor human habitation. But population increase alone does not explain our environmental impact. It is equally related to a disconnect between people and the land – a disconnect that accompanies urbanization, loss of local experience, a growing dependency on, and faith in, technology, and a persistent inability to understand and predict the longer term and cumulative consequences of our actions.

How can we solve the water problems? By top-down government policy, or by bottom-up, local control of the land and the processes that deliver water from it in a way that serves human and non-human needs? The latter is conceptually the better approach, but with a rapidly increasing proportion of the world's population living in cities and demanding more water or water-related values than this local control may deliver, it is insufficient on its own. The NIMBY syndrome also reduces the effectiveness of local solutions as in a larger context it may simply push the problem from one location to another without actually dealing with it. The top-down government regulation approach has a dismal record of success, largely because centralized decision making, subject to a wide variety of political pressures, generally fails to respect ecological, social and biological diversity, and because economic and urban imperatives frequently overwhelm local

interests. However, government regulation may be the only way of assuring that the regional and bigger picture issues are being addressed, and that the complexities of environmental problems are considered.

In the late 1960's, the Club of Rome was formed to examine global issues and to consider if there were limits to growth. After all, the world's wood supply could be produced from a small fraction of the world's forested land, as could the world's food supply from a small proportion of agricultural land. And there is plenty of water in the world if only its use was managed sustainably. The Limits to Growth study concluded that indeed there is little reason to think that there are any individual technical, sectoral problems that cannot be solved if they could be considered in isolation, but that the interconnectedness between them prevents this and results in failure to provide solutions – that there are indeed limits to growth because of the interconnectedness of the world system. It is the connections between problems and not the problems themselves that often results in the elusiveness of sustainable solutions.

A problem is an issue that does not get solved. An issue that gets solved quickly is not a problem. Problems often persist because they are complex and connected to other issues, and the solutions that are offered ignore or fail to recognize this complexity and these interconnections. It is time for a new Club of Rome-type of study to examine at a global scale and in an on-going process the complex, interconnected world system that we are currently mismanaging, and in which water plays a key role.

The UNESCO World Commission on the Ethics of Scientific Knowledge and Technology is in the formative stage of attempting to generate such a new study. Unlike the top-down world economics model of the Club of Rome study, a new world model must be a combined top-down – bottom-up conception of the world that incorporates a much wider range of controls on world dynamics. Not one of government regulation, the international market place or local processes will address adequately the complexities and linkages we face. It is time to link the different levels of the stewardship process in a series of models at different temporal and spatial scales to help to define what is ethical in water and watershed management, and how water interacts with the other components of the world system of which it is a critical part. ▲

Successful Partnering for Watershed Restoration

The Bonaparte Stewardship Group- What Makes It Work?

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- 1. A Brief History of the Society - What Made it Come About**
 - Early Spring 2000- The need to organize
 - April 26, 2000- Test the waters for interest
 - June 24, 2000- Planning workshop
 - November 23, 2000- Further planning workshop
 - February 6, 2001- Incorporation
 - March 19, 2002- First annual general meeting
- 2. What Projects Have Been Carried Out to Date**
 - One whip cutting day
 - One whip planting day
 - Three tree planting days- seven sites
 - Bank stabilization- six sites (including, in some cases, fencing)
 - Off-stream watering- one site
 - Wrapping trees for beaver protection- three sites
 - Workshop
 - Exploration of other projects
- 3. What has Made it Work**
 - Interest and awareness of members
 - Active interest of a few
 - Developing and using partnerships
 - Common foe or threat
 - Habitat Conservation and Stewardship Program (a shameless commercial for the program)
- 4. What Will Enable it to Continue to Work and Thrive**
 - More of the above
 - Effective turnover from, or some continuation of the HCSP
 - Emphasis on labour intensive projects
 - Succession of management ▲



Partnering for Watershed Success: The City of Kelowna's Experience

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The creeks in the Kelowna area, like those throughout North America, have been impacted by human development. Forestry, agricultural, industrial and urban activities have resulted in altered drainage patterns, reduced riparian vegetation and increased erosion and pollution. The success of the City of Kelowna's Watershed Stewardship program at overcoming these problems is due in part to the variety of partnerships formed since the program's inception in 1996.

Partnerships provide benefits to both of the parties involved. In a time of scarce funds for environmental works, partnerships are extremely important to accomplish the education and restoration that needs to be done to keep our watersheds healthy. The City has utilized partnerships in all three aspects of its watershed stewardship program: education, stewardship and restoration. Partnerships have been formed with local and provincial governments, businesses, landowners, and non-profit groups.

Working with the Regional District, Fisheries and Oceans Canada and non-profit groups has proved to be a successful way of educating students and the community on a variety of environmental education initiatives. Working together provides a medium where people can learn about different numerous local environmental issues.

Partnering with the community to keep our streams healthy helps instill a sense of stewardship of our local waterways. The City facilitates numerous volunteer opportunities including creek clean-ups; invasive weed removal, replanting and storm drain marking. Organizations participating in the City's "Adopt A Stream Program" receive recognition, through signage, when they commit to stewarding a stretch of stream for a 2-year period.

Partnerships with landowners and businesses allow for restoration and enhancement to occur on private land and in many instances provide valuable in-kind or monetary donations to projects. Government agencies also partner on projects to provide expertise.

Funding partners have been instrumental in implementing many of the educational and restoration projects. Provincial programs such as the Habitat Conservation Trust Fund and local businesses such as TELUS have

substantially expanded the amount of restoration work that the City could achieve with its annual allotted budget. Programs, such as the E-Team program provide staff to implement restoration and to maintain past works, ensuring long-term project success.

The City of Kelowna has been proactive in recruiting and maintaining partnerships with government, businesses, landowners and volunteer groups. These partnerships contribute to the overall success of the Watershed Stewardship Program. ▲

Successful Partnerships: The Adams Lake Experience

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Since 1995, Adams Lake Lumber has embarked on an ambitious plan to restore damaged watersheds in the Adams Lake area from past resource extraction activities. This included problems resulting from forestry as well as agriculture and private land management. Because of the proximity of the operation to the famous sockeye salmon run on the Adams River, the need for a coordinated approach by all stakeholders was essential to develop a comprehensive restoration strategy to ensure positive results.

Working with local First Nations, private landowners, and various agencies, Adams Lake Lumber has completed all priority works in the area. This would have not been possible without the involvement of all the partners. With the past problems essentially completed, Adams Lake has now turned to the future to ensure the future health of the watershed.

Future strategies involve the following: restoring salmon populations in the area to a significant enough level to allow for a traditional fishery in the area every year for local Bands. In addition, Adams Lake is working with local researchers to practice new watershed management techniques to ensure future harvesting does not adversely affect the system.

The presentation highlighted a variety of partners including the Adams Lake Indian Band, Ministry of Environment, Ministry of Forests, Fisheries and Oceans Canada, Landowners, Thompson Basin Fisheries Council, Forest Renewal BC, Fisheries Renewal BC, and BC Hydro. There was a focus on procedures we used to help build trust among these organizations so that everyone could focus on the common issues. ▲

Salmon River Watershed Project: 10 Year History of Successful Partnership

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The Salmon River Watershed Project is a community driven initiative that has successfully accessed support for nearly a decade from a broad range of partners to advance a collective vision of watershed sustainability. The process followed, results yielded and lessons learned are offered as a case study in the versatility and effectiveness of a consensus based, ecosystem approach to watershed planning.

What began in 1991 as an expression of “concerns-in-common” between local First Nations and municipal government representatives regarding the condition of the Salmon River came to involve landowners, industry, other government agencies, non-government agencies and citizens in a proactive approach to problem solving. Over the next three years project participants developed an ecosystem approach to watershed sustainability as reflected in the guiding principles, mission statement, vision, goals and objectives of the Salmon River Watershed Roundtable. Since then the SRWR has succeeded in building partnerships with a broad range of stakeholders by maintaining a watershed perspective, using consensus planning methods and by demonstrating respect for all concerns. FRBC contributed significantly during a four-year period (1997-2000) furthering progress toward sustainability goals, along with many other partners, as will be described in the case study. Many planning, field action, monitoring and educational products have resulted from these partnerships. In hindsight, undertaking these activities concurrently has proven critical to enfolded greater stakeholder participation.

The nature of the SRWR organization facilitates incremental pursuit of a collective sustainability vision that considers economic, ecological and social concerns. Past practices are not criticized; proactive approaches are sought. The versatility of the planning mechanisms used has enabled the SRWR to accept varying levels of technical and funding support from partners while maintaining a community based vision through a set of goals and objectives. The process accepts both technical and non-technical input. This has enfolded participation and support on key issues from a broad stakeholder base and has helped identify avenues through which to advance sustainability goals. ▲

Range and Agriculture and its Effect on Water Quality

Not Your Typical Riparian Restoration Project

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Innovation in the agricultural industry can be like a mudslide, slow to get moving, but as momentum grows large scale changes can result. The riparian restoration project undertaken on the Brady Property of Louis Creek is one such example.

The project involves 13 separate agencies and/or landowners and took over two years to actually get to work on the ground. Fisheries & Oceans provided the funding through the Habitat Restoration & Salmon Enhancement Program (HRSEP). Forest Renewal BC and the Kamloops Stockmen's Association provided research funding.

The innovation in this project is twofold:

1. Riparian restoration techniques
2. Science used in assessing cattle use

A typical fisheries riparian restoration project on ranchland simply installs a 15 m setback fence and incorporates some planting in the reserve zone between the fence and the creek. This project used a combination of a very large (51 ha) cattle exclusion plot, an open grazing area with off-channel watering sites (83 ha) and two rotational grazing pastures with watering sites (46 ha). The landowner initiated the project with the idea that by using carefully controlled grazing we could enhance the shrub/tree component of the riparian corridor while utilizing the valuable grasses found near the stream. The test of the grazing theory comes next year when the 300+ head of cattle are managed in the project area.

