Protocol for

Evaluating the Condition of Streams and Riparian Management Areas

Riparian Management Routine Effectiveness Evaluation

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FREP ABSTRACT

The Forest and Range Practices Act (FRPA) introduced the transition to a results-based forest practices framework in British Columbia. Under this approach to forest management, the forest industry is responsible for developing results and strategies, or using specified defaults, for the sustainable management of resource values (subject areas) identified under FRPA. The role of government is to ensure compliance with approved results and strategies, and other practice requirements, and evaluate the effectiveness of forest and range practices in achieving government's objectives for FRPA's resource values.

Resource stewardship monitoring is a key component of the provincial Forest and Range Evaluation Program (FREP).

Resource stewardship monitoring will help identify implementation issues regarding forest policies, practices, legislation, and Forest Stewardship Plan results and strategies. As a result, RSM will be a fundamental component for implementing continuous improvement of forest management in British Columbia.

FREP has been established as a multi-agency program to evaluate whether practices under FRPA are meeting not only the intent of the current FRPA objectives, but to determine whether the practices and the legislation itself are meeting government's broader intent for the sustainable use of resources.

FREP is a long-term commitment designed to:

- assess the effectiveness of FRPA and its regulations in achieving stewardship objectives
- determine if forest and range policies and practices are achieving government's objectives with a priority on environmental parameters and consideration to social and economic parameters where appropriate
- identify issues regarding the implementation of forest policies, practices and legislation as they relate to the achievement of stewardship objectives
- implement continuous improvement of forest management in British Columbia. In order to accomplish these objectives, FREP will:
    1. develop specific monitoring and evaluation questions to be addressed
    2. document the status and/or trends of resource values over time through the use of detailed protocols
    3. identify causal factors where the status or trend is found to be undesirable
    4. determine whether resource values are being managed in a sustainable manner through proven or alternative forest practices
    5. communicate the results of evaluations
    6. recommend changes to forest and range policies and legislation, where required.

FOREWORD

This handbook is for anyone with a basic working knowledge of streams and/or riparian habitats, including forest and range planners, developers, and other land users. It is not essential that a person have expert knowledge on any aspect of the subject. In fact, generalists are apt to be more consistent in their assessments because they are less likely to interpret the questions and their indicators or get overly involved in detailed measurements at the expense of other indicators.

This handbook and the associated checklist are like having a professional or expert on stream-riparian interactions and land-use impacts in your back pocket. The checklist guides the user to a conclusion on the relative health of a stream and its riparian habitat in a timely fashion. Field experience indicates that, with a little practice, riparian assessments can be completed in 1–2 hours.

Even experts can benefit from using the riparian checklist because it covers almost all the basic information required to support "expert opinions," which can be difficult to defend without data. The checklist encourages observation with a repeatable methodology that can be used to support the results of a field review. The methodology has been field tested by people with varied backgrounds and levels of experience and found to be a consistent method of assessing the health of streams in BC. Perhaps more importantly, the conclusions drawn from the checklist make sense and ring true because they can usually be clearly linked to specific indicators that can be consistently observed or measured.

DOCUMENT PURPOSE

The following protocol was created to provide background information and instructions for data collection on the functioning condition of streams and riparian areas. This protocol was developed for the BC Ministry of Forests and Range Evaluation Program (FREP).

GOAL OF RIPARIAN AND STREAM CHANNEL MONITORING

The goal of monitoring the condition of stream channels and their adjacent riparian management areas is to determine whether FRPA standards and practices governed by regulation are achieving the desired result of protecting fish values by maintaining channel and riparian functions.

> *"Are riparian forestry and range practices effective in maintaining the structural integrity and functions of stream ecosystems and other aquatic resource features over both short and long terms?"*

OBJECTIVES OF THE EVALUATION PROCESS: WHY ASSESS EFFECTIVENESS?

The routine riparian evaluation arose out of a need to assess the effectiveness of riparian management practices, rather than compliance with a highly prescriptive set of rules. Prior to FRPA, there was an implicit assumption that compliance with legislation and regulations would lead to improved riparian management. Only rarely, however, was this assumption ever tested.

In 2000, the Forest Practices Board of British Columbia conducted a special investigation on the impacts of coastal logging on streams five years after implementation of the Forest Practices Code. The results showed marked improvements over the level of impacts in most streams prior to the Code (Tripp 1992, 1995); however, some streams were still being impacted. That study assessed relatively few attributes of streams, and even fewer attributes of the riparian area. The condition of streams and their riparian habitats as a functioning system was not assessed.

PRINCIPLES OF SITE SELECTION

Several statistical design principles were used to develop site selection protocols for FREP assessments. These principles ensure that the data collected and analyzed can be used at multiple scales (district, region, and province) with statistical validity and credibility.

The sampling population is the entire range of potential sites that could be sampled for a given resource value. In this case, sites are selected using cutblock opening IDs since the current focus of the assessments is on logging. To ensure the results are objective and defensible, all cutblocks selected for riparian assessments are selected using random sampling. The number of sites sampled can vary by year depending on available resources, but the minimum target to achieve is 30 over the most recent 5-year sampling window.

For additional information on the site selection process, refer to *Protocol for 2009 Resource Stewardship Monitoring* at https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/frep/frep-docs/resource-stewardship-monitoring-framework.pdf.

Site Selection Criteria for Riparian Stream Assessments

Each participating district will be provided with a population list of 200 sites (cutblocks) every year that is randomly generated from the Forest Tenure Administration system (FTA). The list of cutblocks is limited to those harvested between one to three years ago to ensure at least one storm season has passed and conditions reflect recent harvest practices. The list is located on FREP Information Management System application found here: https://apps.nrs.gov.bc.ca/ext/frep/.

From the list of 200 blocks, each district will begin at the top of the list and select 10 sample blocks, working down in sequential order. Check FREPmap (government employees) or another mapping application to confirm that each of the blocks has at least one stream within or adjacent to it and that the stream is long enough to qualify for a sample. Samples should represent consistent riparian management on at least one bank for 100m or 30 channel widths, whichever is greater. Adjacent streams are defined as any stream reach that flows along the outside of the block (i.e. not away from the block) and lies within two riparian management area (RMA) widths of the block boundary. It may be difficult to tell if a stream is within 2RMAs without knowing its riparian classification, but if there is one that could potentially qualify, it is best to ask the licensee for the site plan, which will confirm the classification. Doing this will also help eliminate drainages that may appear to be streams, but in fact have been classified by the licensee as NCDs (non-classified drainages) and therefore do not qualify for sampling.

Once classes are confirmed using site plans, re-asses the length to confirm the distance from the block is within 2 RMAs for any adjacent streams and that the minimum sample length is likely to be achieved before travelling to the site. Do not include road crossings within the sample reach. Assessments should be done downstream of any crossings, unless there is not enough room to sample the minimum length required, at which time they can be moved upstream of the crossing. Assuming the default channel widths indicated in Table 1 for the various riparian classes, you will need a *minimum* of 600 m of stream length for all S1 streams, and 150 m of stream length for all S2 streams. All other riparian classes will need a minimum of 100 m of stream length. Actual stream lengths needed for a sample will increase if stream widths in the field are much wider than the default widths in Table 1.

Sample reaches within the same block should be on topographically separated streams (independent tributaries) and any sample reach should not drain into another within the same block. This will support the assumption that all samples are statistically 'independent'. Thus, cutblocks will be ignored in the data analysis and the sample size will consist only of stream reaches. Adjacent streams are included in the population because it is rare for large streams (Riparian classes S1–S3, S5) to flow through cutblocks, but are often used to help define block boundaries. By including streams adjacent to cutblocks, it is hoped that harvest treatments alongside larger streams with higher fisheries values will be better represented in the sample.

***Table 1**. Stream riparian classes, RMA slope distances and default stream widths for determining stream adjacency in the office*

Stream riparian class	Stream width (m)	RRZ (Reserve zone) width (m)	RMZ (Management zone) width (m)	Total RMA width (m)	Default stream width in office (m)	Min. stream length (m)	2 RMA widths
S1	> 20	50	20	70	20	600	140
S2	> 5 ≤ 20	30	20	50	5	150	100
S3	1.5 ≤ 5	20	20	40	1.5	100	80
S4	< 1.5	0	30	30	1.5	100	60
S5	> 3	0	30	30	3	100	60
S6	< 3	0	20	20	1.5	100	40

The number of riparian samples will vary from year to year, but the target is 30 over the most recent 5-year window. The goal is to sample one stream only from each cutblock that has been randomly selected. Only sample more than one stream per block when it is clear there are some blocks that lack streams. For each block selected, do the stream with the "highest" riparian class first (e.g., S2 before S3, or S5 before S6), followed by the next highest riparian class, time and resources permitting. If the stream being considered is a non-fish bearing stream (S5 or S6), try and do the reach closest to a fish stream. Where the streams all have equal value (all the same riparian class and drainage areas), randomly select the stream(s) to be sampled.

Stream Selection Example #1:
A cutblock lies adjacent to an S2 stream and has, within the boundaries, one S4 stream and four S6 streams that flow directly into a fish stream 200 m outside the block. Each stream forms a homogeneous reach. There is only time available to sample three streams. Following the above protocol for reach selection in cutblocks, one would sample the S2 stream, the S4 stream, and one S6 stream. The S6 stream would be selected using some simple random method (e.g., dice).

In the above example, if there were only time to sample one stream, the S2 stream would be sampled. If there were time for two streams, the S2 and the S4 would be sampled.

Stream Selection Example #2:
On the map for this cutblock, it looks like a large S1 stream parallels the lower 600 m of the cutblock. A second smaller S2 tributary of the S1 stream parallels the upper 300 m of the block. Both streams form homogeneous reaches with regard to size, gradient and treatment.

It turns out that the S1 stream has an average channel width of 25 m, while the S2 stream has an average channel width of 8 m. In this example, the S1 stream would not be sampled because we need 750 m of stream length. Since there is only 600 m of stream beside the block, the stream length available is too short. The smaller 8–m–wide S2 stream is, however, eligible because the required length (30 x 8 m = 240 m) for a reach is encompassed by the block.

There is no upper limit on the number of stream reaches that can be sampled, nor the number of cutblocks.

If a district completes assessments at the minimum number of stream reaches needed to meet their annual target and wishes to collect additional data, the next blocks should continue to be selected sequentially from the random list. If sampling is desired at specific streams not on the random list in order to obtain information on an area, licensee or practice, the sample must be identified as “targeted” in the data submission.

Blocks should only be removed from the list for very specific reasons, which must be recorded. If a block clearly does not belong to the population, for example because there are no streams within or adjacent to the block, it can be deleted. Questions regarding whether a block is in or out of the defined population should be referred to the Resource Value Team Lead (RVTL). One reason a block may be deleted from the population is if active nearby harvesting or other activities in the block make it too dangerous to sample. If there are other reasons for considering deleting a site, discuss these with the RVTL.

INTRODUCTION

What is Properly Functioning Condition?

As a measure of overall stream and riparian health, properly functioning condition is a concept that had not been used much in forest harvest planning in BC prior to 2006 but has been a widely accepted concept in range planning since the 1990's. The *Riparian Management Area Guidebook* (Province of B.C. 1995) states that riparian habitats will be maintained in properly functioning condition if the impacts of development on the attributes of the riparian area are:

1. on average, small or within the range of natural variability of the habitat; or
2. large and beyond the range of natural variability in no more than a small portion of the habitat.

The key underlying assumption is that if the range of impacts attributable to the management activity affecting the riparian habitat lies "within the range of natural variability over the length of stream being assessed, it is likely that the natural ecological functions of the habitat will be maintained."

Properly functioning condition as defined in the Forest Practices Code is the ability of a stream, river, wetland, or lake and its riparian area to:

a. withstand normal peak flood events without experiencing accelerated soil loss, channel movement or bank movement;
b. filter runoff; and
c. store and safely release water.

The above definition is expanded here to include the requirement for stream connectivity, so that fish habitat is not lost or isolated as a result of some management activity. The ability of the riparian habitat to maintain an adequate root network and LWD supply, and to provide shade and reduce bank microclimate change, is also included in the definition of properly functioning condition. These additions are consistent with recommended best management practices for logging beside different stream types in the *Riparian Management Area Guidebook* (Province of B.C. 1995).

How is Functioning Condition Assessed?

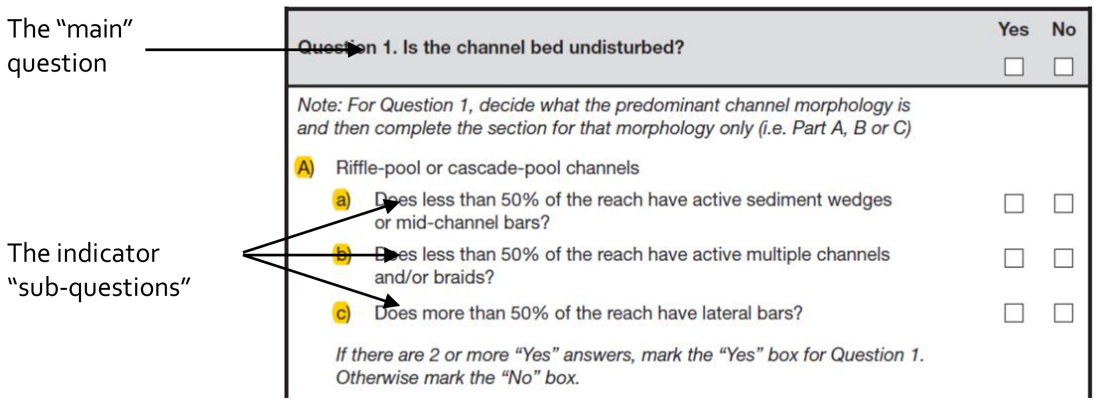
To assess the functioning condition of each reach, 15 main questions are asked that represent the characteristics of healthy streams and their riparian habitats. As summarized in Table 2, these 15 questions are the types of queries that stream and riparian experts might ask themselves in order to assess the condition or health of a stream at a given point in time. Note, the assessment assumes there is no long-term data available such as basic water quality parameters, and in almost all cases, the opportunity for multiple visits will also be very impractical, thus the assessments should be considered "snap-shots" in time.

Table 2. *Fifteen questions used to assess the relative health, or "functioning condition" of a stream and riparian habitat*

Question 1.	Is the channel bed undisturbed?
Question 2.	Are the channel banks intact?
Question 3.	Are channel LWD processes intact?
Question 4	Is the channel morphology intact?
Question 5.	Are all aspects of the aquatic habitat sufficiently connected to allow for normal, unimpeded movements of fish, organic debris, and sediments?
Question 6.	Does the stream support a good diversity of fish cover attributes?
Question 7	Does the amount of moss present on the substrates indicate a stable and productive system?
Question 8.	Has the introduction of fine sediments been minimized?
Question 9.	Does the stream support a diversity of aquatic invertebrates?
Question 10.	Has the vegetation retained in the RMA been sufficiently protected from windthrow?
Question 11	Has the amount of bare erodible ground or soil compaction in the riparian area been minimized?
Question 12.	Has sufficient vegetation been retained to maintain an adequate root network or LWD supply?
Question 13.	Has sufficient vegetation been retained to provide shade and reduce bank microclimate change?
Question 14.	Have the number of disturbance-increaser plants, noxious weeds and/or invasive plant species present been limited to a satisfactory level?
Question 15.	Is the riparian vegetation within the first 10m from the edge of the stream generally characteristic of what the healthy unmanaged riparian plant community would normally be along the reach?

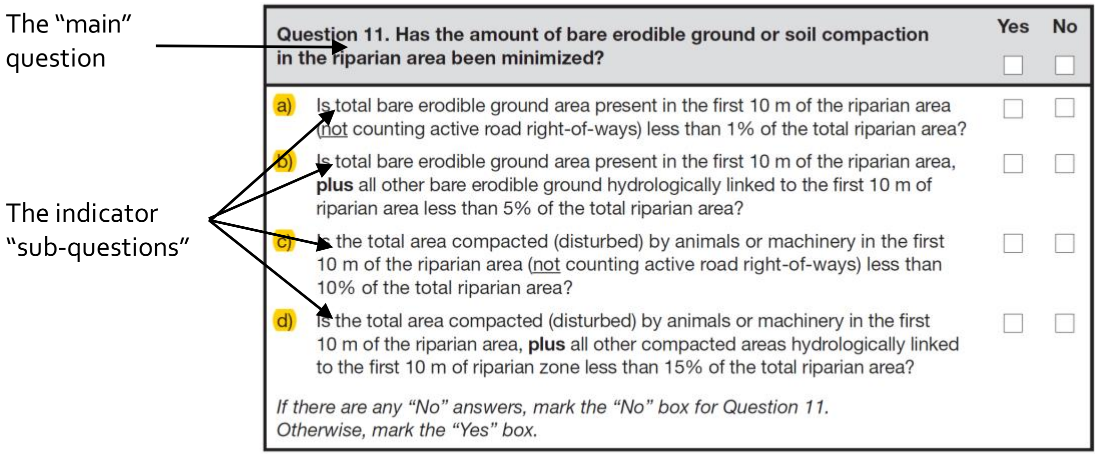
The answer to any question may not be immediately obvious or certain. To help experts and non-experts alike answer the questions, several indicator sub-questions are provided, and these also require a Yes or No answer. The indicator sub-questions are related to specific attributes that can be objectively assessed or measured to provide support for the response to the main questions. The number of Yes or No responses to indicator sub-questions determines whether the 15 main questions are answered Yes or No. Note that the indicators are always phrased so that a Yes answer equates to good health or proper functioning condition, while a No answer equates to poor health.

Question 1 below about whether the streambed is undisturbed is an example of a main question and associated indicator sub-questions. The latter are the upper or lower limits on the lengths of sediment wedges or mid-channel bars, multiple channels or braids, and lateral bars considered indicative of undisturbed stream beds. For Question 1, two Yes answers to the indicator sub-questions are required in order to answer Yes to the main question. The need for a Yes answer to only two of the three indicator sub-questions indicates that some of the indicators are inherently quite variable, and that the question is judged relatively leniently.



TIP: Read all indicator sub-questions carefully. Sometimes the meaning or intent of the question is not immediately clear. This is because all questions are phrased so that a **Yes** answer is "good" or "healthy." **No** answers are always "not good" or "unhealthy."

Question 11 below is an example of a question on the amount of bare erodible or compacted ground present within or connected to the riparian area where less lenience is allowed. If the answer is Yes to all of the indicator sub-questions, then the answer to Question 11 is Yes. If any of the answers are No, then the answer to Question 11 is No. Question 11 does not allow for any No answers to the indicators because of the sensitivity of streams to bare erodible or compacted ground within or hydrologically linked to the riparian area.



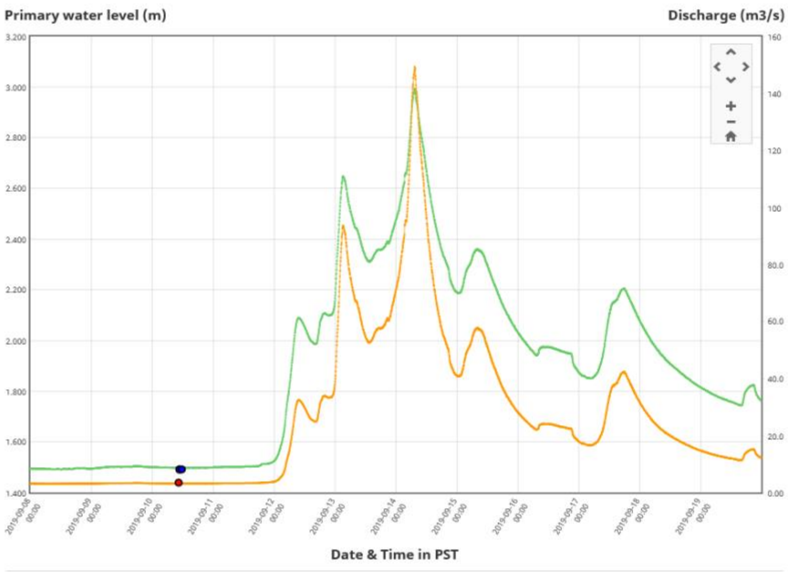
Question 11. Has the amount of bare erodible ground or soil compaction in the riparian area been minimized?	Yes	No
a) Is total bare erodible ground area present in the first 10 m of the riparian area (not counting active road right-of-ways) less than 1% of the total riparian area?	☐	☐
b) Is total bare erodible ground area present in the first 10 m of the riparian area, **plus** all other bare erodible ground hydrologically linked to the first 10 m of riparian area less than 5% of the total riparian area?	☐	☐
c) Is the total area compacted (disturbed) by animals or machinery in the first 10 m of the riparian area (not counting active road right-of-ways) less than 10% of the total riparian area?	☐	☐
d) Is the total area compacted (disturbed) by animals or machinery in the first 10 m of the riparian area, **plus** all other compacted areas hydrologically linked to the first 10 m of riparian zone less than 15% of the total riparian area?	☐	☐

If there are any "No" answers, mark the "No" box for Question 11. Otherwise, mark the "Yes" box.

Ten of the 15 questions will be applicable to all sites. There are five questions that may not be applicable. When a question is not applicable, it should be marked NA. For example, Question 4 on stream morphology is only applicable to alluvial-type streams i.e., riffle/cascade-pool or step-pool streams. It is not applicable if the stream is "non-alluvial", i.e., a stream that does not actively erode, transport and deposit bank materials and where the streambed is formed mainly of organic or mineral sediments that are not moveable during normal peak flows. This definition of non-alluvial includes small low gradient "wetland" types of streams with mainly soil or organic substrates, and small steep gradient streams where most of the substrate is large and non-moveable. The four other questions that could be NA include:

- Question 6 on fish cover characteristics if the stream is non-fish-bearing. Treat non-fish-bearing streams in community watersheds as fish-bearing regardless of their RMA classification.
- Question 7 on the amount of moss present in shallow sections of the stream. This question will be NA if the streambed is naturally composed of muck, fines, or organics. Streams in non-harvested basins are good references to check when deciding if conditions are "natural".
- Question 8 on the amount of fine inorganic sediments present if the streambed is naturally all muck, fines, sands or organic material, including shallow riffle areas.
- Question 9 on the diversity of benthic invertebrates present if high water conditions prevent effective sampling or the stream is dry or has recently been dry or exposed to high flows due to natural conditions. Note that streams that are dry or dewatered due to human activities would not be a reason to call Question 9 NA. To check as to whether flows may have been high immediately before your sample date, search for hydrometric data (discharge and water levels) in a stream nearby on the Water Survey of Canada website here: (https://wateroffice.ec.gc.ca/google_map/google_map_e.html?map_type=real_time&search_type=province&province=BC)

The example below shows how sampling on the 10th or 11th for invertebrates would likely produce representative results for invertebrates in the same or a nearby watershed but sampling a week later would not.



All other questions besides Questions 4, 6, 7, 8 and 9 should be applicable. There may be some indicator sub-questions that are not applicable, but other than the 5 questions mentioned above, the main question itself will always be applicable, and in need of a Yes or No answer. Some common examples of main questions or indicator sub-questions that are sometimes thought to be NA, but which are always applicable, are as follows:

- Question 10. *Has the vegetation retained in the RMA been sufficiently protected from windthrow?*

Question 10 is always applicable at all streams, even those that are 100% logged to the bank. Best management practices include some retention around non-fish streams but it is not required, which means that many S6 RMAs will legally have no tree retention at all. For S6 streams that fall into that category, Questions 10 a) and 10 c) are NA, but 10 b) would be Yes. This might seem odd but harvesting everything is one way to reduce windthrow and its impacts. The disadvantages in this strategy in terms of overall stream and riparian health are picked up by other checklist questions.

- Question 12. *Has sufficient vegetation been retained to maintain an adequate root network or LWD supply?*

Indicator sub-question 12 a) is applicable to all streams, regardless of the RMA class. While the rest of the sub-questions may not be applicable, a Yes or No answer is always required for 12 a). Steep, non-LWD dependent S5 or S6 streams that do not flow directly into fish-bearing streams have no recommendations for retention of any dominant or co-dominant trees. However, there is always a recommendation to retain understory trees, shrubs, and herbaceous vegetation to the fullest extent possible within 5 m of the channel to maintain a root network for bank stability. A good rooting system will be usually be composed of a diversity of shrubs, understory and overstorey trees. If the forest is second growth and trees have not matured enough to contribute to canopy gaps, it is possible that the undergrowth and thus the root network is deficient and will not be resistant to flooding. In these cases, look for signs of bank erosion that indicate that the root network is not adequate.

No questions are restricted entirely to one activity such as logging or grazing by cattle. Question 12 is focused on logging, but heavy browsing by wildlife or grazing by cattle could lead to a No answer for Question 12 if the browsing or grazing adversely affects riparian characteristics.

- Question 15. *Is the riparian vegetation within the first 10 m from the edge of the stream generally characteristic of what the healthy, unmanaged riparian plant community would normally be along the reach?*

Question 15 and its four indicator sub-questions all require a Yes or No answer. None of the indicator sub-questions are to be considered NA. The main thrust of the question focuses on logging and cattle impacts, but other significant impacts on the riparian vegetation should be considered as well. This includes clearing activities conducted for other industries or even natural causes that affect riparian vegetation such as beavers, wildfires, wind storms, sloughs, slides, or beetle epidemics.

Note: Riparian evaluations are not affected by questions that are NA for one reason or another. The conclusions about properly functioning condition depend only on the number of No answers. Eliminating questions that are answered NA may reduce the sensitivity of the assessment in some cases, but this may not be entirely inappropriate for those streams.

Note: Each question in the checklist has equal weighting. Some attributes may naturally be more important or sensitive than others, but these differences in importance have been considered by varying the thresholds for each indicator or changing the number of indicator sub-questions that need to be met to obtain a Yes answer to a main question. Attributes that are naturally quite variable, such as the amount of eroding bank present, have a relatively high threshold. Others that have low variability or are naturally rare, such as the amount of bare ground present, have a lower threshold.

CONCLUDING ON PROPERLY FUNCTIONING CONDITION

The relative health or "functioning condition" of the stream and its riparian habitat is based on the total number of No answers to the 15 main indicator questions, as follows:

- 0–2 No answers – Virtually all stream and riparian experts would agree the stream is healthy and in properly functioning condition. 76% of FREP reference streams had 0-2 No answers. The average for all reference streams was 1.4 No answers.
- 3–4 No answers – Functioning but at risk. Most, but not all stream and riparian experts would agree the stream is functioning properly. Some red flags are apparent. 20% of FREP reference streams had 3-4 No answers.
- 5–6 No answers – Functioning but at high risk. Most, but not all stream and riparian experts would agree the stream is not properly functioning condition. Many red flags are apparent. 4% of FREP reference streams had 5-6 No answers.
- 7 or more No answers – Virtually all stream and riparian experts would agree the stream is not functioning properly. No FREP reference streams had 7 or more No answers.

For presentation purposes, FREP uses four colour codes to report out on the four classes of functioning condition – green for proper functioning condition, light green for functioning at risk, yellow for functioning at high risk and orange for not properly functioning. Various corresponding impact ratings are very low, low, medium and high. The "very low" and "low" ratings are considered consistent with the Province's goal of sustainable resource management.

HOW TO ASSESS PROPERLY FUNCTIONING CONDITION

Selecting Eligible Reaches

When you have sequentially selected a cutblock from the random list of 200 cutblocks provided to each forest district, verify with a suitable map that the block has a stream within or adjacent to it. At least one stream must have a length equal to a minimum of 100m or 30 channel widths. The riparian treatment must also be consistent along this length. If these criteria are met, the block is an eligible block. If it does not meet the criterion for streams, the next block on the list is selected and examined for streams in the same way. Keep selecting and discarding blocks until you have a minimum of 10 blocks containing streams for the riparian effectiveness evaluations.

Once the blocks are selected, the streams within or adjacent to the blocks will need to be marked off into stream "reaches." For the purposes of determining stream and riparian functioning condition, a "reach" is a stream section that is relatively homogeneous with respect to fish use, channel width, gradient, confinement, and riparian treatment. This is an office exercise that will require information on fish presence/absence, road and trail locations, the RMA treatment proposed, and suitable elevation (i.e., contour) information to determine stream gradient and confinement. The online tool developed for government staff, FREPmap, should have most of this information loaded, including high quality imagery. Assume channel width is constant between junctions of tributaries. Consult contour layers or google earth 3D to determine channel gradients and confinement.

Once there is at least one potential stream verified in a block, request the site plan from the licensee to confirm that the stream was classed as a stream (S1-S6). If the site plan shows the stream labeled as an NCD and if no other options exist, omit the block from the sample population and move to the next one on the list. If there is a stream classed as S1-S6 on the site plan that was not identified during your preliminary review of the GIS layers and imagery, it may be considered using the same criteria with respect to reach length and homogeneous treatment. Identify all the reaches eligible for sampling in and adjacent to each cutblock on a map. Mark also the order that each stream should be sampled (1, 2, 3, etc.). Where multiple streams of the same RMA class might be sub-sampled, randomly assign separate numbers to these streams (e.g., 2-1, 2-2, 2-3) so that if only one of the streams is sampled, it is randomly selected.

For cutblock areas where the impacts of logging are the main concern, the simplest way to select a reach is to consider any stream with the same stream classification and management activity on it within the block to be a reach. In most cases, the stream will probably have similar physical characteristics as well. Gradient and channel confinement are probably the most important characteristics to consider. If the pre-field information or your familiarity with a block or range area is sufficient to clearly distinguish multiple reaches with different physical characteristics within a harvest area, by all means do so. Often, this will not be possible until you are physically on site.

TIP: Roads, including ditch lines and cut and fill slopes, and cattle crossings can often cause significant changes to streams. They should always be considered when establishing reach boundaries or assessing the effects of any management activities. The priority is to sample downstream of any crossings, though if the minimum reach length cannot be achieved downstream, placing the site upstream of the crossing will be satisfactory. Roads should not be included within the sample reach, though it is acceptable to omit the road and combine the upstream and downstream portions if you've arrived at the site and realize both segments are too short to achieve the minimum required length.

Once the sample locations have been identified in the office, it is advisable to complete the GIS-related upstream information on page one before leaving for the field portion of the assessment. Use ArcMap or FREPmap online to complete the required fields related to upstream development and number of road crossings. Useful GIS layers include topographic information (to delineate the drainage area upstream of sample reach), tenure boundaries (range, aggregate, recreation, utilities, etc.), cutblocks, and forestry roads. Imagery will also be useful to identify any mass wasting that may have occurred and help you make determinations on causal factors. These layers are already set up in FREPmap for government staff, and opening IDs can be found using the search box; contact the value lead to obtain the current FREPmap link and password. Use the tools provided in FREPmap, ArcMAP, Google Earth, or a georeferenced pdf to draw polygons and calculate the areas of both the watershed and upstream development to help estimate the % watershed development. Include road right-of-ways, agriculture pastures, existing cutblocks, transmission lines, and any other man-made features when calculating the area of development. Use the information collected online to help inform causal factor determination during the field assessments. For example, although hydrological response to development can vary greatly depending on landscape sensitivity, it is important to specify upstream causal activities if there are signs of recent increased flows or sedimentation in your sample reach, especially if more than 20% of the upstream watershed has been cleared and non-harvested basins are not similarly impaired. Consider road density and number of crossings upstream and note them for field inspection while on site if it turns out these could explain negative responses to the indicator questions.

Stream and Reach Verification in the Field

Once in the field, ensure that the management activity or streamside treatment is generally the same throughout the reach. The reach should also be homogeneous with regard to gradient and confinement. If significant differences exist, the reach boundaries should be adjusted to ensure the reach is generally the same throughout.

TIP: Tributary streams that are close to the same size as the main stream frequently mark reach breaks. This is because the channel usually widens at this point in response to the extra water.

TIP: Road crossings frequently mark reach breaks. The upper boundary of a reach with a road at the upstream end should start at the treeline on the upper edge of the disturbance caused by the road right of way.

Once in the field, verify the stream(s) selected for sampling are in fact streams and not wetlands, non-classified drainages (NCDs) or fisheries sensitive zones (FSZs) as defined in the Forest Practice Code *Riparian Management Area* and *Fish Stream Identification* guidebooks. If the stream on the plans turns out not to be a stream, delete it from the sample and select the next stream. Most stream classification errors will involve NCDs that have been overclassified as S6 streams or fisheries sensitive zones (FSZs) that have been overclassified as S4 streams.

