**Annual Operational Report**  
April 7, 2003

**Project Title**: Assessing Soil Erosion  
**Recipient Agreement No.**: R02-34  
**Project Contact**: Mike Younie  
Senior Ecosystem Specialist  
Ministry of Water, Land and Air Protection  
2nd Floor-10470 152nd St.  
Surrey, BC V3R 0Y3  
604-582-5391  
mike.younie@gems8.gov.bc.ca

**Keywords**: Soil Erosion, Sedimentation, Mitigation, Best Management Practices, Coastal BC

**ABSTRACT**

Soil erosion and sedimentation from forest roads can adversely impact drinking water quality as well as the water quality upon which aquatic life is dependent. A recent audit (Younie 1999) of forest roads indicated that the majority of soil erosion field assessments were not being completed when required by the Forest Practices Code of BC Act. The lack of completion was attributable to a lack of guidance around soil erosion field assessments.

The objectives of this project were (i) to examine the critical factors for assessing soil erosion and sedimentation from forest roads in the coastal BC area, (ii) to explore the strategies and techniques for mitigating soil erosion and sedimentation that could be reasonably expected to be incorporated into road design prescriptions and (iii) to develop extension products and disseminate this information to personnel involved with designing and constructing forest roads in coastal BC. Forest Renewal BC funding was secured to address objectives (i) and (ii) while Forestry Innovation Investment funds were secured to address the third objective.

A hypertext presentation regarding all aspects of assessing soil erosion and sedimentation in coastal BC was produced. The presentation also included information on coastal hydrology and mitigation techniques. Two hundred copies of the CD were produced and will be distributed free of charge to personnel involved with designing and constructing forest roads in coastal BC. Articles and other presentations were also produced to raise awareness of soil erosion issues. It is expected that this product will form one of the tools available to practitioners in the new “results-based” regime.

**SUMMARY OF ACTIVITIES, RESULTS & OUTPUTS**

This project was the second year of a two year project originally initiated under Forest Renewal BC funding. The objectives of the project were to:
(i) Examine the critical factors for assessing soil erosion and sedimentation from forest roads in the coastal BC area;
(ii) Explore the strategies and techniques for mitigating soil erosion and sedimentation that could be reasonably expected to be incorporated into road design prescriptions; and
(iii) Develop extension products and disseminate this information to personnel involved with designing and constructing forest roads in coastal BC.

Objectives (i) and (ii) were met in the first year of this project with the production of the Carson (2002) report. Forestry Innovation Investment funding was secured in order to meet objective (iii) over the past year.

Objective (iii) was met through a variety of extension products developed over the last year. The most significant product developed was the hypertext presentation included on the enclosed CD. The CD is designed to be used by those personnel involved with designing and constructing forest roads on the BC coast. The CD was purposely designed to avoid the use of jargon in order for those not familiar with the technical subjects discussed to gain an understanding of soil erosion, sedimentation and mitigation techniques. A draft version of the CD was reviewed by several professionals and their comments were included in the final version where appropriate.

The CD is designed as a training module for personnel to learn about the following topics:

- Watersheds and Water Quality
- Characteristics of Coastal Watersheds
- Surface Erosion versus Mass Wasting
- Measuring Erosion and Sedimentation
- Forest Roads and Water Quality
- Managing Forest Roads for Water Quality
- Best Management Practices

Two hundred CDs were professionally produced and will be provided free of charge to industry and consulting personnel as well as to anyone else who requests a copy. The Ministry of Water, Land and Air Protection is also looking at ways to include a downloadable version on their website.

In addition to the CD, several articles and presentations were developed. A presentation, using a draft CD, was given at the December 2002 International Erosion Control Association’s Pacific Northwest Chapter Annual Conference in Surrey. Another presentation was given to staff of the Greater Vancouver Water District. The presentation has also been accepted at the Canadian Water Resources Association (BC Chapter) annual conference in Victoria later in 2003.

A short summary of the project appeared in the Forest Research Extension Partnership’s (FORREX) newsletter publication (Austin 2003). A copy of the article has been included
in Appendix 1. A longer article has been submitted and accepted for publication in the Streamline periodical. The submitted draft is also provided in Appendix 1.

**EVALUATION OF PROJECT OUTCOME**
To date, the CD has been well received by those who have seen the product. Many people who have read about the product have already contacted the project contact for their copy.

This project originated after an audit (Younie 1999) of several cutblocks and roads determined that soil erosion field assessments were not being completed when required by the Forest Practices Code of BC Act and Regulations. In discussions with industry, it was determined that the lack of standards was the primary reason for lack of compliance. It is expected that the extension products developed here have increased awareness of soil erosion, sedimentation and mitigation and this awareness will result in higher quality roads being constructed and less impacts to water quality.