Cattle locations are being recorded every 5 minutes using collars with GPS capability. This data will

allow detailed examination of livestock behaviour in the open grazing area and will aid in developing management systems aimed at minimizing livestock use of the stream. Pre-project assessments on fish usage, riparian vegetation composition and benthic invertebrate populations, were all completed to provide a base line for monitoring the response of the system to the alterations of the grazing plan. Long term monitoring of this unique riparian restoration project will hopefully show that carefully controlled cattle use can occur within the riparian zone in conjunction with improvements to overall watershed health.

Participants are coming to realize that the project must be approached with a 20-200 year perspective in order to be successful, and that a single 3 or 4 year funding cycle will not bridge the existing gaps between current condition and sustainability. Many issues identified during planning activities to date remain at the forefront of planning and field action objectives, and have not yet been effectively addressed. Meanwhile, the SRWR continues to make progress. Signs of success continue to encourage greater participation toward the collective vision of sustainability. This presentation outlines the process, partnerships, field actions and lessons learned during the 10-year history of the SRWR as well as an action outline for the future. ▲

Two Ways of Looking at Things

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The Whitevalley Community Resource Centre Society [WCRC] has been partnering with local landowners from the agricultural community for the past five years completing habitat restoration activities on local creeks and rivers. Through cooperation with the government agencies, First Nations, forest companies, BC Hydro and local community groups, over 70 projects have been completed.

The successful implementation and acceptance of these projects in the local agricultural community is through the efforts made initially by the Resource Centre's Program to involve the landowners in the planning process. Through my past involvement as a consultant with government agencies implementing similar types of projects, I was often frustrated by the lack of "buy -in" from the landowners as they tended to look upon these programs as only benefiting the fish, while having negative impacts on their day-to-day operations. This may have been caused by the lack of communication that occurs if the technical staff assigned to design the projects have limited

understanding of how the agriculture industry depends on access to the water resource when developing their projects. An emphasis of simply completing the environmental work such as fish habitat structures or channels as required by the funding proponent without consideration to the rancher or landowner, often results in a compromise situation with the landowner, rather than a true partnership when completing projects.

Through the WCRC program, efforts have been made to design the projects to meet the funding proponents concerns such as bank stability or riparian management, but the project is designed to first meet the landowner requirements. The reason it has worked for us is that while the traditional approach of cost estimating the majority of the budget as direct costs to environmental improvement; we see how the landowners, neighbours or perhaps community becoming involved to supply materials or services at reduced rates or in exchange to expand the project. As an example, in exchange for including purchasing a livestock waterer that will allow a producer to better manage his pasture and winter-feeding area; he supplied "cat" work to cut down the cleanup costs on the project through his property. These and other types of cooperative exchanges allow us to extend the budget usually by an additional 30 – 50 % with no additional cash outlay on the part of the landowner. This approach to projects has allowed irrigation system upgrades, new fencing and bank stabilization projects to be completed from funding that was earmarked for fish habitat. The environmental concerns are addressed; but the involvement of the landowner allows for land management improvements to be completed that are cost effective. The involvement of the landowner in this process allows them to become informed as to how his management practices must be designed to meet the proponents objectives with this project. After all, it is going to be the commitment of the landowner as a steward to provide the long-term maintenance of these projects if they are to be successful.

My location, and a personal involvement from the initiation of the restoration program, have allowed me to maintain an active and supporting roll in its present activities. In my capacity as Stewardship Coordinator with the British Columbia Cattlemen's Association, I now draw on the experience gained through being involved with this program to promote similar approaches for ranchers and watershed organizations planning their own restoration projects. Having access to these project sites for tours has allowed me the unique opportunity to be able to take a rancher on a site to demonstrate how a cost-effective irrigation intake system was designed by re-watering an overflow channel. Then, when I take biologists to the same site, I show them the more than 1500 square metres of habitat channel that was built and complexed for less than \$7000. ▲

Ranching and Water Quality

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The ranching industry is a major segment of British Columbia's agri-food industry. Most ranches are located near watercourses and have the potential to affect water quality because of ranching activities. A two-year monitoring study is currently being conducted to determine differences between the upstream and downstream quality of water flowing through ranches in the southern interior of British Columbia.

In 1999 five ranching sites were selected and established for sampling and monitoring over the next two years (2000 and 2001). Site selection was based on the criteria that each ranch should have at least 200 head of cattle or more have winter-feeding and/or spring calving areas with a small or intermediate stream flowing through or by the ranch. Data was collected weekly in February and March, and biweekly from April until July 2000 and then monthly for the remainder of the year.

Data gathered at each site includes temperature (air, soil, and water), flow (velocity and discharge with flow meter, stageboards and Star Flow equipment), riparian condition was assessed, and ongoing agricultural activity is monitored. Water quality parameters measured include: bacteria (fecal coliform and fecal streptococcus), pathogens (Giardia and Cryptosporidium), nutrients (nitrate, ammonia, total nitrogen, ortho-phosphate, and total phosphorus), non-filterable residue, pH, dissolved oxygen, conductivity, turbidity, and sediment. First year results generally show higher concentrations of nutrients downstream of the ranch. Second year sampling and analyses needs to be completed by December of 2001 before proper interpretation of data can occur.

Generally the results are showing that downstream values for stream temperature are higher than upstream sites, but there is lots of variability. Generally in water quality measures, bacteria was

found in higher concentrations downstream (fecal coliforms and streptococci) however this data is difficult to interpret and several samples are required. Pathogen studies show that Giardia is present in approximately half the downstream locations, Cryptosporidium is present in approximately twenty percent of the downstream locations. These studies are difficult and time-consuming to sample. Nutrient study analysis demonstrated a mean nitrate value that was higher downstream, but it should be noted that all sites had values well below the drinking water criteria. There was no strong trend seasonally. ▲

Integrated Riparian Management: An Introduction to Agroforestry Concepts

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Historically, agriculture has developed on the productive lands, with good soils and access to water – such as deltas, flood plains and valley bottoms. As population, scientific knowledge, and competing demands for finite resources increases, more pressure is placed upon the food production system to produce more food with less impact on the environment. This often results in both economic and resource constraints being placed upon the food producers.

Agroforestry is a land management approach that deliberately combines the production of trees with other crops and/or livestock. By blending agriculture and forestry with conservation practices, agroforestry strives to optimize economic, environmental and social benefits. Agroforestry involves intentional management of the interaction between the components of an integrated agro-ecosystem. Some examples of this intentional management include: alley cropping; forest farming, also known as shade farming; silvipasture, shelter-belts, and integrated riparian buffers.

Integrated riparian management is the management of riparian zones to enhance and protect aquatic resources, while also generating economic benefits. While the long-term economic cost of working the last few metres of land up to the water's edge may be greater than the short-term gain, agricultural businesses need to deal with the realities of cash flow and current revenues. Setting land aside for what is often perceived as a distant, poorly defined societal benefit is not something many producers can justify.

By introducing the concept of managed riparian buffers, with the potential for some income generation while still protecting soil and water resources, it is

hoped that more landowners will adopt this type of management. Riparian restorations have reduced soil erosion and flood damage, improved aquatic resources, and produced marketable products from the riparian buffer. ▲

Watershed Plans, Monitoring and Evaluation

Watershed Prioritization in the Okanagan

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The Okanagan is identified as one of Canada's most endangered ecosystems. Serious declines in fish stocks in the Okanagan have prompted a keen interest by both government and community in watershed restoration and planning for fisheries recovery. At the same time the competition or demand for water is fierce. This area has all of the problems that are inherent when the water is a limiting resource. The community approach, coordinated by the Okanagan Similkameen Boundary Fisheries Partnership (OSBFP), has been to develop inclusive community watershed roundtables that work with NGOs, business and governments in the forestry, agricultural and urban sectors towards a common watershed-based vision and coordination of plans and efforts. This presentation outlined the OSBFP "watershed prioritization" process developed to guide community watershed roundtables and other fisheries stewardship efforts. This process is being integrated with other agency technical fisheries recovery plans (produced by the intergovernmental Okanagan Basin Technical Working Group). The OSBFP had a clear objective to protect and restore indigenous fish stocks. The framework involved development of a strategic plan which is now available on the website. There is currently a governmental track and a community track that have come together in the preparation of these watershed-based fish sustainability planning. Tracking the various plans is a very important part of the process. Please look at the results on the website at www.sylix.org. ▲



Pacific Salmon Endowment Fund: Development and Status

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In June 1998, the Government of Canada announced the Canadian Fisheries Adjustment and Restructuring (CFAR) plan, which included a series of initiatives to fundamentally alter and secure the future of Canada's salmon resource on the West Coast. As part of the CFAR, \$30 million was allocated to provide a permanent endowment fund, to be delivered "arms length" from government, to support the goal of achieving sustainable salmon resources and habitat. Because of his unique ability to bring diverse interests together around a common goal and strong, lifelong interest in the environment, Rick Hansen was selected and agreed to act as a "champion" to establish the Pacific Salmon Endowment Fund. He has spearheaded the selection of a steering committee and technical committee. The steering committee came up with a vision statement and a mission.

The vision of the PSEFS is: *To achieve healthy, sustainable and naturally diverse Canadian Pacific salmon stocks.*

Salmon recovery will be supported and implemented through six main program areas. Each program area will be focused and strategic in planning and implementing activities to promote salmon recovery. The program components are:

- develop science-based strategic recovery plans for salmon recovery to set objectives and priorities for investments.
- coordinate investments in watersheds and salmon recovery with government and non-government organizations.
- coordinate and implement recovery, monitoring and assessment activities.
- provide a leadership mechanism to sustain volunteer commitment to salmon recovery and stewardship throughout BC
- rigorously monitor and evaluate program elements and report with a high standard of excellence.
- educate and raise public awareness.