To be a stream, there must be a continuous definable channel (which could be subsurface) and a streambed that consists of alluvial materials or scour down to a mineral substrate. A stream could lack one of these characteristics and still be a stream, but not both. Note that the continuous definable channel portion of the definition may not always be that continuous or definable in the field, but it could still be a stream if there are alluvial deposits or scour to a mineral substrate. Conversely, the feature in question could still be a stream with neither alluvial deposits or scour to a mineral substrate if it has a continuous definable channel. "Organic" streams associated with peat bogs and other wetland habitats are good examples of streams that typically lack mineral substrates. While these streams have well defined banks that water flows between, the streambeds and banks in these streams are usually composed of organic debris.

The Stream Classification Reference Card that follows is a "key" that can be used to determine if a water course or drainage feature is a stream, an NCD, or an FSZ.

A key for identifying fish streams, non-fish streams, FSZs and NCDs

1	Does the drainage feature have any alluvial deposits and/or scour to a mineral substrate, or continuous definable banks?	Y (4)	N (2)
2	Does the drainage feature have a gradient < 20%?	Y (3)	N (NCD)
3	Does the drainage feature flow into known non-fish-bearing water, or end before reaching a water body with no possibility of a connection at high flows?	Y (NCD)	N (FSZ)
4	Does the drainage feature have any alluvial deposits or scour to a mineral substrate?	Y (5)	N (13)
5	Are the alluvial deposits or scour to a mineral substrate continuous or in sections less than 10 m apart?	Y (6)	N (13)
6	Is the drainage feature < 100 m long?	Y (7)	N (10)
7	Does the drainage feature flow into known non-fish-bearing water, or end before reaching a water body with no possibility of a connection at high flows?	Y (NCD)	N (8)
8	Is the drainage feature directly connected to potential fish bearing water (stream, wetland, lake or FSZ), or potentially connected to these features at high flows?	Y (9)	N (NCD)
9	Is the gradient < 20%?	Y (S1–S4)	N (S5–S6)
10	Does the drainage feature flow into a known non-fish bearing stream?	Y (S5–S6)	N (11)
11	Is the gradient < 20%?	Y (S1-S4)	N (12)
12	Is there any potential fish habitat upstream?	Y (S1-S4)	N (S5-S6)
13	Is the drainage feature < 100 m long?	Y (14)	N (17)
14	Is the drainage feature directly connected to a potential fish-bearing stream, wetland, lake or FSZ, or potentially connected to any of these features?	Y (15)	N (NCD)
15	Is the gradient < 20%?	Y (16)	N (S5–S6)
16	Does the drainage feature receive more than 2/3 of its water from groundwater seepage, overland flow, or floodwater from adjacent water bodies, with less than 1/3 of its water from a lake, wetland or stream?	Y (FSZ)	N (S1–S4)
17	Is the gradient < 20%?	Y (18)	N (NCD)
18	Does the drainage feature flow into known non-fish-bearing water, or end before reaching a water body with no possibility of a connection at high flows?	Y (19)	N (20)
19	Does the drainage feature receive more than 2/3 of its water from groundwater seepage, overland flow, or floodwater from adjacent water bodies, with less than 1/3 of its water from a lake, wetland or stream?	Y (NCD)	N (S5–S6)
20	Does the drainage feature receive more than 2/3 of its water from groundwater seepage, overland flow, or floodwater from adjacent water bodies, with less than 1/3 of its water from a lake, wetland or stream?	Y (FSZ)	N (S1–S4)

* A wetland can end up being classified as a FSZ, NCD or S1-S6 stream. If the stream reach, FSZ or NCD in question has hydrophytic plants and subhydric or hydric soils, wetland is probably a more appropriate classification.

When to do Riparian Evaluations

Properly functioning condition can be assessed at any time of the year as long as the streambed and the ground conditions in the riparian area are clearly visible. However, the optimum time for assessment is a low flow period during the active growing season, when the streambed, stream banks, and ground in the riparian area are visible, there is flowing water in the stream, and vegetation foliage is fully developed. During winter, when the stream is frozen and the stream and riparian area is covered in snow, or during high flow periods, are the worst times to assess functioning condition.

Low water temperatures alone should not affect the overall assessment, though invertebrates can often be more difficult to find. Long rubber gloves can keep hands from becoming numb at low water temperatures when collecting benthic invertebrates. When sampling benthic invertebrates in the fall or spring, be sure to choose sections of the streambed that were wetted at low flow. At higher flows, shallow water sections may have been dry for long periods of time and lacking benthic invertebrates as a result. If the entire streambed was recently dry or frozen to the bottom, it is probable that benthic invertebrates may not have yet re-colonized and it is best to answer NA to Q9. However, if the stream has been dewatered as a result of other factors, such as increased aggradations after forest activity, sampling should still be attempted and given a NO answer if numbers/diversity is low. Benthic invertebrates should not be sampled during or soon after very high flows as numbers will not be representative of usual conditions.

Several indicators, such as the length of reach with gravel bars or the presence of dewatering, are stage dependent, and therefore best observed at a low flow period. Conducting the assessment at higher flow periods, when pool areas or gravel bar dimensions may be hard to see, means the evaluation may not be as sensitive to declines in properly functioning condition. Pool and gravel bar lengths may also be hard (though not impossible) to measure when the stream is flooded or dry. Stream invertebrates are impossible to assess when the stream is dewatered or dry, but if the reason for dewatering is due to harvest related activities, the answer would be No rather than NA.

For most areas of BC, the optimum conditions for evaluations coincide with the summer low-flow period from July 1 to September 30. However, many streams, particularly streams in areas that lack snow cover or have early spring run-off, can be assessed at other times of the year. Lower-elevation sites in coastal BC, for example, can often be assessed in April, May, or June after plants have leafed out, or in October before leaf fall or fall rains.

Be aware that season influences riparian evaluations, just as the year of the evaluation has an effect. Streams and riparian habitats are dynamic, and therefore constantly changing. Windthrow can differ from month to month or even day to day. Fine sediments that are introduced during high flow periods may only be visible on the streambed during the first low flow period and gone the next. Shade will be hard to estimate after leaf fall unless deciduous vegetation is absent or “twig” or “branch” density can confidently be related to percent shade cover. In some cases, for example, if there is a dense network of leaf-bearing branches present at any given observation point, it may be safe to assume 95–100% shade cover at that point.

How Long Should the Reach Be?

A distance equal to 30 channel widths, or 100 m, whichever is greatest, is considered the minimum distance necessary for a riparian evaluation. This means that a stream with an average width of 20 m should be assessed over 600 m. A stream 5 m wide would be assessed over 150 m. A stream 2 m wide would be assessed over 100 m.

TIP: When you are assessing streams with beaver dams, try to find a section that has no dams or ponds on it to determine average stream width. If the entire stream is ponded, then select a section that looks least affected by the dams. Use the width of this section to determine how much of the stream length should be assessed.

If there is still some doubt about the representativeness, accuracy or completeness of the assessment after a reach has been evaluated, more of the stream should be examined. For example, it may not be clear if large quantities of fine sediments noted on the streambed are related to conditions within the reach (e.g., windthrow) or to some other sediment source above the stream reach in question. This should be determined by walking to the upstream limit of the treatment being assessed and looking at conditions present upstream. It may be even more worthwhile to look at the stream just above the upper cutblock boundary, especially if the gradient, floodplain width, and channel confinement are similar.

As another example, it may be noted in the field that the reach section selected in the office does not really capture the effects of some windthrow because of the patchiness of the windthrow. In these cases, it may be necessary to assess longer sections of the reach, or to conduct separate assessments, one in the windthrow section and one outside the windthrow.

How Wide Should the Riparian Area Be?

Questions 10–15 focus on the riparian conditions beside the stream. Unless otherwise specified, the minimum width of the riparian area to consider for these questions is 10 m. Wider areas should be considered for Question 10 on windthrow if there are reserves present or management zones with prescriptions for some retention that goes beyond the first 10 m. In these cases, the entire reserve or management zone is assessed for windthrow.

For Question 11, the amount of bare erodible ground or compacted ground beyond the first 10 m from the stream edge is only considered if the ground is hydrologically linked to the sample reach including the stream itself and up to 10 m from the edge. Any ground on a 10% or greater slope, from the edge of the first 10 m of riparian area up to the first topographic break, is considered hydrologically linked to the first 10 m of the riparian area. Bare ground further away is hydrologically linked if a distinct channel, slide track, or sediment trail connects the bare ground to the first 10 m of the riparian area. Include upstream road crossings, approaches and ditch lines in this determination if road sediments are identified within the sample reach stream channel and connectivity from the road to the stream is apparent. A Water Quality Effectiveness Evaluation should be completed at the crossing and information obtained can help determine the values needed to answer Question 11 in the riparian assessment.

What If You Can't See All of the Reach?

Other than where safety is the main concern, a significant effort should be made to see the entire stream reach. This is typically easy to do on larger streams, but it can be challenging on small streams. When assessing small streams covered over with brush, it will probably be necessary to get down under the brush or pull it away to see the stream. If excessive amounts of debris are suspended across the channel, then it may be necessary to pull the brush aside and peer down between the debris pieces. Some streams may flow under the forest floor, with limited visibility in many sections.

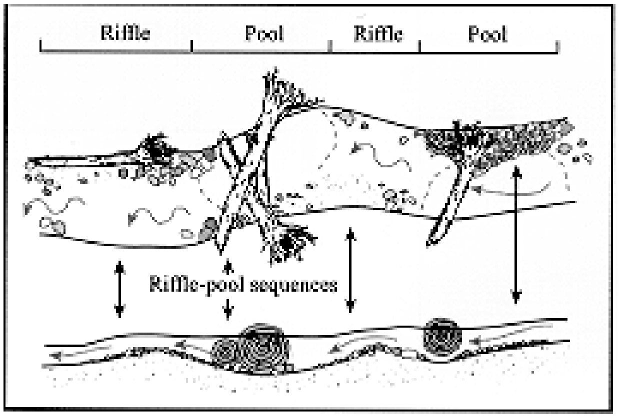
If sections of the stream or riparian area are not observed, do not include these sections or areas in the calculations of percent coverage or occurrence. Either consider the reduced length of stream or riparian area observed in your calculations or increase the stream length or riparian area assessed. Measurement thresholds based on the length of the stream channel (e.g., percent of reach with stable undercut banks, percent of reach with mid-channel bars) should only be based on the length of the channel that is actually observed. Similarly, areas of riparian indicators recorded (e.g., percent bare ground) should only be based on the area of the riparian habitat measured.

Some stream channels may be filled with debris such that it is no longer possible to see any evidence of a stream. In these cases, detailed measurements of the channel conditions are probably not needed. The answers to Questions 1 to 5 especially can be safely assumed to be No because it should be obvious that the streambed, stream banks, LWD processes, channel morphology, and channel connectivity are all drastically altered. The answer to Questions 6, 7, and 9 can similarly be assumed to be No since it is very likely that moss, fish cover, and stream invertebrate populations are also negatively affected. Only Question 8 (Has the introduction of fine inorganic sediments been minimized?) will be impossible to answer since it is possible that fine sediments are not abundant. In this case, try to remove enough debris from even a portion of the channel to observe the streambed. Do not answer "No" for this question unless you are sure excessive sediments have been introduced. Some stream channels may be simply covered with debris that is *spanning* the channel. This will also make viewing and measuring indicators difficult, but because debris has not been introduced below the high-water mark, it is likely a lot of the indicators have been left intact. Try to choose less-congested sections to take measurements from and decide if the debris is simply spanning the stream or within it.

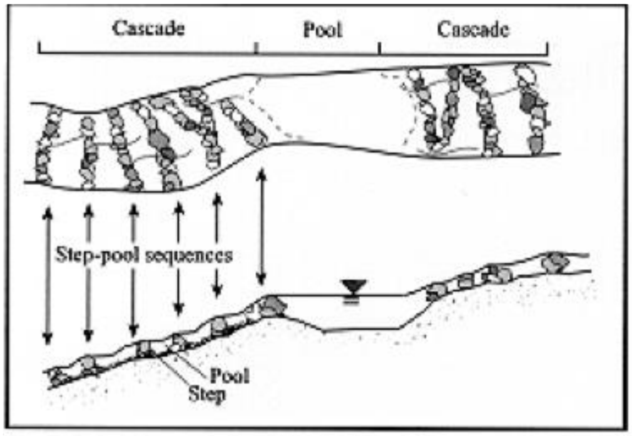
What is Stream Channel Morphology (Questions 1 to 4)?

The answers to Question 1 to 4 are sensitive to differences in channel morphology. To answer Questions 1 to 4, one therefore needs to decide what the main channel morphology is for the reach being evaluated. Ideally the reach selected would have a single uniform morphology since most of the key determinants of channel morphology (stream size, gradient, and sediment supply) should also be uniform. If one or more of these key variables differs markedly over the reach, then you probably do not have a uniform or homogeneous reach. If the reach is not uniform, shift the boundaries of the reach to achieve a more uniform reach. Alternatively, decide what the morphology is mainly and use that. To be considered mainly one morphology where more than one morphology is evident, the dominant morphology should represent at least 2/3 of the reach. Less than that and it is probably better to shift the boundaries (if possible) to achieve a more uniform reach.

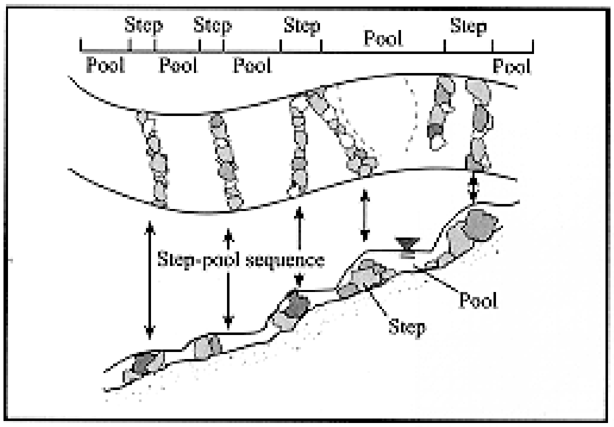
Four types of channel morphology are referred to in Questions 1 to 4. They include riffle-pool and cascade-pool type streams, step-pool streams and non-alluvial streams. Since riffle-pool and cascade-pool type streams are treated the same, there are effectively only three categories of streams in the protocol – riffle/cascade-pool streams, step-pool streams and non-alluvial streams. These terms describe most of the streams you will encounter with substrates made up of gravels, cobbles, boulders and/or bedrock. Idealized pictures riffle, cascade and step-pool morphologies are illustrated in Figure 1, together with a graph that shows the effects of channel width and channel gradient (slope, %) on these morphologies. Use this figure and the general characteristics of each channel type in Table 3 to help decide what the main morphology of the reach may be. Do not focus on a single characteristic to decide. Use all the characteristics together to determine the "most likely" morphology as it is not unusual for a stream reach to have characteristics of more than one type.



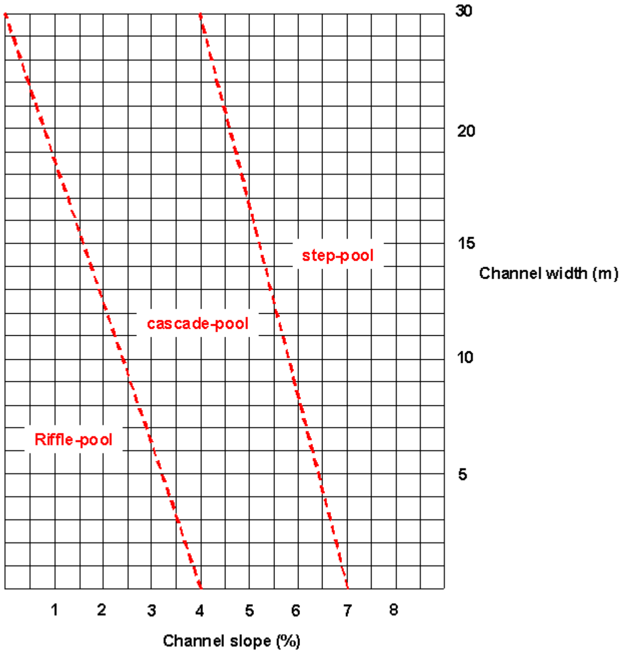
a) Riffle-pool morphology (RP_g and RP_c)



b) Cascade-pool morphology (after Grant et al. 1992)



c) Step-pool morphology (after Church 1992)



d) This figure shows how channel morphology changes with increases in channel width and stream slope. As channel width increases, the slopes that define different morphologies decline.

***Figure 1**. The three alluvial channel morphologies for small and intermediate-sized stream channels (a, b, c), and effects of channel width and channel slope on these morphologies (d)*

Table 3. *Stream channel morphology – general characteristics for small to medium-sized (1-30 m) streams*

Channel characteristic	Channel morphology				
	Riffle-pool	Cascade-pool	Step-pool	Large non-alluvial	Small non-alluvial
Gradients (%)	0-3	> 3-7	> 5	variable	variable, usually > 10
Stones	small, smooth	medium, smooth	large, smooth	large, sub-angular	small, angular
Pools	lateral	pockets, plunge	plunge	plunge	plunge
Moss	present on stable stones	present on stable boulders	common on steps, sides	common on sides	common everywhere
Wood	typically present, with effects on sediment movement and pool-riffle form	often absent, with minor effects on pool formation if present	typically absent, little to no effect on pool formation if present	typically absent, no effects on channel morphology if present	often present, roots and small logs across stream may form small plunge pools
Main bank material	alluvium	alluvium, colluvium	bedrock, coluvium, alluvium	bedrock, colluvium	colluvium
Floodplains	yes	yes	limited	no	no
Gravel bars	yes	yes	limited	no	no
Deposition or transport characteristics	mainly deposition	mainly deposition	mixed	mainly transport	mainly transport

Questions 1 to 3 have three different sets of indicators, depending on the predominant morphology of the stream (or lack thereof). There is one set of indicators for riffle-pool and cascade-pool type streams, one set of indicators for step-pool type streams, and one set of indicators for non-alluvial type streams. Only complete the section that best represents the sample stream reach.

Question 4 has two different sets of indicators, one for riffle/cascade-pool type streams, and one for step-pool type streams. The main question is whether channel morphology has been altered. Non-alluvial streams do not have a morphology that can be characterized by erosion, transportation, and deposition processes, and while pools, riffles and steps may be present, their arrangement rarely forms a consistent pattern. In non-alluvial streams, randomly located bedrock outcrops, non-moveable boulders, logs or roots have a greater bearing on the location of the pools, riffles and steps present, making the identification of an altered morphology difficult. Therefore, non-alluvial streams should be given an NA for Question 4.

Step-Pool Streams

The "steps" in step-pool streams are formed of boulders that have been arranged into lines across the channel by stream flows. Such steps are also called "stone lines". Steps formed of bedrock, logs or roots across a channel do not make a stream a step-pool channel, even when there are distinct plunge-pools below them. To be a step-pool stream, the steps need to be boulders arranged in some sort of line across the channel. Streams with rock, wood or root-controlled steps would be classified as riffle-pool or non-alluvial type streams, depending on the other main characteristics summarized in Table 1 (e.g., gradient, width, substrate, banks, moss, etc.).

Note that not every "step" or "stone line" will have a plunge pool below it. Some plunge pools and stone lines in step-pool streams can be "drowned out" by excessive amounts of cobbles or gravels. The only visible evidence of a step or stone line may be the tops of some distinctly larger boulders arranged in a line all or part ways across the channel. Be aware that the plunge pools that would normally be associated with these stone lines may be temporarily filled in.

Non-Alluvial Streams

Non-alluvial streams can be any size, large or small. Key characteristics in Coastal regions are the lack of lateral movement (meandering), banks composed of bedrock or colluvium, and a mostly non-moveable substrate that is angular or sub-angular (not smooth or rounded). The lack of a floodplain can also be a good indicator but should be considered in combination with other factors as cascade and step-pool streams could also lack floodplains. Steep non-alluvial stream reaches typically represent "transport" zones where any moveable sediments introduced into the channels are quickly carried downstream during high flows. Riffle-pool or cascade-pool type stream reaches in contrast are "deposition" zones where much of the moveable sediment present is temporarily stored in gravel bars or on a floodplain. Non-alluvial streams in the Interior regions are markedly different because of their low gradients and fine substrates, but they typically also lack power to erode their banks. Downcutting is more common than lateral movement of the channel.

Most small (< 1.5 m) S6 streams or S4 streams with gradients over 15% will be non-alluvial streams where the post-glacial morainal or colluvial materials that the stream flows through are large relative to stream width. These small, steep streams are considered non-alluvial because the stream does not have enough energy to sort the parent bank material once it is washed out of the stream bank and falls into the stream. Since the boulder, cobble or possibly gravel-size particles that wash out of the bank do not move very far in these low-energy streams, the particles usually have rough or sharp edges. Unless it is trapped behind debris jams, small gravel, sand or fine-sized particles will be carried out of the reach as alluvium. Because they don't move, the cobbles, boulders and bedrock that form the banks and streambeds of non-alluvial streams frequently have a thick growth of moss.

TIP: If the cobbles and boulders on the streambed have mostly sharp or rough edges, the stream is probably non-alluvial because rough or sharp edges means the substrate is not tumbling downstream and becoming rounded.

Streams with Muck, Fines or Organic Substrates

Low gradient streams with all organic, muck or sand-type substrates are best treated as non-alluvial streams because the substrate in these streams mostly does not move. They are often the upper headwaters of a stream where water is just beginning to collect and lacks sufficient energy to move even fine-sized particles. They can also be wetland-type streams where the characteristic pool or pond habitat conditions also mean sediments are mostly stationary. Both stream types usually also lack a floodplain formed of alluvial deposits originating from upstream.

GETTING STARTED

The following is a list of materials you will need to conduct a routine riparian evaluation:

- a Riparian Management Routine Effectiveness Evaluation Checklist, either on hard copy cards or the e-version on an ipad;
- the Protocol for Evaluating the Condition of Streams and Riparian Management Areas;
- the Field Supplement to Evaluating the Condition of Streams and Riparian Management Areas;
- a GPS receiver (for recording UTM coordinates at the upstream or downstream end of the stream reach);
- a calculator for calculating totals, averages or percentages of measured attributes;
- normal field gear (e.g., rain gear, hard hat, vest, pencils, a field notebook, safety/first aid supplies);
- suitable footwear. Riparian evaluations involve walking in, down, and across streams. Unless the streams are small, with little water, waterproof boots are recommended at a minimum. Waders may be needed for larger, deeper streams;
- measuring devices (at a minimum, a hip chain or a logger's tape, a hand-held tape, a clinometer, and a compass. Laser range finders are useful for large streams (> 15 m), but rarely practical for small streams);
- flagging tape and marking pens (for marking the reach boundaries, fixed sample points and the edge of the riparian areas or reserves);
- cover class standards (for help estimating shade or moss coverage at fixed sample points);
- benthic invertebrate example pictures;
- a white plastic tray (recommended minimum size approximately 200 mm x 150 mm x 50 mm deep) for examining benthic invertebrates;
- a cruise vest sized 0.5–1.0 mm mesh dip net (recommended net opening approximately 200 mm x 150 mm) for sampling benthic invertebrates;
- a flat-bottomed clear glass or plastic tray, bottle or glass. Like a diver's mask, this can be placed on the water surface to see the streambed when flowing water or slight turbidity obscures your vision;
- lists of invasive plant species, weeds and disturbance-increaser plant species, with pictures of the most common species (e.g., Field Guide to Noxious Weeds and Invasive Plants Identification Field Guide);
- lists of moisture-loving plants, with pictures of the more common species;
- a camera;
- handheld pH and temperature meter.

Basic Components of Routine Riparian Evaluations

Once a stream reach has been selected for evaluation, there are five basic steps to a routine riparian evaluation:

1. describing the reach,
2. collecting the field data;
3. answering the questions;
4. determining functioning condition; and
5. describing the activities or factors that caused or led to any No answers to the main questions.

Describing the Reach

Stream/Opening Identification

The first part (and the first page) of a routine riparian evaluation is the descriptive information needed to identify the reach. It includes space to record basic information such as the forest district, the opening ID, licensee, the year of harvest and harvest method. Much of this information can be obtained during the office review portion of the assessment. If the area is also covered by a Range License, record the license # and if appropriate, the range unit (or pasture ID). Other basic information to record includes the name of the stream and whether the stream is within the block or adjacent to the block and which side has been harvested. Note that there may be reaches that have older harvesting on one side and newer harvesting on the other. If the older harvest is found to be contributing to indicator effects (i.e., such as not providing adequate shade) it is best to indicate both sides have been harvested, but if the reach is outside of the block being assessed, you should also tick "Adjacent to block" in terms of stream location. This is to provide more accurate information back to the licensee whose block was selected for sampling. Record also the stream class on the site plans and once in the field, the stream class in the field. There are several other fields on the first page that can be filled out during the office review that will help later in the assessment to determine causal factors, such as information on upstream development and number of road crossings.

Once in the field, record channel width, actual stream classification, gradient, the dominant substrate and channel morphology. It might be necessary to walk the stream first before completing these fields. Once an average channel width is confirmed, the sample reach length can be laid out with equidistant point stations identified with ribbon. Do not be surprised if your field stream class is different that the site plan class, as often increases in surface flows to streams post-harvest can cause widening. However, if you do see fish in a stream that was classed as non-fish bearing, the stream should be reported to the value lead and/or the local C+E officer for further investigation. This is particularly important for S1-S3 streams that have had their reserves harvested.

The evaluation is sensitive to small differences in the reach section assessed, especially if management-related impacts are present. For this reason, it is important to describe the exact position of the reach. Record the distance (in metres) from a landmark, such as a block boundary crossing or road crossing, to the lower (downstream) or upper (upstream) end of the reach. Also mark the ends of the reach with flagging tape. These procedures will allow for repeated measurements over time if a reach is selected for monitoring in later years. It will also ensure quality assurance checks are conducted over the same stretch of stream.

A GPS receiver should also be used to record the location of one end of each sample reach.

If there is a problem with the GPS in the field, use a georeferenced map to obtain coordinates once back in the office. ***It is critical that all sites are geo-referenced for data analyses and reporting purposes.*** UTM or albers coordinates are best for locating all positions. If the filemaker app is being used to record data in the field, the google icon on the first page will auto-locate your position and assign albers coordinates to the sample.

Riparian Retention Information

In addition to stream class, information on riparian retention will be used to stratify the samples for analysis. It is recognized that there are many different ways of expressing retention. For purposes of this evaluation, express retention as percent of the dominant and co-dominant stems retained. If retention is expressed as a percent of basal area in the plans, assume this refers to the dominant and co-dominant trees present. For example, for a plan that specifies 50% basal area retention, assume this equals 50% retention of the dominant and co-dominant trees.

Photo Section

Photographs are not required for the evaluation; however, they can capture the appearance of a leave strip or stream in a way that numbers cannot. They can also confirm or clarify some of the data entry questions that frequently come up. An upstream view of the stream and adjacent riparian area from the downstream end of the reach and/or a downstream view from the upstream end of the stream reach is recommended. Other useful photographs could include lateral or oblique views of the riparian areas from the cut block, aerial shots if accessing the stream by helicopter, stream crossings or landings associated with the reach, a close-up of the streambed, and unusual or specific activities or conditions that affected functioning condition of the stream (e.g., windthrow, major erosion, over grazing, beaver dams).

Collecting the Field Data

Collecting information or data on the various indicators used to answer the main questions on properly functioning condition is the most important aspect of the evaluation. When completed, this data is a record of the supporting material used to determine the outcome of the assessment. Other people can use the information to double-check the answers in the case of a discrepancy between the number of Yes and No answers to the indicator sub-questions and the Yes or No answer to the main question. This information can also be used to complete the checklist if a question was overlooked.

Many attributes can be measured in different ways. The methods suggested in this handbook are believed to be practical in terms of consistency and/or time, but other methods may be suitable if the results provide a fair assessment. For example, some experienced people may be comfortable making visual estimates of stem density for percent windthrow. Others may not be familiar with windthrow and will want to use a consistent or straightforward method, such as direct counts of standing versus downed trees. If plot counts are used, (e.g., number of stems in 10 m x 10 m square plots), a minimum of three plots on each side of the stream are recommended.

Conduct the assessment by walking along the reach in the stream or along the bank, and back down again if necessary, measuring, estimating, or counting indicators as required. One person can complete an assessment, but it is easier if done with a two-person crew. It is frequently well worth the effort to pre-walk the reach before recording any information to get a feel for conditions and to identify where the edge of the 10-m-wide riparian area is located.

Experience indicates that a two-person team is initially best for people who might be unfamiliar with the riparian evaluation procedures. One member of the team should have a hip chain to record the overall reach length sampled, and thus the total riparian area surveyed. Both members should also have retractable style metre tapes to measure indicators like pool lengths, bar lengths, recently disturbed banks, upturned root wad lengths on the banks, and lengths of multiple channels. You could divide the indicators so that one person measures (and records) certain indicators, while the other person measures other indicators and calls out the results to the recorder – whatever works best. Not all indicators will need to be measured since some will be obviously over or under the threshold values that are used in the indicator questions. Experience suggests that most indicators will require at least some measurement until the thresholds are exceeded.

Having complete measurements for the entire reach is best, since that data can be mined later for related purposes, but if it is obvious that an indicator is much higher or lower than a threshold, making measurements throughout the entire reach unnecessary, it is a good idea to give a good estimate for the total length so this data can be used in future analyses.

Initially, it may be difficult to remember all the measurements and/or observations that need to be made during a riparian evaluation. However, this becomes much easier with experience using the checklist and conducting the measurement processes. The process also becomes easier as users become familiar with the threshold values that determine Yes or No answers to the indicator questions.

Recording the Field Data

The riparian checklist requires data or observations on three types of indicators – "Point", "Continuous" and "Other". Field data tables for the "Point" and "Continuous" indicators are located on Pages 2 and 3 of the checklist, respectively. A checklist for "Other" indicators is located on Pages 4 and 5, with extra tables on Page 6 to help compile the information needed to answer the "Other" indicators.

For the "Point" and "Continuous" indicators, the first column on the left of the field tables refers to the Question that the indicators are used for. If needed, the descriptions of each question that are provided later in this protocol can be read for additional information on the indicators.

The second to last column of the field tables is the space for the "Total". For the "Point" indicators, this is where you record the total of all your point samples for each indicator. For the "Continuous" indicators, this is where you record the sum of your measurements for each indicator, or your estimate of the total, however you derive it. Unless there are no samples, measurements or estimates, every space in the "Total" columns should have a number.

The last column of the "Point" indicators field tables is for the mean of all the points sampled for each specific indicator. For the "Continuous" indicators table, the last column is for the % of the reach length, % of stems, or % of the riparian area represented by each indicator. Like the "Total" column, unless there are no samples, measurements or estimates, every space in the last column of the "Point" and "Continuous" indicators tables should have a number.

Point Indicators

Point indicators are measured at discrete points along a traverse, then averaged to arrive at a mean value. A minimum of six measurements spaced at approximately equal intervals along the traverse is recommended. Fewer measurements may suffice if users are confident the measurements are representative of the whole reach, or it is clearly evident the threshold value for the indicator is exceeded or not.

When selecting specific points for the point samples, make sure that the points are located in riffles or other shallow, flowing areas of the stream. Information on moss, fines and benthic invertebrates should all be collected in these habitats. If your point sample falls at a pool, move the sample to the closest suitable riffle if such areas are available.

Only record a number for each sample point if that point was sampled. Do not record a number (e.g., "0") in any space that was not sampled. For each point indicator, total up the numbers at each sample point and record this total in the "Total" column. Next calculate the mean and record this number in the "Mean" column. The mean is based only on the sample points that were actually sampled.