These expectations will be evaluated in several years time when Ministry of Water, Land and Air Protection staff will undertake a new effectiveness evaluation study to determine if improvements in erosion control are being routinely implemented when constructing forest roads in sensitive areas.

**APPLICATION OF RESULTS AND END USERS**
This component of the project was entirely related to end users and implementation of the results. By distributing the CD to a variety of end users, it is expected that the results can be implemented immediately.

**FILLING THE KNOWLEDGE GAP**
As mentioned above, this project was designed to address the lack of attention being given to soil erosion, sedimentation and implementation of mitigation techniques that was determined to exist by an earlier audit (Younie 1999). The project reported here confirmed the techniques required for assessment of erosion and sedimentation potential as well as the mitigation techniques are well documented in existing literature. All that remains is for practitioners to make a strong commitment to using these techniques. It is expected that the move to “results-based” legislation will assist with encouraging practitioners to adopt these techniques on a more regular basis. There is no need for further research.

**VARIANCES**
This project was implemented as originally proposed, no variances were required either in operations or budgetary.

**REFERENCES**
Austin, B. 2003. Research project aims to reduce soil erosion. Link: 4(3). Forest Research Extension Partnership (FORREX)

APPENDIX 1

The following article appeared in Link.

FORREX—Forest Research Extension Partnership

Research project aims to reduce soil erosion

by Brenda Austin, Contributing Writer.

In October 2000, the provincial government released a report on drinking water quality that identified a relationship between water turbidity and diagnoses of gastroenteritis in the Greater Vancouver area.

Since then, Mike Younie, a researcher with the Ministry of Water, Land and Air Protection, has been working on a project that identifies the techniques forest managers can use to assess a road’s potential for soil erosion, which can lead to turbidity in water.

Building on a previous government-funded project that documented road-related erosion in the interior of British Columbia, this new project updates the assessment procedures for the coast. Now funded through the Forestry Innovation Investment (FII), the second phase focuses on getting that information out to government, consulting, and industry personnel.

Yinnie and his team want to send the message that if practitioners use these techniques throughout the entire process of constructing and maintaining forest roads, they can mitigate soil erosion and sediment delivery without prohibitive costs.

Site conditions on each road segment strongly influence the measures taken, as do the personal commitment, experience, and training of road construction practitioners.

Personnel need to walk the alignment during road construction, especially in wet conditions. “The most important component of this system,” says Younie, “is that it be used within the context of adaptive management. Good observation skills and analytical assessment by road construction personnel and watershed managers, as well as a willingness to work together for innovative solutions, will result in effective management.”

Previous research discovered that the three most important factors influencing the impact of a road segment on stream water quality were:

- the amount of fine-textured sediment,
- the nature of the water flow, and
- the relationship between road drainage and natural drainage features.

Techniques that work well on the coast for mitigation of soil erosion and protection of water quality include the use of coarse ballast for road surfacing and ditch lining near streams; the use of overland construction techniques wherever possible; the disconnection of ditches from stream crossings; the use of swales in the road as perennial water bars; the dispersion of all water (ditch, surface) rather than its concentration; the avoidance of traffic during wet conditions; outspreading roads; prompt revegetation, and maintenance of properly angled cut slopes, with rough surfaces to promote vegetation.

“Using the guidelines we have developed encourages sustainability of the forest industry and affects its long-term future,” says Younie. “If companies log in sensitive areas such as coastal watersheds, the public demands a higher standard of environmental protection.”

This project falls under the FII mandate that involves the extension of research knowledge to forestry-industry practitioners to keep the industry on the cutting edge and to promote sustainable forest management in British Columbia.


The second part of the project will extend the knowledge of effective road construction practices in community watersheds. Activities will include presentations to industry and production of a CD, which will be available shortly. There is no cost for the CD, but supplies are limited. Contact mike.yinnie@gemls.gov.bc.ca for a copy.
The following article was submitted and accepted for publication in an upcoming issue of Streamline.