The plan now is to mobilize people and resources from all sectors around the program vision and components. The projects that are chosen need to be monitored and evaluated for both short-term and long-term effectiveness. The projects chosen have been holistic and realistic in their ability to be done successfully. They were within

a target geographic region and had a target species. They had the advantage of being suitable projects to leverage funds from other sources. The two that have been initiated are the Englishman River in the Georgia Basin and Coldwater River in the Thompson Basin. For the first two projects the plan was to ensure a high level of “do-ability.” These projects are planned to be ongoing, not a “sunset” program. At this time, through living recovery planning and coordination to allow for adaptive management, the objective is to engage and achieve. ▲

Road Deactivation for Hillslope Restoration: Lessons Learned on the Escalante Watershed Restoration Project

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This abstract is based on the paper published in the proceedings of the Vancouver Geotechnical Society Symposium on Land Reclamation Geotechnique, 25 May 2001. Co-authors are Mike Wise, Mike Leslie, Glynnis Horel, Denis Collins, and Warren Warttig.

Permanent deactivation is often carried out using hillslope restoration for roads on moderate to steep hillslopes. In the Escalante River area, many potentially unstable roads were deactivated in the late 1990s with roadfill pullback due to stability concerns, and the remainder of the roads were cross-ditched with some light pullback. In January 1996, intense rainfall caused approximately 400 landslides on these deactivated roads. Funded by Forest Renewal BC, the Escalante Watershed Restoration Project was initiated to assess the roads in the watershed and carry out deactivation work where needed for long-term road stability. Assessment of the existing deactivation work after the storms provided valuable information on its effectiveness in preventing landslides. Due to the existing roadfill pullback and landslide sites, it was necessary to assess the roads in terms of the expected deactivation work. Several techniques were developed to improve the standard of deactivation and reactivation.

Deactivation prescriptions provided site-specific objectives along the road corridor. Standard operating procedures were developed for the work in the Escalante

to complement the prescriptions and establish expectations and approaches for carrying out the deactivation work. The new techniques that were developed improve the safety and effectiveness of the hillslope restoration work during roadfill pullback and culvert removal. Safety was a prime concern within work on these very steep slopes. A program of “mentoring” was developed to teach less experience operations the deactivation techniques developed by the more experienced operators. Conservative wet weather shutdown criteria were also used, to suspend activities when landslides were relatively more likely to occur. Sorting materials during the pullback enhanced the site productivity. This is achieved by placing fine and organic soil on the upper surface of the roadfill pullback and scattering large woody debris (logs and stumps) on top. Many of the techniques that were developed are now documented in a Best Practices Handbook regarding hillslope restoration (Wong et al, 2001).

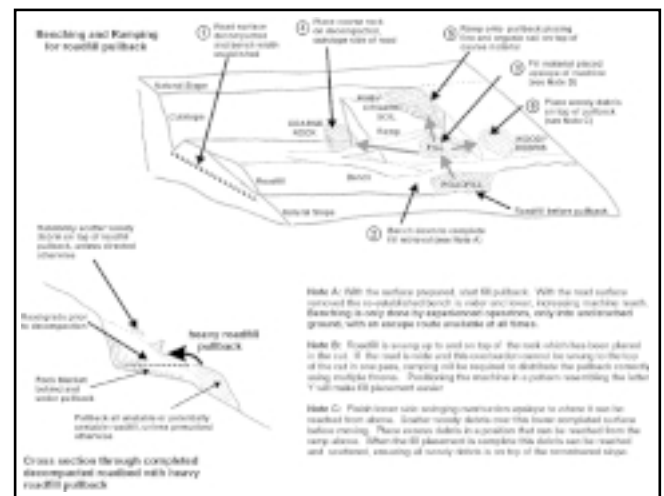


Figure 1. Benching and ramping for retrieval of roadfill during hillslope restoration. Numbers in top sketch indicate suggested sequence for placing material in roadcut.



Figure 2. Photo of roadfill pullback and end-hauling in gully area; note truck and excavator on left side of gully. Systems usually represent a higher risk to downslope areas, due to increased debris flow runoff distances and greater sediment transport rates in these areas. ▲

Restoring and Management of Fish and Wildlife Habitat

In-Stream, Off-Channel and Fish Access Restoration: A Provincial Evaluation of Performance

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A Provincial performance evaluation of in-stream, off-channel and fish access components of the Watershed Restoration Program was conducted in 2000 and 2001. The objective of the evaluation was to determine the success of projects in terms of meeting restoration objectives and make recommendations on how to improve rehabilitation effectiveness. A total of 18 fish access, 32 off-channel and 552 in-stream sites or structures were evaluated from all regions of the Province. Expert teams using standardized forms to minimize inter-team variation evaluated projects subjectively. All sites were visited on the ground and ratings made at the time of viewing. Projects were selected after having experienced 1-3 years of freshet floods. Preliminary results indicate that aquatic activities of the Watershed Restoration Program has had a high success level for all three restoration components: 96% of fish access projects, 93% of off-channel and 81% of in-stream structures were meeting or exceeding restoration objectives. However, the success of in-stream restoration was predicted to drop to 68% when performance was forecast over a 20-year period (the minimal interval over which most projects are designed to remain functional). Quality of construction contributed significantly to the projected decrease in project success. This and other factors relating to success and failure in both the short-term and long-term are discussed, as are recommendations

to increase success at meeting or exceeding performance objectives in the future.

Editor's Note: the complete paper on this topic is presented on p.3 of this issue of Streamline. ▲

Riparian Restoration: What, Where, When, Why and How

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As the Watershed Restoration Program (WRP) winds down, efforts are being made to ensure that the techniques developed and the lessons learned are documented so that future practitioners can proceed with effective restoration projects. One area of expertise that has been poorly defined and communicated is riparian restoration at the stand-modification level. In fact, when the history of riparian restoration projects was examined, only approximately 20 of the almost 450 riparian projects identified in the Fisheries Project Registry and elsewhere were stand-modification projects. Currently, most riparian restoration in BC is done via 3 programs: WRP, Terrestrial Ecosystem Restoration Program (TERP) and Sustainable Harvest (SH). The US Pacific Northwest has also been quite active in riparian restoration for over a decade now. With WRP, TERP and SH all being eliminated, and government's now role being defined as "they who write standards", the need for riparian restoration Best Management Practices (BMP) has become evident. To this end, a workshop was held in Richmond March 7-8, bringing together top riparian practitioners from BC, Washington and Oregon. The workshop participants identified certainties, uncertainties and opportunities for multi-objective prescriptions. Tanis Douglas gave a presentation on riparian prescriptions with wildlife habitat objectives. One new technique involves shooting bullets charged with fungus into trees, resulting in viable trees with holes for dens. This talk emphasized the need to address biodiversity rather than single species, and the potential difficulty in providing habitat on a timeline that is appropriate for the species being targeted. Workshop results are being written up (#1 below) and some aspects of the workshop will be incorporated into publication (#2

below), which focuses on silviculture treatments. Non-silviculture riparian restoration BMP's are not completed yet, but an excellent foundation has been laid for the completion of this project.

Several documents on riparian restoration will be available soon. Some of those documents and the contacts for them are listed here:

1. Riparian Restoration BMP Workshop results (Heather.Deal@gems1.gov.bc.ca)
2. Recommended Riparian Zone Silviculture Treatments (Brendan.Holden@gems3.gov.bc.ca)
3. Guidelines for Enhancement of Second Growth Forested Riparian Zones (Glen.Johnson@gems2.gov.bc.ca)
4. Silviculture and Restoration Standards and Best Management Practices (Colene Wood, MWLAP) ▲

Restoring Fish Habitat in the Pine River Near Chetwynd

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In August 2000, Pembina Pipeline Corporation's crude oil pipeline burst near its crossing of Pine River at Calazon Creek, about 80km upstream of Chetwynd BC. About 450 m³ of crude oil entered the river coating the bed and banks as well as numerous log jams between the break site and Big Boulder Creek – a distance of approximately 30km. As part of river cleanup, most log jams were either fully or partially removed by crews or excavators and the contaminated wood burnt on-site. The log jams had been an important component of channel morphology and their removal led to a situation where the main channel could avulse or reoccupy side, back or abandoned channels, as occurred during a small storm while cleanup was underway. The potential channel instability was thought to have negative long-term implication for fish habitat, sediment supply and infrastructure along Pine River.

Northwest Hydraulic Consultants Ltd. (nhc) was contracted in the fall of 2000 to assess potential morphologic impacts of logjam removal on Pine River and mitigate the effects or restore the jams, where practical. We assessed the more than forty sites where cleanup work had occurred, prioritizing each for reconstruction based on the potential for channel

shifting, danger to existing floodplain infrastructure, bed material recruitment or erosion, and fisheries concerns. Nine logjams were rated as a high priority for immediate reconstruction and were rebuilt or repaired in the fall of 2000. The key issues addressed in design and construction were re-creating log jam functions with smaller volumes of wood, anchoring or attaching the new log jams, and restoring appropriate portions of flow in the main channel and its side channels to maintain channel stability and fish habitat.

Post-freshet monitoring surveys in June 2001 revealed that three of the nine sites required some maintenance and one log jam had failed. A variety of factors lead to this failure including channel bed adjustments and increased flows in the main channel compare to the side channel, following cleanup work. To ensure that the repairs at the site were stable, an additional log jam at the head of the side channel to reduce the flow into the channel was constructed. Work will continue in 2002 with post-freshet monitoring.



Figure 1. These huge logjams were constructed following removal and subsequent burning of logjams that were in place in Pine River during a Pembina Pipeline oilspill that occurred in August 2000. ▲

Preliminary Biological Assessment Results of Fish Habitat Restoration Projects and Implications on Project Development

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Assessment of existing fish habitat restoration projects to determine fish utilization was undertaken in the southern interior of BC during the summer of 2001 and continued during the winter of 2001/02. For FOC, coho are the primary species of concern and the focus of the work, though numbers of chinook, rainbow/

steelhead trout and other species are recorded. In addition to the trapping process physical measurements are taken of the sites including but not limited to riparian density and recovery, flow, temperature, and instream cover/habitat type. A mark re-capture protocol using gee traps is being used as the primary method used for enumeration with very limited use electroshocking in a few special cases to verify presence/absence. Control sites are chosen for comparison to riparian stabilization techniques and ground/surface water off-channel complexes. Within these project types, specific habitat features, such as pools, rock clusters, undercut banks, and woody material, are chosen to determine fish preference of these different structures. Juvenile assessment is planned to continue for the next several years.