Specific point indicators and suggested methods of measuring them are as follows:

Width of riparian buffer strip – Provide a measurement or estimate of the width of riparian retention for each bank. If there has been partial harvesting, this measurement should equate to a width containing full retention. For example, if 50% of the volume of trees were harvested within a 10m buffer, the value to enter would be 5 metres. If it appeared as though only one out of five trees in the outer 5m was harvested within a 20 m buffer, the value to enter would be 19m ((20-(5 x 0.2)). If the buffer has not been harvested, the value to enter is the entire width of the retention up to a maximum value of 100 m. ***The width of treed retention at each point station is especially important and will be the retention value used in most of the data analysis.***

% Moss – Record percent of the substrate covered by moss, from the bottom of one bank to the bottom of the other bank. Estimate percent coverage of a square plot on the streambed that is as long as the stream channel is wide. As a guide to estimating coverage in the square plot, calculate what the dimensions would be for a square patch of moss equal to 1% of the square plot. For example, 1% of a 2 m x 2 m square plot (4 m^2) would be a square 20 cm x 20 cm. Alternatively, use standard comparison charts for estimating foliage cover.

% Fines – Record percent coverage by inorganic fines or sands < 2 mm in diameter along a line across the channel, from the bottom of one bank to the bottom of the other. Do this for riffle habitats only. If the point transect does not land on a riffle, go to the nearest riffle. To calibrate your eye, stretch a tape from bank to bank across the riffle and measure the length of the line occupied by fines. Divide the length of the line with fines by the total length of the line, multiply by 100, and that is the percent coverage by fines. Do not disturb or dig down into the streambed to see what fines are there. Only record the fines you can see on the surface of an undisturbed streambed. If the water is too deep, turbid or fast-flowing to see the bottom, try holding a clear flat-bottomed tray or glass on the water surface to improve visibility. If you still can't see the stream bottom, do not record anything unless you are positive of the condition of the streambed.

No. sensitive invertebrate types – sample the benthic invertebrates at each sample station with the dip net, using the white tray to sort through the sample and see the invertebrates present. Record the number of different invertebrate types present that are usually regarded as "sensitive" (e.g., mayflies, caddisflies or "case-builders," stoneflies, riffle beetles, "helgrammites", clams). As an example, if you found three different looking mayflies, two different looking stoneflies and one caddisfly, record "6" for the number of different "sensitive" invertebrate types present. Do not record the total number of sensitive invertebrates present, only the number of different "kinds" present.

No. major invertebrate groups – Record the number of major invertebrate groups present in each sample. Insects, mites, flatworms, segmented worms, nematodes, and crustaceans are all examples of a major invertebrate group. If all the invertebrates collected are insects, then record "1" for the number of invertebrate groups. If most of the invertebrates collected are insects, but you also sampled a worm, record "2" for the number of major groups present. If you sampled insects, a worm, and a flatworm, record "3" for the number of major groups present.

No. insect types – Insects dominate the invertebrate fauna of healthy streams. Record the number of different insects present at each sample station. If the sample had 2 types of mayflies, 3 types of caddisflies, 1 diptera and 1 midge then you would record 7 insect types for this sample.

Total No. invertebrate types – Record the total number of different invertebrates present. It's helpful to record the actual types (e.g., 1 stonefly, 3 mayfly types, 2 case-builder types, 1 midge, 1 blackfly, 1 snail, 1 leech, and 1 worm together represent 11 different invertebrates). A table is provided in the field checklist below the point indicators for recording the different types of invertebrates at each sample station.

% Shade – Percent shade at any one point is the average of the two shadiest of the E, S, or W aspects. Measure shade at a 60-degree angle above the horizontal. Looking through a circle made by your thumb and forefinger and held straight out above your head at a 60-degree angle to the E, S, and W is a useful area upon which to base visual estimates. For small streams < 2 m wide, shade can be estimated from the center of the channel. For wider streams, estimate shade on both sides of the streams and record the average of those two estimates.

% Disturbance-increaser species – Record what percent of a 10-m long line is occupied by disturbance-increaser plant species in the first 10 m of the riparian area on each side of the stream. Record the average of the two lines. All lines should be perpendicular to the main axis of the stream reach.

% Noxious weeds – Record what percent of a 10-m long line is occupied by noxious weed and/or invasive plant species in the first 10 m of the riparian area on both sides of the stream. Record the average of the two lines. All lines should be perpendicular to the main axis of the stream reach.

Continuous Indicators

Continuous indicators are measured or estimated over the entire length of the reach, rather than at discrete points. Careful measurements are needed when the estimated % of the reach or % of the riparian area represented by the indicator is unknown or close to the threshold. In other cases, when it is obvious that the threshold value for an indicator will or will not be exceeded, it is sufficient to record estimated values in the "Total" and "%" columns.

As an example, the threshold for length of reach with pools is 25%, but if after walking the reach it is clear there are no pools, or the habitat is half pool or all pool, then it is enough to record "0", "50" or "100" as the case may be in the "%" column. Record also the estimated total length of pool in the "Total" column.

Note that not all indicators have to be measured in all stream types. Non-alluvial streams for example do not need any data for mid-channel bars, lateral bars, multiple or braided channels, stable undercut banks or pool length. Non-alluvial streams are the only streams that need data on the length of reach with moss. Step-pool streams do not need any data for gravel bars or pool length.

Specific continuous indicators and suggested methods of measuring them are as follows:

Mid-channel bars, wedges (m) – **On riffle/cascade-pool streams only**, record the reach length occupied by mid-channel bars and sediment wedges. Use a hip chain, logger's tape or hand-held tape to directly measure the length of the reach with these bar types, or visually estimate the length in short manageable sections of known length. Where the same type of gravel bars overlap, do not measure the overlap twice. Note that the lengths recorded for gravel bars is not just the lengths that are exposed to air in wetted streams. It includes the sediment that may still be covered in water. At high flows, all of the gravel bars may be covered with water and thus hard to identify. Similarly, gravel bars may not be immediately evident if the stream is completely dry.

Lateral bars (m) – **On riffle/cascade-pool streams only**, measure the reach length occupied by lateral bars. Use a hip chain, logger's tape or hand-held tape to directly measure the length of the reach with lateral bars, or visually estimate the length in short manageable sections of known length. Where two lateral bars overlap, do not measure the overlap twice.

Multiple channels and braids (m) – **On riffle/cascade and step-pool streams only**, record the reach length where multiple side channels and braids are present. Braids are channels separated by bare gravel bars. Side channels are channels separated by vegetated islands. Do not measure the reach length twice where side channels and/or braids overlap.

Moss (m) – **On non-alluvial streams only**, record the length of stream bed that has any growth of moss in between the toe of the banks, regardless of its overall abundance. This is not an aerial measurement of moss abundance like the measurement made for moss at the point samples. It is a linear measurement of moss presence only along the entire length of the stream bed. As an example, a thin strip of moss along the entire length of the stream bed may be less than 1% of the channel bed area at a point sample, but it is present along 100% of the stream reach.

Non-erodible banks (m) – **On all streams**, record the reach length where naturally non-erodible banks (e.g. bedrock, large immovable boulders) are present on both sides of the same section of stream. Note that this does not include man-made changes to the bank that are non-erodible such as rip-rap. These are included with "recently disturbed banks". Reach length with naturally non-erodible banks on both sides of the same section of stream is subtracted from total reach length to give total "erodible" reach length. Percent of reach length with undercut banks and deep-rooted vegetation is based on "erodible" reach length, and not total reach length.

Recently disturbed bank (m) – **On all streams**, record the reach length with recently eroded or disturbed banks, regardless of which side of the channel the eroded or disturbed bank is located on. Do not measure the reach length twice where a recently disturbed bank on one side overlaps a recently disturbed bank on the other side.

Stable undercut bank (m) – **On all streams with erodible banks**, record the reach length with stable undercut banks present, regardless of which side the undercut bank is located on. Be aware that sections with non-erodible boulder or bedrock banks on both sides are not to be included in the calculations of percent of reach with undercut banks. Do not measure the reach length twice where undercut banks overlap each other.

Deep/shallow rooted bank (m) – **On all streams**, record the naturally erodible reach length with deeply rooted stream banks. Alternatively, measure the length of naturally erodible stream reach where one bank or the other is not deeply rooted, and subtract this number from the total naturally erodible length to come up with length of naturally erodible reach with deep rooted banks.

Deep-rooting plants include deep-rooting grass species, all shrubs and all trees. Assume the roots of all these plants extend out to the "drip line" or the edge of the foliar cover. Mosses, sod-forming grasses (e.g., bluegrass) and herbaceous vegetation are not deep-rooting.

Upturned bank root wads (m) – **On all streams**, record the reach length with recently upturned root wads at the edge of the bank, regardless of which side of the channel has the upturned bank root wad. Measure the length of each root wad from the upstream edge to the downstream edge. Do not measure the reach length twice where upturned bank root wads overlap each other. Note that the scar left along the bank by new or recently up-turned bank root wads is to be included as recently disturbed bank.

Pool length (m) – **On riffle/cascade-pool streams only**, record the length of each pool present in the entire sample reach, or until satisfied the amount of pool habitat present exceeds the threshold for the indicator question. Give an estimate for the total reach length if measurement ceases after the threshold is reached.

New windthrow (No.) – **On all streams**, count the number of recent (i.e., post-harvest or post-treatment) windthrown trees present in the designated reserve or management area and record this number in the "Total" column. Compare this number with the number of standing trees to estimate % windthrow and record this number in the "%" column. If the number of windthrown trees or the number of trees present is too difficult to count, sub-sample the riparian area with fixed area plots to estimate total number of trees or windthrows present. With experience in assessing percent windthrow, a simple visual estimate of percent windthrow is appropriate if the percent of trees windthrown is clearly much greater than 10%

of the trees, or less than 1%. Estimate % new windthrow by dividing the number of new windthrows by the sum of the new windthrows and the standing trees, all multiplied by 100, as follows:

$$\% \text{ New Windthrow} = \frac{(\#\text{ New Windthrow})}{(\#\text{ Standing Trees} + \#\text{ New Windthrow})} \times 100$$

Old windthrow (No.) – **On all streams**, count or estimate, using a suitably rigorous method, the number of old (i.e., pre-harvest) windthrown trees present if it looks like the amount of old windthrow needs to be accounted for in assessing the significance of recent windthrow. To be counted as old windthrow, the tree should still have a root wad with the main branch roots attached. Old wind-snapped trees should be identified as a snag. Estimate % old windthrow by dividing the number of old windthrows by the sum of the old windthrows, the new windthrows and the standing trees, all multiplied by 100, as follows:

$$\% \text{ Old Windthrow} = \frac{(\#\text{ Old Windthrow Trees})}{(\#\text{ Standing Trees} + \#\text{ Old Windthrown} + \#\text{ New Windthrown})} \times 100$$

Standing trees (No.) – **On all streams**, count or estimate the number of standing trees present if the percent of trees windthrown could be between 1 and 10% of all stems, or where you lack confidence in estimating percent windthrow. Rough estimates of the number of trees standing are appropriate if windthrow is clearly less than 1% or greater than 10%. Record your count or estimate in the "Total" column.

Bare soil in first 10 m (m^2) – **On all streams**. Bare soil and bare erodible ground are the same thing. Bare ground is also the same thing if all the ground is erodible, with no vegetation, litter, wood or gravel or rock protecting the surface. Net out all non-erodible material on bare ground to estimate bare soil (= bare erodible ground).

Locate and measure the area of each patch of bare ground present in the first 10 m of the riparian area on both sides of the entire sample reach (10 m on one side and 10 m on the other side), including all permanently deactivated or de-built roads. Do not include active (managed) roads or road right-of-ways unless there is connectivity to the stream. If there is evidence that road sediments are making their way to the stream channel from an active road, include all bare ground from the road that is within the 10 m riparian area in this measurement. The portion outside of the 10m will be captured in the hydrologically connected category.

Where bare ground is not present as discrete bare patches that can be measured individually, but is dispersed throughout the vegetation, use the percent cover class card to estimate the amount of bare ground. Always net down bare ground that is mixed or armored with woody debris or stones and rocks to come up with an estimate of bare soil or bare erodible ground.

Record the total amount of bare soil present in the "Total" column. Calculate what percent of the total riparian area this represents and record this number in the "%" column. E.g. 24 m^2 of bare erodible ground in the first 10 m of the riparian area on a 120m long stream reach = 24 m^2 /2,400 m^2 (total riparian area) x 100 = 1.0% of the total riparian area

Bare soil exposed to rain in first 10 m (m^2) – **On all streams.** For each patch of bare soil recorded above as present in the first 10 m of the riparian area, record what amount of this area is outside of the treed drip line and therefore exposed to rainfall. Record recent upturned rootwads as bare soil exposed to rain if the stem or crown is on the ground. Bare erodible soil exposed to rain in the first 10m of the riparian area does not include the fines and sands present on adjacent active (managed) roads unless there is evidence of connectivity to the stream. If there is clear evidence that road sediments are entering the channel, include the surface of the road exposed to rain within the 10 m in the measurement.

Bare soil in first 10 m, plus all bare soil hydrologically connected to first 10 m (m^2) – **On all streams.** After calculating all bare ground within 10 m, look for any bare ground beyond that which may be hydrologically connected to the sample reach including the 10 m riparian area. This could include roads, ditchlines exposed fill/cutslopes, and landings. Bare erodible ground outside the first 10 m of the riparian area could also include sloughs, slides, or torrents that may be far from the riparian area but nevertheless hydrologically connected in some fashion, either by ditch lines, slide tracks, or stream channels. Road crossings upstream of the sample reach are assumed to be hydrologically connected if there is evidence of connectivity to the stream and road sediments are observed within the sample reach. If you are not sure, look upstream of the road to compare sediment levels in the stream channel. When calculating the area of hydrologically connected bare soil at an upstream crossing, it may be helpful to use the area data collected for the Water Quality assessment at that site if the evaluations are being completed together to help inform this measurement.

The number to record in the "Total" column is the sum of the bare soil area recorded for the first 10 m, plus all other bare erodible soil found and believed to be hydrologically connected to the first 10 m. To indicate that bare erodible soil in the first 10 m was included in the total for this indicator, write this number down in the space provided for individual measurements and circle it. Calculate the percent of the riparian area the total represents and record it in the "%" column. E.g., 24 m^2 of bare erodible ground in the first 10m of the riparian area on a 120 m long reach + 144 m^2 of bare erodible ground hydrologically connected to the first 10 m of the riparian area = 168 m^2 / 2,400 m^2 x 100 = 7.0% of the total riparian area.

Compacted ground in first 10 m (m^2) – **On all streams**. Compacted ground includes damage by pugging, hummocking, or rutting, and is usually caused by animals, heavy equipment, or vehicles. It may have bare soil associated with it, but the main characteristic or concern associated with compacted ground is associated with higher rates of run-off. Most trails (machine or animal) and roads, especially the running surfaces, represent compacted ground.

Locate and measure the area of all compacted ground present in the first 10 m of the riparian area on both sides of the entire sample reach (10 m on one side and 10 m on the other side), including all roadways within the 10 m that have connectivity to the stream channel. Record the total area of compacted ground present in the "Total" column and the percent of the riparian area this represents in the "%" column.

Compacted ground in the first 10 m, plus all compacted ground hydrologically connected to first 10 m (m^2) – **On all streams**. After calculating all compacted ground within 10 m, look for any compacted ground beyond that which may be hydrologically connected to the sample reach including the 10 m riparian area. This could include road surfaces and log sorts or landings. If there is a crossing immediately upstream of the sample reach, include it in the calculation if there is clear evidence of hydrological connectivity to the stream channel. Look for signs of erosion at the margins of the road surface or piles of road sediments at the edges of the stream channels directly below the culvert or bridge, indicating fluvial transport. When calculating the area of hydrologically connected compacted ground at an upstream crossing, it may be helpful to use the road surface area data collected for the Water Quality assessment at that site if the evaluations are being completed together, to help inform this measurement. It is not necessary to examine crossings that are further upstream because the surface water/ground water exchange within the hyporheic zone is an unknown factor, which can result in variable effects at your sample reach. However, it is important to include the number of upstream crossings on the first page of assessment so this information is considered during interpretation of the results.

Compacted ground on any slope with a gradient >10% that impinges on the 10 m riparian area can be considered hydrologically connected if it is within 30 m of the riparian area. If the toe of the slope ends before the 10m riparian area, then there should be concrete evidence of water flow from the toe of the slope to the 10 m wide riparian area.

For compacted ground that is located on a slope more than 30 m away, there should be evidence of flow to stream or that portion of the slope that lies within 30 m of the riparian area.

The number to record in the "Total" column is the sum of the compacted ground area recorded for the first 10 m, plus all other compacted ground believed to be hydrologically connected to the stream reach, including the first 10 m. To indicate that compacted ground in the first 10 m was included in the total for this indicator, write this number down in the space provided for individual measurements and circle it. Calculate the percent of the riparian area the total represents and record it in the "%" column.

Other Indicators

"Other" indicators are indicators that need to be noted or counted during the traverse; however, they don't need to be measured at five or six discrete points or continuously along the traverse. These indicators are best recorded after one has looked at the entire stream and riparian area to be assessed, but before any detailed measurements are made. This way, an assessor will gain a better appreciation of what may or may not have to be measured or counted more carefully.

The format for "Other Indicators" is a checklist of questions that requires a Yes or No answer for each indicator. Pages 4 and 5 are the questions that each require a Yes or No answer. Page 6 is a series of four tables designed to help tally the various attributes needed to answer the question for selected indicators. The latter includes the boulder line/step characteristics of step-pool channels, the wood characteristics of all channels, and the structure, form, vigor and recruitment characteristics of ten riparian layers or components of all riparian areas.

The questions for each Other Indicator and guidance on what you are being asked for on each question or group of questions are listed below. The checklist Question where the indicator is referenced is indicated at the beginning of each Indicator question.

Q1-Q4 Channel Spanning Steps (**For Step-Pool Channels Only**)

Q1(a) – *Do 50% or more of the boulder lines/steps span the channel?*

Q1(b) – *Do 25% or more of the boulder lines/steps have moss?*

Q4(a) – *Do 25% or more of the boulder lines/steps have plunge pools as deep as the largest rock in the line?*

Q4(b) – *Do cascades lacking boulder lines/steps represent less than 25% of the reach?*

This series of indicator questions deals exclusively with "boulder lines" (sometimes called "stone lines" or "steps") in step-pool type streams. In undisturbed step-pool channels with "stable" sediment loads, the largest moveable stones end up arranged in straight lines across the channel, either perpendicular or diagonal to the main axis. These stone lines can be made up of any number of stones across the channel, but they are usually only one stone wide. Because the stones are stable, they usually have a good growth of moss on them, particularly the stones at the edge of the stream. There is typically also a plunge pool below each line of stones. Together the plunge pool and the stone line form a "step" because of the sudden drop over the stone line. The drop looks like a small waterfall.

Intact channel spanning steps are easy to recognize because of the plunge pools and the obvious lines of large stones across the channel. They become harder to recognize or tally as they break down and start moving downstream due to unusually large floods. They can also remain in place but be buried or "drowned out" by major increases in sediment loads in the channel. In these cases, all that may be visible are the tops of some large boulders arranged in a partial line across the channel, with no plunge pool whatsoever. Whatever the cause, in disturbed step-pool channels, plunge pools start disappearing, boulder lines become less continuous across the channel, and moss on the stones gets scoured away. What was once a uniform series of boulder lines across the channel starts to look more and more like a cascade with randomly distributed boulders all over the channel.

Use Table 1 on Page 6 of the checklist to count the number of stone lines, how many span the channel, how many have moss and how many have deep plunge pools. A deep plunge pool is defined here as a pool that is as deep at "zero" flow as the largest stone in the stone line. All stones have three dimensions, the longest, the shortest and a middle. Use the middle dimension to see if the plunge pool is as deep as the largest stone.

Do not confuse the definition of a "deep plunge pool" with the definition of a "deep pool" used later in Question 4. In Question 4, a deep pool is measured from the deepest part of the pool to the top of the channel as defined by the rooted edge on the bank. To determine the depth of a deep plunge pool, subtract the deepest depth of the water at the downstream end of the pool from the deepest part of the pool. This is the depth of the pool at zero flow, when the stream is no longer flowing, and water trapped in the pools is stagnant. Another term for this measurement is "residual pool depth".

Boulder-line/step characteristics of a step-pool type reach 210 m long by 7 m wide

Table 1. Boulder-line/step characteristics of step-pool type reaches (Q1B, Q4B)				
Number of boulder lines/ steps	Number of channel spanning boulder lines/steps	Number of boulder lines/ steps with moss	Number of boulder lines/steps with a deep plunge pool	Length of reach with no boulder steps and plunge pools
卌 卌 卌 卌 卌 ||	卌 ||||	卌 |	卌	25,33,10 (Total= 68 m)

The example above shows what a completed table might look like for a step-pool reach 210 m long by 7 m wide. All together there were 27 boulder lines identified. Since only 9 of these spanned the channel, check the No answer to the first indicator question "Do 50% or more of the boulder lines/steps span the channel?" Since 6 of the boulder lines had moss, check the No answer to the second indicator question "Do 25% or more of the boulder lines/steps have moss?" Since only 5 of the boulder lines had a deep plunge pool, check No to the third indicator question "Do 25% or more of the boulder lines/steps have plunge pools as deep as the largest rock in the line?" Finally, since more than 25% of the reach (68 m out of 210 m) lacks boulder steps and plunge pools, check No to the fourth indicator question "*Do cascades lacking boulder lines/steps represent less than 25% of the reach?*"

Q1 Sediment and LWD Storage Characteristics (**For Non-Alluvial Channels Only**)

Q1(b) – Do sediment and/or LWD deposits that completely fill the channel up to the top of the banks represent less than 5% of the reach length?

If large enough, sudden inputs of sediment or debris can exceed the ability of any stream to transport the material. At these times, accumulations of sediment and debris may completely fill the channel, burying the streambed and banks in the process, and possibly diverting the stream. Mark No to this question if more than 5% of the reach length is full to the top of the banks with sediment or debris. Do not count debris that is suspended across the channel unless you are sure the debris also completely fills the channel.

Q1(c) – Are moveable sediments widely distributed in small pockets along the entire stream reach, not concentrated in a few relatively large compartments?

Moveable sediment is usually scarce in non-alluvial streams, and what is present tends to be uniformly distributed along the stream reach. Large pockets of sediment are typically formed when the channel is obstructed, and sediment ends up trapped behind the obstruction such as a log jam, or a slough off one of the side slopes. Mark No if there any such large conspicuous accumulations of sediment in the channel.

Don't confuse non-moveable sediment with moveable sediment. Moveable sediment is sediment that can be expected to move during normal flood levels that occur every 2-5 years. In small steep streams, non-moveable sediment tends be large, angular or sub-angular, and mossy. In small very low gradient streams, however, non-moveable sediments can also be small, especially when the habitat is mostly pools or ponds.

Q3 Wood Characteristics (**For All Streams**)

Q3 (a) – *Is the wood in the channel mainly old and/or stable?*

Q3 (b) – *Do 1-12 accumulations of wood span the channel?*

Q3 (c,c b) – *Do half or more of the wood accumulations present lack "new" or recently deposited wood that is unstable?*

Q3 (d,d,c) – *Is the wood in the channel mainly across or diagonal to the main axis of the stream, not parallel?*

Q3 (e,e,d) – *Is the wood in the channel intact; i.e., not recently lost or removed by hand, catastrophic floods, debris flows, debris torrents?*

This question deals with wood that is in the channel below the high-water mark or rooted edge. It does not include wood above or across the channel. Wood is defined here as any piece of wood with a diameter equal to 10% or more of the channel depth at riffles. If the channel depth is 30 cm, then wood has to be 3 cm in diameter to be considered. Smaller diameter pieces are excluded. If the channel depth is 1 m, then only wood with a diameter of 10 cm or greater is considered. Length is not a factor. Wood can include all or parts of the stems (trunks), root wads, or branches as long as it is of large enough diameter.

Use Table 2 on Page 6 of the checklist to decide what the main characteristics of the wood are if it is not immediately clear or obvious. Start by identifying and counting the number of accumulations of wood present in the reach. The goal is to count and classify the characteristics of enough accumulations that you can confidently describe the characteristics of the wood in the reach as a whole.

An accumulation of wood is any clump of wood that stands alone. The pieces in the clump usually touch each other, but not the wood in other clumps. In debris-choked channels where every piece of wood may be ultimately connected to every other piece, try to identify the main clumps. Since "most" means more than half when trying to decide if most of the debris is old or new, or parallel or not, sample an odd number of clumps to avoid ties. If you have a tie and you have counted every clump or accumulation of wood in the reach, go to the next clump outside the reach to break the tie.

In Table 2, for each accumulation of wood identified, determine if the accumulation has any "new" wood associated with it and record it under the column "Number of accumulations with new wood". A wood accumulation with even one piece of "new" wood qualifies as an accumulation with new wood. "New" wood is any piece of wood that was recently deposited **and** is not incorporated into the streambed, banks or log jams. "New" wood is often related to post-harvesting activities (e.g. recently cut or broken stems and branches, windthrow), but it can also be a piece of old looking wood that has been washed downstream and recently deposited. Old looking wood that is not incorporated into stable log jams, streambanks or the streambed is unstable wood and thus "new".

Next look at the accumulation and decide if the accumulation spans the channel. If it does, record this in the column "Number of channel-spanning accumulations". Then decide if the wood in the accumulation is mainly new or old wood in terms of the overall volume present. Record this as "O" or "N" in the column

"Main age of wood in each accumulation". Finally, decide if the wood in each accumulation is mostly parallel to the main axis of the channel as opposed to across or diagonal. Record parallel as "P" and across or diagonal as "X". To be mostly parallel, more than half the volume of the accumulation should be pointing within 30 degrees of directly downstream.

Repeat the above assessment for each accumulation of wood tallied. The example table below shows what a completed Table 2 might look like for a reach where 13 separate accumulations of wood were identified.

Wood characteristics of a riffle-pool type sample reach

Table 2. Wood characteristics of sample reach (Q3)				
Number of wood accumulations	Number of wood accumulations with new wood	Number of channel spanning wood accumulations	Main age of wood in each accumulation (Record "O" for old, "N" for new)	Main orientation of wood in each accumulation (Record "P" for parallel, "X" for across or diagonal)
### ### ///	### ////	///	OOONOOO NOOOOO	XXXPXXP PXXXXP

Of the 13 accumulations of wood, most (9) had new wood associated with them, 3 spanned the channel, most of the wood (at 11 of 13 accumulations) was old, and most of the wood was across or diagonal to the stream (at 9 of 13 accumulations). Together this information is used to answer the first four "Other Indicator" questions for wood in a riffle-pool type stream reach, as follows: Yes for the first, second and fourth questions, but No for the third question.

Q3 Wood Characteristics (Use Table 2 to help answer the questions)

Q03 Wood Characteristics (Use Table 2 to help answer the questions)				
Q3(a)	Is the wood in the channel mainly old?	X		
Q3(b)	Do 1-12 accumulations of wood span the channel?	X		
Q3(c,c,b)	Do half or more of the wood accumulations present lack new wood?		X	
Q3(d,d,c)	Is the wood in the channel mainly across or diagonal to the main axis of the stream?	X		

The last question asks if the wood in the channel is intact; i.e., not recently lost or removed by hand, catastrophic floods, debris flows, or debris torrents. To answer this question, look for wood that is piled up along the banks or deposited there by flood flows or during excessive hand cleaning operations. Look up and down the channel as well. If the channel looks open, with little or no wood across the channel, then floods have probably washed most of the wood away. Streams that were logged in the past or streams beside roads or developed areas frequently have this appearance because there has been little new recruitment of wood to the channel, to replace what is normally lost every year. Remnants of some very old logs may remain sticking out of the stream banks.

Q4 Surface Sediment Texture **(For Riffle-Pool and Cascade-Pool Streams Only)**

Q4(b) – Is the texture of the surface substrate mainly heterogeneous and well sorted?

A heterogeneous substrate is well sorted, with distinct aggradations, clusters or lines of different sized boulders, cobbles, gravels, sands, fines, etc. In streams with strongly heterogeneous substrates, there are clear differences in substrate composition between pools, pool-riffle breaks, and riffles. There are also differences in substrate composition from the shallow edge of the channel to the deepest part of the channel.

The opposite of heterogeneous is homogeneous. A homogeneous substrate is therefore a substrate with mainly just one size class of sediment present, such as mud, sand, gravel, cobbles or even boulders. Homogeneous substrates, however, can also be composed of different sediment size classes (e.g., small gravels, large gravels and cobbles) if the different size classes are randomly mixed together with no obvious sorting by water. Picture a truckload of sand, gravel and cobbles all thoroughly mixed together and you have a uniformly random mixture of sediments that is not heterogeneous. A streambed with clumps of boulders or large cobbles in the riffles with distinct bands of smaller cobbles, gravels and sands reaching to the margins is representative of a heterogeneous substrate.

Q4 Deep Pools (**For Riffle-Pool, Cascade-Pool and Step-Pool Streams Only**)

Q4(c) – Are two or more deep pools present?

To be a "deep" pool, channel depth at the deepest part of the pool has to be twice the channel depth of stable, undisturbed riffles. Like deep pools, measure the channel depth in riffles from the deepest part of the riffle to a line even with the rooted edge of the bank. This is equal to the "high water mark" or the "bankfull mark". Ignore the actual water level when checking to see if you have a "deep" pool. Water level is not relevant for determining channel depth or the presence of "deep" pools.

For step-pool type channels, do not confuse "deep pools" with the "plunge pools" you are asked to measure above for Q4 B a. A "plunge pool" in a step-pool channel only has to be as deep at zero flow as the largest rock in the boulder step or line that forms the plunge pool. This may or may not be as deep as twice the channel depth for the step.

When measuring channel depth in step-pool type streams, do not measure channel depth at a riffle right at the step. Instead, measure riffle depth from the channel bed just upstream of the step to the top of the bank. The top of the bank should be the same as the rooted edge. Measure pool depth from the deepest part of the pool to the top of the bank (i.e., the rooted edge).

Q5 Connectivity (**For All Streams**)

Q5 a) *Are temporary blockages to fish, sediment, or debris absent?*

Q5 b) *Is down-cutting that blocks fish movements or isolates the channel from the adjacent floodplain absent?*

Q5 c) *Are sediment or debris buildups absent at or in all crossing structures immediately upstream or downstream?"*

Q5 d) *Is down-cutting below any crossing structure that blocks fish movements upstream by any size fish, at any time, absent from fish streams?*

Q5 e) *Is upstream fish passage maintained in culverts located immediately upstream or downstream?*

Q5 f) *Is dewatering absent?*

Q5 g) *Are trails, roads or levees that isolate off-channel areas or divert normal overland flow away from the reach absent?*

Q5 h) *Is all water in the stream still flowing in its original channel, not withdrawn or diverted elsewhere?*

These eight other indicators are essentially the same indicators used for Question 5 on the checklist. Answering the questions to these indicators will therefore give you the answer to Question 5 on the checklist. If it seems the question is not applicable, record the answer as Yes, NA, or leave it blank. Additional notes, tips or information to help answer the questions are as follows:

Any obstruction such as a logjam, weir, or beaver dam should be considered temporary. Whether the obstruction is also a blockage to fish moving upstream or wood and sediments moving downstream depends on how complete the obstruction is. As a rule of thumb, consider any structure across any stream an obstruction to debris or sediment movements downstream if sediments and debris are clearly still accumulating above the blockage, or the stream is being actively diverted around the structure. In the latter case, there should be recent bank or channel erosion present. A log step across a channel is not considered a blockage to sediments moving downstream if sediments or debris are no longer accumulating and the banks at the step are stable with no evidence of recent ongoing erosion.

On fish streams, consider obstructions that fish have to jump over (i.e. there is no other path that fish can take to swim around) blockages if the height of the blockage above the rooted edge of the channel at the base of the obstruction is greater than the channel depth at the base of the blockage.

Down-cutting into the streambed can create vertical walls that fish have to overcome if they are to move further up the main stream or out of the main stream into tributary streams or off-channel areas. These are frequent problems where new channels are carved out through forests, in areas with deep erodible soils where the bank vegetation has been severely altered, or where culverts block normal channel erosion processes.

Problems with culverts immediately upstream or downstream can affect the transfer of water, nutrients, particulate matter, insects and fish to the sample reach. Include the crossings on the road that you might have driven on to get to your site to help answer Q5. Fish passage should be evaluated as part of the Water Quality assessment at these same crossings and this information can be used to help answer Q5e. See Appendix 1 for more information on criteria to consider in terms of fish passage.

