Potential Uses of the FREP Water Quality Effectiveness Evaluation Procedure

FREP

Extension Note #31

Prepared by Brian Carson and David Maloney

December 2013

1.0 INTRODUCTION

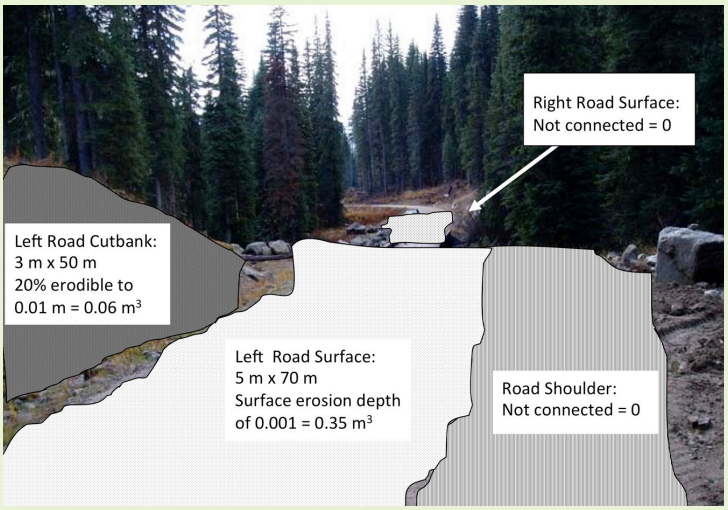
This extension note, which is intended for natural resource managers, water purveyors, and government monitoring staff, describes some of the many potential uses of the Forest and Range Evaluation Program's Water Quality Effectiveness Evaluation (WQEE) protocol.[1] It also outlines some current issues regarding protocol use and new refinements that will improve its application for more intensive evaluations.

FREP originally designed the WQEE procedure to provide a representative snapshot of the effects of forest management on water quality. It allows routine/extensive evaluations to be conducted simply and quickly in the field by non-specialists to determine sediment generation potential, a key factor influencing of water quality.

In forest operations, sediment inputs from surface erosion can occur, usually from resource road development and use. From estimates of sediment volume at a site (see Figure 1), WQEE users can rank a sampled area according to its "fine sediment generation potential" (or "water quality impact rating"), a classification that reflects an experts' consensus on the severity of impact a particular site may have on a watershed.

Sites where fine sediment generation exceeds a certain threshold are further assessed to consider management actions or prescriptions to reduce impacts to water quality.

Stream Crossing Site



Total estimated annual sediment contribution to stream from this site = 0.41 m³ per year

Figure 1. *Example of a water quality effectiveness evaluation at a bridge crossing.*

[1] For more information about the Water Quality Effectiveness Evaluation Protocol, go to: http://www.for.gov.bc.ca/ftp/hfp/external/!publish/frep/indicators/Indicators-WaterQuality-Protocol-2009.pdf

Key message: Road networks are likely the single most important influence on water quality in a forest setting. The FREP water quality evaluation procedure provides a systematic approach for assessing and ranking a site's sediment generation potential; and as such, it has a broad range of potential uses outside of FREP including ongoing road assessments and helping licensees meet their certification monitoring needs.

The FREP Mission:
To be a world leader in resource stewardship monitoring and effectiveness evaluations; communicating science-based information to enhance the knowledge of resource professionals and inform balanced decision-making and continuous improvement of British Columbia's forest and range practices, policies and legislation. *http://www.for.gov.bc.ca/hfp/frep/index.htm*

BRITISH COLUMBIA

2.0 CURRENT RESULTS USING THE WQEE PROTOCOL

The WQEE protocol has provided the Ministry of Forests, Lands and Natural Resource Operations with an objective assessment of how well licensees maintain water quality within the government's results-based management system. Between 2008 and 2012, FREP used the protocol to sample water quality impacts at 4033 randomly selected sites in 24 forest districts throughout British Columbia. Of these sites, 34% were classified as "Very Low," 37% as "Low," 24% as "Moderate," 4% as "High," and 1% as "Very High" potential for sediment generation (Figure 2). The relative water quality results were fairly consistent across the districts and between sampling years.