In addition to furthering knowledge of interior coho life history, improvements in the development and selection of restoration prescriptions can be made. The type of projects developed to benefit fish can be based on preferred habitat area such as riparian, instream or off-channel for a specific watershed. From each of the specific habitat features assessed, the fish preferred physical parameters such as flow, DO or temperature can be used for improving the design of projects. We did find out that coho seem to prefer the woody structures, while steelhead and Chinook prefer the riprap. Design alterations may include altering the placement or orientation of structures, construction methods used to build the structures, or changes in materials used such as increasing the use of rock or wood. ▲

Computer Models in Forest Management

Criteria and Indicators Development: The Foothills Model Forest Experience

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The Foothills Model Forest (FMF) is a multi-partner based research organization located in the Foothills and Rocky Mountain regions of west-central Alberta. It encompasses an area of 2.75 million hectares and includes the landbases of Jasper National Park of Canada, Weldwood of Canada's (Hinton Division) Forest Management Agreement Area, Willmore Wilderness Area and Alberta Crown Management Units. It is part of a network of 12 Model Forests across Canada, which as members of the Canadian

Model Forest Network, seek to research and address Sustainable Forest Management (SFM) issues at a number of different scales.

An important focus of the Foothills Model Forest program over the past four years has been the development for reporting of Local Level Indicators (LLI) in support of the Canadian Council of Forest Ministers' commitment to the development and reporting of criteria and indicators of SFM.

The FMF addresses the process of LLI development in a multi-partnered, multi-jurisdictional environment. A process was undertaken to achieve agreement of shared values, goals, and objectives in the development of its initial draft set of indicators of SFM for the FMF landbase. This process had challenges of its rationalization of the initial draft indicator set in a multi-jurisdictional environment with partners of varied resource and land management mandates. It came down to a common and agreed set of meaningful, relevant, cost-effective indicators, which can be reported in a common format for all four landbases encompassed in the FMF. ▲

The Emergence of New Catchment-Based Tools and Spatial Data Models

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Catchment, or watershed-based, approaches are currently being rediscovered as tools of choice for coordinating the involvement of scientists, regulators, politicians and the concerned public in discussions pertaining to developing policies, plans and operational management decisions for catchment areas.

Scientists can make a major contribution to effective watershed management approaches by providing credible, cost-efficient and useful data and tools that describe the physical environment of defined watersheds of interest. Effective descriptions of the environment of watersheds must describe not only the physical characteristics of the environment at specified locations (e.g. its soils, vegetation communities, geological materials) but also the major processes that operate within the watershed. Several spatial data models have emerged in recent years that aim to develop and describe explicit hydrological linkages between adjacent spatial entities (Maidment, 2000; Flanagan et al., 2000; Band et al., 2000).

These spatial data models not only describe the physical characteristics and current status of specific

locations in the landscape, but also facilitate procedures for modeling the movement of water, or materials carried by water, between adjacent entities. This presentation illustrated the concepts involved in, and the advantages derived from, defining integrated land and water spatial entities. It uses examples from a recently completed pilot project within the Cariboo Forest Region of BC. This work was done in collaboration with Tracey Earle from Lignum in the Cariboo region. The examples illustrate how spatial entities defined from digital elevation data by considering both geomorphic shape and hydrological connectivity were useful in predicting the environmental conditions required for estimating the most likely ecological classification (Site Series) at given locations. The examples also demonstrate how definition of hydrological linkages between defined spatial entities (e.g. hillslopes, portions of hillslopes, sub-watersheds, channels and sinks) may offer significant advantages for many other analyses of interest for assessment of watershed processes and their possible impacts.

It is argued that such new, integrated, land and water spatial data models will become increasingly necessary and valuable for supporting watershed-based management approaches. The models describe, and can directly support modeling of, interactions between entities arising from the movement of water from any entity to its downslope neighbor or neighbors. Both the data needed to support them and the tools needed to implement them are becoming increasingly feasible and affordable to obtain.

References:

- Band, LE, C.L. Tague, S.E. Brun, D. E. Tanenbaum, and R. A. Fernandes. 2000. Modelling watersheds as spatial object hierarchies: Structure and dynamics. *Transactions in GIS*. 4(3):181-196.
- Flanagan DC., CS. Renschler and TA. Cochrane. 2000. Application of the WEPP model with digital topographic information. (in) *Problems, Prospects and Research Needs. Proceedings of the 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4); 2000 Sep 2-8; Banff, Alberta, Canada.* <http://www.colorado.edu/research/cires/banff/upload/330/index.htm>. Accessed 2001, Feb 1.
- Maidment, DR. (editor) 2000. ArcGIS Hydro data model: Draft data model and manuscript. Prepared for presentation at the GIS Hydro 2000 pre-conference seminar, 20 th Annual ERSI User Conference, San Diego, CA. http://utwired.engr.utexas.edu/crwr/cd_Consortium_2000/GisHydro2000.htm. Accessed Jan 29, 2001.



Streamflow Models In Integrated Forest-Watershed Planning: How Much Complexity Is Warranted?

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Annual water yield models have been criticized as watershed assessment tools because of their limited ability to represent the full range of forest harvest effects on hydrologic processes governing streamflow in forested watersheds. However their relatively modest data requirements along with their ability to project the cumulative effect of forest disturbance and subsequent hydrologic recovery on streamflows make models of this type particularly suitable for integrated forest watershed planning. Annual water yields in Alberta are reasonably well correlated with both average and maximum annual peakflow events allowing for adequate representation of these hydrologic variables using annual water yield models along with broadly available hydrometric and climatic data. The forest planning in Alberta is accomplished by strategic, tactical and operational levels. Options for model simplification will be discussed using two annual yield models (WRENSS and ECA - Alberta). Simple cause and effect modeling are not often possible because of the two driving variables – climate which can't be predicted and forest condition. The ECA (Equivalent Clearcut Area) model can be criticized because of lack of data. The WRENSS is a serious attempt at a detailed water balance simulation. In conclusion, there was an agreement by the presenter with the quote: "All models are wrong, but some are useful." ▲

Water Resource Optimization Modeling for Forest Management

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There are broad modeling issues and problems involved in optimizing water quality, storage and flow in forest management planning. The level 1 IWAP is our current basic watershed-modeling tool. The IWAP method uses a series of basic variables to analyze probable changes to watershed hydrograph as a result of management activities. This presentation looks at the data and variables behind the IWAP, and

watershed modeling, and examines the potential benefits of using more sophisticated watershed models. Issues examined include:

- The basic variables influencing watershed modeling
- The magnitude of variation expected for each variable due to changes in land use at both the stand and watershed level
- Potential tools for managing hydrograph and water quality within a forestry setting
- Economic implications, both benefits and costs, of water storage and flow optimization. ▲

Research and Science in Watersheds

Science, Watershed, and Stream Channel Morphology

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The objectives of this presentation were to outline what is known about stream channel morphology and to apply this knowledge to the management of streams. Generally channel morphology depends on many factors of which sediment and debris supply, riparian vegetation and direct disturbance of channel bank and bed are the most important in a forestry context. In a coastal stream the morphology varies longitudinally from stream mouth to the headwater. It includes riffle-pool habitat, cascade-pool habitat, and near the top of the system, very stable step-pool morphology in the headwater zone. In plateau regions of the province's interior, the morphology is different. The headwaters of the river may be riffle-pool, and the step pools may occur downstream.

Large Woody Debris (LWD) is critical in riffle-pool morphologies where it causes scour and fill, leading to channel complexity. The LWD is supplied by landslides on the coast, while it is more often generated from floods inland. Large loads of debris are delivered episodically and create huge logjams. Over time, a complex and diverse stream evolves from these initial disturbances.

In a results-based code world, it may be difficult to determine cause of identified channel disturbances. Three case studies illustrate the potential problems.

Dramatic changes in a section of Carnation Creek (Vancouver Island) could have been attributed to logging, when the actual cause was more influenced by hillslope processes upstream. The Yakoun River (Queen Charlotte Islands) shows the importance of historical management activities. Removal of LWD at the turn of the twentieth century influenced channel conditions for much of the century. Finally, an extreme example from Donna Creek (MacKenzie Forest District) illustrates the problems of determining the cause of channel changes due to legal arguments. These studies are intended only as a caution when using channel disturbance as a measurable result in results-based management. ▲

Sediment from Road Erosion and Landslides – Application of Research Results to Watershed-Scale Risk Assessment

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Sediment in streams is a natural and important component of watershed systems. However, too much sediment, or short-term increases in sediment yield, can reduce the value of a stream for domestic water supply and for fish habitat. Sediment from forest development is therefore an important management issue, and drives much of the content of the Forest Practices Code concerning watersheds. There are two main sources of development-related sediment: erosion from roads, and landslides.

Two long-term sediment budget studies are in progress in the Nelson Forest Region, in the West Arm Demonstration Forest and the City of Cranbrook watersheds. Results from these studies show that forest development can cause an appreciable increase in sediment supply to streams, mostly from erosion of logging roads. Increases observed so far are mostly of short duration and have had only minor impacts on water quality. Sediment inputs vary greatly from place to place, due to the geologic and hydrologic properties of the watersheds as well as to engineering practices.

Recent research into road erosion processes has enabled us to develop improved methods for mapping and assessing erosion and sedimentation risks from forest development.

Also in the last five years, we have studied the distribution and frequency of landslides in the Nelson Forest Region. Because no landslides occur in most watersheds in most years, sediment input from landslides must be treated as a risk, not as a continuous

process. In any watershed containing landslide-prone terrain, there is a very small probability of a very large input of sediment to the stream. A risk assessment approach must be used in planning forest road systems, to minimize risks to stream channels and water quality.