Dewatering occurs when excessive accumulations of coarse sediment causes flowing water to percolate through and under the streambed instead of on top. In dewatered channels water can be seen disappearing into the streambed. Do not call the channel dewatered unless water can be seen disappearing into the streambed at some point or heard flowing underneath the streambed. To be sure the stream has water and is not just dry, look for impermeable or rocky outcrops within or above the sample reach that water has to flow over.

Roads that collect or divert small streams down a ditch to other streams or new channels may result in the loss of fish habitat beside the stream reach. Roads can also cut off access to tributary streams or off-channel areas if the crossing structures that connect the main stream to these smaller streams or tributaries in the sample reach are absent or inadequately constructed.

Q6 Fish Cover Diversity (**For All Fish-Bearing Streams**)

These indicator sub-questions on fish cover are the same indicators used in Question 6 on the checklist. Like Question 5, by answering Yes or No to each of these indicator sub-questions, you will be answering Question 6 on the checklist.

Remember, each type of cover is regarded in a cumulative manner and then compared to the channel area (length of reach x width of stream). It is best to start the process by recording the channel area directly onto page 5 of the riparian assessment. Then, calculate 1% of this value and record this onto the card. Now you know that once your estimates for each cover type exceeds this value, you can select YES for that cover type. For example, if your reach is 150 m long by 5 m wide, total channel area is 750 m^2. To be considered present, each type of cover should encompass an area equal to 7.5 m^2 (1% of the channel area).

Q8 Fine Sediments (**For All Streams**)

Q8 a) *Is the channel free of fine or sand-size sediments that "blanket" the streambed?*

Q8 b) *Is the channel free of "quick sand" or "quick gravel"?*

Q8 c) *Is the substrate mostly un-embedded?*

These three indicator sub-questions deal with sand and fine-size inorganic sediments on the surface of the streambed over the entire stream reach in addition to the data collected at the fixed sample points. They also include the larger size particles (e.g., small gravels) that may be "cementing" the streambed together or forming water-saturated pockets of "quick sand" or "quick gravel".

The first question asks if any fine and sand-size sediments "blanket" the streambed. These are sediments that cover the streambed to such an extent that large gravels and cobbles are buried and no longer visible. As a guideline, a single continuous area equal to one channel width in length is enough to say that fine and sand-size sediments blanket the channel. Since only fine and sand size sediments that bury gravels, cobbles and boulders are to be recorded, it should be evident that these coarser sediments are likely present under the fine sediments. If the streambed is thought to be naturally composed of sand and smaller sized particles, this question would be answered NA.

The second question asks if the streambed is mostly unembedded, i.e. free of smaller sediments that lock or cement larger material in place and reduce intra-gravel flows. To be considered embedded the sides of most gravel or small cobble-size sediments should not touch each other. They should also be difficult to move by hand. The best opportunity to check embeddedness is when the benthic invertebrate samples are collected. If the gravel and cobbles checked during the invertebrate sampling are easy to dig up or manipulate, then the stream bed at these points is probably not embedded.

The last question asks if the channel is free of any fine to gravel-size sediments that a foot or stick can be easily pushed into. Such deposits are evidence of recent introductions of sediment that can contribute to later more widespread infilling and embedding problems. As a guideline, a single continuous area equal to one channel width in length and width is enough to say that "quick sand" or "quick gravel" is present. As an example, in a stream that is 5 m wide, a single contiguous deposit of quick sand or quick gravel 13 m long by 2 m wide (= 26 m^2) is a large enough deposit to record as present. Deposits that are smaller than an area equal to one channel width in length and width (25 m^2 in this case) should not be recorded.

Q13 Bank Microclimate (**For All Streams**)

Q13 c *Are moisture-loving plants present and in good condition?*

Q13 d *Are the bank soils moist and cool?*

Moisture loving plants are invariably present in riparian habitats. They include true aquatics such as pond weeds, emergent plants that have their "feet" in water such as cat tails and rushes or sedges, and plants dependent on a high-water table or seasonal inundations such as skunk cabbage, Devil's Club, salmon berry and willows. Moisture loving plants also include a wide variety of bryophytes such as ferns, mosses and liverworts.

Mark Yes to Question 13 c if these plants are present and in good condition, not scorched, mottled, desiccated, brittle or otherwise stressed due to the habitat drying out. Do not confuse dead vegetation at the end of the growing season or last year's growth with vegetation dried or killed by drought conditions.

Soils in riparian areas should be cool and moist. Mark Yes to Question 13 d if this is so. Mark No if there are areas along the stream reach that show evidence of having a different soil moisture microclimate due to post-treatment changes to the riparian area. The latter could include direct impacts to soil integrity by cattle, road construction, infilling, riprap, sloughs, slides, windthrow, yarding, or machine crossings to name a few. It could also reflect indirect impacts on shade, air temperature and humidity due to removal of the riparian vegetation by harvesting or grazing.

Q15 Riparian Structure (**For All Streams**)

Q15 a Does the distribution and relative abundance of the vegetation layers and forest components present collectively approach 75% of what the healthy unmanaged riparian plant community would normally be along the reach?

A healthy riparian area is usually a tangle of herbaceous vegetation, shrubs and trees. Other conspicuous non-living components typical of healthy, unmanaged forests often or invariably include gaps in the canopy and dead wood, either standing snags or fallen and broken stems and branches on the ground. For this indicator, we recognize ten vegetation layers and other structural components, including gaps, snags, and dominant and co-dominant trees, under story trees, tall shrubs, low shrubs, herbaceous vegetation, ground cover, lichens, and CWD.

Use Table 3, on page 6 of the checklist, to help answer this Other Indicator question. The answer to this indicator is also the answer to Q15 a in the checklist. For each box under a vegetation layer or structural component in Table 3, record approximately what percentage of that component you feel is present compared to an otherwise healthy unmanaged area. In most cases this will be a comparison with a mature climax forest. Do this for each layer and component. In the second to last box, record the total of all the percentages. Divide the total of the percentages by the number of vegetation layers or structural components assessed and record this number in the last box. If the last number is 75% or more, mark Yes for the question indicating that collectively the riparian area approaches what is expected of otherwise healthy, unmanaged riparian areas.

An unmanaged riparian area with severe windthrow (50%) and bare ground exposure in the CWH

Table 3. Riparian Structure (Q15a). Using the table below, estimate whether the distribution or relative abundance of the forest components present collectively approach 75% of what the healthy unmanaged riparian plant community would normally be along the reach.

Snags (%)	Gaps (%)	Over-story trees (%)	Under-story trees (%)	Tall shrubs (%)	Low shrubs (%)	Herbs (%)	Mosses (%)	Lichens (%)	CWD (%)	Total (Sum of %'s)	Average % (Answer to Q15a)
50	100	50	50	100	100	90	90	100	50	780	78

A 60–year–old managed stand in the CWH

Table 3. Riparian Structure (Q15a). Using the table below, estimate whether the distribution or relative abundance of the forest components present collectively approach 75% of what the healthy unmanaged riparian plant community would normally be along the reach.

Snags (%)	Gaps (%)	Over-story trees (%)	Under-story trees (%)	Tall shrubs (%)	Low shrubs (%)	Herbs (%)	Mosses (%)	Lichens (%)	CWD (%)	Total (Sum of %'s)	Average % (Answer to Q15a)
0	0	100	50	100	50	50	100	25	25	500	50

The two example tables above show what completed tables might look like for two different riparian areas in the CWH. The first example is an unmanaged stand that had 50% of the snags, dominant, co-dominant and under story trees blown over. For this reason, 50% was recorded for the expected number of snags and different tree layers. 50% was also recorded for CWD due to the increase in new CWD (from the windthrow). Note that for values over and above what is expected, such as this CWD, the percent given should be less than 100% and represent the proportion that is away from that which is normal. There was considerable ground exposure due to the windthrown trees, which is why 90% was recorded for the herbaceous and ground cover layers. All other layers and components were within the range of most natural variations. The total of the 10 layers was 780%, for an average score of 78% (780 ÷ 10). Since this exceeds the 75% established as the cutoff, the answer to Q 15a would be Yes.

The second example is a second growth forest that was first harvested 60 years ago. It has a tall, closed canopy formed exclusively of Douglas firs, no snags, little CWD except what was left when the forest was first harvested, few under story trees, heavy browse on the few small shrubs present, and an under-developed lichen community. A score of "100" was recorded for the main tree layer, but a score of "50" was recorded for under story trees because they were almost absent. Similarly, scores of "0" were recorded for the snags and gaps because these components were missing altogether. The moss layer was well represented, but not the low shrub or herbaceous layers, possibly due to heavy browse by deer. The lichen community was very sparse. The total score for the 10 layers was 500%, for an average score of 50% (500 ÷ 10). Since this is less than the 75% established as a cutoff, the answer to Q 15a would be No. Note that the score for the main tree layer could also be much less than 100 if the number of expected species is factored in. If the site naturally has 2-3 other species such as hemlock and cedar in addition to the spruce, a score of 25 or 33% may be reasonable to account for the "missing" tree species.

Each score assigned to a vegetation layer or structural component should be based on what you believe the minimum or maximum value would be. If you know that the shrub layer is highly variable but typically covers 20-60% of the area in a certain BEC zone or BEC zone variant, then any coverage of 20-60% should get a score of 100%. If shrubs only covered 10% of the area, then your score might then be 50%.

For some areas you may know that a certain layer or component should be present, but more specific information on what the coverage should be is lacking. In this case any representation at all should probably get a score of 100%. As an example, you may know that the normal healthy, unmanaged riparian area has standing snags, but not how many. In this case it is probably wisest to give a score of 100% for any snag, and 0% if there are no snags.

Note that not all riparian areas are expected to have each of the layers or components listed in Table 3 of the checklist. Natural grasslands, sedge meadows, or shrub-carr complexes, to name a few vegetation communities, may naturally lack snags and trees. CWD levels and the lichen community can also be expected to be quite different. Other riparian areas may naturally have a well-developed, tree layer with few openings, but lack herbaceous vegetation or moss cover. For these simpler types of communities, record "NA" for the layers or components not expected. Base the overall average percentage in the last box on the number of layers or components expected.

For more information on this indicator, please see Q15 (pg 92) in the next section: The Routine Riparian Evaluation Questions.

Q15 Riparian Form, Vigor and Recruitment **(For All Streams)**

Q15b *Does the form, vigor and recruitment of the vegetation layers or forest components present collectively approach 75% of what the healthy unmanaged riparian plant community would normally be along the reach?*

Use Table 4 on Page 6 of the checklist to help answer this Other Indicator question. In Table 4, each vegetation layer and structural component of the riparian community is given a Yes or No in terms of its form, its vigor and its recruitment. Where one or more layers or components are naturally lacking in the mature, healthy unmanaged state, record "NA" for those layers. Also record "NA" where the vigor of a gap, snag or CWD component makes no sense. Record the total number of Yes answers in the third column from the right, and the total possible number of Yes answers in the second column from the right. Calculate the percent of eligible cells with Yes answers and record this in the last column. If the last number is 75% or more, mark Yes for the question indicating that collectively the form, vigor and recruitment of the riparian area approaches what is expected at similar but otherwise healthy, unmanaged riparian areas.

The table below is an example of an assessment for a riparian area that has been clear-cut to the stream edge, including all snags, understory trees and tall shrubs, and re-planted. Since the snags, trees, under story trees and tall shrubs were all reduced to stumps their form was considered poor. Other layers or components were still intact. Because they were stumps, the tree, understory and tall shrub layer vigor was also considered poor, but so was the lichen community which showed signs of disappearing due to the increased light and drier conditions. Vigor for the non-living components is NA. Lacking mature trees, there was no recruitment for snags, CWD or a normal lichen community. Seedlings are not considered recruits for snags or CWD because they are too many layers away from a contributing layer. Without trees, there was also no possible recruitment for "gaps". In fact, because there was already a single large "gap" (i.e. the clear-cut) the idea of recruitment for another gap made no sense. All other layers had satisfactory evidence of recruitment due to the presence of the newly planted seedlings and the existing moss, herb and low shrub layers.

Riparian vegetation form, vigor and recruitment for a riparian area clear-cut to both edges of the stream

Table 4. Riparian Vegetation Form, Vigor, and Recruitment (Q15b). Using Yes or No answers for each table cell below, determine if 75% or more of the cells have Yes answers, indicating that, collectively, form, vigor and recruitment is satisfactory.

	Snags	Gaps	Overstory trees	Understory trees	Tall shrubs	Low shrubs	Herbs	Mosses	Lichens	CWD	Total possible number of Yes answers	Actual number of Yes answers	% of cells with Yes answers (Answer to Q15b)
Form	N	N	N	N	N	Y	Y	Y	Y	Y	27	12	(12/27 X 100) =44%
Vigor	NA	NA	N	N	N	Y	Y	Y	N	NA			
Recruitment	N	N	N	N	Y	Y	Y	Y	N	N			

The final score was 12 Yes answers out of a possible 27, for a total score of 44%. The target (75%) was not achieved which means you would record a No answer for this Other Indicator question.

The second example below is the 60–year–old stand on the coast that started as a clear cut. As before, it has a tall, closed canopy formed exclusively of Douglas fir, no snags, little CWD except what was left when the forest was first harvested, few under story trees, heavy deer browse on the few small shrubs present, and an under-developed lichen community.

Riparian vegetation form, vigor and recruitment for a riparian area clear-cut to both edges of the stream 60 years ago

Table 4. Riparian Vegetation Form, Vigor, and Recruitment (Q15b). Using Yes or No answers for each table cell below, determine if 75% or more of the cells have Yes answers, indicating that, collectively, form, vigor and recruitment is satisfactory.

	Snags	Gaps	Overstory trees	Understory trees	Tall shrubs	Low shrubs	Herbs	Mosses	Lichens	CWD	Total possible number of Yes answers	Actual number of Yes answers	% of cells with Yes answers (Answer to Q15b)
Form	N	N	Y	N	Y	Y	Y	Y	N	N	27	12	(17/25 X 100) =63%
Vigor	NA	NA	Y	N	Y	N	Y	Y	N	NA			
Recruitment	Y	Y	N	N	Y	Y	Y	Y	Y	Y			

With no snags or understory layer, no gaps in the overstory and CWD in an advanced state of decay only, a No is given to these layers and components for form. The lichen community was similarly absent. Vigor is conceptually impossible to score for snags, gaps and CWD and so "NA" is recorded for these components. No is recorded for the understory and lichen layers that are missing and thus of low vigor by default since they should be present. Except for the low shrubs, all other layers showed normal vigor. Vigor for the low shrubs was given a No due to the heavy deer browse evident.

A Yes is recorded for snags, gaps and CWD by recruitment because there is a well-developed tree layer present that should soon start contributing to the snag and CWD components and forming gaps in the canopy. Recruitment to the tree and under story layers themselves is poor due to the absence of any seedlings. All other layers showed some recruitment in the form of smaller or younger specimens.

The total score was 17 Yes answers out of a possible 27, for an overall average of 63%. Although close to the target of 75%, a No answer is given for this Indicator Question. Note that had the stand been 20-40 years older with a snag or two and a more open canopy, or some windthrow, it is more likely the target score would have been achieved.

Q15 Browse, Grazing (**For All Streams**)

Q15 c Is heavy browse absent?

Heavy browse on a plant is browse down to second-year wood over most (> 50% of the branches) of the plant (Figure 2). If any one plant in the riparian area can be categorized as heavy browse, the answer to this Indicator question is No. A beaver cut stem is heavy browse.

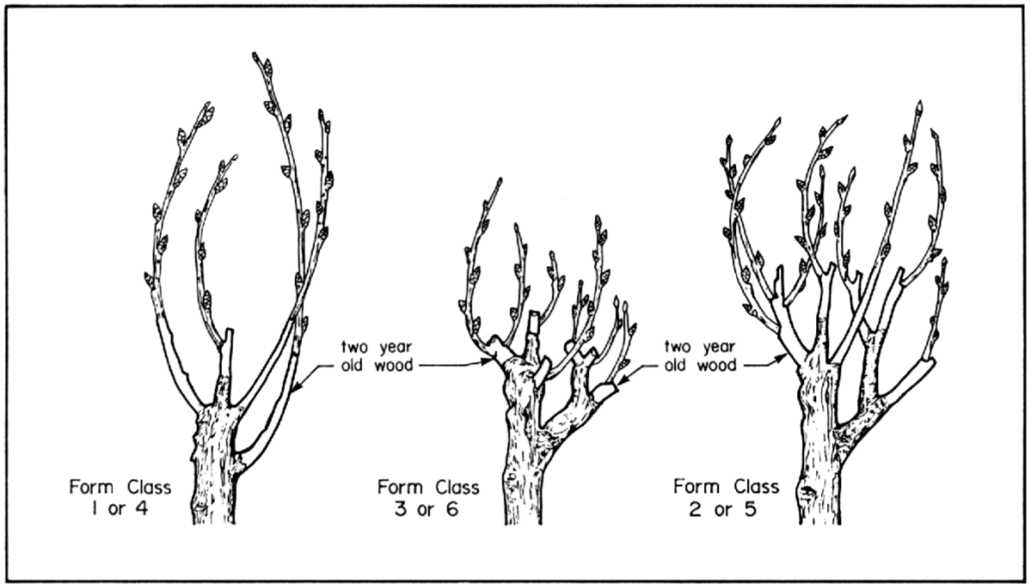


Figure 2. *Comparative browse forms for estimating levels of browse impacts within riparian areas*

Q15 d Is most (90%) of the available forage free of heavy grazing?

Heavy grazing is grazing down to less than the recommended stubble height for the dominant forage species present. If heavy grazing is evident anywhere, but it is not clear what average stubble height is for the dominant forage species, you will have to sub-sample the entire riparian area. Try to measure the height of 10 plants in each of six plots on each side of the stream reach. Average the plot measurements to estimate average stubble height. See the description of Question 15 later in the protocol for the recommended minimum stubble heights of different forage species.

Minimum Data Requirements

Some discretion on the number of plots, samples, measurements, or counts required is allowed when they are unnecessary, or that the answer to a question is unequivocal. The length of stream examined, however, should not be shortened. The protocol suggests that a minimum distance equal to 30 channel widths be inspected, or more if that is what it takes for the assessor to be confident of the conclusion on functioning condition.

Complete measurements or a full complement of transects may not be required for many variables in an intact reserve zone with a vigorous growth of climax vegetation and no evidence of any man-made or natural disturbances (e.g., no floods, no fire, no roads, no windthrow, no bare ground, and no weeds). It should also be obvious that many variables (e.g., shade, windthrow, standing trees and vegetation structure) will not require detailed measurement in riparian areas that are logged to the edges of the stream. Simply noting the extent of the logging in these cases is sufficient if it clearly explains why there was no need to estimate the variables in question. In other cases, for example where fine sediments on the streambed initially appear to be completely absent, it may be sufficient to record the observation as a note and skip making any additional measurements. The danger in making these types of assumptions is that if fine sediments are observed later on, it may be necessary to re-do parts of the assessment.

Whatever method or approach is used to determine the value of an indicator, note that a value is required for the "Total" column on the Point and Continuous indicators tables. This value might be based on a complete survey, a partial survey of the reach where the result is extended to the whole reach, or a visual estimate.

A value for the "Mean" or "%" columns is also required for the Point and Continuous indicators tables. For the Point Indicator table, the "Mean" value should be the "Total" divided by the number of points sampled. For the Continuous Indicators table, the "%" value should be the total divided by the total reach length or total riparian area, as appropriate, all multiplied by 100.

A defensible document that will support your conclusion on stream functioning condition or the effectiveness of a specific management activity will include:

- complete information on the location of the stream reach and a description of the retention planned or achieved;
- complete field data cards with adequate notes explaining why any variable did not require detailed measurement;
- a completed checklist;
- a summary of the No answers and your conclusion on functioning condition;
- a description of the activities, conditions, or events that led to each No answer; and
- a sketch or some photographs of the stream.

A conclusion based on a quick visual survey with no notes, no data, or any actual measurements is not defensible.

Answering the Questions

After completing the reach inspection and indicator data collection aspects of the evaluation, answer each of the
15 questions about the channel, bank, and riparian characteristics of the reach. Guidance, definitions, tables, graphs, and tips to help answer each question are provided in "The Routine Riparian Evaluation Questions" section later in this protocol.

The Summary Page

Page 16 of the checklist (after the questions) is a summary page to record the Yes, No or NA answers to each main question. Add up and record the number of No answers and conclude on properly functioning condition as described in the "Concluding on Properly Functioning Condition" section.

List the questions that had a No answer in the table at the bottom of the summary page and check off what you believe was the main reason for the problem. This is a very important part of the assessment. We want to know if natural events, upstream events and/or treatment events caused the No answer. We want to know this for each No answer so that background impacts can be separated out from treatment impacts. In this way we can judge the effectiveness of the treatment more accurately, while also providing information on what aspects of the treatment were not effective.

A No answer due to natural causes would include any natural events such as insects, fires, floods, slides, or diseases that were clearly unrelated to man's activities in the stream or adjacent riparian area. Check logging, cattle, roads or other impacts as a cause if any of these factors directly affected the specific stream or riparian area assessed in this evaluation.

In some cases, there might be a No answer for more than one reason. If so, indicate only what the main reasons were for the impact. Do not include factors which had only a small effect on the No answers.

Check Upstream factors only if the cause could not be explained at the sample reach and it is suspected the problem originates upstream. All Upstream factors will default to unknown. If the upstream cause of the No answer is known, identify it first in the table on page 16, then number the appropriate location box in the table on page 17 to signify it is within the reach, above the reach, or within and above the reach.

Specific Impacts for All No Answers Combined

Page 17 of the checklist (see Appendix 1) is a list of more specific impacts. Tick off the number of each question on functioning condition that had a No answer in the checkbox along the top, then find the cause along the left-hand side. Some indicators may have only one causal factor, but some may have more than one. Choose which main specific causes are associated with the general causal categories that were identified in the previous table. If Q7 or Q8 received a No answer because of excessive fine sediments in an area with high natural background levels of fines, an additional cause of the excessive sediments MUST be checked in addition to "high sediment levels". For example, if a road with direct connectivity to the stream at an upstream crossing was the cause for large sediment wedges observed in your sample reach, check the appropriate boxes for naturally high levels of sediment AND surface erosion from roads. If the only cause of No answers for Q7 or Q8 is high natural levels of sediment, reconsider if conditions aren't representative for the area, and if conditions are natural, answer those questions NA rather than No.

Once the specific causal factor is chosen for each No answer, enter numbers 1-3 in the appropriate box to indicate whether the cause was within the reach (1), above the reach (2) or within and above the reach (3).

Do not record a number for a specific impact if the question had a Yes answer, even if one of the indicator sub-questions had a No answer. For example, if there was excessive browsing (Beaver) that caused 15c to be No, do not identify Q15 in the table on page 17 unless the main question was also answered No.

Final Comments

Use the "Final Comments" page at the end of the protocol (page 18) to complete the assessment. Indicate if you agree with the conclusion on functioning condition, and if not, why not.

Be as specific as possible about the nature of the problems, especially if they were not listed in the table on page 17. Natural events could include soil erosion due to a forest fire in or adjacent to the riparian area, or a landslide on the unlogged side. Treatment impacts relate to impacts within the stream and riparian area that can be linked to the activity which is usually harvesting, but possibly also cattle grazing, lot development, other agriculture activities, or right-of-way clearing for pipelines or transmission corridors. Decide if there were any specific problems that affected the assessment more than others.

Note whether there were any management practices that were prescribed and implemented that led to good or bad outcomes. For example: "high stumping around the stream seems to have limited damage by equipment and prevented debris from rolling into the channel." Other strategies that might or might not be identified in the site plan can be outlined here if it was observed they were or were not particularly effective.

Indicate whether the stream could be a potential "reference reach" meaning there is little disturbance upstream in the watershed, and a large enough buffer was left around the reach such that there were no impacts owing to human activities.

The FREP WQ Effectiveness Evaluation is desired at any immediate upstream crossing (ie. the block road that provided access to the site). Enter the WQ ID number on pg 18 to ensure this information can be cross referenced.

THE ROUTINE RIPARIAN EVALUATION QUESTIONS

This section of the protocol describes the rationale for each question on the riparian checklist and background information on the specific indicators used to help answer each question. Additional information is also provided to describe the indicator and how to measure it in the field.

Some or most of this information is described in earlier sections of the protocol under "Point", "Continuous" and "Other Indicators".

The indicator statements for each question are more properly called "Logic" statements that require a "True" or "False" answer. Yes or No answers, however, are used for the sake of consistency with the answers to the questions. If some of the indicator statements are confusing, it may help to remember that Yes always means "healthy" while No always means "not healthy".

Question 1. Is the channel bed undisturbed?

A significant increase in the supply of sediment to a stream system can lead to severely aggraded channels. This condition is often noted in watersheds with many recent or active slides, eroding roads, or collapsing/eroding banks. As a channel aggrades, or fills in, channel morphology becomes simpler because the riffles extend longitudinally into pools. In severely aggraded streams, the pools get filled in, eventually disappearing altogether. Resting and feeding areas with good cover for fish are lost.

The opposite of channel aggradation is channel degradation. In this case, the damage to fish habitat is the result of too little sediment. This condition is often noted downstream of obstructions such as weirs or dams (man-made, beaver), logjams, or culverts that block or impede the natural downstream movement of sediment (boulders, cobbles, gravel, sand, and silt). As the local channel sediment below obstructions is moved downstream by normal fluvial processes, with no replacement of sediment from either upstream or the banks, channel morphology becomes less complex. It may ultimately result in severe fish habitat loss. Spawning habitat is especially affected.

For both excessive aggradation and degradation, the result is usually a reduction in deep or shallow sections of the channel (i.e., channel depth becomes more uniform, the number of pools is reduced, and the amount of productive fish habitat is reduced).

Indicator Sub-Questions

The indicators needed to answer Question 1 are sensitive to channel morphology. This is the reason Question 1 is divided into three sections — one for riffle-pool and cascade-pool type streams (Section A), one for step-pool streams (Section B), and one for non-alluvial streams (Section C). To determine the answer to Question 1, first decide what the predominant channel morphology is, then complete the section for that morphology.

Riffle-Pool and Cascade-Pool Streams (Section A)

Question 1 on riffle-pool and cascade-pool type streams (Section A) needs information on three indicators (sediment wedges and/or mid-channel bars, lateral bars, multiple channels) to answer the question. Only two out of three indicator sub-questions need a Yes answer in order to answer Yes to the main question.

The answer to indicator sub-questions may be obvious in some streams. The stream reach in question, for example, may not have any gravel bars at all, or any other channels beside the main channel. In this case, record zeros in the space reserved for recording the measurements on the "Continuous Indicators" page, the "Total", and "%" of the reach length the total represents.

As another extreme example, there might be a side channel that runs along the entire length of the stream reach, and sediment wedges that completely fill the channel. In this case, record the entire length of the stream reach in the spaces reserved for recording the measurements and "Total" on the "Continuous Indicators" page, and "100" in the "%" space.

When the answer to the indicator sub-questions is not obvious, more careful measurements are required. For example, there may be a mixture of different bar types present, none of which are obviously over or under the thresholds indicated in the indicator sub-questions. In this case, use a hip chain or hand-held tape to directly measure the length of each general bar type present in the reach, or visually estimate the lengths present in short manageable sections of known length. Where the same types of bars overlap, do not measure the overlap twice.

TIP: Mid-channel bars, diagonal bars, spanning bars, and braided bars should all be treated as mid-channel bars. They all indicate aggrading channels. Sediment wedges are gravel bars that are piled up behind an obstruction, usually LWD. They are called wedges because a longitudinal section through them resembles a wedge. Like mid-channel bars, they are usually an indication of an aggrading channel, and should be recorded with mid-channel bars. Both indicate aggrading channels (see Figure 3), so measure them together.

TIP: Multiple channels include any active channel that is separated by an "island," whether the "island" is vegetated or not. Bare, unvegetated mid-channel bars have multiple channels also called a "braid" or "braids" that equal the bar in length.

TIP: Lateral bars, point bars, and sidebars are different names for essentially the same type of gravel bar (see Figure 3). These bars are typical of stable, meandering medium-to-large gravel-bedded streams, where a gravel bar forms on the inside of the meander bend. The bars are formed mainly from sediments that are being continually eroded out of a bank on the opposite side of the stream, usually just upstream of the gravel bar. To form the bars, the stream must therefore have enough energy to erode the stream banks. Since not all streams have the energy to continually erode the stream banks, not all streams have lateral bars. Once a channel is eroded, the remaining bank material may be too large for the stream to continue to erode.

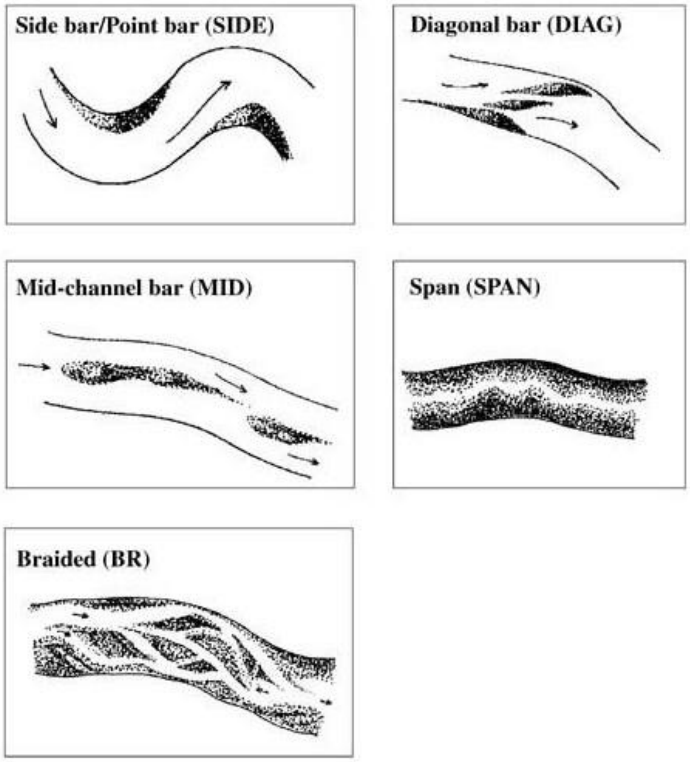


***Figure 3**. Types of channel bars*

Step-Pool Streams (Section B)

Section B of Question 1 is for step-pool streams which need information on two other indicators. One still needs to know the length of the reach that has active multiple channels or braids, but no information on the different gravel bars present is needed. The other two indicators deal with "boulder steps", also sometimes called "stone lines". These are the sites along a step-pool type stream where the largest moveable stones are arranged by stream flows into a line across the channel. The size of the boulders in these lines is distinctly larger than the particles between the lines. There is often a plunge pool below each line of stones so long as there have been no recent introductions of sediment.

The first indicator sub-question asks if 50% or more of the steps present completely span the channel. To assess this, count the steps or stone lines present, noting which ones span the channel and which ones do not. Note that not all steps will necessarily have a plunge pool. Some may be a distinct line of boulders that are mostly buried in a matrix of smaller particles.

The second indicator sub-question asks if 25% or more of the steps have moss. Note that not every boulder in the step or stone line has to have moss, just one, and it is usually a boulder on the side of the stream. The amount of moss present is also not an issue for this indicator, although the moss should not look like remnants of what was once there. The presence of moss on the boulders is a measure of stability, so there should be little evidence of moss being scoured away.

Table 1 on Page 6 of the field checklist can be used to count the number of stone lines present, how many span the channel, and how many have moss. Note that the same table is used for Question 4 to count the number of steps that have deep plunge pools, and to determine what length of the reach lacks steps and plunge pools. The example table below shows what a completed table might look like for a step-pool reach that is 210 m long by 7 m wide.

Boulder-line/step characteristics of a step-pool type reach 210 m long by 7 m wide

Table 1. Boulder-line/step characteristics of step-pool type reaches (Q1B, Q4B)				
Number of boulder lines/ steps	Number of channel spanning boulder lines/steps	Number of boulder lines/ steps with moss	Number of boulder lines/steps with a deep plunge pool	Length of reach with no boulder steps and plunge pools
𝍸 𝍸 𝍸 𝍸 𝍸 // = 27	𝍸 //// = 9	𝍸 / = 6	𝍸 = 5	25, 33, 10 (Total = 68 m % = 32)

All together there are 27 boulder lines identified. Since only 9 out of 27 span the channel, check the No answer to the first indicator question "Do 50% or more of the boulder lines/steps span the channel?" Since only 6 out of 27 have moss, check the No answer to the second indicator question "Do 25% or more of the boulder lines/steps have moss?"