**Managing Coastal Forest Roads to Mitigate Surface Erosion and Sedimentation: An Operational Perspective**

Brian Carson and Michael Younie

It has long been a concern in British Columbia that soil erosion from forest roads threatens water quality. In an effort to address this concern, the intent of the Forest Practices Code of BC Act (FPC) was to improve watershed management through a regulatory process that addressed, among other issues, ways to minimize the potential for timber harvesting activities to cause catastrophic and short-term mass wasting events. The FPC therefore included regulations pertaining to erosion and sedimentation. Specifically, the code legislated requirements for soil erosion field assessments when resource extractors constructed roads within community watersheds, and also for industry to undertake the steps necessary to prevent sedimentation to watercourses in general. For many years, industry in British Columbia has followed FPC guidelines by routinely undertaking terrain stability assessments for which government and professional organizations have provided well-defined expectations (Ministry of Forests 1999).

However, compared with terrain stability field assessments, government has done less well under the FPC in defining expectations for soil erosion field assessments. A recent audit (Younie 1999) revealed that industry had failed to complete approximately 60% of the soil erosion field assessments that FPC legislation required. Industry personnel indicated that the FPC lacked clear guidelines to support such assessments. This has caused confusion and has led to poor implementation of applicable regulations. Given that chronic soil erosion can have adverse impacts on drinking water supplies over a much longer term than mass wasting events, it is imperative to define best management practices (BMPs) that minimize erosion and sedimentation within a set of guidelines designed to avoid confusion and facilitate implementation of existing regulations. This article describes such mitigation techniques and strategies, focusing on chronic surface erosion and sedimentation processes based on thirteen case studies in B.C.’s coastal region.

Although watershed managers have identified forest roads as the primary source of chronic sediment mobilization, regardless of the region, we have directed our attention primarily to coastal regions in B.C., as the original project upon which this article is based had addressed chronic surface erosion and sedimentation in coastal situations only. However, the processes we address are significant concerns in the interior of B.C. as well, and many of the suggestions we make also apply equally well to interior forest roads. In addition, readers should note that episodic mass movements (i.e., earthflows, landslides, debris flows, etc.) are beyond the scope of this discussion.

We acknowledge, however, that surface erosion from forest roads can also be episodic in nature; plugged culverts, for instance, may lead to mass movements with subsequent
erosion of exposed soils. In addition to degrading drinking water quality, high sedimentation rates can also be adverse to fish where fine sediment clogs gills, obscures prey or fills gravel interstices resulting in decreased oxygen availability and waste removal for developing fish embryos. Excessive turbidity may also have an adverse impact on the productivity of aquatic habitat by reducing the total amount of solar radiation it receives. Managing sediment from all forest roads is therefore paramount, and it is this issue that we address here.

Our objectives are both to identify realistic best sedimentation and erosion control practices related to coastal forest road management, and to encourage road construction personnel to adopt a technically sound approach to constructing forest roads on the coast. In addition, one of the original aims of this project was to develop a guidebook to support soil erosion field assessments under the FPC. With the move towards a results based code, we hope that the approach we put forward here will become part of industry’s suite of best management practices (BMPs), and that industry personnel will implement these routinely as part of their due diligence obligation.

Study Area
We have used thirteen case studies to illustrate the range of sedimentation and erosion control problems that arise in coastal B.C., as well as the mitigation techniques appropriate to these problems. We chose gravel forest road networks in the vicinity of Mission, Vancouver, Gibsons, Sechelt and Powell River, based on the results we gathered in these locations that demonstrate typical sedimentation and erosion control problems and mitigation techniques. We made no attempt to compare roads with similar ages, maintenance schedules or construction standards – we simply wanted to alert people to typical problems and solutions. The study areas are within the Coastal Western Hemlock Biogeoclimatic Zone and the Georgia Basin Hydrologic Zone. Mean annual temperatures of the area are approximately 10ºC with mean annual precipitation ranging from 1250mm to 3000m, depending on elevation. The elevation of the thirteen case studies was generally below 500m.

For each case study, Carson (2002) estimated:
- surface erosion that had occurred
- surface erosion that would likely occur
- sediment transport from the road segment to streams
- impact of road segment on water quality of streams
- effectiveness of mitigation works present at the site

Observed Results
Results of the case studies indicated that it is critical to consider site physical and hydrological conditions when designing, constructing and maintaining roads. Case studies demonstrated that it is possible to design, construct, and maintain even potentially high hazard road alignments to prevent degradation of water quality. Study results confirmed that those working in the field are aware of and use the majority of these sediment and erosion control design, construction and maintenance techniques. The result is adequate protection for water quality, primarily as a result of the use of these
techniques. We indicate in Figure 1 many of the various mitigation techniques we observed at the sites. Which of the mitigation techniques is appropriate at a given site depends on the physical situation (e.g. soil type, hydrology, availability of slash, rock, etc.).