The sediment load of streams is mainly a function of climate and geology, but forest development can lead to risks from increased sediment supply. The episodic nature of sediment inputs from road erosion and landslides raises important questions about how risk can be evaluated, and water quality impacts monitored, under the proposed results-based Forest Practices Code. ▲

Science-Based Forest Management on Fans

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Throughout the province, forest managers have encountered problems on fans. A fan is a landform the surface of which forms a segment of a cone that radiates downslope from the point where a stream emerges from the confines of a mountain. Bridges are characteristically of insufficient size to withstand periodic debris flows, hyperconcentrated flows and bedload/debris associated with major floods (hydrogeomorphic events). Roads are frequently eroded by unexpected broadcast flows. Riparian reserves are absent where there are no fish values, or too narrow to contain sediments and water, resulting in impacts to growing sites and improvements. The BC Forest Practices Code provides little direction for forestry activities on fans and the current terrain stability mapping does not identify hazards on fans.

To address this knowledge gap, a research project was initiated in 1999 to develop a hazard classification for forestry on fans. The classification is based on an inventory of 63 fans and their watersheds in the Prince Rupert Forest Region. Forest stands are the leading indicator for the classification. Other site features and watershed attributes are also used.

Forest stand types are used to identify zones of activity on a fan rather than to typify a whole fan. We found that disturbances as expressed in forest stands range

from narrow (4 m. along the channel) to wide (1 kilometre from the present channel). However, very few cases were found where the whole fan surface is being actively influenced by hydrogeomorphic events. On the other hand, all fans showed some level of disturbance (i.e., we didn't find any stable fans).

Reliable use of airphotos for forest stand type classification is limited to FS4 cohorts that are at least 20 meters wide. On airphotos, FS3 stands may be confused with open grown stands on devil's club ecosystems. Field identification is required to positively identify forest stand types and determine time periods of disturbance. Forest cover maps were not found to be reliable for stand type classification.

Fieldwork is also required to identify a range of site features related to forestry prescriptions. In particular, the nature of the stream channel, the hydrogeomorphic role played by riparian vegetation, and evidence to identify the type of hydrogeomorphic processes.

Analysis of watershed attributes is currently ongoing. Several trends are emerging. The objective of the research project over the next two years is to test the fan hazard classification and provide training to operational foresters, engineers and geoscientists in other areas of the province. This research and extension project has demonstrated that sustainable forest management is possible on fans.

(Editor's note: This paper is presented in its entirety in Streamline 6:03.) ▲

Is Water Quality Sampling an Effective Means of Monitoring Watershed Condition?

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Many forest management and watershed rehabilitation activities are undertaken with the objective of protecting water quality. In a "results based" context, the monitoring of water quality would appear to be a means of assessing the effectiveness of those activities. A review of several studies indicates that it is difficult and expensive to monitor water quality in such a manner that the land use impacts are detectable. In order for a monitoring program to be effective one must be able to separate the natural variation in a parameter from the incremental effects of land use. We examined three case studies in southeastern B.C., where we monitored effects of land use. These are:

1. Matthew Creek study wherein we looked at the effects of a fire for 10 years after the fire, which had burned a 22 km² area. Impacts of nitrate and a number of other parameters were detectable for 4 years after the fire. An upstream/downstream sampling design and an unburned control were factors that made this monitoring effective.
2. A Monitoring Program to Study the Effects of Cattle Grazing on Water Quality on McMurdo Bench. An upstream/downstream sampling design provided local residents with assurance that there were minimal effects of grazing on their drinking water.
3. A Sediment Budget study to test the Watershed Assessment Procedure. The sediment yield was compared in 11 watersheds subjected to various levels of historic cut.

Common characteristics of each program were: a sampling frequency that was appropriate to the parameter being measured, a means of separating the treatment effect from natural variation, sampling of parameters known to be impacted by that land use, appropriate replication where possible, and sampling locations as close to the activity to be able to identify which land use was causing the problem. There were problems inherent with setting water quality objectives. The results of the McMurdo Beach study demonstrated that if you keep the cattle out of the stream the local water user can have the same water quality as protected areas. The conclusions based on all the watersheds studied were that watersheds change in a complex manner. The water quality changes continually in response to many variables. In order to measure and interpret the results, there must be a control. ▲

Assessing the Effectiveness of Logging Road Deactivation Using Stream Silt and Aquatic Invertebrates

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A five-year, multi-proponent watershed study is being conducted in the Nahatlatch River Watershed west of Boston Bar, B.C. The study was initiated because the Boothroyd Indian Band had concerns about the water quality and it seemed that road deactivation was causing turbidity. This study examines logging road deactivation levels and techniques and their ongoing impacts on stream silt levels and stream invertebrates. This FRBC-funded project has provided the

opportunity for scientists, First Nations, logging companies, and other government and private firms to explore the effects of logging roads on water quality. Results will be used in the development of management strategies.

We examined water quality in six streams chosen for their varied logging road histories. We measured Total Suspended Solids (TSS) and Turbidity daily using ISCO 6700 automatic water samplers. Stream invertebrates were collected using Hester-Dendy multi-plate invertebrate samplers following a 42-day colonization period. The combination of silt characteristics and invertebrate communities within each stream was used to gauge the effectiveness of that stream's road deactivation methods.

Log and Mehatl Creeks, and the Upper Nahatlatch River were on the order of ten to twenty times as silty (measured both as TSS and turbidity) as Kookipi, Squakum, and Tachewana Creeks. These streams differed in their levels of road deactivation (Squakum and Tachewana Creeks: roads over 20 years old, un-deactivated; Log and Kookipi Creeks, and Upper Nahatlatch River: active logging roads, un-deactivated; and Mehatl Creek: no roads). Mehatl and Log Creeks, and the Upper Nahatlatch River also have glacial influences (excessive silt), which need to be quantified in order to accurately assess the effectiveness of that stream's road deactivation scheme. The multi-plate invertebrate samplers were dominated by Ephemeroptera, specifically by the families Heptageniidae and Baetidae. EPT (Ephemeroptera, Plecoptera and Trichoptera) and diversity indices were used to compare the biology of the streams.

The conclusions were that the two sub-basins with active logging have turbidity and sediment issues. Old logging roads do not contribute sediment to the streams. Natural sources of sediment also affect the turbidity. ▲

Snow Research and Watershed Assessment in the Southern Interior

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Watershed assessment guidelines in British Columbia

use rates of harvest and regrowth to evaluate forestry-related hydrologic change. In the interior, these guidelines are based on the idea that snowmelt generated streamflow is one of the key watershed processes that can be affected by forest land-use. Snow research generally involves detailed measurements of basic processes at the plot or stand scale. The results of this research are often extrapolated over broad geographic areas and forest types for use in operational planning. Research results may also be used to develop provincial forest practices guidelines. However, with increasing regulatory constraints on timber harvesting and with greater concern for water resources, the validity of guidelines based on limited local data and on indicator criteria, such as snow, is often questioned.

Snow research in the Kamloops and Nelson Forest Regions, as well as in other parts of the province, is beginning to improve our understanding of the interactions between forest cover, snow, and local watershed processes. Research in the southern interior has focussed on mature, clearcut, and juvenile stands of lodgepole pine, Engelmann spruce and subalpine fir at Mayson Lake and Upper Penticton Creek, and of mixed species at Trapping Creek. The results of this research show significant differences in snow accumulation and melt rate among forest types, a varied effect of juvenile stands on snow processes, and that snowmelt from desynchronised stands over a watershed can become synchronised following harvesting. Currently, these results would be extrapolated to other stands based on tree height. The research has shown that other forest inventory variables, representative of the interception capacity and shading characteristics of a stand, are likely to be more effective predictors of differences in peak snow accumulation and melt among stands. Understanding the relationships between stand characteristics and fundamental hydrologic processes, such as snow accumulation and melt, will improve our ability to assess the effects of changes in forest cover on watershed response. ▲

Stream Channel Monitoring in the Southern Interior of British Columbia

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Stream channels are in a state of dynamic equilibrium as streamflow and sediment supply vary and framework elements develop, erode, and migrate

downstream. There is, however, a lack of knowledge on the diversity of stream function and on the rates of change found in streams in the four main biogeoclimatic zones in the southern interior of British Columbia: Interior Douglas-Fir (IDF), Montane Spruce (MS), Interior Cedar-Hemlock (ICH), and Engelmann Spruce-Subalpine Fir (ESSF). This project is designed to monitor channel morphology in unlogged and logged watersheds throughout the southern interior of British Columbia. Permanent cross-sections provide detailed topographic survey information, which, with a complementary orthoimage, present a readily repeatable and descriptive tool to monitor channel change. A total of 29 cross-section reaches have been established in 13 watersheds to begin the process of systematic collection of data for southern interior streams. These reaches will provide insight on the framework and function of streams and the rate of change in the channels. Over time this should include some major climatic events (rainfall, snowfall, snowmelt or fire) that may cause more change in one event than many years of normal weather. This photographic methodology is a relatively new technique for monitoring a watershed and supplies the spatial and temporal indicators of management activities on watersheds and riparian zones. It can be used to detect long-term and short-term changes. ▲



Each year it is heartwarming to see that there are more and more indications that industry is assuming the role of environmental stewards. In this case industry is supporting the watershed stewardship groups financially. Harry James, General Manager, Health, Safety & Environment for Gibson Petroleum presented cheques to Wes Ilinsky from the Eagle River Roundtable Society and Mike Wallis from the Salmon River Watershed Roundtable Society to support the successful work that has been accomplished in these two watersheds.

...continued from page 12.

are not approved at that time. If the money is not spent by Mar. 31, it is lost. There is no possibility for credits to be issued if a manager is careful, and may not have spent all that money.

Long-term funding would allow work to proceed at the optimal time of year. The San Juan WRP was based on long-term fund management because much of the funding was from the private forest companies. Results-based management may also assist in this management over the long term, however, this will only work if there are annual expectations for the monitoring and reporting.