Non-Alluvial Streams (Section C)

Section C of Question 1 for Non-alluvial streams has three completely different indicators that deal mainly with the distribution of moss along the length of the stream reach (it should be abundant), the volume of individual pockets of sediment (they should be small), and the distribution of sediments in the channel (it should be even).

Q1C a) Does 25% or more of the channel bed length have moss on the substrate?

The distribution of moss along the length of the reach is not the same measurement as moss area at a point transect. It is a measure of how much of the channel length between the toe of the right and left banks has any moss at all, regardless of its actual abundance at any spot. If moss is rare but nevertheless present at every point along the reach, then 100% of the reach has moss. Answer Yes if 25% or more of the reach length has moss. Do not "double count" sections where separate patches of moss overlap each other. Low gradient, small muck, sandy or organic bottomed headwater streams that naturally lack large sediment particles will not have any moss. Wetland-type streams with mainly pool or pond-like habitat and organic bottoms will also lack moss, as will naturally fine-bottomed streams common in glacial lacustrine areas like the central interior. Answer indicator sub-question a) "NA" for these types of non-alluvial streams.

Q1C b) Do moveable sediments and/or debris deposits that completely fill the channel up to the top of the banks represent less than 5% of the total reach length?

Non-alluvial streams are typically transport zones, and do not store much sediment or debris. However, if large enough, sudden inputs can temporarily exceed the ability of the stream to transport the material. At these times, accumulations of sediment and debris may completely fill the channel, burying the streambed and banks in the process. Answer Yes to this sub-question if there is little evidence of the channel being full of debris or sediment anywhere. Mark No to this question if more than 5% of the reach length is full of sediments or debris that reach the top of the banks.

Q1C c) Are moveable sediments widely distributed in small pockets along the whole stream reach, not concentrated in a few relatively large compartments?

Moveable sediment is usually present in smaller patches in non-alluvial streams. Large pockets of sediment are typically formed when the channel is obstructed, and sediment ends up trapped behind the obstruction such as a log jam, or a slough off one of the side slopes. Mark No if there are any such large conspicuous accumulations of sediment in the channel. Otherwise mark Yes.

Question 2. Are the channel banks intact?

Streams and stream channel banks are erosion features. When we ask if the channel banks are disturbed, we are really asking if they are recently disturbed. Over time, banks do stabilize and become vegetated if there is adequate soil. The tops of the banks especially become vegetated because they are high enough above the mean annual flood level to escape the constant negative effects of flow on germinating seeds and seedlings that lack developed root systems. As vegetation grows and encroaches on the stream, overhanging banks develop because the root mat is strong enough to be "cantilevered" out over the stream when stream flows erode the soil out from underneath.

The stream banks of most small to medium size streams (streams less than 30 m in width) in their natural undisturbed state are usually protected from excessive fluvial erosion by vegetation with well-developed root systems. Most trees, shrubs, and native grasses will serve this function. These plants also trap sediments to build and restore banks.

Forest harvesting or excessive grazing can reduce or eliminate the amount of deep-rooted vegetation present on the banks of aquatic habitats, thereby reducing the ability of the banks to withstand erosion through fluvial action. When the sediment load in a channel is increased, banks can be further eroded as the channel widens in order to deliver the sediment-laden flow downstream. Falling, yarding, windthrow, and trampling by large animals can also directly crush, collapse, shear, or otherwise damage stream banks.

Recently-disturbed stream banks, usually equate to a loss of stable undercut bank or overhanging vegetation. If widespread or serious enough, recently-disturbed banks can be directly responsible for filling in or blanketing the substrates with fine and sand-size sediments. They can also contribute substantial quantities of coarser sediments (gravel, cobbles, and boulders), leading to a cycle of aggradation and more bank erosion until a new equilibrium is reached between the erosive powers of the stream, the strength of the banks, channel volume and mean annual flood levels.

Recently disturbed banks can be identified by some of the following characteristics:

- there is no overhang, or there is but it was created by recent scour, leaving exposed roots behind;
- banks are sloped backwards or vertical with no vegetative cover;
- live exposed roots have a ragged appearance, with numerous fine rootlets exposed;
- live roots have de-barked areas with no signs of recent healing;
- exposed soil is largely unoxidized;
- exposed soil lacks any evidence of natural armoring; or
- clumps of bank material that have collapsed or been sheared off rest on the stream bottom.

Both naturally erodible or non-erodible (e.g. bedrock) banks that are buried by recent sediment or debris deposits, or replaced with rip-rap, are also considered disturbed banks. In each case, the banks no longer provide the same type of cover that was originally present. In many of these cases, the stream channel may also be constricted, resulting in fish passage problems or channel bed changes downstream. If the banks are buried enough, stream flows may leave the channel altogether, eroding new channels elsewhere downstream of the point where the banks are buried.

The first two sections of Question 2 for riffle-pool and cascade-pool streams (Section A) and step-pool streams (Section B) have four indicator sub-questions:

a. length of stream reach with recently disturbed banks;

b. length of stream bank with deeply rooted vegetation;

c. length of stream reach with stable undercut banks;

d. length of stream reach with recently upturned root wads.

Section C for non-alluvial channels has only three indicator sub-questions (a, b, and c). The indicator sub-question about stable undercut banks does not apply to non-alluvial channels.

For the bank indicators, consider both banks when looking for the measurement feature (disturbed, deep rooted, stable undercut, upturned root wads) even if the management activity being assessed occurs on only one side of the stream. However, do not record stream length twice where the indicator on one bank overlaps the same indicator on the other bank.

Percent of the reach with deeply-rooted banks, or stable, undercut banks is the length of each indicator divided by the total erodible reach length. Total erodible reach length is total reach length minus non-erodible (i.e., bedrock controlled) bank length. Percent of reach with recently-disturbed banks and upturned bank root wads is the length of each indicator divided by total reach length, regardless if it is non-erodible or not.

TIP: Banks that have lost or lack deeply rooted vegetation are not considered disturbed until there is also evidence of recent disturbance on the face of the bank.

TIP: Non-erodible banks (i.e., banks composed of large rock or bedrock) that are naturally non-erodible on both opposite banks are not considered part of the reach when assessing undercut banks or deeply rooted banks. If the banks are composed entirely of non-erodible material, there is little likelihood they will be disturbed.

The length of reach present with non-erodible banks refers to banks that are "naturally" non-erodible on both sides. This does not include rip-rapped banks or other man-made features. Including rip-rapped these as non-erodible banks would reduce the impact of these structures or materials on the percent of reach with undercut banks or deep-rooted vegetation. Rip-rapped banks or other man-made features are recorded as disturbed banks. They are also not deeply rooted. To more swiftly measure the length of reach with deeply rooted bank, simply measure the length of the reach that is not deeply rooted (i.e. shallow rooted banks) and subtract that from total erodible reach length.

For example, a stream reach is 100 m long, and it has a rip-rapped berm with a total length of 30 m. It has no bedrock anywhere on both sides of the stream, but it does have sections where one or both sides of the stream lack deep roots due to grazing in the first 1m of the riparian area beside the stream.

- Besides the rip-rap section, the other sections that lack deep roots are 3, 5, 2, 15 and 16 m long, respectively. The total length of stream reach that is not deeply rooted, including the rip-rap is 3 + 5 + 2 + 15 + 16 + 30 = 71 m. Total length of reach that is deeply rooted is 100 - 71 = 29 m.

- Note that the naturally erodible bank in this example reach is 100 m since as far as we can determine there were no sections where both opposite banks were non-erodible in their natural state.
- The length of reach with recently disturbed banks in this example is 30 m due to the rip-rap. If other sections of the stream had recently disturbed banks present, their length would have been added to this 30 m.

Deeply rooted banks can be an item of uncertainty for trainees. A good rooting system will be composed of a diversity of overlapping shrubs, understory and overstory trees. To help in the assessment, consider the following:

- Any portion of the reach where there are NO deeply rooted plants (e.g., bare soil, moss, herbs) on the bank, then consider the length of this observation to be shallow rooted, regardless of the same location on the bank directly opposite this location having deeply rooted plants. A record of 0m of shallow rooted banks means that BOTH the left and right banks are 100% deeply rooted for the entire reach.
- Deeply rooted banks are to be diversely vegetated with both trees and shrubs, will generally show evidence of stability, and cantilevered undercut banks will be common.
- Where banks are comprised of only ONE type of deeply rooted cover (i.e., only shrubs or only trees) then we are missing half of the optimum elements for stable banks. Record a value that is 50% of the length of the banks that are rooted by only one component. (e.g., a clearcut has no mature trees but has deeply rooted shrubs along its full length on both sides – record 50% as being shallow rooted, because you have shrubs but no trees).
- A listing of deeply rooted plants can be found in Appendix 3.

TIP: When assessing the amount of bank with deeply rooted vegetation, consider only the vegetation within 1 m of the rooted edge.

TIP: Deeply rooted banks are not the same as stable undercut banks. All of the banks could be deeply rooted due to the trees and shrubs present, but this is no guarantee that the banks will also be undercut.

Stable, undercut banks are banks that are usually vegetated and overhanging the stream. The root mass of the vegetation holds the soil together as the stream erodes away the deeper, non-rooted portions of the bank underneath the vegetation. The bank ends up looking "cantilevered" out over the stream. The extent of the overhang will depend on the strength of the root mat, the size of the stream and the type of bank material. Fine-grained soils with a vigorous cover of vegetation will be more undercut and stable than coarse grained, weakly rooted soils.

The depth of undercutting present refers to the horizontal distance from the edge of the bank to the back of the undercut (Figure 4). There are no firm guidelines on how much undercutting is required before undercut banks can be said to be present. For the purpose of this protocol, this depth should be at least 2% of the total channel width. The height of the undercut should also be within two times this distance. Thus stable undercut banks on a stream that is 2 m wide, should be at least 4 cm deep (2% of 2 m) and no more than 8 cm in height. A stream that is 10 m wide, should have undercut banks 20 cm deep and no more than 40 cm high.

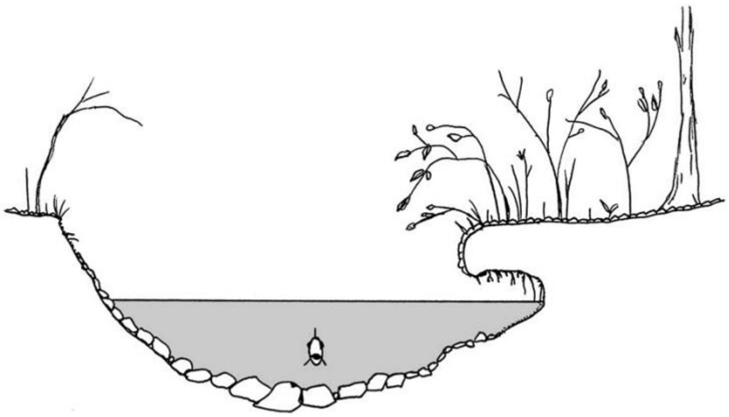


__Figure 4.__ A cross-sectional view of a small stream showing a stable vegetated overhanging bank on the right. The bank is "cantilivered" out over the channel, with no obvious signs of recent erosion

A stream bank can overhang the stream, but if the overhang is less than 2% of the channel width, or more than twice this length above the streambed, it probably should not be counted as an undercut bank (Figure 5). A stable undercut bank should be distinctly cantilevered out over the stream, not just overhanging because it is in the process of collapsing.

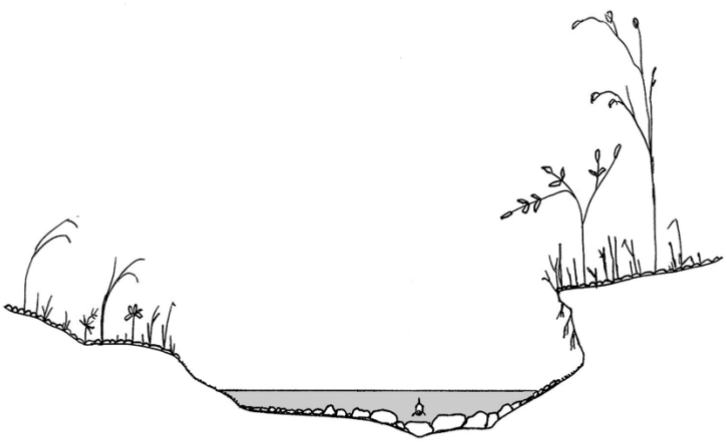


__Figure 5.__ A cross-sectional view of a small stream with an unstable, overhanging bank on the right side. The distance from the streambed to the top of the bank is distinctly more than twice the extent of the overhang. The bank is not clearly "cantilevered" out over the stream

Question 3. Are channel LWD processes undisturbed?

LWD stands for "Large Woody Debris" or more simply "wood". Channel LWD processes are the how, when, and where of what happens to wood after it enters a stream channel (i.e., how, when, and where it is stored, broken down, and transported down the channel). Changes in channel wood processes can have a major impact on the fish habitat characteristics of streams, regardless of whether the streams are dependent on wood or not. For the purposes of this protocol, wood is defined as branches or stems with a diameter equal to 10% of the channel depth at the crest of the riffles. For small streams where the channel depth may be only 15 cm, wood is any piece of wood with a diameter of at least 1.5 cm. For a stream with a channel depth of 50 cm, wood is any wood with a diameter of at least 5 cm. Length is not a factor.

In Question 3, there are up to five indicator sub-questions for each of the three categories of channel types – riffle-pool/cascade-pool, step-pool, and non-alluvial. To answer the question, first decide what the predominant channel morphology is, then complete the answers to the indicator sub-questions for that section.

All three channel types share four of the same indicator sub-questions, as follows:

Q3 a) for Sections A, B and C. Is wood in the channel mainly old and/or stable?

Mark Yes for this indicator if half or more of the wood accumulations you counted in Table 2 of the Riparian Evaluation Checklist field cards were composed mostly of old wood. Mark No if the accumulations are mostly new wood.

TIP: "Most" is more than half the apparent volume. "Old" usually refers to wood that was present before the treatment (i.e., the most recent harvesting or road building). However, if there has been recent wood deposited, but it has been incorporated into the channel bed and/or bank and is not causing erosion or contributing to a blockage, this wood is considered "stable" and should be counted as such.

TIP: To be considered "in the channel," the wood must actually extend into the channel (i.e., below the high-water mark). Logs that are suspended on the banks above the channel are not included, but any branches associated with the log could be in the channel and can be counted if they meet the minimum diameter for LWD.

TIP: Post-harvest windthrow-related wood is considered "recently deposited wood" if it extends into the channel.

Q3 b) for Sections A and B only. Do one to twelve accumulations of wood span the channel?

Riffle/cascade-pool and step-pool type streams have an additional indicator that non-alluvial streams do not have. For riffle/cascade-pool type streams, it is the number of wood accumulations that span the channel that need to be counted. For step-pool channels, the indicator is the number of wood accumulations present, whether they span the channel or not. For both stream types, answer Yes if there are 1–12 such accumulations present. Answer No if there are no accumulations present or more than 12.

Accumulations of wood are characteristic of most healthy riffle, cascade or step-pool type streams. A lower and upper limit to the number of accumulations is used here to identify streams that have a shortage or abundance of wood beyond the range of natural variability. For non-alluvial streams, the number of wood accumulations is too variable to be useful – there could easily be none or there could be one after the other.

TIP: A "logjam" is an accumulation of wood that spans the channel. However, not all wood accumulations are logjams. Some are just clumps of wood that only partly span the channel.

TIP: Strictly speaking, a wood accumulation is any collection with more than one piece of wood. Practically speaking, consider a meaningful accumulation of wood to be at least 3 pieces of wood.

TIP: In a situation where all or most of the stream reach is filled with wood, and the individual accumulations cannot be distinguished, record that more than 12 accumulations are present so that the result is a NO answer. Otherwise, this large, and apparently single accumulation of wood will be recorded as being within the normal range of 1–12 accumulations and result in a YES answer or false positive.

Q3 c) for Sections A and B, or b) for Section C. Do half or more of all wood accumulations present lack new or recently deposited wood that is unstable?

Mark No if half or more of the wood accumulations examined have even one piece of wood that can be considered new since the treatment (logging or road building in most cases) and is not yet stabilized within the channel. Mark Yes if most of the accumulations are all just old and/or stable wood.

TIP: Wood accumulations may be made up entirely of "old" wood that was present before the management activity being assessed took place. They may also be made up of "new" or "recent" wood that was introduced into the channel. In many cases, wood accumulations will be "old" wood with a new layer of "recent" wood. Wood accumulations with only new wood are treated the same as old wood with additional new wood. Both are counted as wood accumulations with recent wood.

Q3 d) for Sections A and B, or c) for Section C. Is wood in the channel mainly across or diagonal to the main axis of the channel, not parallel?

Mark Yes if most of the accumulations counted in Table 2 of the checklist were composed mainly of wood positioned across or diagonal to the main axis of the channel. Mark No if most of the wood accumulations examined had wood that was mainly parallel to the banks.

When judging if an accumulation of wood is mainly parallel or not, mark it parallel if more than 1/2 of the volume in the accumulation is clearly parallel. If not, count the accumulation as mainly diagonal or across the stream.

TIP: Parallel means not angled away or toward a bank more than 30 degrees off parallel. A long log that is more or less pointing downstream but which goes from one bank to the other bank is not parallel to the stream banks.

Q3 e) for Sections A and B, or d) for Section C. Is the wood in the channel mostly intact, (i.e,. not recently lost or moved by hand, floods, debris torrents, debris flows)?

Mark Yes if the wood in the channel looks undisturbed. In low gradient, wood-dependent streams, accumulations of wood should be easy to see at almost any point along or across the stream. Streams that have lost wood will have long stretches where the channel looks very open. Mark No if the channel looks mainly clear of wood, especially if the wood has been placed on the bank by hand or there are saw cut logs sticking out of the banks.

Look also up and down the channel. If the channel looks open, with little or no wood across the channel or in obvious clumps alongside the channel, then floods have probably washed most of the wood away. Older logged streams, streams beside roads or streams in urban areas frequently have this appearance because there is little or no recruitment of new wood to replace what is normally lost every year. Remnants of some very old logs may remain sticking out of the stream banks.

Table 2 on Page 6 of the field checklist can be used to sum up the characteristics of the wood in a stream reach. The example table below shows what a completed Table 2 might look like for a reach where 13 separate accumulations of wood were identified.

Wood characteristics of a sample reach

Table 2. Wood characteristics of sample reach (Q3)				
Number of wood accumulations	Number of wood accumulations with new wood	Number of channel spanning wood accumulations	Main age of wood in each accumulation (Record "O" for old, "N" for new)	Main orientation of wood in each accumulation (Record "P" for parallel, "X" for across or diagonal)
~~||||~~ ~~||||~~ ||| = 13	~~||||~~ |||| = 9	||| = 3	OOONOOO NOOOOO "O" = 11	XXXPXX PPXXXPP "X" = 8

Each accumulation of wood identified along the stream reach is examined separately and assessed for: the presence of any new wood, whether the accumulation spans the channel, the predominant age of the wood in each accumulation, and the predominant orientation of the wood. When determining the predominant age or orientation, consider only the total volume of wood present in the accumulation, not the number of pieces. Of the 13 accumulations of wood noted in the example, most (9) had new wood associated with them, 3 spanned the channel, most of the wood (at 11 of 13 accumulations) was old, and most of the wood was across or diagonal to the stream (at 8 of 13 accumulations).

Together this information is used to answer the first four indicator sub-questions for wood in a riffle-pool type stream reach, as follows. The answer is Yes for the first, second and fourth questions, but No for the third question.

Question 3. Are channel LWD processes undisturbed?	Yes ☐	No ☐
A) Riffle-pool or cascade-pool channel		
a) Is wood in the channel mainly old and/or stable	☐	☐
b) Do one to twelve accumulations of wood span the channel?	☐	☐
c) Do half or more of all wood accumulations present lack new or recently deposited wood that is unstable?	☐	☐
d) Is wood in the channel mainly across or diagonal to the main axis of the channel, not parallel?	☐	☐
e) Is the wood in the channel mostly intact (i.e. not recently lost or moved by hand, floods, debris torrents, debris flows)?	☐	☐

Beaver Ponds and Dams

Treat a beaver dam as wood that spans the channel. If the dam is active, then it almost certainly has new wood on it. If it is inactive, then the dam is probably just old wood.

When you are assessing streams that are ponded up by beaver dams, try to find a section that represents the normal width of the stream had it not been ponded. Use the width of this section to determine how much of the stream length should be assessed.

Question 4. Is the channel morphology intact?

Question 4 only has indicators for riffle/cascade-pool type streams and step-pool type streams. Only complete the indicators for the type of stream being assessed. If the stream is non-alluvial, then it has no flow-related morphology, and the question is therefore Not Applicable.

The frequent repetition of distinct pool-riffle sequences in streams is one of the hallmarks of productive fish streams. Factors such as an excess of sediments (especially gravels, cobbles or boulders) that blur the differences between pools and riffles or cause an actual reduction in the number of pools or riffles often reduce the amount of productive fish habitat. A variety of well sorted sediments is also characteristic of productive streams.

Riffle-Pool and Cascade-Pool Streams (Section A)

Section A of Question 4 has three indicator sub-questions, two on pool habitats and one on sediment variability. The two indicator sub-questions for pools ("a" and "c") are as follows:

Q 4A a) Are pools are present along > 25% of the reach?

Mark Yes if 25% or more of the reach length has pool habitat. Be aware that the downstream end of a pool is the point where you stop walking uphill as you walk down the pool. The upstream end of a pool is harder to identify in the field, but it is at the same elevation as the downstream end of the pool. Only consider the main pools in a stream (Figure 6), not the small pockets of pool-like habitat that are frequently present behind boulders in a cascade, or pieces of wood along the stream edges.

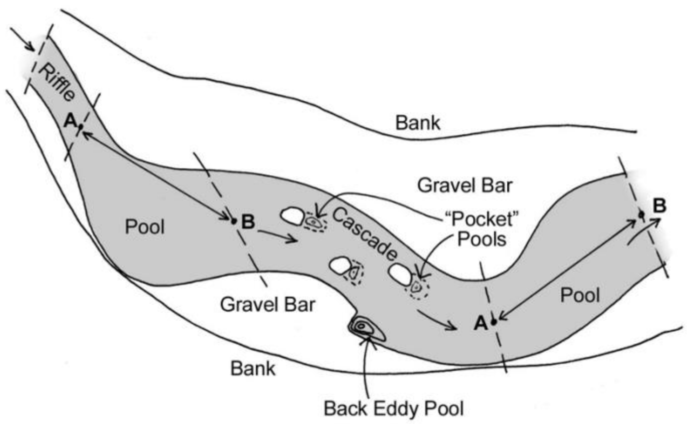


Figure 6. *This is a plan-view sketch of two pool-riffle/ cascade sequences in a stream. To determine the length of the reach with pool habitat, only measure the length of the main pools that occupy the width of the wetted channel, not back eddies or small scour holes or "pocket" pools behind boulders. Measure the length of the main pools from A to B, the mid-points of the pool-riffle boundaries*

Q4A c) Are two or more deep pools present?

Mark Yes if there are two or more deep pools. A deep pool is a pool with a channel depth twice the average depth at stable, undisturbed riffle crests (Figure 7). A riffle crest is the upstream end of the riffle, where water in the pool upstream "spills" out of the pool. Try to get an average of three channel depths at riffle crests, but if there is only one riffle present in the reach, then use that height to decide if you have deep pools.

Measure maximum channel depth for a pool from the deepest part of the pool to the "top" of the channel. This is channel depth at the deepest part of the pool. Compare this depth with channel depth at the riffle crest. Like pools, measure channel depth at the riffle crest from the deepest part of the riffle to the top of the channel. Stretching a string or tape across the stream from one bank to the other at the rooted edges will better identify where the "top" of the channel is.

Maximum pool channel depth is the vertical distance from the top of the bank to the deepest part of the pool. Channel depth at the riffle crest is the vertical distance from the top of the bank to the deepest part of the riffle at the pool/riffle break (Figure 7).

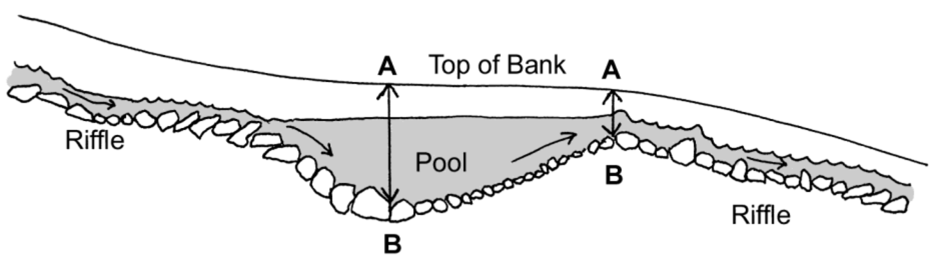


Figure 7. *To see if you have a "deep" pool, measure pool depth from the deepest part of the pool to the top of the bank (A to B). Then measure riffle depth at stable, undisturbed pool/riffle breaks from the deepest part of the riffle to the top of the bank (A' to B'). Channel depth at deep pools needs to be twice the channel depth at pool/riffle breaks.*

The third indicator of a healthy riffle-pool or cascade-pool stream is a heterogenous substrate.

Q4A b) Is the surface substrate texture mainly heterogenous and well sorted?

Mark Yes if there is a wide range of sediment size classes present (more than 2) and the different size classes are not all randomly mixed together. A heterogenous substrate is well sorted, with distinct clusters or lines of boulders, cobbles and gravels. In streams with well sorted heterogenous substrates, there are usually clear differences in substrate composition between pools and riffles, and between gravel bars and main stream channels.

The opposite of heterogeneous is homogeneous. Homogeneous substrates may be composed of different sediment size classes (e.g., small gravels, large gravels, and cobbles), but the different size classes are randomly mixed together. Picture a truckload of sand, gravel, and cobbles all thoroughly mixed together and you have a uniformly random mixture of sediments that is not heterogeneous. Picture a streambed with clumps of boulders in the riffles separated by smaller gravels and cobbles with sands along the margins and you have a heterogeneous substrate. A list of commonly accepted size classes for different sediment types is summarized in Table 4.

Table 4. Sediment size classes

Class	Description
Fines	Smaller than flea size
Sands	Smaller than ladybug size
Gravels	Ladybug to tennis ball size
Cobbles	Tennis ball to basketball size
Boulders	Basketball size to table size
Rock	Larger than table size, including bedrock

Step-Pool Streams (Section B)

Section B of Question 4 has three indicators, all of which deal with pools, as follows:

Q4B a) Are plunge pools frequent, i.e. are >25% of the steps associated with a plunge pool with depths similar to the size of the largest rock in the step?

In a healthy step-pool stream, most steps or stone lines will have plunge pools below the stone line. A step is a stone line that has a plunge pool with a small waterfall. They are formed when water flows over a stone line and scours out a pool. The resulting "step" will look like a small waterfall. In a step-pool stream that has not had a chance yet to scour out pools, the stone lines will not be that obvious because they lack the small waterfalls and plunge pools. In some cases, where excess sediments are substantial, all you might see are the tops of some large boulders arranged in a line across the stream.

To decide on the correct answer to this indicator, first tally up all the stone lines you can identify, noting which ones have a plunge pool that is as deep as the largest rock. Every rock has a length, a width and a depth that can be measured. The "middle" measurement defines the size of the rock. Note that a deep plunge pool as defined by the size of the largest rock in the stone line is not necessarily the same as a deep pool as defined above in Figure 7, where channel pool depth is twice the channel riffle depth.

Mark Yes if 25% or more of the stone lines identified also have deep plunge pools as defined above. Otherwise mark No.

Q4B b) Does the channel alternates almost exclusively between steps and pools?

Mark Yes if 75% or more of the reach is formed of steps and plunge pools. Mark No if there are long sections with no steps that collectively add to more than 25% of the reach. A step-pool channel that has been "filled in" with excess sediments will look like a long cascade, with no obvious stone lines or plunge pools.

Q4B c) Are two or more two deep pools present?

This is the same indicator you use for riffle-pool and cascade-pool type streams. Do not confuse deep pools as defined here and in Figure 7 with "deep plunge pools" as defined earlier for step-pool indicator sub-question a). A deep pool is still a pool with a channel depth twice the average depth at riffle crests (Figure 7). The riffle crest in a step-pool stream is the streambed immediately upstream of the stone line forming a step. Try to get an average of three channel depths at riffle crests for comparison with pool channel depths. As before, stretching a string or tape across the stream from one bank to the other at the rooted edges will help identify the "top" of the channel.

Mark Yes if there are two or more deep pools. Otherwise mark No.

Question 5. Are all aspects of the aquatic habitat sufficiently connected to allow for normal, unimpeded movements of fish, organic debris, and sediments?

Many aspects of forest harvesting can compromise or block fish access to upstream, tributary, or off-channel habitats.

- Newly formed logjams, especially those formed with logging debris, are usually effective sediment traps that can adversely affect fish habitat in the short term (< 10 years) by blocking sediment movement downstream. If large or solid enough, they may also hinder fish movements.
- Bridges or culverts can also block sediment movement downstream, and they may also constrict flow and create velocity barriers or impassable jumps for fish.
- Roads that lack drainage structures can directly block off-channel areas.
- Access to tributaries or off-channel areas from the main channel can also be blocked if the streambed degrades or cuts down into the streambed ("down cutting") as a result of a constriction or blockage that impedes sediment movement downstream.
- Excessive aggradations (accumulations of sediment) may similarly block fish access upstream due to dewatering. At dewatered areas in a stream, the water that normally flows over the streambed now percolates through the gravel.

It is difficult to determine if an obstruction that does not completely block off a channel is in fact an obstruction. As a rule of thumb, consider any potential blockage across a stream an obstruction if most of the water present at low flow has to "seep" through or flow over or around the structure instead of flowing through or around it. "Most" should be at least two-thirds.

There may be more than one reason for a lack of connectivity. Knowing all the reasons why connectivity is affected is important for assessing the effectiveness of the riparian treatment because it may indicate that landscape- or watershed-scale events upstream are contributing factors.

Question 5 uses eight indicator sub-questions to cover the scope of land use impacts on aquatic connectivity. Because of the importance of maintaining connectivity at all times, the answer to Question 5 is No if the answer to even one indicator sub-question is No.

Questions 5c, 5d, and 5e relate to any crossing that may be immediately upstream or downstream outside of the sample reach. This will usually mean at the road that was used to access the sample site.

c) *On all streams, are build-ups of sediment or debris within any crossing structure or portion of the stream channel within the road right-of-way immediately upstream or downstream of the sample reach absent?*

d) *On fish streams, are all crossing structures immediately upstream or downstream of the sample reach free of any down cutting that blocks fish movements upstream by any size fish at any time?*

e) *On fish streams, does the culvert immediately upstream or downstream of the sample reach score less than 15 using the rapid assessment for barrier determination, indicating fish passage is unimpaired?).*

Although the riparian evaluation is specific to a reach of homogeneous riparian treatment, it is important to consider the fluvial connections to the sample reach from both directions in order to account for potential "unseen" impacts. The crossing structure above or below the assessed section has to allow the unimpeded bi-directional passage of fish in all known and defaulted fish streams (<20% gradient). In all streams, the upstream structure is the conduit for the transfer of nutrients, organic materials, water, stream invertebrates, and sediments from higher in the watershed. The latter is especially important because the flow of water moves sediment downstream continually in all streams. This material needs to be replaced by a supply from upstream sources. When the supply is cut off or reduced, the channel in the reach in question will become degraded (down cut) to the bedrock or coarser rocky components and habitat will be altered/lost. Sediment wedges will then form upstream of the blockage further impairing connectivity.