The study results also demonstrated that the amount of erosion generated from a road segment did not always provide a reliable measure of the segment’s effect on stream water quality. The most important factors that influenced road segment impact on stream water quality in the case studies included:

- the amount of fine sediment the road generated,
- the amount of surface and subsurface water the road concentrated, and
- connections between road drainage and natural drainage.

The study demonstrated that it is essential to understand the inter-relationships between the three factors at each road segment. In particular, some case studies demonstrated that water quality impacts were significant only when considered in the context of all three factors. In these cases, segment assessments in isolation from the other two factors would have suggested no apparent impact. Moreover, to assess the impact of each of these factors on a particular road segment requires evaluation of various other parameters. For example, an evaluation of the fine sediment supply requires knowledge of specifics such as the amount of vehicle use, the age of the road, erodibility of the sediment, and hydrology.

**Management Implications**

The common message drawn from our thirteen case studies was that road builders could mitigate soil erosion through careful design, construction and maintenance of roads in accordance with mitigation techniques that are well described in existing guidebooks (Ministry of Forests 2002a; 2002b) and technical documents (Ministry of Forests 1980; Ministry of Forests 2001) (Figure 1). As the case studies show, satisfactory mitigation is achievable with a sufficiently strong commitment on the part of personnel.

The FPC stipulated that a qualified registered professional complete soil erosion field assessments prior to road construction within community watersheds. Our analysis of the results of the case studies suggests that while these assessments are important, particularly for initial design considerations, road construction personnel should place a greater emphasis than is typically the case on information they can gain by walking the road alignment not just during construction, but subsequently, in wet conditions. These additional assessments will allow personnel to identify problems and implement any necessary mitigations. Following this protocol when working in sensitive areas (i.e., community watersheds, streams with downstream fish values) ensures that field workers can readily observe and understand unique site conditions and the interactions between hydrology and surficial materials. This understanding will result in a well-built road that should not require a significant amount of maintenance over the long term.

Techniques that worked extremely well in the case studies to mitigate surface erosion from road segments on the coast included the following:
• Use of coarse ballast for road surfacing and ditch lining near streams (1)
• Use of overland construction techniques wherever possible but especially in areas with groundwater tables at or near the surface
• Disconnect ditches from stream crossings by frequent use of cross ditches or drainage culverts and allowing water and sediment to be trapped by the forest floor (2)
• Construct bridge running surfaces slightly above grade of approaching roads where possible and armour approaches with non-erodible ballast (3)
• Use swales in road as perennial water bars (4)
• Disperse all ditch and surface water rather than concentrate
• Avoid traffic during wet conditions
• Outslope roads as much as possible
• Revegetate with prompt hand or hydroseeding to minimize sediment supply and to minimize need for culvert and ditch cleaning operations (5)
• Maintain cutslopes at mechanically stable angles (6)
• Maintain a rough surface on cutslopes, ditches and fillslopes to promote natural revegetation – smooth surfaces do not allow seeds to collect
• Sort, store, and seed spoil materials for use in deactivation at a later time
• Keep spoiled materials out of riparian management areas
• Narrow road crossing right of way clearings at stream crossings

(Note that the road in the photograph in Figure 1, below, features several of these techniques in use. The illustrated techniques are numbered 1 – 6 in the list and are so marked in the figure.)

The above list is not exhaustive and not all techniques will be relevant in all situations. In particular, we have omitted silt fencing from the above list as our experience indicates that it is rarely installed correctly and requires constant maintenance. While in some instances silt fencing is useful in the short term for sedimentation control, our goal is to implement practices that are effective at controlling erosion and sedimentation in the long as well as short terms; we do not consider silt fence to be an appropriate long term solution.
The techniques that we observed were effective in controlling sediment and erosion at the various sites of this project are not necessarily new to most road construction personnel. Although existing guidebooks and technical circulars define most such techniques well, we noted that in certain case studies in which we identified problems, road construction personnel had seemed reluctant to employ these techniques. Indeed this reluctance appears to be commonplace on the coast regardless of factors such as the age of the road or the site characteristics. The most important factor in determining the end result of a new forest road, our case studies have shown, is the commitment of road construction personnel to implement these techniques.

Carson (2002) has designed a five-step system for managing forest roads to reduce water quality impacts in sensitive areas. The following is a partial list featuring highlights of the five steps in this system:

1. Plan Road Layout
   - Communicate with water licensees.
   - Acquire and study applicable terrain information.
   - Budget for costs associated with best management practices.
   - Thoroughly review road layout in the field and identify areas that will require mitigation techniques.
2. Design Road
   • Design road according to expected use. Consider temporary roads in places where roads will not be required after harvesting is complete (i.e., spur roads).
   • Dissipate rather than concentrate water through frequent culverts, swales and cross ditches.
   • Maintain road drainage distinct from natural drainage wherever feasible.