Technical Expertise

Some individuals chose watershed restoration as a career, and embraced that career. Many of these individuals have strong training in forestry, or engineering, or environmental studies. There are, however, other individuals who found themselves in watershed restoration because of the economic situation in the province. Still others fell into it as a member of a stewardship society. Now, members of societies are providing project management for many WRP projects. Some people had embraced the concept and objectives of the program, while others were just trying to piece together a living in the area that they live. Some of these individuals saw the opportunities in Watershed Restoration Program, or were talked into it during the years when there were many projects requiring crews. All individuals were provided the opportunity for training. They were often displaced forest workers, or their chosen work may have been in commercial fishing and guiding but they did need to supplement their chosen work. Watershed restoration wasn't a chosen field for all, and sometimes this was reflected in the quality of the work.

The lesson learned is to provide projects with sufficient technical expertise to support the project staff. The referral process ensures that experts from other disciplines check the project, but most frequently it is preferable to obtain technical advice prior to the referral stage. This should be done by involving a variety of disciplines in the assessment and planning process.

We have come such a long way in training a brain trust that it would be a pity to lose many of these individuals to new opportunities outside BC or to different careers because the whole program has been cancelled. Practitioners have all learned from the training, from observing successes and failures and from monitoring. The restoration work has been far better during the past few years. The protocol set in action by FRBC in 1999 has led to a much more focussed and organized program.

Projects really don't have many problems any more, as much of the Routine Effectiveness Evaluation (REE) is showing 80 - 90 % success (Wilson, et al., 2002).

Spend restoration money where there is the technical / physical ability to fix the problems.

This warning may be particularly useful to licensees that are assuming new work in watershed stewardship. It was heartening to hear that one of the criteria for projects that will be funded by the Pacific Salmon Endowment Fund is "do-ability." Some of the early work in particular that was funded within the Watershed Restoration Program was in areas that we did not have knowledge about all the processes, such as alluvial and colluvial fans. Research has been ongoing about this topic and is reported in Wilford, et al., 2002. It will be interesting to have more information on treating problems within the instability of fans. If the process isn't understood, it is difficult to predict what will happen. Another example where we may not have the technical or physical ability to fix the problems are found within watersheds that were heavily affected by riparian logging. It is important that the results or information determined are disseminated quickly.

Hillslope Restoration

Approximately eighty percent of WRP funds were expended on hillslope restoration. Although I began by talking about the importance of a holistic, top-down approach to watersheds, perhaps it was overdone in some cases. Full deactivation in certain cases at considerable costs was done to a very high standard, when partial deactivation would have been successful in meeting objectives for water quality and fish habitat. We have learned lessons in managing forest road deactivation and some of these lessons were outlined in Allison and Tait, 2000. More careful analysis assists decision makers and managers to more carefully choose the level of deactivation that is required. Part of the problem may have been a cautious approach by professionals because of their liability, but part of the problem may have been a result of unclear objectives for the program and inefficient prescriptions. Partial deactivation would have sometimes accomplished the objectives, with full deactivation reserved for the sites of most risk of slope failure. Recent deactivation work has been significantly more cost effective, so we have learned from our past mistakes. Road deactivation in the U.S. seems to have followed the same evolution from full deactivation, or obliteration, to partial deactivation.

Channel Structuring Elements

In mature and old-growth forests, streams are filled with abundant pieces of large wood that store sediments

Feature

and affect the morphology of the stream. Hundreds of large-scale projects to replace lost channel-structuring elements were implemented to restore the amount and quality of fish habitat. Many of the projects involved the addition of large woody debris (LWD) to the streams. The lessons learned regarding instream restoration structures are well summarized in *Evaluating the Performance of Channel and Fish Habitat Restoration Projects in B.C.'s Watershed Restoration Program* on p. 3 - this Streamline.

One of the lessons learned by practitioners was to “go big”. Of course this depends on the size of the system. For instance, LWD structures in small streams could be a waste of money and effort. In a small stream, successful channel structuring may involve construction of a stone line. However, in medium-sized and large streams, particularly when there is a large fluctuation in flow, large composite structures are required. These structures should be as large as possible, well-anchored, and ballasted. In some systems the importance of large boulders and woody debris combined with boulders is evident, and practitioners also mention the importance of sufficient ballast. Proper anchoring and ballasting has been shown to increase the success rates of LWD structures by 7 to 30 % (D'Aoust, 2001).

Another lesson learned was that “logs are not trees”. Whenever possible the use of whole trees to create structuring elements will be most successful. The rootwads in particular, add complexity and trap smaller woody debris to provide additional cover for fish.

A recent and interesting example of channel structuring was seen in the work on the Pine River. This project was undertaken after a huge oil spill from the Pembina pipeline. As part of the river cleanup, most of the log jams were either fully or partially removed by crews or excavators and the contaminated wood burnt on-site. The log jams had been an important component of channel morphology and their removal led to a situation where the main channel could avulse or re-occupy side, back, or abandoned channels. The potential channel instability was thought to have negative long-term implications for fish habitat (Abstracts, p. 12A). Northwest Hydraulic Consultants Ltd. was contracted to provide assessment and subsequent mitigation where practical. Monstrous logjams were quickly constructed during the fall of 2000, very soon after the oil spill. Post-freshet monitoring revealed that three of the sites needed maintenance, a new jam needed to be constructed and one logjam had failed.

Riparian Restoration

On the topic of riparian restoration, I received differing opinions. One person felt that the best investment of

all during the process of watershed restoration had been in riparian restoration, and that if the program were to begin over again, he would suggest riparian restoration be a place that more money was invested. A differing opinion was that riparian restoration had been a waste of money because returns are in the distant future. The R.R.S.P. of WRP, it is true that this is a long term investment. The hopes of riparian restoration is to accelerate a successional process that would usually take about 200 years.

Sometimes the riparian restoration is very simple, such as installing anti-browsing tree cones to protect trees like red cedar. An example of some excellent riparian restoration has been the work done at the Keogh River by Western Forest Products and Poulin & Associates. These treatments included thinning (with thinned trees added to existing LWD structures in-stream) and creation of wildlife trees and dens.

Bioengineering

There were many lessons learned in bioengineering along the way. Many details are presented in David Polster's article for *Streamline* Vol.4, No.4. This is another instance where technical expertise is required to have the work be successful. More than a few individuals mentioned that it shouldn't be a fish biologist, or a hydrologist designing the bioengineering work. This is a place for a vegetation management specialist or an ecologist to be consulted. Some of the lessons that we hope have been learned are:

1. Know your species – there were examples where trembling aspen was used instead of willow, resulting in 100% mortality.
2. Don't plant in August – depending on your region, but in many of the interior zones, the August plantings don't make it. The plantings will leaf out beautifully in September and October, but by next April they are dead.
3. If possible, attempt to get cuttings or whole shrub clumps planted deeply along streambanks so that they are into the water table. Dessication over winter is a significant problem, particularly in the interior.
4. Plantings require maintenance, nutrients and water. Many of the ideal examples come from small stream slope stabilization projects where the landowners will continue to water and care for the bioengineering projects on an ongoing basis.
5. Black cottonwood isn't the right species for bar stabilization

Culvert Replacement

Hundreds of kilometres of fish habitat have been

recaptured by replacement of culverts and bridges. Although this is particularly true in the Cariboo and Omineca-Peace regions, most regions have benefitted from this type of WRP projects. All of the practitioners that I spoke with felt that restoration money had been well-invested in fish passage assessments and replacements. This conclusion is borne out by the REE process (Wilson et al., 2002).

Off-Channel Projects

For the most part, the construction of off-channel and side channel projects have been a big success for investment of restoration funding. A major key to the success of any off-channel project is the development of an intake that will supply a constant supply of water. There have been many off-channel projects constructed, as well as side channels and ponds.

One of the many successful examples of off-channel habitat that was created is the Anderson Creek off-channel pond (Figure 3). It was constructed to restore off-channel pond and fish habitat cut off by road construction. It has resulted in an excellent low maintenance site with high productivity and refuge values for fish. It has also been excellent for educational opportunities and provided additional habitat value to waterfowl and wildlife.

Although off-channel projects have been very successful, they will require continuing maintenance. Beavers are a significant threat to preventing fish access into many off-channel projects, particularly as vegetation succession occurs enough to provide cover and forage for beavers. For instance, the outlet of Anderson Pond is a prime example where several beaver dams have likely reduced access for juvenile fish, although adults gain passage during peak flows. Vegetation management will likely be required during the next few years to minimize beaver activity in the outlet channel that are crucial for access by juvenile fish, searching for over-wintering habitat.

Concluding Remarks

There are people that view WRP through rose-coloured glasses, while others that think it was a colossal waste of money. WRP has left a legacy for future generations of British Columbians. Although it has been demonstrated that we can increase fish populations by treating streams, by adding complexity, or nutrients, we cannot protect some species of fish from global warming and other challenges to their survival in the ocean. WRP has accomplished what could be done at the local level; it has improved aquatic resources in key watersheds throughout the province. WRP has increased the management of watersheds, and provided ample opportunities for community based



Figure 3. Off-channel habitat constructed at Anderson Channel is an example of mitigation for damage caused to the mainstem of the river by past forest practices.

employment, training and stewardship. The legacy of well-trained people from industry, consulting companies, First Nations, and stewardship groups will keep our streams and rivers as a vital resource for future generations.