Locating a crossing "immediately" upstream or downstream is usually going to mean at the block road that was used to reach the site, with the crossing in close proximity (ie. within 100 m up or down) of the sample reach. It is recommended that a Water Quality Effectiveness Evaluation be completed at this crossing, and so evaluating fish passage and sediment/debris blockages at the same time is a useful approach. The Rapid Connectivity Assessment (Appendix I) will help to determine whether there is a barrier at the crossing structure or right-of-way and can also be found in the WQ application. This assessment should be done at every WQ crossing to deliver information on watershed connectivity. The fish passage portion of the assessment is not necessary for non-fish streams or non-fish reaches above the culvert and Q5 d) and e) can be answered NA at those sites. If the stream is not classified, default any stream less than 20% gradient to fish-bearing. All open-bottom structures are assumed to pass fish and thus 5 e) can be answered Yes at these crossings without any measurements

TIP: Dewatering refers to a lack of surface flow. The channel appears dry; however, there may in fact be water flowing beneath the surface. To see whether the channel is truly dry or not, look for bedrock outcrops or very large in-stream boulders where any water present will be visible at the base of these features. Streams typically dewater first in the most downstream, low gradient reaches of a channel because this is where sediments tend to accumulate. Widespread dewatering can result in large-scale fish kills when fish become trapped in isolated pools that subsequently dry up.

TIP: If a stream is dry, be sure it is not because water has been withdrawn or diverted upstream. For our purposes, water withdrawn or diverted from the stream reach is not a diversion if all the water rejoins the original channel before the end of the reach.

The diversion channel must also have the same degree of connectivity with upstream areas, off-channel areas or other habitats as the original channel.

TIP: A stream should be considered incised and cut off from its adjacent floodplain if the average two-year flood cannot escape the channel.

TIP: Treat beaver dams as logjams, and therefore natural breaks in connectivity to fish, sediment, and debris movements. Answer No to Question 5 a) if the beaver dam is intact and two thirds or more of the water present at typical non-flood flows has to flow over the dam. By definition, all active beaver dams are new because beavers will constantly maintain the dam. Answer Yes to Question 5 a) if the beaver dam is inactive and a third or more of the water flows around or through breaks in the dam.

Question 6. Does the stream support a good diversity of fish cover attributes?

TIP: Question 6 is NA if the stream is a non-fish bearing stream (RMA class S5, S6).

Question 6 determines the presence of seven possible different types of fish cover. The answer to Question 6 is No if there are two No answers, but Yes if there are less than 2 No answers. Note that in areas of high background levels of fine sediments such as sand, silt or clay (central interior) there may not be boulders, cobbles or gravels naturally present. In these cases, it is acceptable to answer NA for these two types of fish cover. Examine the cut profile of the bank to understand whether larger substrate should be present and/or consider other unmanaged reaches in the same watershed.

To be considered "present", each type of cover should represent at least 1% of the channel area. For a channel that is 2 m wide by 100 m long, with a total channel area of 200 m^2, each cover type should have a cumulative total area of 2 m^2 (1% of 200 m^2) to be considered present. For a channel that is 5 m wide by 150 m long, with a total area of 750 m^2, each cover type should have an area of 7.5 m^2 (1% of 750 m^2) to be considered present.

The seven types of cover include:

1. *Deep pools* – slow moving water that is twice as deep as the average channel depth in riffles. Pools usually have some deep, quiet water, but also often contain some shallow parts as well.
2. *Stable, unembedded boulders* – provide both overhead cover from predators and resting areas from the current for both large and small fish. Boulders with moss and/or organic stains are considered stable. Unembedded means that the edges of two boulders (if present) are touching each other. To estimate the total area of stable boulder cover, multiply the average boulder footprint area by the number of boulders. If the stream is composed mainly of organic or sandy materials and boulders are naturally absent (not buried under excessive fine sediment) answer NA to this type of cover.
3. *Stable root wads, woody debris (large or small) and other organic material* – provides protection from the current and/or predators. More complex arrangements provide better protection from flows and better cover from predators. A single smooth log in a riffle provides minimal cover, whereas a large permeable logjam on top of a pool provides very good cover. If needed, multiply the estimated length of individual pieces or clumps of woody debris by the estimated width to estimate total area coverage. "Other" organic debris cover is made up mostly of uncompacted leaf and /or wood particles that small fish can hide in.
4. *Stable (usually vegetated) undercut banks* – provide excellent protection from predators and the current. The lower the bank and the deeper the undercut extends horizontally under the bank, the better the cover. Measure the length and depth of the undercut to estimate total area.
5. *Submerged or emergent aquatic vegetation* – aquatic vegetation refers to flowering plant species and long filamentous species of aquatic moss. Measure the approximate length and width of the coverage to estimate total area.
6. *Overhanging vegetation* – terrestrial vegetation that arches over the channel is considered cover if it is within 1 m of the water surface when the channel is full. Measure the length and extent of the arching vegetation over the channel surface to estimate total coverage.
7. *Stable unembedded gravels and cobbles with void spaces for fish to hide in* – stable, unembedded gravels and cobbles with obvious nooks and crannies underneath the particles represent good cover for small young fish. Unembedded means the sides of the gravels and cobbles can be seen touching each other. If the stream is composed mainly of organic or sandy material and gravels and cobbles are naturally absent (not buried under excessive fine sediment) answer NA to this type of cover.

A diversity of fish cover types is typical of undisturbed aquatic systems with well-developed riparian habitats. Actual amounts of fish cover can vary substantially, but it is rare for stable streams and riparian habitats in properly functioning condition to not have a variety of different types of cover present. The number of different cover types available can be reduced when riparian vegetation is removed, banks begin eroding, and sediment supplies are suddenly increased or reduced.

Be aware of the different types of cover present as you walk up or down the stream, or along the banks. Make a mental note of whether or not there is enough of each cover type to qualify as being present. Some types of cover tend to be very common. Overhanging vegetation, for example, is often present along the entire stream. Other types of fish cover, such as aquatic vegetation, tend to be uncommon and confined to low-gradient, slow-flowing reaches.

Question 7. Does the amount of moss present on the substrates indicate a stable and productive system?

A healthy growth of moss on the cobbles and boulders of stream riffles indicates clean water, stable flows, a stable streambed, and adequate shade and nutrient levels. The relative abundance of moss on cobble or boulder-bedded streambeds is correlated to fish numbers and/ or invertebrate productivity. Poor moss growth in riffle sections usually indicates an unstable substrate, low nutrient levels, or both. Mark "NA" if the stream reach is all pool habitat, or the streambed is composed of organics or sand/silt, with no gravels, cobbles, boulders or bedrock. "Mainly" means 90% of the reach length has an organic or sand/silt substrate, and at least 5 of the 6 point sample stations lack substrate larger than sand. Do not answer NA if the naturally rocky channel bed has been buried in fine sediments. Examine the cut profile of the channel banks at low flows to verify the potential composition of the channel and/or compare with another channel in the same area to confirm whether fine sediments are natural or excessive.

TIP: Moss is almost always restricted to shallow riffles and the margins of pools that are dry during low flow periods. Moss will not grow where it is completely covered with water for too long. It is therefore naturally absent in deep pools of all streams and the deep central sections of riffles/cascades in large streams.

TIP: Shallow, low flowing streams directly exposed to sun all the time will frequently have patches of bright green, filamentous material waving in the water. It is limp and threadlike when pulled out of the water, with a slightly slippery feel. This is green algae, not stream moss, which closely resembles the common terrestrial species of sphagnum moss.

TIP: When measuring moss % at each transect, make a tally of the number of patches, then indicate how many were embedded, buried, or scoured. If > 50% were not intact, then answer NO to Q7b.

Question 7 has three indicator sub-questions. The first is a measure of abundance:

a. Are moss patches on stable mineral substrates easily observed from almost any point along the margins, riffles or shallow pools of the stream? Where visibility is poor, is average coverage on mineral substrates 1% or more of the channel bed?

Answer Yes if you feel the abundance of the moss in the reach is described by the sub-question. Also answer Yes if you feel that the number of moss patches can best be described as present, common, frequent, or abundant, not lacking, little, or occasional. For more guidance on moss abundance, consider 1% coverage the cut-off for a Yes answer if you wish to use foliage cover standards (see Figure 8).

The second and third indicator sub-questions for Question 7 are related to the condition of the moss. If no moss is present, the sub-questions are marked NA. Unless the moss is intact and vigorous, the answers to indicator sub-questions b) and c) will be No. The moss will be dead, desiccated, scoured, or buried.

TIP: Healthy moss has a thick spongy appearance, with bright green tips on top of dark green or black stems when new growth is present.

TIP: Thin brown patches on the largest rocks mark patches of moss that have had their green stems washed away, leaving only a smooth, brown root mass. In severely scoured areas, dark blackish stains on the largest rocks may all be that is left of the moss.

TIP: If you can readily see moss on the streambed upstream of a recent slide deposit or road failure, but none in the area of the deposit, it is probably safe to assume the moss has been buried.

TIP: Rolling stones gather no moss.

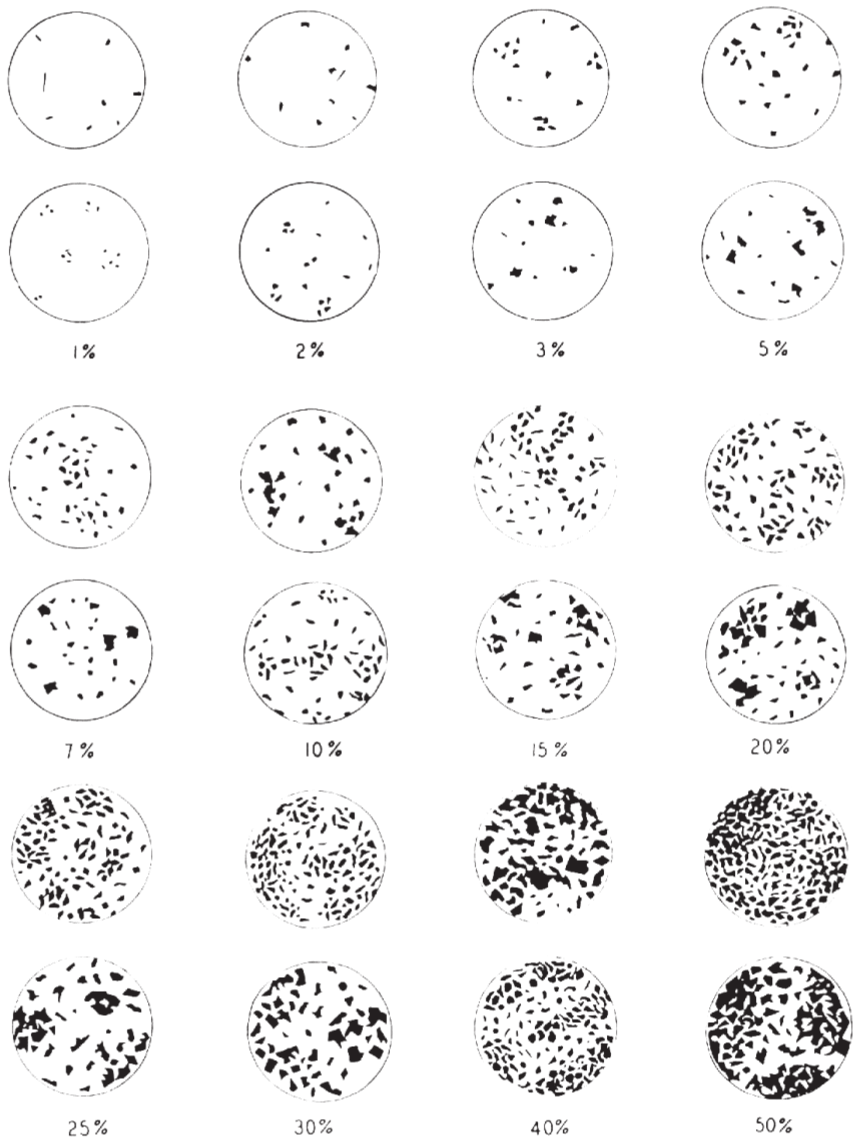


Figure 8. *Comparison charts for visual estimation of foliage cover (from Luttmerding et al. 1990)*

Question 8. Has the introduction of fine inorganic sediments been minimized?

An increase in sediment supply can lead to harmful channel aggradations. If the sediment supply is fine textured, it can also lead to harmful impacts on inter-substrate fish and invertebrate habitats by filling in the nooks and crannies in the substrate or blanketing the surface. Note that this question only applies to streams with a mineral substrate. Mark the question "NA" if the stream has a "mainly" organic substrate or is naturally composed of sand or smaller-sized grains. "Mainly" means 90% of the reach length has an organic or sand/silt substrate, and at least 5 of the 6 point sample stations lack substrate larger than sand. Do not answer NA if the naturally rocky channel bed has been buried in fine sediments. Examine the cut profile of the channel banks at low flows to verify the potential composition of the channel and/or compare with another non-treatment channel in the same area to confirm whether fine sediments are natural or excessive. Soft "dunes" within the channel, recent wedges behind woody debris that may be causing erosion or dewatering, and/or sediment trails leading from sources such as roads or landings all indicate that fine sediment inputs are above what is natural for the stream.

Fine sediments may be easily observed on the surface of the streambed, particularly when recently deposited. Over time, fine sediments may be incorporated into the streambed where they are not as visible. In some cases, the streambed may be so completely filled in with fine or sand-size sediments as to be completely impermeable, yet the streambed may still look fine on the surface.

Because of their complex nature, four very different indicator sub-questions are used to assess the impacts of fine and sand-size sediments on streambeds. Many other potential assessment methods exist (e.g., measurements of subsurface dissolved oxygen concentrations, flow rates, percent composition), but these are typically time consuming and expensive to conduct.

The four indicator sub-questions for Question 8, with explanatory notes, are as follows. If the answer to any indicator sub-question is No, the answer to Question 8 is also No.

a. Are inorganic ("gritty" feeling) fine and sand-sized sediments in riffles or critical spawning areas best described as little or lacking? Little or lacking is when average coverage in riffles or critical spawning areas is less than 10%, and no one area of this habitat equal to 1% or more of the total channel area is completely covered ("blanketed") with fines or sands.

TIP: Organic materials are not considered to be sediments. Unlike organic sediments, inorganic sediments usually have a "gritty" feel to them that can be used to distinguish the two types of sediment. Sand-sized particles are particles up to 2 mm in diameter.

TIP: Do not add up discreet measures when assessing large pockets of quicksand/gravel. In order to determine if no one area is completely covered or easily pushed into consider each pocket individually when comparing to the 1% threshold.

b. Are individual wetted areas of gravel or sand that a foot can be easily pushed or wiggled into all smaller than an area equal to 1% of the total channel area? Mark NA if the stream is dry.

TIP: Wetted areas that a foot can be pushed or wiggled into feel like "quicksand" or "quickgravel." As a guideline, a single continuous area equal to one channel width in length and width is enough to say that "quick sand" or "quick gravel" is present. As an example, in a stream that is 5 m wide, a single contiguous deposit of quick sand or quick gravel 13 m long by 2 m wide (= 26 m^2) is a large enough deposit to record as present. Deposits that are smaller than an area equal to one channel width in length and width (25 m^2 in this case) should not be recorded.

c. Are gravels and cobbles unembedded in a matrix of sand or finer sized particles? Unembedded means that most of the gravel and cobbles are touching each other and easy to move.

TIP: Gravels and cobbles that are embedded in fines and sand look as if they are cemented into place. Fines and sands occupy the space between the gravel or cobble particles. If the gravels, cobbles and boulders present at your sample sites are easy to move around when you are collecting benthic invertebrates, then the substrate is not embedded. Embedded gravels, cobbles and boulders are difficult to move.

d. Is there an average of one or more sensitive invertebrate types at invertebrate sample sites? Mark "NA" if high water conditions prevent effective sampling or the sample sites are dry due to natural conditions.

TIP: Because they have external gills, caddisflies (i.e., "case-makers"), mayflies, and stoneflies are the insects most commonly considered to be sensitive to the effects of fine and sand-size sediments. Others include "mussels", some gill-breathing snails, "hellgrammites", "net-winged" midges, and "mountain" midges. Aquatic invertebrates are so common in almost all aquatic environments that their complete absence is rare and is often a problem with sampling time, location or methods.

Question 9. Does the stream support a diversity of aquatic invertebrates?

Healthy gravel-, cobble-, or boulder-bedded streams that flow most or all of the year will almost always have many different kinds of invertebrates at all times of the year. Easily affected by a wide range of substances, such as sand, silt, toxic compounds, inorganic or organic pollutants, the diversity of the benthic invertebrate community can be a direct assessment of properly functioning condition.

TIP: Question 9 is considered NA if the stream is dry, or strongly suspected of being dry most of the year. If a stream only flows during winter, the number of invertebrates may be very low because the stream has to be colonized by invertebrates every year. Even streams that flow year-round can seem barren if the area being sampled has only recently been covered with water. Winter colonization rates on previously dry portions of a stream can be very slow.

Most of the aquatic invertebrates in streams are called "benthic invertebrates." The word "benthic" means bottom. Benthic invertebrates therefore live on the stream bottom, mostly under the rocks, but also on the top and sides of rocks if the rocks are stable or protected from flows. They also occur on aquatic plants or wood, if present. Generally, the more angular and stable the rocks, the higher the number of benthic invertebrates living on them. Substrates composed mostly of fines or organic detritus also have benthic invertebrates, but they are usually not as abundant or diverse as on stable gravel and cobble substrates.

Sample Methods

There are many different ways invertebrates can be sampled in streams. For the riparian checklist, simple hand collections with a small portable net and small white tray are recommended. Select a riffle with a substrate that can be stirred up by hand as close as possible to each sample station, not too large (e.g., large boulders), but not too small either (e.g., all mud). While holding the net on the streambed, stir up the substrate upstream of the net so those invertebrates clinging to the substrate are washed down by the current into the net. Sample an area as wide as the dip net and two to three times the area of the dip net opening. Try to minimize the amount of mud, sand, or organic debris collected. Empty the net and its contents into the white tray with a little water.

With clear water and not too much debris in the tray, any invertebrates present in the sample should be quite visible. If there is too much debris, put some of the debris back in the net and examine smaller amounts until the entire sample is examined. If the water is cloudy, gently tip the excess water out and replace it with clean water. Because invertebrates are heavier than water, they will sink to the bottom of the tray as you tip excess water out of the tray. The invertebrates are usually still as soon as they are transferred to the tray, but after a minute or two they will start to move around.

A hand lens can help identify or confirm the presence of invertebrates. Most invertebrates, however, are identifiable as to their main type with the naked eye. As a person gains experience, rocks can be picked up and examined directly to identify the type of invertebrates present. Remember, it is only the number of different types of invertebrates present that is important, not the number of each type of invertebrate.

Ponded or Organic-Bedded Streams

Some streams may be almost all pool habitat with deep, quiet water and substrates composed of fine organic detritus. For these streams, we recommend gently dragging the dip net along the bottom or sides of the stream for 20–30 cm to collect a sample of the substrate that is 1 to 2 cm thick.

Number of Sites to Sample

We recommend six sites be sampled to determine overall average invertebrate diversity for the stream reach. In some very uniform reaches, however, it may be possible to determine that the reach has a variety of invertebrates by just looking at one site. If this is not the case, investigate the site more thoroughly. If it still looks like there are only one or two types of invertebrates present, at least two other locations should be sampled before drawing conclusions on invertebrate diversity.

Identifying Invertebrates

Look at the illustrations in Figure 9 for some of the most common benthic invertebrates found in streams. Most invertebrates will be insects, but other major groups include worms (nematodes, flat worms, true worms) or snails or clams. Crustaceans (freshwater shrimp, water fleas) may also be found if lakes or wetlands are flowing into the stream. The most common benthic invertebrates found in streams typically include mayflies, caddisflies, stoneflies, chironomids (midges), other Diptera (true flies) larvae, and oligochaetes (small worms).

Sensitive Invertebrate Types

Insects with external gills and freshwater clams are sensitive invertebrate types. Insects with external gills include mainly mayflies, stoneflies, and caddisflies. The two or three tails present can readily identify mayflies and stoneflies. Caddisflies can also be easily identified because almost all build distinctive cases to live in made of sand, small pebbles, wood, twigs, or needles. Free-living caddisflies or caddisflies that have lost their cases can be identified by the presence of two prolegs at the end of their abdomens. Each proleg will have a single hook. Other sensitive invertebrates include mountain midges, net-winged midges, riffle beetle larvae, Dobson flies (“helgrammites”), mussels, and snails that have their opening on the right when held toward you with the open end on the bottom.

Scoring

Answer Yes to Question 9 if two or more of the indicator sub-questions are answered Yes.

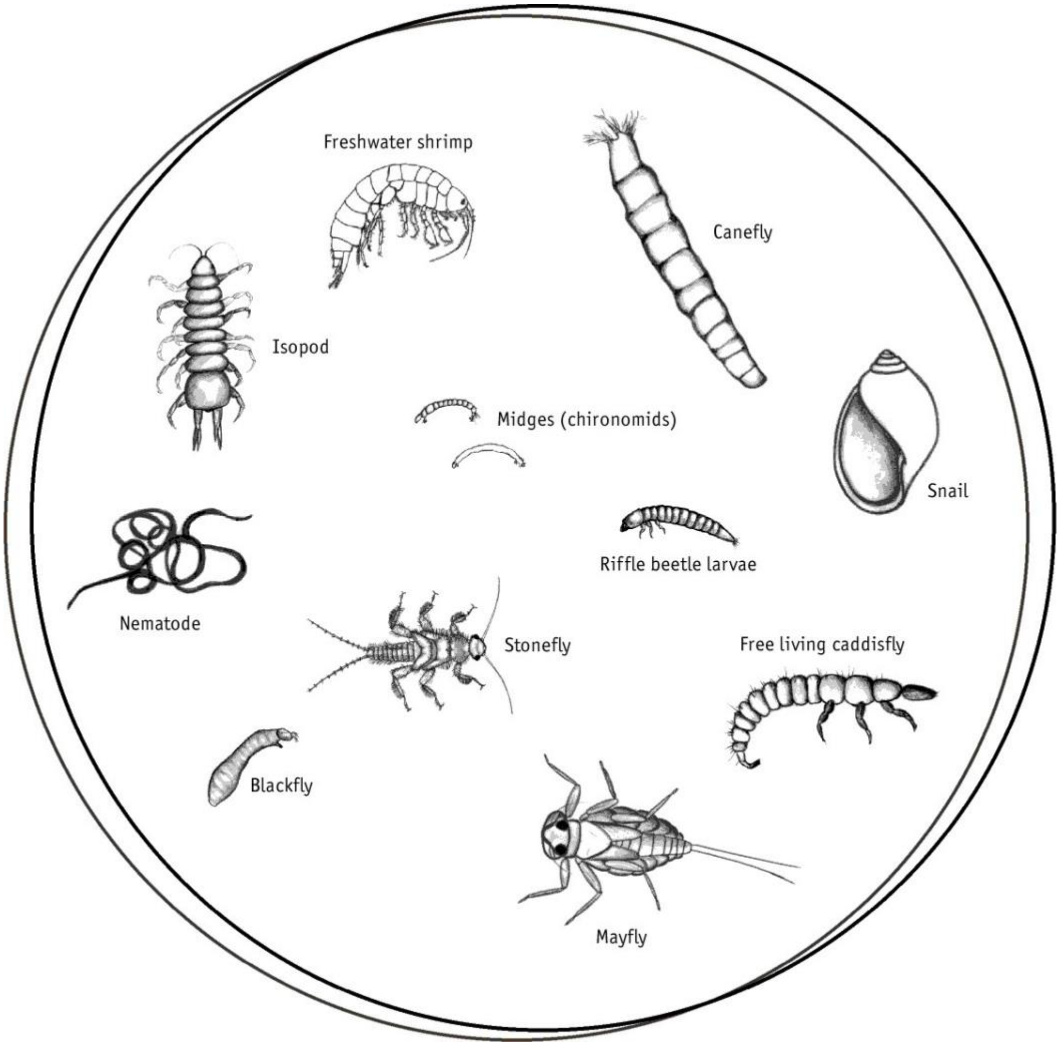


Figure 9. *Examples of common benthic invertebrates*

To help with identifying invertebrates and their sensitivity, refer to the Field Guide to Freshwater Invertebrates in Appendix 2. Other sources include Appendix 1 (Field Identification and Pollution Tolerance Chart) and Appendix 2 (Key to Invertebrate Groups) from the DFO/BC Streamkeepers' Training Module 4 (http://www.pskf.ca/mod04/index.html). The field guide, "Macroinvertebrates of the Pacific Northwest", and the companion CD, "Stream Bugs as Biomonitors: Guide to Pacific Northwest Macroinvertebrate Monitoring" by Jeff Adams and Mace Vaughan of the Xerces Society is another excellent introduction to benthic invertebrates.

Question 10. Has the vegetation retained in the RMA been sufficiently protected from windthrow?

One of the main objectives of an RMZ is to protect riparian reserves from excessive windthrow. The amount of windthrow present in riparian reserves is, therefore, a direct indicator of how successful or effective the management zone is in protecting the reserve.

On streams that lack riparian reserves, management zones are used mainly for retaining key wildlife habitat attributes characteristic of natural riparian systems, providing some shade to reduce bank microclimate changes, and maintaining bank and stream stability. In this regard, windthrow is a direct indicator of management success or failure. If retained trees blow down, then it is likely that key wildlife attributes will also be disrupted. If windthrow is extensive, there is a good chance that the integrity of the stream and stream bank environment is also compromised.

Question 10 has three indicator sub-questions, only one or two of which will be applicable to any given stream. The number of applicable sub-questions depends on if a reserve is present, if only a management zone is present, or if designated wildlife trees or wildlife tree patches are present beside the stream.

Sample Methods

Percent windthrow over and above what was naturally present in the riparian area prior to the treatment must be estimated in order to answer the indicator sub-questions. A simple visual estimate of percent windthrow is appropriate if the percent of trees recently windthrown is clearly less than 1%. A visual estimate is also appropriate if the amount of windthrow is clearly greater than 10% of the trees in reserve zones, or 20% of the trees in management zones. Whatever estimate is used to answer the questions should be noted on the field data card.

More quantitative measures of windthrow are needed if the threshold values in the indicator sub-questions have not obviously been met or exceeded. Any method is suitable, provided it is reasonably accurate and readily reproducible. A direct count of all standing and windthrown trees is the simplest and most straightforward method. All trees in the reach can be enumerated this way. Alternatively, representative sections of the reach could be subsampled and averaged to estimate total numbers of standing and/or windthrown trees.

A simple, reproducible and very defensible method of estimating standing and/or windthrown trees is to lay out three 10x10 m square plots on each side of the stream and count the stems in each plot. When counting windthrown trees, be sure to only count those trees that originated in the 10x10 m plot. Extrapolate the average of the square plots to the riparian area being assessed.

In some cases, a total count may be the best method of estimating windthrow where the number of stems involved is small or patchy. In other cases, where the distribution of standing and windthrown trees is very uniform, a plot approach may be best. In most cases, a combination of methods will work best, plots for estimates of the total number of trees, and total counts for the number of windthrows.

Types of Trees to Count

Windthrow is any dominant or co-dominant tree that has been snapped off or tipped over by a strong wind. Only trees that were live at the time of windthrow are counted. Sub-dominant trees are not included in the counts unless they were the only trees retained. To be called windthrow, a wind-snapped tree must be linked to the stem it snapped off. Tipped over trees must have a definite root wad or root plate attached to it. Trees that have no obvious root plate or a root plate that only has the "stubs" of the main roots present should not be counted as windthrow, old or new. Snags that snap off should also not be counted as windthrow.

The terms “new,” “recent,” “post-harvest,” and “post-treatment” windthrow all mean the same thing. Harvest refers to logging, while treatment is a more inclusive word meant to cover any and all management activity, including harvesting. Other treatments being assessed could include cattle grazing, urban development, or hydro development.

“New,” “recent,” “post-harvest,” and “post-treatment” windthrow is windthrow that occurred after the treatment being assessed was initiated. Old windthrow is any windthrow recognizable as such that occurred before the treatment. Sometimes the “new” windthrow can look quite old if a cutblock was last harvested many years ago. In these cases, one often must be a bit of a detective to separate out trees that had blown over before the harvesting started. Aging conks growing on the different trees is one method that can be used to decide if a windthrow was old or new. Age the conks by counting the annual “growth rings” on their back but determine whether the conks in your area have two growing seasons per year (two rings) or just one. Classification of the integrity of the branches, stems and roots is another method of deciding what is “new” windthrow and what is not and whether recently-downed trees were alive at the time they were windthrown.

Width of Riparian Area to be Assessed

If a reserve is present in an RMA, the entire reserve should be assessed for windthrow, but not the management zone. Only check for windthrow in the management zone if there was no reserve zone.

1. $$\%\ \text{Old Windthrow} = \frac{(\#\ \text{Old Windthrow Trees})}{(\#\ \text{Standing Trees} + \#\ \text{Old Windthrown} + \#\ \text{New Windthrown})} \times 100$$

2. $$\%\ \text{New Windthrow} = \frac{(\#\ \text{New Windthrow})}{(\#\ \text{Standing Trees} + \#\ \text{New Windthrown})} \times 100$$

To calculate percent new windthrow over and above the natural pre-treatment windthrow, subtract calculation 1 from calculation 2.

Question 11. Has the amount of bare erodible ground or soil compaction in the riparian area been minimized?

Bare erodible ground is any soil or fill with particles smaller than 4 mm (small “pea” gravel or coarse sand) that is not covered by plants, litter, lichens, moss, downed wood, coarser gravel or rocks. Bare erodible ground is exposed soil or erodible mineral deposits that water can wash into the adjacent stream. Examples include road surfaces, cut-and-fill slopes, bladed trails, gouges and scalps due to yarding, tipped over root wads and windthrow scars, slides, and slumps. It also includes animal trails or recreation trails if mineral soil is exposed. Exposed soil subject to erosion contributes to stream channel infilling and bank erosion, reduces sediment entrapment, alters rainfall run-off rates, and provides an opportunity for invasion by weeds.

Bare erodible ground includes discrete patches of ground such as root wad scars left when a tree blows over. For this type of bare erodible ground, estimate and record the area of the ground exposed at each site, and tally up the total at the end of the survey. For root wads, there may be two surfaces to consider, the root wad itself if it has soil attached to it and is susceptible to erosion, and the root wad scar, which may still contain soil that can erode.

Bare erodible ground also includes the ground exposed in thinly vegetated areas, possibly due to over grazing. For this type of bare ground, use the percentage cover cards to estimate total bare ground area (see Figure 8). If the surface of the bare erodible ground is partially covered with non-erodible material such as plants, litter, lichens, moss, downed wood, or coarse gravel, the area has to be "netted down" to arrive at a more accurate estimate of the area of bare erodible ground. In complex areas, stratify the area and estimate bare ground in each stratum.

Note: Sediment deposited on the ground in the first 10 m of the riparian area from upslope sources is considered bare erodible ground for Question 11, but not if the sediment is deposited due to flooding (i.e., overbank deposits).

Bare Erodible Ground in the Riparian Area vs Bare Erodible Ground Hydrologically Connected

All bare erodible ground is considered bare erodible ground within the first 10 m of the riparian area past the edge of the stream, even if it is not obviously hydrologically connected to the stream. For hydrologically connected bare ground, there is no limit on how far away the bare ground is from the first 10 m of the riparian area, as long as it is hydrologically connected to the stream or riparian area. To be considered hydrologically connected, bare ground should be:

a. drained by a channel capable of moving fine sediments to the stream or riparian area;

b. drained by a channel capable of moving fine sediments to a steep slope that is within 30m of the riparian area, but only if the toe of the slope touches the riparian area; or

c. located within 30m of the riparian area, on a steep slope where the toe of the slope touches the riparian area.