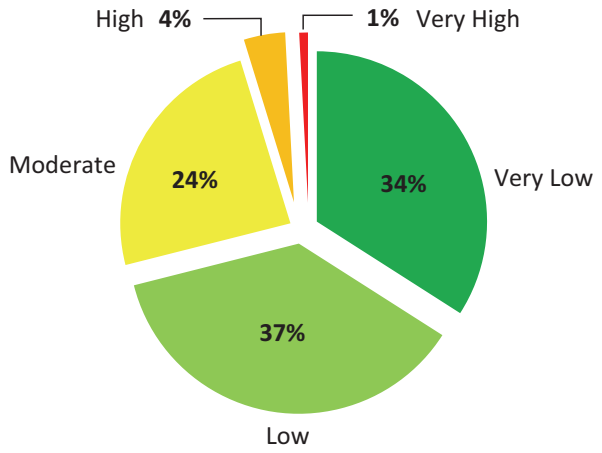


Figure 2. *Proportional distribution of water quality impact ratings for 4033 sites evaluated in British Columbia between 2008 and 2012.*

Sites that had a "Moderate," "High," or "Very High" water quality impact rating were further evaluated to determine management actions to reduce sediment generation (Figure 3). For more information, see FREP Report No. 35 (Carson and Maloney 2013).

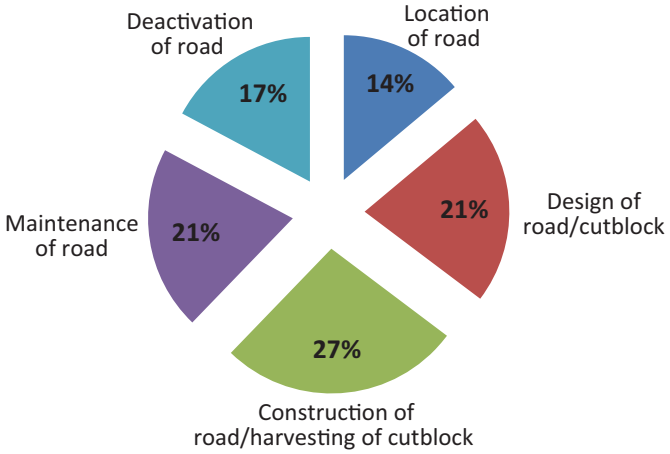


Figure 3. *Areas of management concern associated with water quality impact sites ("Moderate" rating or higher; 1924 management observations).*

3.0 OTHER USES OF THE WQEE PROTOCOL FOR WATERSHED MANAGEMENT

Outside of FREP evaluations, the WQEE protocol has more recently been used by various watershed managers, including water purveyors, road supervisors, Forest Practices Board auditors, and Compliance and Enforcement Branch officers, to meet their environmental monitoring needs. A road network is likely the single most important influence on water quality and, in some instances can affect the timing of discharge in a watershed. A survey of a road network within a watershed can be conducted quickly and effectively using the WQEE methodology. In a small watershed, it is relatively easy to sample all potential sediment-generating sites within a few days. In larger watersheds, a careful stratification of sample sites can provide an effective evaluation.

3.1 FOREST LICENSEES

Forest licensees can use the WQEE protocol to improve the location, design, construction, maintenance, and deactivation of specific road alignments. At least four major licensees in British Columbia have been trained in the use of the WQEE protocol as a part of their own environmental monitoring to meet certification needs. The protocol clearly illustrates why slopes with erosive soils, such as those derived from lacustrine sediments, should be avoided in road construction, or why special prescriptions are necessary to control sediment production on landscapes prone to erosion. It allows the user to easily ascertain how much sediment is generated on a road and if it is transported to nearby water bodies. The protocol also allows users to weigh various management options before a road is even constructed by defining the differing effects on sediment generation. By estimating how much fine sediment a new cutbank and ditchline may generate, the road builder can optimize the design and install a road drainage network that minimizes impact on water quality. For example, the distance that a road parallels a stream will influence the number of culverts required on a particular alignment. In addition, the closer the road is to a stream, a shorter distance between culverts will be required to ensure that the forest floor can recapture sediments generated in the road prism. Similarly, the combined effects of many common road characteristics and treatments, such as road gradient, angle of bridge approach, spacing of culverts, crowning of roads, seeding, and the location of cross-ditches and waterbars, can be evaluated concurrently within the WQEE framework, thereby optimizing a road's technical specifications to address sediment-generation concerns.

A simple pre-assessment of a site using the WQEE protocol provides the road layout engineer with a reasonable estimate of how a planned approach to a stream crossing will affect sediment production. For example:

- How will (as yet un-generated) road sediment be managed?
- Where is the optimum location for an inter-drainage culvert?
- Is crowning the road an effective alternative?
- If a particular road alignment does not have good sediment-recapturing qualities, is another, better alignment available?