References

- Allison, C. and D. Tait. 2000. The Application of Decision Analysis to Forest Road Deactivation Problems - an Example in Coastal British Columbia. *Streamline* (5)2: pp.1-6.
- Chatwin, S., M. Gaboury and C. Alexander. 2000. Watershed Restoration Program. Planning and Priority Setting for the Next Five Years. Phase 3 Watershed-level Planning. Prepared for the WRP Provincial Coordination Team.
- Cleary, Jaclyn and Donna Underhill (eds.) 2002. Annual Compendium of Aquatic Rehabilitation

Feature

- Projects for the Watershed Restoration Program 2000 – 2001. Province of British Columbia,. Watershed Restoration Project Report No. 19: 228p.
- Iverson, B. and D. Epps. 1998. The San Juan Watershed Agreement. Streamline (3)4: 5-11
- Muller, R. and E. Muller. 1999. Spring 1999 San Juan Riparian Follow-up and Additional Work. Streamline (4)1: 13 –16.
- Polster, D. 1999. Soil Bioengineering for Steep/ Unstable Slopes and Riparian Vegetation. Streamline (4)4: 1 – 8.
- Underhill, Donna (ed.) 2001. Annual Compendium of Aquatic Rehabilitation Projects for the Watershed Restoration Program 1999 –2000. Province of British Columbia, Ministry of Environment, Lands and Parks and Ministry of Forests Watershed Restoration Project Report No.18: 200p.
- Wilford, D., M.Sakals and J. Innes. Forest Management and Restoration on Fans. Streamline (6)3: pp.1-8.
- Wilson, A., P. Slaney and H. -Deal. 2002. Evaluating the Performance of Channel and Fish Habitat Restoration Projects in British Columbia's Watershed Restoration Program. Streamline (6)4: pp.3-7.
- Zaldokas, D.O. (ed.) 1998. Annual Compendium of Aquatic Rehabilitation Projects for the Watershed Restoration Program 1998 - 1999. Province of British Columbia, Ministry of Environment, Lands and Parks and Ministry of Forests Watershed Restoration Project Report No.8: 138 p.
- Zaldokas, D.O. (ed.) 1999. Annual Compendium of Aquatic Rehabilitation Projects for the Watershed Restoration Program 1998 - 1999. Province of British Columbia, Ministry of Environment, Lands and Parks and Ministry of Forests Watershed Restoration Project Report No.13. ▲

Technical Tip

Environmental Mitigation Prescriptions

James D. Hogarth and P. Mark Hawley

A site-by-site assessment of previously prescribed road deactivation and slope stabilization measures was undertaken on northern Vancouver Island in the spring of 1996. The purpose of this assessment was to prescribe appropriate environmental mitigation measures that would enable road deactivation and slope stabilization works to proceed, where possible, outside the fisheries timing window.

Preliminary standard prescriptions for access and deactivation were developed prior to the field assessment work. These incorporated stream classifications and various mitigative measures and environmental controls into separate access and deactivation prescriptions. Field assessments consisted of stream classification by a fisheries specialist in conjunction with an Erosion and Sediment Delivery (ESD) risk assessment by a geotechnical engineer. It is important to note that an ESD risk assessment should be conducted by an individual with an understanding of erosion processes, slope stability, and road deactivation and slope stabilization activities. Based on the results of the stream classification and

the ESD risk, site specific Environmental Mitigation Prescriptions (EMPs) were prepared utilizing the standard prescriptions as a guide. Modification of the preliminary standard prescriptions during the field program was necessary to reflect the results of the field assessment.

Environmental Mitigation Prescriptions consist of site specific prescriptions for mitigative measures, environmental monitoring and timing of work with respect to peak flows. They are to be employed during the implementation of prescribed road deactivation and slope stabilization measures, including activities associated with redeveloping access to old roads. While applicable predominantly at stream crossings, EMP's may be applied to any site.

To determine the appropriate EMP for a site, the Erosion and Sediment Delivery (ESD) risk is first estimated based on three basic parameters:

- i) **Connectivity:** The proximity and connection of the stream crossing or site to a fish-bearing stream or fisheries sensitive habitat.

Technical Tip

EROSION/SEDIMENT DELIVERY (ESD) POTENTIAL	
CONNECTIVITY ¹	
NC	No connection to fish-bearing stream or fisheries sensitive habitat. Gap in the channel system (e.g. flat or fan with no channel, non-fish bearing lake or wetland, ditch or cross ditch with no direct or indirect connection to an existing channel).
IC	Indirect connection to a fish-bearing stream or fisheries sensitive habitat. Channel has a gradient of less than 5% for greater than 100m before reaching a fish-bearing stream or fisheries sensitive habitat.
DC	Direct connection to a fish-bearing stream or fisheries sensitive habitat; or channel discharges into a non-fish bearing stream that discharges into a fish-bearing stream or fisheries sensitive habitat within 100m, or the channel gradient remains greater than 5% until it reaches a fish-bearing stream or fisheries sensitive habitat.
WATER TRANSPORT POTENTIAL ²	
L	Low water transport potential. Water Power Index <8; Upstream catchment <9 ha; Scattered, unsorted woody debris only, with no log jams; Sediment wedges/bed load sand sized or finer.
M	Moderate water transport potential. Water Power Index 8 to 11; Upstream catchment area ≥ 9 ha; Small woody debris jams; Sediment wedges/bed load up to cobble sized.
H	High water transport potential. Water Power Index >11; Upstream catchment area ≥ 9 ha; Large woody debris jams or evidence of debris flows or channel cleaning due to flooding; Sediment wedges/bed load up to boulder sized.
SEDIMENT SOURCE POTENTIAL	
L	Low potential as a source of sediment. Shallow cross ditches and culverts (<1m deep); coarse road bed materials (<10% fine fraction) being excavated or trafficked. Coarse bed load (<10% fine fraction) in channel being trafficked.
M	Moderate potential as a source of sediment. Moderately deep cross ditches and culverts (1-3m deep), well graded road bed material (10 to 20% fine fraction) being excavated or trafficked. Graded bed load (10 to 20% fine fraction) in channel.
H	High potential as a source of sediment; Deep cross ditches and culverts (>3m deep), fine grained road bed material (>20% fine fraction) material being excavated or trafficked. Fine-grained bed load (>20% fine fraction) in channel.
Notes: 1. Connectivity definition based on descriptions in the Gully Assessment Procedures Guidebook, February, 2001. 2. Water Power Index and Water Transport Potential are as defined in the Gully Assessment Procedures Guidebook, December 1995.	

Figure 1. Definitions of the parameters utilized to determine Erosion and Sediment Delivery Risk.

- ii) **Water Transport Potential:** The potential of the stream to carry sediment to a fish-bearing stream or fisheries sensitive habitat.
- iii) **Sediment Source Potential:** The availability of deleterious sediment (i.e., silt and fine sand) at the stream crossing or site that may be introduced into a stream by access or deactivation activities.

Each of these parameters is discussed in Figure 1. Where practical, the methodology contained in existing publications under the Forest Practices Code of B.C. was used, or modified as appropriate, to define the various levels for each parameter.

The ESD risk is then calculated based on the matrix given in Figure 2.

ESD RISK MATRIX ¹			
Sediment Source Potential	Water Transport Potential	Connectivity	ESD Risk
L	L	NC	L
L	L	IC	L
L	L	DC	L
L	M	NC	L
L	H	NC	L
M	L	NC	L
M	M	NC	L
M	H	NC	L
H	L	NC	L
H	M	NC	L
H	H	NC	L
L	M	IC	M
L	H	IC	M
M	L	IC	M
M	M	IC	M
H	L	IC	M
L	M	DC	H
L	H	DC	H
M	L	DC	H
M	M	DC	H
M	H	IC	H
H	L	DC	H
H	M	IC	H
M	H	DC	VH
H	M	DC	VH
H	H	IC	VH
H	H	DC	VH
Notes: 1. The methodology for assessing ESD potential described above is intended to be used as an interpretive tool by individuals with the appropriate experience and understanding of erosion processes, slope stability and road deactivation/slope stabilization activities. It is a subjective rating scheme and is intended only for assessment of the potential for erosion/sediment delivery at discrete locations. ESD potential ratings should be verified by the Environmental Monitor during implementation of the recommended works and mitigative measures.			

Figure 2. Matrix used to calculate the Erosion and Sediment Delivery Risk.

Technical Tip

In developing this risk matrix, connectivity was given a higher weighting than either Sediment Source Potential or Water Transport Potential. Once the ESD risk has been calculated for access and deactivation works and the stream classification known, it is then possible to determine the appropriate EMP category for each site for access and deactivation activities. Standard prescriptions and category codes (i.e., A1, A2, ...) for access activities are shown in Figure 3 and prescriptions and category codes (i.e., D1, D2, ...) for deactivation activities are shown in Figure 4.

Where a site falls into a category represented by codes A1 to A3 for access and D1 to D3 for deactivation, appropriate environmental mitigation measures for the site are to be determined by the Environmental Monitor during the implementation phase. The higher categories generally deal with larger fish-bearing streams or sites where in-stream works are recommended. As detailed in Figures 3 and 4, suitable, site-specific, EMPs can be developed for sites of this type by a geotechnical engineer in consultation with a fisheries

specialist, preferably with appropriate experience in sedimentation mitigation procedures and road deactivation and slope stabilization activities. Once determined, the codes corresponding to the EMP category for access and deactivation are then incorporated into the deactivation prescription spreadsheet (e.g., A2:D3) and shown on the deactivation plan map. Where site specific EMPs were developed, they are also included in the prescription spreadsheet.

Following completion of the Vancouver Island assessments, this system was applied to six watersheds in the Queen Charlotte Islands during the spring and summer of 1996. During the course of this work, further modifications were made to the standard prescriptions to clarify apparent inconsistencies. Except for minor modifications, the standard prescriptions resulting from the Queen Charlotte Islands work are the ones presented in Figures 3 and 4. To date, EMPs have been utilized in a total of eleven study areas in the Queen Charlotte Islands Forest District and the Port McNeill Forest District.