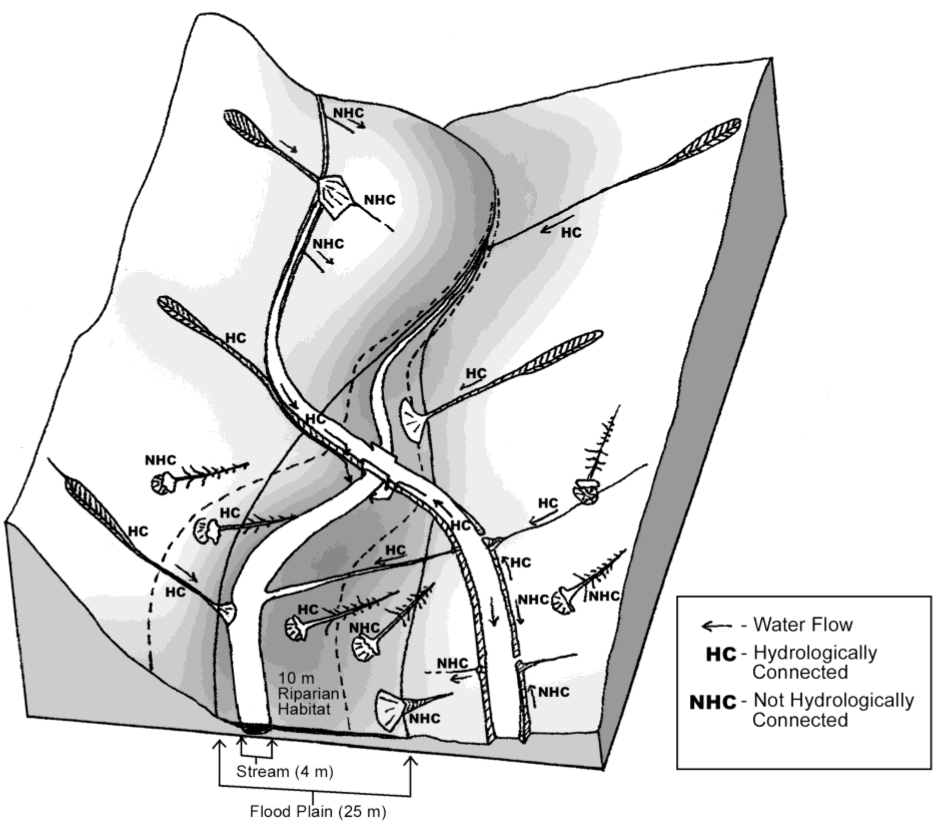


Figure 10. *A hydrological connection diagram showing where erodible soils (from windthrow, road surface, ditch, or slope failures) are hydrologically connected to a non-gully type stream reach*

The hydrological connection of some exposed soils will be obvious. For example, a slide or slump that starts 50 m above the riparian area and extends to the stream is obviously connected. Other sources will not be so obvious. Cross-ditches or culverts on roads will frequently form short channels on the slopes below the road, but dissipate further down the slope. To be hydrologically connected, the sediments should reach the stream channel as in the case of an upstream road crossing, or the first 10 m of the riparian area, or the first 30 m of a steep slope that impinges on the first 10 m of the riparian area. Bare erodible ground with no channels or evidence of water flow capable of transporting sediments to the stream or the first 10 m of the riparian area is not hydrologically connected. If road sediments are observed within the sample reach and there is clear connectivity to the channel from an upstream crossing, consider the road surface and any associated ditchines and cut/fill slopes as hydrologically connected.

Hydrological linkage should be estimated based on the ability of the water involved to carry sediments into the stream. It is not just a measure of whether water by itself will enter the stream. Evidence of hydrological linkage should be conspicuous, such as ruts, rills or eroding tracks down the road, to a spot at the crossing where water spills directly off the edge of the road into the stream or a ditch that is clearly connected to the stream. If the number or size of sumps and/or ditch blocks present is enough to capture all of the sediment that washes into the ditch, then a ditch may not be "hydrologically connected" to a stream in terms of sediment transfer.

Estimating the area of bare erodible ground hydrologically connected to a stream or its riparian area can be challenging. Not all surfaces have the same amount of material susceptible to erosion. Some surfaces may be all erodible soil, others may be a mixture of rock, vegetation, other debris, and erodible material that has to be discounted to accurately estimate the amount of erodible ground present. Not all surfaces will be equally connected to the stream. Some may show direct movement of sediments from the source to the stream via a conspicuously eroded channel. However, others may have only a small chance of making it to the stream due to vegetative cover, ground infiltration or ruts and berms on a road that carries water safely across a stream and further down the road. Use the information collected during the Water Quality Effectiveness Evaluation at any upstream crossings to help determine the potential amount of hydrologically connected bare ground associated with roads.

Estimating Bare Erodible Ground Hydrologically Connected to a Stream

For a complex area like a road crossing, start by breaking the different areas or surfaces present into sections that are generally similar to each with respect to bare erodible ground exposed and the degree of connectivity to the stream. Photographs 1 and 2 show upstream and downstream views of a culvert crossing on a small S6 stream. The red lines in each photograph delineate the areas that were similar with respect to the amount of bare erodible ground exposed and the degree of hydrological connectivity to the stream. Because the road continued downhill below the crossing, only the 75 m of road and ditch upslope of the stream crossing was a concern. Further uphill, a second road intercepts and directs all water away from the present road and the ditches that direct water toward the crossing.

Five distinct areas or sections can be identified at the road crossing with different amounts of soil exposure and connectivity to the stream. Section 1 with the crushed rock represents the entire running surface of the road. Sections 2 and 3 represent two sections of a ditch line on the left side of the road looking downslope (Photograph 1) while Sections 4 and 5 represent two sections of a ditch on the on the left side of the road looking upslope (Photograph 2). Specific areas, bare erodible ground exposure and the degree of connectivity for each section are as follows.

Section 1. The entire road surface is composed of free draining crushed rock with very few fines on the surface (Photograph 3). Approximately 4.5 m wide, the road extends 75 m uphill from the stream crossing to another road that represents the height of land upslope from the stream crossing. On a scale of zero to one, hydrological connectivity to the stream is zero (0) because of the high infiltration rate on the road surface, and the continuous slope that would transport surface water downhill past the stream crossing. There was no conspicuous evidence anywhere where water had run off the road into the ditch or stream.

Section 2. The upper ditch on the left side is 73 m long by 6 m wide, and approximately 70% of the surface is bare erodible ground. Hydrological connectivity is considered zero (0) due to the small drainage area, a thick layer of fines that eroded off the surface in two "sumps" along the ditch, and a low ditch block within 2 m of the stream.

Section 3. This is a small area 2 m long by 1.5 m wide between a ditch block and a hay bale beside the stream. Approximately 70% of the surface is composed of erodible ground. However, the area was only partly connected to the stream due to a hay bale across the ditch and a thick deposit of drain rock at the end of the ditch on the other side of the hay bale. Connectivity was hard to judge. Therefore, on a scale of zero to one, hydrological connectivity was considered 0.5; i.e., just as likely to be connected as not.

Section 4. The stream that used to flow directly across the road now flows down the lower 10 m of the ditch on the right side of Photograph 1. Approximately 2.5 m wide, this section of the ditch is obviously all directly connected to the stream. Bare erodible soil along the ditch line averages 70% of the total area.

Section 5. This section of the ditch line is 65 m long by 6 m wide. It slopes directly into Area 4 with the stream, with numerous small rills and water channels present running directly down to Section 4. With no blockages present, it is considered directly connected to the stream via Section 4. Like most of the ditch surfaces along this section of the road, bare erodible ground is 70% of the total surface area (Photograph 4).

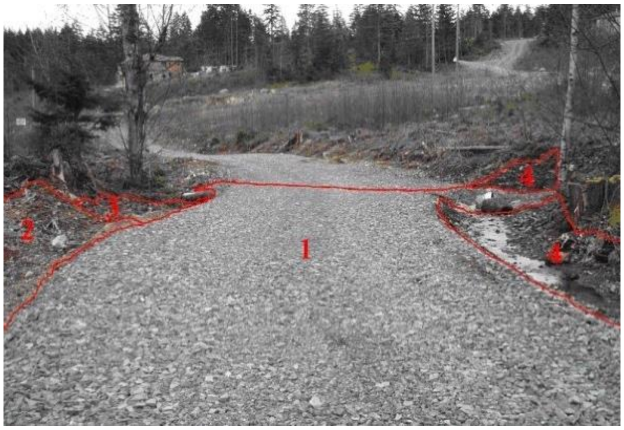


Photo 1. Downstream view of a culvert crossing on an S6 stream. The stream flows down the right side ditch, then across the road from right to left. The red lines and numbers delineate areas that are similar with respect to the amount of bare erodible ground exposed and the degree of hydrological connectivity to the stream.

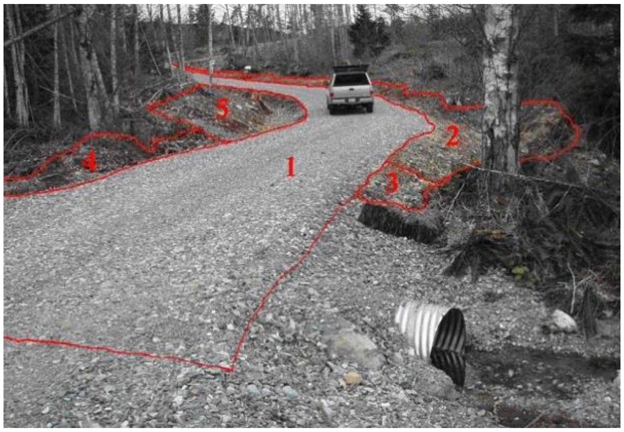


Photo 2. Upstream view of a culvert crossing on an S6 stream. Like Photograph 1, the red lines and numbers delineate areas that are similar with respect to the amount of bare erodible ground exposed and the degree of hydrological connectivity to the stream.

Photo 3. The road surface on the slope draining toward the stream crossing (Section 1) was all free draining crushed rock. Overall average bare erodible ground exposure was at most 1%.

Photo 4. Bare erodible ground made up 70% of the surface of the ditches in Sections 4 and 5. These sections were also fully connected to the stream.

Table 5 is an example of how the information on area, % bare erodible ground and the degree of hydrological connectivity can be compiled for each section in our example to determine total amount of bare erodible ground present that is hydrologically connected to the stream. For each section, bare erodible ground hydrologically connected to the stream in the last column is the product of the section area (L x W), % bare erodible ground, and the degree of hydrological connectivity.

***Table 5.** Estimating total bare erodible ground hydrologically connected to the stream*

Road section	L X W (m)	Bare erodible ground (%)	Hydrological connectivity (0 – 1)	Bare erodible ground hydrologically connected to stream (m^2)
1 (main surface)	75 X 4.5	1	0 (none)	0.0
2 (upper right ditch)	73 X 6.0	70	0 (none)	0.0
3 (lower right ditch)	2 X 1.5	70	0.5 (partial)	1.0
4 (lower left ditch)	10 X 2.5	70	1 (all)	17.5
5 (upper left ditch)	65 X 6.0	70	1 (all)	273
Total bare erodible ground hydrologically connected to stream = Sum of road sections 1 + 2 + 3 + 4 + 5 = 0 + 0 + 1.0 + 17.5 + 273.0 = 291.5				291.5 m^2

After estimating the total area of bare erodible ground hydrologically connected to the stream, divide this area by the total riparian area and multiply by 100 to determine what percentage of the riparian area the total bare erodible ground represents. This is the value to use to answer Indicator sub-question b) in Question 11.

For our example:

(A) Total Bare Erodible Bare Ground Hydrologically Connected to Riparian Area (m^2) = 291.5 m^2

(B) Total Riparian Area (m^2) = 100 x 20 (both sides) = 2,000 m^2

(C) Total Bare Erodible Ground Hydrologically Connected to Riparian Area (% of Riparian Area) = A/B x 100 = 291.5/2000 x 100 = 14.6

Disturbed/Compacted Ground

Disturbed ground is ground that is compacted and sheds water quickly. It may not be otherwise susceptible to erosion because it could be largely covered with vegetation, wood, mulch, duff, gravel, or rock. Disturbed ground also includes the pugging and hummocking found where cattle are walking through heavy, saturated soils. When cows or other hoofed animals step into the soft vegetated ground in riparian areas, their track shears off the vegetation around the edge of the track, leaving what looks like bare ground that has been compacted in the track. In between the tracks, the ground bulges up in response to the ground being compacted by the tracks. The hummocks tend to dry out, substantially changing the characteristics of the riparian soils.

An active, seasonally deactivated or temporarily deactivated road is compacted and can be considered "disturbed" ground. However, the concern over bare erodible ground is greater than the concern over disturbed ground. So, check for bare erodible ground first before including these types of roads with disturbed ground.

Hummocking due to animal activity (usually cattle) is disturbed/compacted ground. The "pugging" associated with "hummocking" could be considered bare or disturbed, but if it is called bare ground, then it should only include the exposed soil that is susceptible to erosion. In practice, it is easier to just measure the whole area that is disturbed by all the tracks and call it disturbed/compacted ground. If the riparian area of interest is so badly trampled that there is no vegetation or duff left, and there is only soil left that will erode or is eroding into the stream, it would be properly called bare ground. To estimate area affected by pugging and hummocking, use the widest dimensions of the area affected. If pugging is considered bare ground, the total area must be netted down so that only bare ground is measured.

Other disturbed ground includes animal trails that are still covered with vegetative material, backspar trails, ruts, and paved surfaces. Because they are compacted by nature, the running surfaces of unpaved roads and landings could be called disturbed ground. Even if they are not erodible, they shed water quickly because of the absence of vegetative cover. They are also difficult to revegetate because of their compacted nature. If a road is "de-compacted" using texturizing methods and is showing signs of revegetation, it should no longer be called disturbed ground, but rather bare ground until it is revegetated or otherwise protected (e.g., mulched) from erosion.

Question 12. Has sufficient vegetation been retained to maintain an adequate root network or LWD supply?

An adequate root network is needed to maintain bank strength in all streams. Together with LWD, roots also help to maintain the channel form of many small streams < 2 m wide. A good root system will be comprised of a diversity of shrubs, understory and overstory trees. A list of common vegetation species and their associated rooting depth can be found in Appendix 3. Overstory trees alone are not a good source of bank stability so riparian areas that have been through a harvest rotation and are not yet old enough to contribute to canopy gaps (ie. < 120 yrs) may have limited shrub and understory growth. In these cases, there is not a sufficient root network to maintain bank stability during flooding, and if shrubs and understory are scarce throughout the reach, this sub-indicator should be answered No.

Roots become less important in maintaining channel form in streams larger than 2 m wide; however, many streams 25–40 m wide continue to be dependent on LWD for much of their form, depending on slope gradient. To determine whether a stream is dependent on LWD, refer to Figure 11.

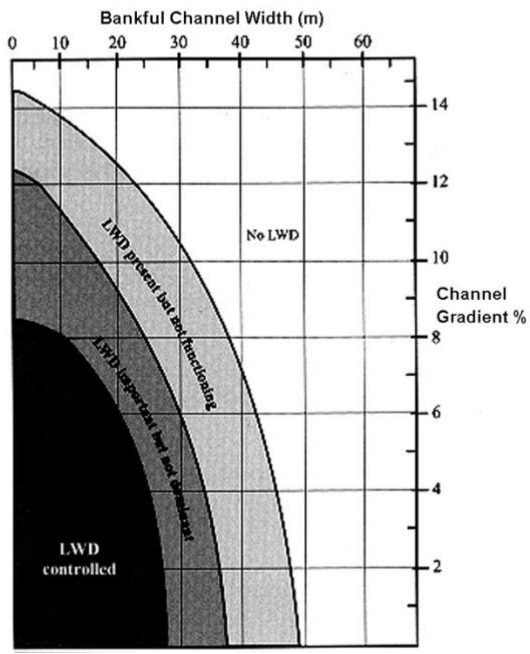


***Figure 11**. Determining the influence of LWD on channel morphology*

Wood can fall directly into a stream from the adjacent bank, it can float downstream from upstream areas, or it can enter a stream from upslope areas via slides. In streams where there is no upstream or upslope supply of wood, 80% or more comes from the first 10 m of the riparian area.

The seven indicator sub-questions listed for Question 12 are based on the stream classification and retention levels recommended as best management practices in the *Riparian Area Management Guidebook* (Province of B.C. 1995). Determining retention levels is fairly straightforward and can be estimated visually very quickly. It is not the intention of a riparian evaluation to confirm that an intact reserve that is 20 or 30 m, has been retained, only that the supply of LWD is adequate within the first 10 m.

To answer Question 12, first answer Yes or No to the first indicator sub-question that is applicable to all streams then the one additional sub-question that matches the classification of the stream reach being assessed. Mark Yes for the question if both indicator questions are also Yes. Mark No to Question 12 if one or both of the indicator questions are No.

TIP: The stream's riparian classification should be indicated in the site plan, silviculture prescription or logging plan maps. Record the riparian class as indicated in these documents. If no stream classification is indicated, try to assign the class on the basis of gradient (< 20%) and channel width (see the *Riparian Management Area Guidebook* or the FRPA Forest Planning and Practices Regulation). If not already classified, default any streams less than 20% gradient to a fish-bearing classification (S1-S4) based on channel width. Non-fish-bearing status will not be possible to determine during this assessment. Riparian classification for difficult sites may need to be addressed after the survey is completed.

TIP: Windthrown trees are included in the retention levels. If all of the trees in an otherwise intact 10-m reserve zone have blown over, the retention level is still 100%.

Question 13. Has sufficient vegetation been retained to provide shade and reduce bank microclimate change?

Shade in riparian habitats is particularly critical on sunny days for moderating air temperatures and maintaining soil moisture levels. Shade cover varies with plant species, height, and density. It is also sensitive to the time of year, aspect, and latitude because it involves a lateral measurement of light penetration by direct rays of the sun.

Vegetative cover includes trees, shrubs, and grasses in riparian areas that mitigate rainsplash erosion on exposed soils as well as serving many other functions. For example, trees and shrubs also supply food and habitat for terrestrial and aquatic invertebrates, both of which are critical food sources for many vertebrates including fish. Harvesting or intensive browsing and grazing can significantly reduce the vegetative cover of trees, shrubs, and grasses along streams.

Question 13 has four indicator sub-questions, three of which must be answered Yes in order to check the Yes box for the overall question.

Q13 a) Is the bare erodible ground directly exposed to rain is less than 1% of the riparian area?

Bare erodible ground exposed to rain is any bare erodible ground not encompassed by the outside edge of the overhead canopy and understory shrubs. This edge is sometimes called the "drip line." It differs from foliar cover, which is a measure of foliage density. If bare erodible ground outside the drip line has some other cover components such as grass, wood, or stones and rocks, net down the bare erodible ground exposed to rain by the estimated amount of cover.

TIP: Canopy and ground cover together shield bare erodible ground from direct rainfall. If there is no bare erodible ground, bare erodible ground exposed to rain is automatically 0%.

Q13 b) Does shade (the average amount of sky not visible due to vegetation) average more than 60%, as estimated visually for any two of the east, south and west aspects at 60° above the horizontal?

Where and How to Measure Shade

Total shade (cover provided by all vegetation types) may be measured at five or six evenly spaced points along the stream reach. Shade is measured at the edge of the stream closest to the area being assessed, while standing in the stream. Where both sides of the riparian area are assessed, and there appears to be a difference in shade cover on the two sides, measure shade on both sides of the stream and average the two measurements. Large streams (> 5 m) will almost always require separate estimates of shade for each side of the stream. Small streams (< 2 m) will likely only need one measurement.

The quickest and probably most repeatable method of estimating shade is to hold your hand up at a 60-degree angle and visually estimate the coverage by vegetation visible in a circle made by your thumb and forefinger. Having a foliage cover class card handy helps to gauge the coverage. Remember that you can use the percentage foliage cover plots to estimate coverage over 50% by reversing the dark and light areas in your mind.

If they are available, another acceptable method for estimating shade is comparisons of visual observations to reference photographs containing examples of percent shade. Taking photographs for later analysis of shade is not recommended. The software for determining shade requires considerable experience. The process is also time-consuming, after which the results must be entered in the checklists. Making visual estimates in the field by eye or with an angular canopy densiometer is much quicker. If using a densiometer, take several counts and average them as there can be a large variability with only a slight difference in position.

Q13 c) Are moisture-loving macrophytes, mosses, ferns, or other bryophytes are present and in vigorous condition, with no indication of stress due to sunburn, drought, or desiccation?

Moisture-loving plants are invariably present in riparian habitats. Besides mosses, delicate ferns and most other bryophytes, moisture-loving plants also include true aquatics such as pond weeds, emergent plants that have their "feet" in water such as cattails and rushes or sedges, and plants dependent on a high water table or seasonal inundations such as skunk cabbage, Devil's Club, salmon berry and willows.

Answer No to this indicator if there are no moisture-loving plants present in the riparian area. Also mark No to this indicator if moisture-loving plants are present but they are scorched, mottled, desiccated, brittle, or otherwise stressed. Do not confuse dead vegetation at the end of the growing season or last year's growth with vegetation dried or killed by drought conditions.

Q13 d) Is the soil in the riparian habitat is moist or cool to the touch?

Soils in riparian areas should be cool and moist. Mark Yes to 13 d) if this is so. Mark No if there are areas along the stream reach that show evidence of having a different soil moisture microclimate due to post-treatment changes to the riparian area. The latter could include direct impacts to soil integrity by cattle, road construction, infilling, riprap, sloughs, slides, windthrow, yarding, or machine crossings to name a few. It could also reflect indirect impacts on shade, air temperature and humidity due to removal of the riparian vegetation by harvesting or grazing.

Question 14. Have the number of disturbance-increaser species, noxious weeds and/or invasive plant species present been limited to a satisfactory level?

Question 14 has two indicator sub-questions.

14 a) Do disturbance-increaser plants (domestic grasses, dandelions, pineapple weed, buttercups, etc.) occupy less than 25% of total area in the first 10 m of the riparian zone?

Disturbance-increaser species are native or introduced plants that are typically absent, or present in low numbers, in undisturbed habitats. Populations of these species can become more prevalent with certain kinds of disturbances such as grazing or active roads and trails. Disturbance-increaser plants are not just invasive or pioneer plants, but plants that tend to thrive under conditions of constant disturbance. Species like red alder or fireweed are invasive or pioneer species, but they rarely establish themselves where there is constant ongoing disturbance.

Disturbance-increaser species are regarded as undesirable because they tend to not provide a deep-binding root mass for bank protection. An increase in the number of disturbance-increaser species indicates a trend away from the natural plant community in riparian areas, and a decline in the proper functioning condition of the riparian habitat. Most of these species provide less soil-holding and sediment-trapping capabilities, as well as less desirable forage and wildlife values. Although the presence of disturbance-increaser species may be natural, they often suppress the growth of other species that may be better at maintaining or re-establishing root networks and bank strength.

A list of disturbance-increaser species is provided in Table 6.

Table 6.*Disturbance-increaser species list*

Common name	Latin name	Common name	Latin name
Strawberry	*Fragaria spp.*	Pineapple weed	*Matricaria matricariodes*
Cinquefoil	*Potentilla spp.*	Dock	*Rumex spp.*
Yarrow	*Achillea millefolium*	Pasturesage	*Artemisia frigida*
Baltic Rush	*Juncus balticus*	Gumweed	*Grindelia squarrosa*
Dandelions	*Taraxacum spp.*	Pussytoes	*Antennaria spp.*
Sow Thistles	*Sonchus spp.*	Buttercups	*Ranunculus spp.*
Foxtail Barley	*Hordeum jubatum*	Bluegrasses	*Poa spp.)*
Goatsbeard	*Tragopogon dubius*	Plantains	*Plantago spp.*
Clovers	*Trifolium spp.*		

12 b) Do noxious weeds and/or other invasive plant species occupy less than 5% of total area in the first 10 m of the riparian area?

Noxious weeds and/or invasive plant species are considered separately from disturbance-increaser species. While they can also be disturbance-increaser species, most noxious weeds are invasive, non-native species that are highly competitive. Noxious weeds can spread rapidly to cover large areas and prevent the development of healthy, native riparian communities.

Lists of noxious weeds and invasive plant species are summarized in Tables 7 to 9.

Table 7. *Common noxious weeds within all regions of BC*

Common name	Latin name	Page number[a]	Description
Annual Sowthistle	*Sonchus oleraceus*	p57, P13	milky juice in stem (garden and roadside weed)
Purple Nutsedge	*Cyperus rotundus*	p14[b]	
Yellow Nutsedge	*Cyperus esculentus*	p362, P21	weed of cultivated fields (leaves triangular)
Canada Thistle	*Cirsium arvense*	p32, P4&55	leaves & stems prickly, flowers less than 2.5 cm (aggressive crop weed, can reduce yield by 100%)
Rush Skeletonweed	*Chondrilla juncea*	P15[b]	yellow flowers, deep rooted, tiny leaves on stems
Crupina	*Crupina vulgaris*	P5[b,c]	
Scentless Chamomile	*Matricaria maritima*	p48, P16	daisy-like flowers (forage area weed)
Dalmatian Toadflax	*Linaria dalmatica*	p136, P6,23	yellow flowers up to 1.2 m – pasture, rangeland and roadside weed
Yellow Toadflax	*Linaria vulgaris*	p138, P23	aggressive rangeland weed
Spotted Knapweed	*Centaurea maculosa*	p28	purple flowers (pasture and roadside weed) – not in Field Guide to Noxious Weeds… of BC
Diffuse Knapweed	*Centaurea diffusa*	p29, P7	white flowers (pasture and roadside weed)
Yellow Starthistle	*Centaurea solstitialis*	p29, 22[c]	yellow flowers
Tansy Ragwort	*Senecio jacobaea*	p59, P18,28	yellow ray flowers – distinguishes it from common tansy, toxic to livestock

a Page numbers following a lowercase 'p' are given for the descriptions found in Weeds of Canada. 1999. Royer and Dickerson. Lone Pine Publishing and The University of Alberta Press. Page numbers following an uppercase 'P' are from the Field Guide to Noxious Weeds and Other Selected Invasive Plants of British Columbia. 2005. Cranston et al. British Columbia.

b NA = not available in the Weeds of Canada publication.

c Not known in British Columbia

Common name	Latin name	Page number[a]	Description
Dodder	*Cuscuta spp.*	p260, P8	climbing parasite on agricultural crops – no green parts
Velvetleaf	*Abutilon theophrasti*	p228, P19	can grow to 2 m plus, weed in corn or soy crops
Gorse	*Ulex europaeus*	P10[b]	spiny shrub, south coastal and islands
Wild Oats	*Avena fatua*	p172, P20	serious crop weed, annual
Hound's-tongue	*Cynoglossum officinale*	P9[b]	seeds like velcro
Jointed Goatgrass	*Aegilops cylindrica*	P11[b,c]	
Leafy Spurge	*Euphorbia esula*	p368, P12	weed of pastures, range and roadsides, poisonous to livestock. Greenish yellow flowers with 2 yellow bracts
Perennial Sowthistle	*Sonchus arvensis*	p54, P13	crop weed, clasping stem with milky latex in stems

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b NA = not available in the Weeds of Canada publication.

c Not known in British Columbia

Table 8. *Common noxious weeds within the boundaries of the corresponding regional districts*

Common name	Latin name	Regional district	Page number*
Blueweed	*Echium vulgare*	Cariboo, Central Kootenay, Columbia-Shuswap, East Kootenay, Okanagan-Similkameen, Thompson-Nicola	p76, P24
Burdock	*Arctium spp.*	Bulkley-Nechako, Cariboo, Columbia-Shuswap, Fraser-Fort George, Kitimat-Stikine, North Okanagan, Okanagan-Similkameen, Peace River, Thompson-Nicola	p21, P25
Cleavers	*Galium aparine*	Peace River	p72, P26
Common Bugloss	*Anchusa officinialis*	Kootenay-Boundary	pNA,[b] P27
Common Tansy	*Tanacetum vulgare*	Bulkley-Nechako, Central Kootenay, Columbia-Shuswap, East Kootenay, North Okanagan	p58, P28
Field Scabious	*Knautia arvensis*	Bulkley-Nechako, Kootenay-Boundary, Thompson-Nicola	p382, P29
Green Foxtail	*Setaria viridis*	Peace River	p198, P30
Hoary Alyssum	*Berteroa incana*	Kootenay-Boundary	pNA, P27
Hoary Cress	*Cardaria spp.*	Columbia-Shuswap, North Okanagan, Thompson-Nicola	p272, P32
Kochia	*Kochia scoparia*	Peace River	p158, P33
Marsh Plume Thistle	*Cirsium palustre*	Bulkley-Nechako, Fraser-Fort George	pNA, P34
Meadow Knapweed	*Centaurea pratensis*	Columbia-Shuswap	pNA, P35
Night-flowering Catchfly	*Silene noctiflora*	Peace River	p326, P36
Orange Hawkweed	*Hieracium aurantiacum*	Bulkley-Nechako, Cariboo, Central Kootenay, Columbia-Shuswap, East Kootenay, Thompson-Nicola	p40, P37
Oxeye Daisy	*Chrysanthemum leucanthemum*	Cariboo, North Okanagan, Thompson-Nicola, Peace River	p30, P38

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c Not known in British Columbia.

Common name	Latin name	Regional district	Page number[a]
Perennial Pepperweed	*Lepidium latifolium*	East Kootenay, Thompson-Nicola	pNA, P39
Plumeless Thistle	*Carduus acanthoides*	Central Kootenay	p27, P40
Puncture-vine	*Tribulus terrestris*	Okanagan-Similkameen	p96, P41
Purple Loosestrife	*Lythrum salicaria*	Comox-Strathcona (by regional district bylaw)	p224, P80
Quackgrass	*Agropyron repens*	Peace River	p170, P42
Russian Knapweed	*Acroptilon repens*	North Okanagan	pNA, P44
Russian Thistle	*Salsola kali*	Peace River	p162, P43
Scotch Thistle	*Onopordum acanthium*	North Okanagan	pNA, P45
Sulphur Cinquefoil	*Potentilla recta*	Columbia-Shuswap, North-Okanagan, Okanagan-Similkameen, Thompson-Nicola	p357, P46
Tartary Buckwheat	*Fagopyrum tartaricum*	Peace River	p82, P89
White Cockle	*Lychnis alba*	Peace River	p328, P36
Wild Chervil	*Anthriscus sylvestris*	Fraser Valley	pNA, P47
Wild Mustard	*Sinapsis arvensis*	Peace River	p266, P48

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b NA = not available in the Weeds of Canada publication.

c Not known in British Columbia.

Table 9. *Invasive plant species of British Columbia*

Invasive plant species	Scientific name	Page number[a]
Anchusa	*Anchusa officinalis*	pNA, P27
Baby's Breath	*Gypsophila paniculata*	p320, P50
Black Knapweed	*Centaurea nigra*	pNA, PNA
Blueweed	*Echium vulgare*	p76, P24
Brown Knapweed	*Centaurea jacea*	pNA, PNA
Bull Thistle	*Cirsium vulgare*	pNA, P55
Canada Thistle	*Cirsium arvense*	p32, P4
Common Burdock	*Arcticum minus*	pNA, P25
Common Tansy	*Tanacetum vulgare*	p58, P28
Dalmation Toadflax	*Linaria dalmatica*	p136, P6
Diffuse Knapweed	*Centaurea diffusa*	P29, P7
Field Scabious	*Knautia arvensis*	P382, P29
Giant Knotweed	*Fallopia sachalenensis*	PNA, PNA
Gorse	*Ulex europaeus*	pNA, P10
Hoary Alyssum	*Berteroa incana*	pNA, P31
Hoary Cress	*Cardaria draba*	P272, P32
Hound's-tongue	*Cynoglossum officinale*	pNA, P9
Japanese Knotweed	*Fallopia japonica*	p91, P71
Leafy Spurge	*Euphorbia esula*	p368, P12
Marsh Plume Thistle	*Cirsium palustre*	pNA, P34
Meadow Hawkweed	*Hieracium caespitosum*	pNA, P37
Meadow Knapweed	*Centaurea debeauxii*	pNA, P35
Nodding Thistle	*Carduus nutans*	p26, P40
Orange Hawkweed	*Hieracium aurantiacum*	p40, P37
Oxeye Daisy	*Leucanthemum vulgare*	p30, P16
Perennial Pepperweed	*Lepidium latifolium*	pNA, P39
Plumeless Thistle	*Carduus acanthoides*	p27, P40
Puncture-vine	*Tribulus terrestris*	p96, P41
Purple Loosestrife	*Lythrum salicaria*	p224, P80
Rush Skeletonweed	*Chondrilla juncea*	pNA, P15
Russian Knapweed	*Acroptilon repens*	pNA, P44
Scentless Chamomile	*Matricaria perforata*	p48, P16
Scotch Broom	*Cystisus scoparius*	pNA, P82
Scotch Thistle	*Onopordum acanthium*	pNA, P45
Spotted Knapweed	*Centaurea biebersteinii*	p28, P17

St. John's-wort	*Hypericum perforatum*	pNA, P85
Sulphur Cinquefoil	*Potentilla recta*	p357, P46
Tansy Ragwort	*Senecio jacobaea*	p59, P18
Teasel	*Dipsacus fullonum*	pNA, PNA
Yellow Iris	*Iris pseudacorus*	pNA, PNA
Yellow Starthistle	*Centaurea solstitialis*	p29, P22
Yellow Toadflax	*Linaria vulgaris*	p138, P23

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Unless their abundance is obvious (i.e., the plants are absent or obviously greater than the threshold values in the indicator sub-questions), record the coverage for disturbance-increaser species and noxious weeds or invasive plants at six points or plots along the reach to estimate overall coverage along the traverse. Plots can be standard circular plots centered 5 m from the stream bank or 10-m-long line transects, which extend 10 m from the stream bank at right angles to the main axis of the stream reach. Use the same bearing for all transects after determining what the bearing is for the main axis of the reach.