If road berms are repeatedly linked with accelerated sediment generation, then providing training for grader operators on berm management techniques may be a very cost-effective way to significantly reduce sediment loads in a watershed. In comparison, shoring up a sandy cutbank on a bridge approach may cost much more than the sediment reduction benefits alone warrant. Considering the cost effectiveness of specific treatments is an especially effective way to evaluate road deactivation plans.

3.2 WATER PURVEYORS

If a watershed manager's primary objective is to maintain clean drinking water at a municipal intake (which is the primary reason for the "Community Watershed" designation), then WQEE sample sites can be further stratified relative to the location of drinking water intakes. Sites immediately upstream of the intake have the greatest potential to affect drinking water quality and are the highest priority for both sampling and then mitigating sites that show the most serious impacts. As one moves back into the watershed, particularly where lakes act as buffers to sediment transport, the effect of sediment generation will be muted. For example, the longer water resides in a lake or pond, the more buffering a distant sediment-generating site upstream will experience, thus decreasing its impact on downstream water quality. Priorities for mitigation will depend first on sites within the zones of most severe consequence. Even a small volume of sediment generated directly above the drinking water intake may affect turbidity at the intake and consequently have high priority for some mitigation effort. Within the same impact zone, sites registering a higher water quality impact rating would be considered for treatment over sites with lower ratings. A simple benefit-cost analysis can be conducted for each site to calculate the cost of preventing a given volume of sediment from reaching the stream. Limited budgets for road upgrades can then be spent more effectively. For an example evaluation see Carson (2010).

3.3 FOREST PRACTICE BOARD WATER QUALITY AUDITS

British Columbia's Forest Practices Board used the WQEE protocol for water quality audits that evaluated all active roads within community watersheds in the Kootenay and Okanagan valleys. These evaluations were considered to provide an unbiased view of water quality impacts and the results have been accepted by both water purveyors and licensees. The Kootenay audit report looked at water management in the Norns and Springer Creek community watersheds (see Forest Practices Board 2006).The Okanagan audit looked at forest and range planning and practices affecting water quality in the Oyama and Vernon Creek community watersheds (see Forest Practices Board 2012).

3.4 COMPLIANCE AND ENFORCEMENT

FLNRO Compliance and Enforcement (C&E) Branch officers have shown considerable interest in the use of FREP water quality data. The WQEE protocol provides a rapid, standardized assessment, repeatable in all snow-free weather conditions, that prioritizes the relative water quality impacts of different sites, and allows for the communication of site disturbances between district staff, licensees, and C&E officers. A site evaluation helps to predict how seriously water quality will be affected by a site disturbance. This outcome can then be used to directly mitigate activities ***before*** serious water quality impacts actually occur.

4.0 CURRENT ISSUES REGARDING PROTOCOL USE

At present, many of the situations influencing water quality noted by FREP evaluators reflect land use issues that are outside the direct responsibility or authority of forest managers. For instance, a major issue concerns situations where the primary users of the road are not the road permit holder, rather it is other road users such as recreationists. Another issue concerns the evaluation of cumulative effects of many disturbed sites within a watershed with the present sampling methodology.

4.1 ASSIGNING RESPONSIBILITY FOR SITES WITH HIGH-SEDIMENT GENERATION POTENTIAL

Evaluators must be careful when assigning responsibility for conditions leading to water quality impacts. Culpability for sediment generation at different sites disturbed during a road network's life often does not fall on any one licensee. Poor roads that are inherited (e.g., roads paralleling streams for long distances) were commonly built in the 1960s and 1970s. Such historic liabilities require special consideration because frequently there are no options to relocate these problem mainlines.

Assigning responsibility for deactivation shortcomings is also complex. Many industrial roads, although no longer part of forestry development plans, are often not deactivated because of ongoing (primarily recreational) uses on the roads. Often roads that are properly deactivated by licensees are informally reactivated by recreational vehicles for non-industrial uses. Under such circumstances, road operators cannot be responsible for broken down cross-ditches and non-functioning waterbars when they have no authority over who uses the road.

Where a new road is constructed, particularly on alignments crossing or adjacent to streams, the licensee carries full responsibility for any sediment generated. Regardless of who locates, designs, or constructs a road, the local road permit holder takes responsibility for road maintenance. Improved road maintenance is almost always the most cost effective way of reducing fine sediment generation on road networks.