ENVIRONMENTAL MITIGATION PRESCRIPTIONS	
ACCESS	
A1	Low ESD risk. Classes S5 and S6 streams with a low potential for erosion/sediment delivery to Classes S1 to S4 streams or Fisheries Sensitive Zones (FSZ). Includes existing bridges and culverts that span all classes of streams and appear to be in serviceable condition. No mitigative measures required. Unrestricted access for tracked equipment and rubber-tired vehicles.
A2	Low to moderate ESD risk. Classes S5 and S6 streams with low to moderate potential for erosion/sediment delivery to Classes S1 to S4 streams or FSZ. Minimize number of times tracked equipment crosses streams. Tracked equipment may require cleaning before crossing stream. Unrestricted access for rubber-tired vehicles.
A3	Moderate ESD risk. Classes S5 and S6 streams with moderate potential for erosion/sediment delivery to Classes S1 to S4 streams or FSZ. Construct Ford or Squamish culvert using coarse rock with minimal fines. Special measures to mitigate erosion/sedimentation may be required as determined by Environmental Monitor (EM) during construction. EM to inspect ford/culvert construction and approve completed structure before use. Minimize number of times tracked equipment crosses stream. Tracked equipment may require cleaning before crossing stream. Unrestricted access for rubber-tired vehicles.
A4	Moderate to high ESD risk. Classes S3 and S4 streams, and Classes S5 and S6 streams with moderate to high potential for erosion/sediment delivery to Classes S1 to S4 streams or FSZ. Repair existing structure or construct Squamish culvert (with provision for fish passage, as required), temporary wooden or metal culvert, or bridge as noted. EM to inspect culvert/bridge repair/construction and approve structure before use. If fish are present, they are to be removed and site screened off before commencement of work. Special measures to mitigate erosion/sedimentation during construction as noted. Access restrictions for Squamish culverts as per A3, otherwise unrestricted access for tracked equipment and rubber tired vehicles following approval of structure. Design and mitigative measures for culverts/bridges that span Class S3 or S4 streams determined in consultation with a fisheries specialist, as noted. Culverts >2m equivalent diameter and bridges to be designed, and completed structure approved, by a Professional Engineer (P.Eng.)
A5	High ESD risk. Classes S1 and S2 streams and Classes S3 to S6 streams with a high potential for erosion/sediment delivery to Classes S1 to S4 streams or FSZ. May require construction of a full span bridge or culvert. Crossing feasibility, design and environmental mitigation requirements determined by a Geotechnical Engineer (P.Eng.) in consultation with a fisheries specialist and other professionals as noted. Full time inspection by EM required during construction of mitigative works, and as required during operations. Completed works to be approved by the Geotechnical Engineer before use. Access restrictions will depend on crossing design and mitigative measures implemented, and are to be determined by the Geotechnical Engineer in consultation with a fisheries specialist.
A6	Very high ESD risk. Any Class S1 to S4 stream with a high fisheries value (as determined by a fisheries specialist) or Class S5 or S6 stream with a high potential for erosion/sediment delivery to a high fisheries value stream or FSZ. No in-stream activity outside of fisheries timing window permitted, unless a full span bridge is installed. Feasibility, crossing design, mitigative measures and restrictions for crossing determined by a Geotechnical Engineer (P. Eng.) in consultation with the fisheries specialist and other professionals, as noted. Fisheries timing window to be determined in consultation with Department of Fisheries and Oceans and B.C. Environment (MELP), as required, prior to commencement of work.

Figure 3. Standard Environmental Mitigation Prescription codes and associated Category Codes for activities related to accessing old roads.

Technical Tip

ENVIRONMENTAL MITIGATION PRESCRIPTIONS DEACTIVATION	
D1	Low ESD risk. Classes S5 and S6 streams with a low potential for erosion/sediment delivery to Classes S1 to S4 streams or Fisheries Sensitive Zones (FSZ). No mitigative measures required.
D2	Low to moderate ESD risk. Classes S5 and S6 streams with a low to moderate potential for erosion/sediment delivery to Classes S1 to S4 streams or FSZ. Routine erosion/sedimentation control measures may be required as determined by Environmental Monitor (EM) during implementation. Periodic inspections by EM.
D3	Moderate ESD risk. Classes S5 and S6 streams with a moderate to high potential for erosion/sediment delivery to Classes S1 to S4 streams or FSZ. Special measures to mitigate erosion/sedimentation may be required as determined by EM during implementation. Frequent inspections by EM.
D4A	Moderate to high ESD risk. Streams with moderate to high potential for erosion/sediment delivery to Classes S1 to S4 streams or FSZ. No fish present at site or low fisheries value as determined by a fisheries specialist. Special erosion/sedimentation control measures, including minor diversions, small sedimentation ponds, etc., as noted. Full time supervision by EM.
D4B	Moderate to high ESD risk. Classes S1 to S4 streams with moderate to high potential for erosion/sediment delivery. Fish present at site. Electroshocking/netting of resident fish and screening off site to be conducted by a fisheries specialist prior to commencement of work. Special erosion/ sedimentation control measures, including minor diversions, small sedimentation ponds, etc., determined in consultation with the fisheries specialist, as noted. Full time supervision by EM.
D5	High ESD risk. Classes S5 and S6 streams with a high potential for erosion/sediment delivery to Classes S1 to S4 streams. Feasibility of proposed deactivation works and design of mitigative measures, determined by a Geotechnical Engineer (P.Eng.) in consultation with a fisheries specialist, as noted. Full time inspection by EM. Works to be inspected by the Geotechnical Engineer at critical stages during implementation. Completed works to be inspected and approved by the Geotechnical Engineer.
D6	Very high ESD risk. Any Class S1 to S4 stream with a high fisheries value (as determined by a fisheries specialist) or Class S5 or S6 streams with a high potential for erosion/sediment delivery to a high fisheries value stream. No in-stream activity outside of fisheries timing window permitted. Feasibility of implementing deactivation works and design of possible mitigative measures, determined by a Geotechnical Engineer (P.Eng.) in consultation with a fisheries specialist, as noted. Fisheries timing window to be determined in consultation with Department of Fisheries and Oceans and B.C. Environment (MELP), as required, prior to commencement of work.

Figure 4. Standard Environmental Mitigation Prescription codes and associated Category Codes for activities related to road deactivation.

Some of the benefits of utilizing this system are:

- Consistency of prescriptions from project to project.
- Provides a more detailed work plan to reviewing agencies. This should help speed up approvals.
- A more detailed work plan also means a more accurate cost estimate can be developed before work begins.
- Applications of this system are not limited to road deactivation. It has applications wherever work in or around streams is proposed.

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Streamline Index

Many readers have requested a Streamline Index over the years. Please note that if you are looking for a specific article on for example, Ballasting, you can still use the keyword index that is on the website: <http://srmwww.gov.bc.ca/frco/bookshop/streamline.html>. In addition, if you are looking for a certain author's submission, you can also find the article and issue number by using the last name of the author.

Issue

Vol.1 No.1

Winter 1996/97

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 The Fish Creek Watershed Analysis: did it survive a 100-year storm event?
 A Preliminary Report on Instream Structure Durability Following 1996 Floods
 Working with beavers to maintain fish access
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Update

Workshops

Design and installation of embedded culverts. Beginning mid-April at locations throughout the province. This one-day training session introduces participants to the installation of stream crossing structures that are designed to accommodate fish passage and peak flow conditions. Contact Phil Blanchard @250-477-5560 or check the website www.fcsn.bc.ca.

Case Studies of Innovative/ Alternative Road Construction Techniques and Costs. May 16, 2002 in Prince George; May 28 in Campbell River. This workshop will present several case studies to highlight innovative/ alternative forest road construction techniques. Contact Kandy Akselson @250-367-7916 or check the website: www.fcsn.bc.ca.

Natural Resources Worker Soil Bioengineering. Offered throughout the province, depending on field site availability, and on demand. Course contact : Tom Rankin @250-573-3092. This is a two-day course, with one and a half-days spent in the field installing soil bioengineering systems. More information on the website: www.fcsn.bc.ca

Stream Classification & Riparian Management. This one-day training course is available on demand. The course contact is Phil Blanchard @ 250-477-5560 or check the website: www.fcsn.bc.ca.

Thank you to Shawn Clough for providing a summary of this recent workshop:

Workshop on Fisheries Restoration Site Monitoring & Evaluation. The Thompson Basin Fisheries Council (TBFC) and Fisheries & Oceans Canada jointly hosted a technical meeting in Kamloops on February 8, 2002. Co-sponsoring the event were Fisheries Renewal BC and the BC Hydro Bridge Coastal Restoration Program. Thanks to all of the sponsors,

this workshop had no registration fee. This encouraged the attendance of more than 70 interested participants!

The Workshop brought together professional, technical and stream restoration practitioners to discuss the variety of monitoring protocols being used throughout BC. The goal of the workshop was to examine practical approaches and consider standardization of monitoring methodologies.

The seven presentations delivered during the day sparked intense involvement from the workshop attendees. The active participation and interaction between the speakers and the audience provided both groups the opportunity to express concerns or ask direct project related questions, which is typically unavailable at most formal symposiums. The level of discussion was a positive sign that the topic was one of interest to people within the stream restoration field.

Conferences

Toward Ecosystem Based Management: Breaking Down the Barriers in the Columbia River Basin and Beyond. April 27-May1. Spokane, Washington. Contact: Donald MacDonald, 2376 Yellow Point Road, Nanaimo, British Columbia V9X 1W5 (Phone: 250/722-3631; E-mail: sff@island.net; Web: <http://www.sff.bc.ca/2002.html>)

Integrated Transboundary Water Management Conference. July 23-26, Traverse City, Michigan. Water resources heed no jurisdictional boundaries. This incontrovertible fact can produce complications in the management of transboundary water resources. Conference topics include Integration of Different Cultures (Academic, Private, Public, Legal, Socioeconomic, Political, Effects on management, analysis and decision-making); Transboundary Water Resources; and global warming. For further information, contact: Tel 202-789-2200; E-mail: ewri@asce.org; Web: <http://www.uwin.siu.edu/ucowr/>.

Streamline

Produced and published by:
Ministry of Forests and Watershed
Restoration Program

Corporate Services; Ministries of
Sustainable Resource Management
and Water, Land and Air Protection
2204 Main Mall, Vancouver, B.C.
V6T 1Z4 Fax: 604-660-1849

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Streamline's goals are to communicate information on practical approaches to watershed restoration including the rehabilitation of stream channels, riparian zones and hillslopes, and to act as a link between geographically separated WRP proponents and their contractors by facilitating the sharing of information and ideas between the regions of B.C.

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