3. Construct Road
   • Use contractors with good performance records.
   • Implement best management practices: coarse ballast, operational shut down criteria, etc.
   • Identify segments of roads as individual catchments in relation to natural drainage.
   • Remain flexible: road design may have to change as previously unidentified site conditions arise. Allow experienced construction personnel the freedom to manage.

4. Operate and Maintain Road
   • Ensure that culverts and ditches are functional.
   • Implement best management practices: operational shut down criteria, install cross ditches and water-bars, etc.
   • Ensure grading operations do not have adverse impacts on water quality.

5. Monitor and Evaluate Road
   • Initiate and support a water quality monitoring program.
   • Monitor roads in wet weather.

A critical component of this system is its use within the context of adaptive management. This system is designed to be consistent with the framework of the new Forest and Range Practices Act. While addressing potential soil erosion problems may increase operational costs in the short term, such costs will not be prohibitive. It is interesting to note that experienced road construction personnel suggest that a well designed and built road will reduce costs over the long term. For example, a road with well re-vegetated cutslopes and ditches will remain stable and will prevent the need for frequent unplugging of culverts and ditch cleaning.

In sensitive areas, controlling surface soil erosion is paramount and public expectations of management frequently centre on adequate protection of non-timber resources. If we fail to manage roads adequately, public opinion may increasingly lean toward denying resource management opportunities.

**Project Extension and Evaluation**
We have planned a variety of extension activities designed to heighten awareness of effective road management practices. One of these is an interactive CD that is currently under development. This product will highlight the importance of sediment and erosion control. In addition, it will list a variety of mitigation techniques and will describe the
best management practices that form an important component of the new results-based Forest and Range Practices Act. When complete, the CD will be available free of charge to those involved with designing, constructing and maintaining forest roads. Those interested in obtaining a copy of the CD should contact the authors.

Other extension products include articles and presentations at a variety of conferences including the International Erosion Control Pacific Northwest Chapter Annual Conference and the 56th Canadian Water Resources Association (CWRA) Annual Conference.

We anticipate that the Ministry of Water, Land and Air Protection, as part of its monitoring role, will conduct a follow-up audit to the project on which this article has been based. This audit will evaluate project and extension product success. The long-term goal of the government is to confirm that industry personnel, when they are constructing and managing forest roads in coastal British Columbia, are routinely implementing sediment and erosion control measures that are effective in protecting water quality.

Summary
Three important factors to consider when assessing sediment production potential are the amount of fine textured sediment, the nature of water flow at the site and the connectivity between road drainage and natural drainage features. We found that existing guidebooks and technical circulars provided good descriptions of techniques that our observations confirm are appropriate for sedimentation and erosion control.

Our results indicate that it is possible to protect water quality from road-related sediment; however, this requires a strong commitment on the part of road construction personnel, who must use best management practices as dictated by site conditions. While these practices may result in slightly higher costs in the short term, our analysis of results achieved in case studies suggests that over the long term, a properly designed and built road will have lower maintenance costs over a less well-constructed road. Implementation of the five step process described here will help to maintain water quality for human health and fish requirements while continuing to allow resource extraction.

Acknowledgements
The authors gratefully acknowledge funding from Forest Renewal BC and Forest Innovation Investment. We also wish to thank staff from Weyerhaeuser and Sechelt Creek Contracting Ltd. for their commitment to improving road design, construction and maintenance through the use of innovative practices. This article has benefited from reviews by the Streamline review committee and two anonymous reviewers.
N.B. Much of this article is drawn from “Assessing Soil Erosion from Roads and Mitigating its Potential to Degrade Water Quality in Coastal British Columbia” (Carson 2002), available at ftp://ftpsry.env.gov.bc.ca/pub/outgoing/wq_report/soil_erosion_rpt/

Contact Information
Brian Carson, P.Ag., P.Geo.
Carson Land Resource Management Ltd.
1861 Lower Road, Roberts Creek, B.C., V0N 2W6
tel: (604) 886-3282
Email: brian_carson@telus.net

Michael Younie, P.Ag., P.Geo.
Senior Ecosystem Specialist, Ministry of Water, Land and Air Protection
2nd Floor-10470 152nd Street, Surrey, B.C., V3R 0Y3
tel: (604) 582-5391
Email: Mike.Younie@gems8.gov.bc.ca

References