4.2 ADDRESSING CUMULATIVE EFFECTS

The WQEE protocol evaluates specific sites disturbed by human activity within a watershed. Nevertheless, the random sampling procedure currently employed to provide a province-wide assessment of water quality impact does not directly address the cumulative impact of (potentially) many disturbed sites within a watershed. One or two sediment-generating sites may not affect water quality some distance downstream, but many such sites may cumulatively have a serious impact of a chronic or acute nature. The original Coastal and Interior watershed assessment procedures (CWAP and IWAP; B.C. Ministry of Forests 1999) represented a first attempt to address cumulative effects in British Columbia by focussing primarily on elevated peak flow and sediment generation. Although this procedure provides useful guidelines, it does not consider management as a means to mitigate the negative effects usually associated with stream crossings and road density within a watershed. For example, numerous well-designed, constructed, and managed stream crossings might have a lower cumulative effect than one poorly designed, constructed, and managed stream crossing. Site quality as well as quantity must be considered when determining cumulative effects in a watershed.

Currently, the WQEE protocol is used to determine fine sediment generation potential. However, with some simple refinements, the protocol could be used for other purposes. For example, areas delimited as “mini-catchments” within a watershed offer a good proxy to assess changes in peak flows by identifying the increase in drainage network. The longer the ditch lines and the larger the disturbed surfaces directly connected to streams, the quicker stormflows will be generated during rainfall events.

Other refinements in data collection using the WQEE protocol could help determine changes in bedload downstream from a site. Unless a disturbed surface experiences some form of mass wasting (e.g., gullies, rills, slumps, or landslides), transport to streams is restricted to fine sediments, such as fine sand, silt, and clay, which directly affects water quality by increasing turbidity. Coarser sediments, medium sand, gravel, and boulders are generally only transported to streams by mass failures and (or) incision by concentrated stormflow. Although coarse sediment particle sizes do not directly affect water quality directly, these materials can profoundly influence stream channel stability and riparian function. By estimating the amount of coarse material that has left the site through mass-wasting events, the evaluator could determine the site’s impact on overall stream bedload.

5.0 NEW DEVELOPMENTS

A more intensive water quality evaluation methodology is currently under development that will take into account stream discharge at the time a site is generating sediment. This will provide an estimate of actual in-stream changes in turbidity. As some fairly complex mathematics are required, the usual paper field cards will not be used to make such assessments. Instead, developers are creating a digital iPad application that not only will analyze sites more intensively but will also provide a more efficient means to collect, store, and manage water quality data.

FOR MORE INFORMATION:

For those interested in learning more about the Water Quality Effectiveness Evaluation Protocol and its uses, visit the website: http://www.for.gov.bc.ca/hfp/frep/indicators/table.htm#water

For additional information, contact the protocol developers: David Maloney (David.Maloney@gov.bc.ca), or Brian Carson (brian_carson@dccnet.com).

REFERENCES

B.C. Ministry of Forests. 1999. Watershed assessment procedure guidebook. 2nd ed., Version 2.1. Forest Practices Branch, Victoria, B.C. Forest Practices Code of British Columbia Guidebook. http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/wap/WAPGdbk-Web.pdf (Accessed May 2013).

Carson, B. 2010. Assessment of water quality impacts of the Powell River Community Forest operations within the Powell River area. Report prepared for Results Based Forest Management Ltd., Powell River, B.C. Unpublished report. http://www.prcommunityforest.ca/wp-content/uploads/2012/03/FinalCommunityForestWQAssessment.pdf (Accessed May 2013).

Carson, B. and D. Maloney. 2013. Provincial water quality effectiveness evaluation results (2008–2012). B.C. Ministry of Forests, Lands and Natural Resource Operations, Forest and Range Evaluation Program, Victoria, B.C. FREP Report No. 35.(soon to be released) http://www.for.gov.bc.ca/ftp/hfp/external/!publish/FREP/reports/FREP_Report_35.pdf

Forest Practices Board. 2006. Audit of water management in Norns and Springer Creek community watersheds. Victoria, B.C. http://www.fpb.gov.bc.ca/ARC82_Water_Management_in_Norns_and_Springer_Creek_watersheds_Arrow_Boundary_FD.pdf (Accessed May 2013).

Forest Practices Board. 2012. Audit of forest and range planning and practices affecting water quality in Oyama and Vernon Creek community watersheds. Victoria, B.C. http://www.fpb.gov.bc.ca/ARC140_Audit_of_forest_and_range_planning_and_practices_affecting_water_quality_in_Oyama_and_Vernon_Creek_Community_watersheds.pdf (Accessed May 2013).