Question 15. Is the riparian vegetation within the first 10 m from the edge of the stream generally characteristic of what the healthy unmanaged riparian plant community would normally be along the reach?

Most riparian areas support a diversity of trees and/or shrubs, with an understory of herbaceous plants and ground cover (mosses, lichens). The presence of woody plants in all age classes (especially young plants), in vigorous condition and in their natural form, is a good indication of a healthy riparian area.

Many aspects of Question 15 compare existing riparian conditions to what healthy unmanaged riparian forests might look like in different BEC zones or BEC zone variants. To conduct proper evaluations, a variety of unmanaged riparian forests in the major BEC zones or BEC zone variants present in each Forest District should be looked at before initiating any riparian assessments. If this is impractical, then compare the characteristics of the riparian zone being assessed to the nearest unmanaged riparian area. This could be the other side of the stream if it is unlogged, or stream reaches immediately upstream or downstream of the block if the riparian areas are otherwise comparable.

Question 15 uses four indicator sub-questions. In order to mark Yes to the question, three of the four indicator sub-questions need to be answered Yes.

15 a) *Are all the major vegetation layers and structural components of the expected healthy unmanaged riparian plant community (e.g., gaps, snags, CWD, gaps, tall trees, understory, tall shrubs, low shrubs, herbaceous plants, mosses and lichens) adequately represented? Adequate representation is:*

1) *the presence of all expected layers and components over 75% of the reach,*
2) *75% of the expected layers or components over all of the reach, or*
3) *any combination of 1) and 2) that collectively averages 75% or more.*

A healthy riparian area is usually a tangle of herbaceous vegetation, shrubs and trees. Unhealthy or intensively managed riparian areas may still support trees, but there is typically a lack of structural diversity. Answer Yes if all of the expected main vegetation layers (trees, shrubs, and ground cover) occur over more than 75% of the stream reach normally capable of supporting vegetation. In most cases, the entire reach would be considered. Sometimes, however, there may be large expanses of bedrock incapable of supporting any vegetation. In this case, only consider the ground that is not bedrock.

It should be relatively simple to decide if all expected layers are present in intact old seral stage riparian areas, or conversely, riparian habitats that have recently been altered by grazing, logging, fires, slides, wind storms, or beetle epidemics. It will be considerably more difficult to decide when all expected layers have been satisfactorily re-established in riparian areas that are recovering from these impacts. Factors to consider include the age, seral stage of the normal climax forest, the frequency and type of disturbance characteristics of the forest, and the characteristic structure and species diversity of the forest. In keeping with the general guidelines used for coverage in the riparian area, any factor that meets or exceeds 75% of the final characteristics desired could be considered a reasonable measure of recovery.

If needed, use Table 3 on Page 6 of the riparian field checklist to help decide the answer for this indicator. In this table, each component or layer of the riparian area is given a percentage score that indicates how closely that component approaches what you would expect to find in an otherwise healthy, unmanaged riparian area. If a portion of the riparian area has been logged, roaded, or is otherwise missing, the remainder is the maximum % attainable for Q15a. For example, if one side is logged and the other is intact, then 50% is the maximum score you can give and this is only if the intact forest consists of an older seral stage with minimal disturbance. If the remaining forest is second growth, each layer may be over- or under-representing natural, unmanaged conditions.

Presence means that there are both representative types and diversity of species throughout the riparian area, reflective of an unmanaged riparian plant community for that BEC unit. The following guidance can be applied to forested riparian areas with some case study examples.

- **Snags:** consider species representation, size (large diameter from all crown classes) and condition (hard, spongy, and soft decay classes – refer to SLR sampling). If you only had MPB killed trees of decay classes 3-5 (hard and spongy), then record 2 of 3 decay classes present (66%). If the riparian area was a burnt, mature forest of only charred trees (hard decay classes), then record 1 of 3 decay classes present (33%). If all the snags were felled from within the riparian area for safety mitigation, then record 0%. If the only snags present are understory suppressed trees, note the mature tree snags are absent.

- **Gaps:** consider a gap to be where more than 2 crown widths of overstory trees are missing (dead or fallen), thus creating an opening where sunlight allows new growth of light-demanding plants to emerge on the forest floor. Consider forested sites to score 100% present where more than 50% of the reach's sampling segments have at least one such gap, or there are broad gaps overlapping sampling of at least two sampling segments. A clearcut is all gap (unnatural) so record 50% instead of 100%.

- **Overstory trees:** consider species diversity, age and presence of Dominant + Codominant trees; a forest younger than 120 years scores <70%, a clearcut scores 0%.
    - A maturing second growth forest younger than 120 years typically has no dominant expression of mature trees (look at the stumps from 1st pass) – record 50% because you only have co-doms.
    - A riparian area is comprised of a mature, natural stand. If there is a 20 m reserve on the left side (100%) and a 10 m treed buffer with 50% retention of dominant and codom tree on the right side (50%) then record 75% [(100+50)/2].
    - A stream has a 20 m reserved stand of mature spruce, pine and aspen. MPB has killed all the mature pine. A wind event post-harvest has caused 100% of the MPB killed pine and 50% of the live spruce to fall. Score the 3 species based upon their presence. All the mature pine are dead (0%), half of the live spruce are felled (50%) and the aspen is intact (100%) with a final score of 50% [(0+50+100)/3] recorded for overstory trees.
- **Understory trees:** consider species diversity and presence of both the intermediate and suppressed tree layers.
    - A maturing but overstocked second-growth stand was spaced at age 20 but has minimal vertical structural diversity (regeneration is scarce). Score understory as 0%.
    - A site was clearcut with a 5m machine free zone, retention of non-merch trees (all understory are present within 5m of the stream), then score 50%
- **Tall shrubs:** consider tall (>1.3m to 5m) regen and tall woody shrub species (e.g., willow, Red-osier dogwood, scrub alder, elderberry, cascara, cherry, crabapple) in terms of coverage and species diversity. Refer to a plant field guide for your area and consider the diversity of species expected for this BEC subzone. If following harvest, there are ANY cut stems of a species then deduct this from the total range of species observed/expected to have been present prior to harvest.
    - A 5m MFZ (50% of 10 m riparian) was established with the protection of all conifer 'shrubs' within this zone but the deciduous shrubs were cut within the entire riparian area (0%). Record 25% for Tall shrubs [(50%+0%)/2].
- **Low shrubs (and ferns):** consider the species diversity and coverage of low woody shrub (<3m height) and fern species. Refer to a plant field guide for your area and consider the diversity of species expected for this BEC subzone.
    - A second-growth forest has a dense under growth, but you notice it is primarily by shade-living plants, record 50%.
    - A clearcut has a prolific coverage by light-demanding plants but is clearly lacking shade-tolerant species; there is over-representation of some species and a lack of others. Record 50%.
- **Herbs:** consider species diversity and coverage, generally the water-loving species and flowers, grasses, sedges, and rushes. Refer to a plant field guide for your area and consider the diversity of species expected for this BEC subzone.
    - A second-growth riparian forest has many species of herbs, but you notice they are primarily located along the banks (within 1-2m of the 10m riparian area). Record 15%.
    - A riparian area has been scarified for planting to within 5m of the stream's edge. In this situation, half of the herbs have been destroyed (albeit temporarily). Record 50%.

- **Mosses** (includes Liverworts) and **Lichens:** consider the species diversity and types (e.g., ground, stem and arboreal). For ground living mosses, you should expect to see representatives of the three main groups (sphagnum, granite mosses and true mosses). The main difference between a moss and a lichen is that moss always has a stem and leaf structure. Lichen is a symbiotic relationship between a fungus and an algae and they prefer light, while mosses prefer shade. Refer to a plant field guide for your area and consider the diversity of species expected for this BEC subzone.
    - Consider a riparian area that was harvested to within 5m of the stream's bank, all the dominant and co-dom trees were removed and therefore so also the moss and lichen that may have been growing on these trees. If you notice the moss and lichens on logs and the ground are still present for the full 10m of the riparian area, record 33% (only the ground moss and lichens are present of the 3 types).
    - A densely-stocked, second growth forest is reserved within 20m of the stream. You notice there is a poorly-expressed presence of arboreal species, but an abundant array of ground and stem species. Record 66% since the arboreal are lacking.
    - You are in a regenerated cutblock and notice that the species diversity of moss is minimal (e.g., only 2 of 8 species commonly found in the adjacent forested area). Record 25% for moss.
    - You are in a regenerated cutblock and notice that the species diversity of lichen is minimal. For example, a crusty form (e.g., *Cladina*) and a leafy form (e.g., *Peltegera*), but you do not see any stringy forms (e.g., *Alectoria*). Record 66% for lichen.
- **CWD:** consider the size (large and full length) and condition (hard, spongy and soft decay classes – refer to SLR sampling).
    - A forested site was clearcut. There might be a lot of CWD on the ground within the riparian area, but most is small diameter (hard decay class) with a mix of spongy large (low merchantability) CWD, and the pre-harvest CWD is still intact. Record 66% since there is a lack of large, hard decay classes (1 of 3 categories is absent).
    - A stream has a 20 m reserved second growth (e.g., 60 years) stand alongside the stream. There is an abundance of understory, self-thinning snags falling to the ground and a range of old CWD from the initial harvesting era. Record 33% since there is only old, large diameter soft CWD (1 of 3 categories is present).
    - A stream has a 20 m reserved stand of mature spruce, pine and aspen. A wind event post-harvest has caused 100% of the MPB killed pine and 50% of the live spruce to fall. Since you see there is now over-representation of the hard decay classes record 66% (2 of the 3 CWD decay classes are present in normal levels).

As a self-check of the final score for Q15A components consider the following outcomes as a guide for when the whole riparian area has a homogenous treatment:

- If the component expected is generally present = 100%
- If the component expected is generally absent = 0%
- If the component expected is developing, partially present or over-represented = 50%

Consider the following guiding tips for answering Q15B within the riparian area:

Form is poor if > 25% of the component was cut or damaged (e.g., by harvesting, browsing, snow press, windthrow, or grazing). Heavy mistletoe, stem goiters and rusts, and leader weevil damage are examples where we consider these to be poor form. Arboreal moss and lichens which are just starting to become established on branches of younger trees would be of poor form. If the substrate the plants were growing on are removed and/or damaged (e.g., harvested, landslide, burnt, scarified) then they are now of poor form because they were removed when the substrate was altered.

TIP: Cut trees/snags (stumps or topped stems) or heavily browsed shrubs are examples of poor form. CWD that has been bucked and/or broken by being skidded over are of poor form.

Vigour considers whether the component is performing well in terms of incremental growth, expressed by large leaves/needles, fronds, rich colour. Remember: Cut, shaded, flooded or drought stressed trees or shrubs are of poor vigour. Similarly, if > 25% of the component was cut (e.g. trees) or diseased then the overall vigour is poor for that component. Trees with thinning crowns, stress cone crops, chlorotic foliage from root disease are poor vigour. Shrubs and herbs which are over-grazed and/or browsed and trampled would be of poor vigour.

TIP: Plants struggling from poor lighting are of poor vigour. Look to the clearcut forest or plants growing in larger canopy gaps and you will see what good vigour looks like for a reference.

Recruitment considers the presence of younger age classes, consider the range of species expected and their distribution within the riparian area.

TIP: If the component (e.g., arboreal and stem moss or lichen) is not detected then recruitment is generally absent. Regeneration is not regarded as a recruit for overstory trees and snags but is a recruit for understory.

Note that not all riparian areas are expected to have all possible layers or components present. Natural grasslands, sedge meadows, and shrub-carr complexes to name a few vegetation communities naturally lack snags and trees. CWD levels and the lichen community can similarly be expected to be quite different in these communities. Other riparian areas may naturally have a well-developed tree layer with few openings but lack herbaceous vegetation or moss cover. For these simpler types of communities, record "NA" for the layers or components not expected. Base the overall average percentage in the last box only on the number of layers or components expected to be present.

15 b) Do the major vegetation layers and structural components of a healthy unmanaged riparian plant community exhibit good vigor, normal growth form, and satisfactory recruitment? Vigor or growth form is poor if plants are discolored, defoliated, brittle, burned, broken, heavily browsed, "mushroomed", windthrown, harvested or dead. Mark "No" if collectively less than 75% of all the plants and structural components expected show good vigor, form, and recruitment.

If needed, use Table 4 on Page 6 the riparian field checklist to help answer this indicator sub-question. In Table 4, each vegetation layer and structural component of the riparian community is given a Yes or No in terms of its form, vigor, and recruitment. For form and vigor, record a Yes when 75% of the components or individuals present in each layer show adequate form and vigor. Otherwise record a No. As remnants of the trees or shrubs that were present, consider all stumps when calculating if 75% or more of the trees or shrubs present have good form or vigor.

For recruitment, record a Yes if the layer that the recruitment comes from is present, or there are vigorous younger specimens present, otherwise record No. The presence of mature trees, for example, represents recruitment for snags, gaps, and CWD. Seedlings, however, are not considered recruits for snags, gaps or CWD because they are too many layers away from the contributing layer. Similarly, a tree seedling would be recruitment to the understory layer but not the overstory.

Where one or more layers or components are naturally lacking in the mature, healthy unmanaged state, record "NA" for those layers. Also record "NA" where the "vigor" of a gap, snag or CWD component makes no sense.

In Table 4, record the total number of Yes answers in the third column from the right, and the total possible number of Yes answers in the second column from the right. Calculate the percent of eligible cells with Yes answers and record this in the last column. If the last number is 75% or more, mark Yes for the indicator. This indicates that collectively the form, vigor, and recruitment for the riparian area approaches what is expected at similar but otherwise healthy, unmanaged riparian areas.

In the example (1), more than 25% of the snags, overstory, and understory trees were reduced to stumps, therefore their overall form was considered poor. All the other layers were relatively intact and thus their form was considered good. Because most of the overstory trees were stumps, their vigor was also considered poor, while the tall shrubs had suffered additional breakage further reducing their overall vigor. All other layers had acceptable vigor. Vigor for the non-living components (snags, gaps and CWD) made no sense and they were thus recorded as NA. Since 50% of the trees were retained, "recruitment" for snags, gaps and CWD was considered satisfactory. In fact, the only layer considered to have poor recruitment was the understory layer due to the absence of younger trees or new seedlings. The final score was 20 Yes answers out of a possible 27, for a total score of 74%. The target (75%) was not achieved which means you would record a No answer for this indicator. Note in this case that small differences in treatment of just one or more layers made a significant difference in achieving or not achieving the target.

Most heavily harvested S6 streams (and many S4 and S5 streams) will get a No answer to Question 15. If both 15 a) and 15 b) are No answers, the riparian vegetation is probably no longer characteristic of other healthy, unmanaged riparian plant communities in the area.

15 c) Is heavy browse absent? Heavy browse on a plant is browse down to second-year wood over most (> 50% of the branches) of the plant.

To determine if there is heavy browse in the reach, look for specimens of a preferred browse species that are accessible to animals along the reach. Examine the plants and decide approximately what percent of the branches are nipped back to second-year wood. Do this for the streamside closest to the treatment being assessed. If both sides of the stream are treated, assess the browse level on both sides. If any one plant can be categorized as heavy browse, the answer to 15 c) is No.

TIP: If beaver-cut stems are noted at a site, record this as heavy browse.

TIP: If a preferred browse species is present but only in inaccessible areas such as on rock bluffs, or high stumps, or fenced enclosures, this can be taken as indirect evidence of heavy browse. Prolonged heavy browsing can eliminate the preferred browse species in accessible areas.

15 d) Is 90% or more of the available grazing area free of heavy grazing? Heavy grazing is defined as less than the recommended target stubble height for the dominant forage species present.

To determine if there is heavy grazing in the reach, measure the stubble height of the dominant forage species (the species most consumed) at six evenly spaced sites along the stream reach. If possible and time permits, measure the stubble height of 10 plants at each site to determine the average stubble height. The overall average stubble height is the average of the stubble heights at each of the sample sites.

Answer Yes to the indicator sub-question if the overall average stubble height exceeds the target stubble height for the dominant forage species. Target stubble heights for riparian and upland forage species are summarized in Tables 10 and 11 (Fraser 2003).

TIP: Forage in overgrazed areas has a "slick" or "smooth" appearance. Undergrazed areas have a "ragged" appearance if there is any grazing at all.

TIP: Look for forage plants that are protected from grazing at the base of dense shrubs, in areas of heavy windfall, or in enclosures to get an appreciation of what the normal height and form of the local forage might be.

Table 10. *Average stubble heights for riparian species*

Species	Average stubble height (cm)	Species	Average stubble height (cm)
Baltic Rush	10	Foxtail Barley	10
Bluegrasses	10	Hairgrass, Tufted	12
Bullrushes	incidental use	Kobresia	8
Canada Reedgrass (Bluejoint)	12	Sedges (Large)	20
Cattails	incidental use	Spikerush	15
Desert Saltgrass	7		

Table 11. *Average stubble heights for upland species*

Species	Average stubble height (cm)	Species	Average stubble height (cm)
Bluegrasses	8	Ricegrass, Rough-leaved	8
Bromes (introduced)	10	Timothy (Alpine)	10
Fescue, Altai	17	Timothy (Domestic)	8
Fescue, Creeping Red	7	Wheatgrass, Bluebunch	15
Fescue, Idaho	12	Wheatgrass, Crested	8
Fescue, Rough	17	Wheatgrass, Northern	15
Needlegrass	12	Wheatgrass, Slender	15
Orchardgrass	10	Wheatgrass, Western	12
Pinegrass	15	Wildrye, Blue	15

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For an updated version of references and support information of this document, please consult the FREP web site at http://www.for.gov.bc.ca/hfp/frep/.

APPENDIX 1. RAPID CONNECTIVITY ASSESSMENT

If any of the answers within part A or part B are NO, connectivity is impaired.

Part A – To be completed at all stream crossings and within road right-of-ways immediately upstream or downstream of riparian assessments and at all WQ assessment sites:

1) The channel is relatively clear and sediment or debris deposits are not preventing more than 2/3 of the flow, at bankfull depth, from remaining in the channel (ie. flow is not or will not be forced above or around the obstruction; look for signs of erosion if flows are low). YES/NO

Part B – To be completed at all crossings on fish streams, or non-classified streams that are less than 20% gradient upstream and downstream of a crossing (default fish streams). Do not complete if the stream has been classified as non-fish above the crossing.

1) The height of a sediment or debris blockage in the channel within the road right of way is less than twice the channel depth immediately below it OR there is debris in the culvert, but it is not restricting flow such that pooling at the inlet is greater than 2x the normal channel width (answer Yes if there is pooling, but the blockage has since cleared from the culvert). YES/NO/NA

2) If crossing structure is a culvert, fill out form below and answer YES/NO.

Attribute	**Measurement**	**Category Score**	**Field Score**
Embedded	Continuous and embedded > 30cm or 20% of pipe diam.	0	
	Continuous, but <30cm or 20% pipe diam.	5	
	Discontinuous or not embedded	10	
Outlet Drop (perch)	< 15 cm	0	
	15-30 cm	5	
	>30 cm	10	
Culvert Slope	<1%	0	
	1-3%	5	
	>3%	10	
SWR *	<1.0	0	
	1.0-1.3	3	
	>1.3	6	
Culvert Length	<15m	0	
	15-30m	3	
	>30m	6	
Total Score			
Fish Passage Maintained?	Answer Yes if score is 14 or less		YES/NO

* SWR = Stream Width Ratio is calculated as natural channel width/ culvert diameter.

For more information on the above measurements, see Section 5 – Field Methodology in the following training course:
https://www.for.gov.bc.ca/hfp/fish/Fish_Passage_Training/player.html

Notes

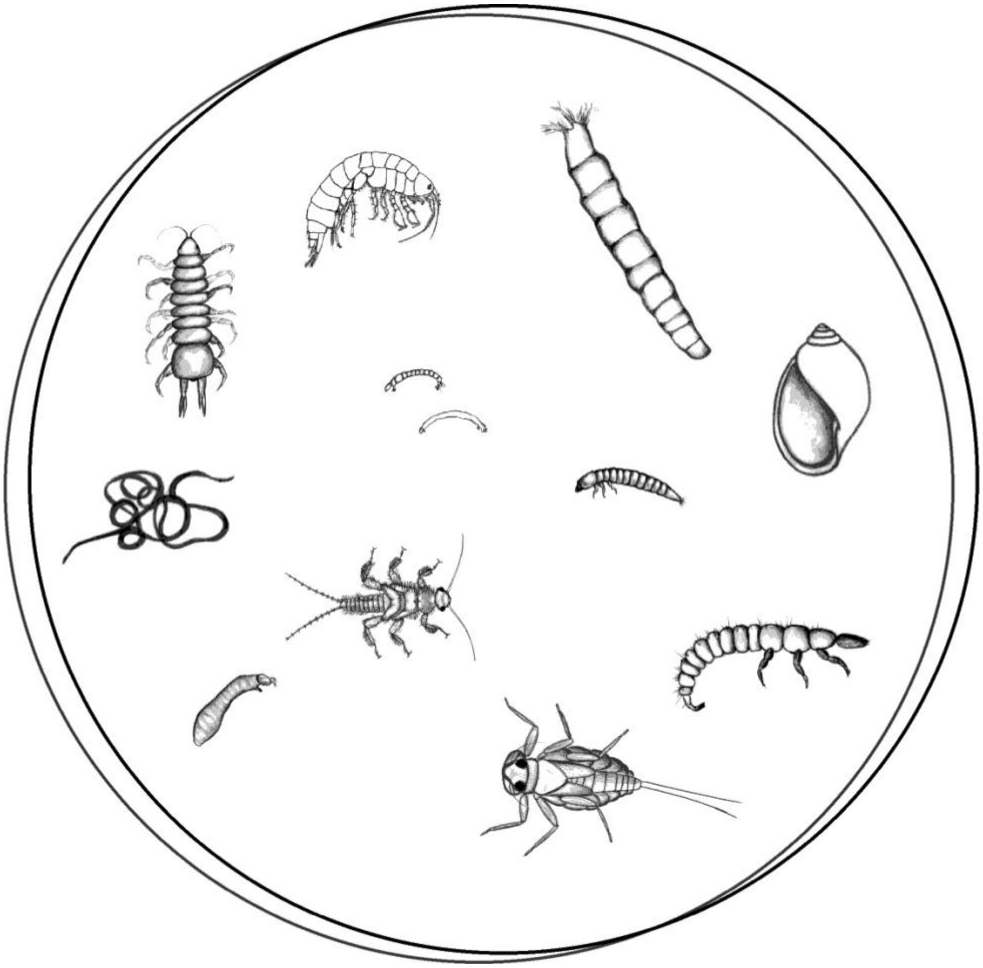
a) For the barrier determination of multiple culverts, use the metrics from the pipe lowest in elevation at the outlet. For pipes installed at the same elevation at the outlet, add diameters for SWR criteria and use the highest slope and length measurement.

b) For the evaluation of part B, properly embedded culverts are considered passable as per natural stream channel and no further consideration of other surrogates is required.

APPENDIX 2. FIELD GUIDE TO FRESHWATER INVERTEBRATES

(from Leska S. Fore; Annabel Wildrick [illustrations])

The animals living in a stream provide the best indicators of that stream's overall health and ecological condition. Human activities that alter a watershed and interfere with the natural processes of a stream have immediate as well as long-lasting effects on the animals that live in the stream. We monitor invertebrates because they represent an enormous diversity of body shapes, survival strategies, and adaptations. Many invertebrates require clear, cool water, adequate oxygen, stable flows, and a steady source of food in order to complete their life cycles. These animals, in turn, provide food for trout, salmon, herons, and kingfishers. Below are descriptions of the invertebrates you might expect to find at an excellent stream site (i.e., a site unchanged by humans), a moderate site, and a poor (i.e., degraded) site.



Petri dish of invertebrates illustrates their approximate, relative size.

http://www.seanet.com/~leska/online/guide.html

Excellent stream site

Here we find a variety of organisms with very different body shapes and ways of making a living. High biodiversity (or taxa richness) indicates a site with low human influence: most of the animals on this guide sheet should be present in a riffle sample. Several different types (or taxa) of stoneflies, mayflies, and caddisflies indicate a healthy site. More than one type of riffle beetle may also be identifiable, some are longer and thinner than others. Some caddisflies are tolerant of degradation, so a large number of caddisflies does not necessarily indicate a good site, especially if they are the same species.

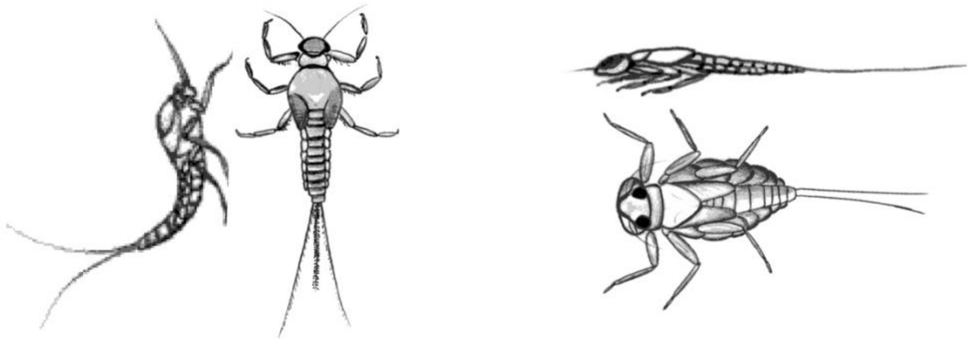
Moderate stream site

The total number of different types of organisms (taxa richness) declines as degradation increases. About half to two-thirds the number of taxa found at an excellent site are found in a moderate site. The primary change from an excellent site is that there will be many fewer taxa of stoneflies. Mayflies will be present, but probably fewer taxa as well. Several types of caddisflies may be present depending on the type of degradation. The relative proportions of soft-bodied worms, baetid mayflies, simuliid flies, or amphipods may increase. Beetles are probably still present; mollusks are not.

Poor stream site

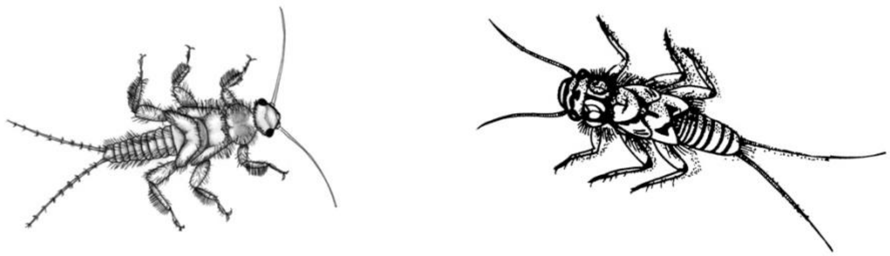
The total number of taxa will be low. Most of the taxa found are soft-bodied animals, e.g., fly larvae, oligochaetes, nematodes, and in very poor sites, leeches, and planaria. Worms are often difficult to distinguish from each other because their shapes are similarly adapted to living in soft sediments. Stoneflies are absent entirely. The only mayflies present are probably baetids (a family of mayflies). Caddisflies may be present, but only a few tolerant types. Amphipods are often present. There may be a large proportion of a single type of animal. In general, animals present may be smaller than those found at an excellent site.

Mayfly nymphs (Order Ephemeroptera)



Mayflies are insects that spend most of their lives in streams, emerging briefly as adults ("ephemerally") to mate and lay eggs. Gills are often visible along the abdomen. If an animal has three tails, it's a mayfly; but some mayflies have two tails. Mayfly nymphs are strong swimmers and move like dolphins. As immature nymphs, many mayflies feed on algae; as adults they do not eat. Mayfly diversity declines as streams are degraded; mayflies are particularly sensitive to mine waste.

Stonefly nymphs (Order Plecoptera)



Stonefly nymphs are typically found on or near stones in the stream. They are rather primitive and may have been among the first insects to develop flight. Adult males and females emerge from the water to mate and locate each other by drumming with their abdomens. Stoneflies move like turtles and many are predators that hide and stalk their prey between stones and cobbles. Stoneflies look similar to mayflies but are stockier and have more of a rectangle shape. The diversity of these animals declines rapidly at the first signs of human disturbance.

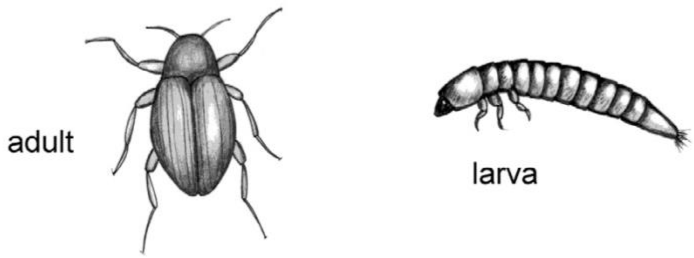
Caddisfly larvae (Order Trichoptera)

Caddisflies use silk (like butterflies) to build cases from gravel, twigs, needles, or sand. Different species build distinct cases, but they often lose them when removed from a stream. Caddisflies are insects that emerge to mate as winged adults. Caddisfly larvae make a living in a variety of ways: some capture food in nets, others scrape algae or shred leaf litter. Free-living caddisfly larvae do not build cases; many are predators and need to move quickly to capture other animals for food. Some caddisflies are very sensitive to human disturbance; others are tolerant.

Adult mayflies, stoneflies, caddisflies

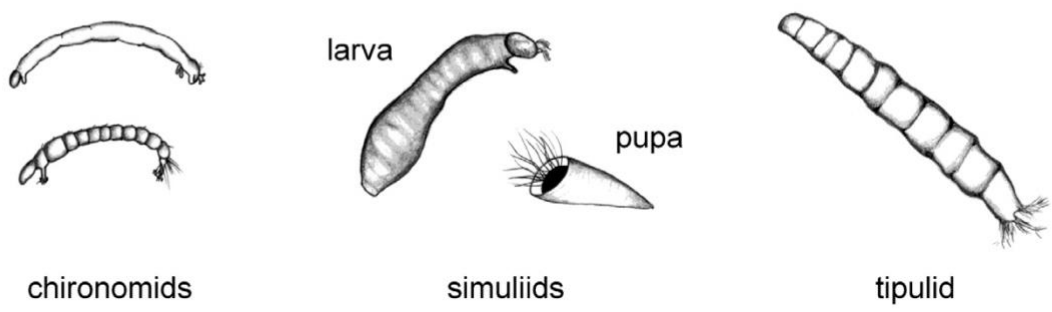
All three of these groups leave the water to mate as winged adults. Large swarms of mating mayflies and caddisflies often occur when all the individuals of a single species emerge at the same time. Stoneflies crawl out of the water and mate on the ground. The females of all three groups fly upstream and drop their eggs onto the water, or dive into the stream to attach them to rocks or leaves.

Riffle beetles (Order Coleoptera)



Riffle beetle larvae are specially adapted to cling to smooth rocks in fast-flowing water (riffles). After emergence, adults fly for a short time but return to the water to feed in the same habitat as the larvae. Both the larvae and adults are rather small, dark-colored, and tend to drift to the bottom of a sample so they may be hard to see. Riffle beetles collect and gather a variety of different foods.

Fly larvae (Order Diptera)

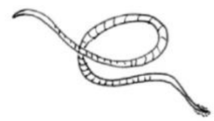


There are many species of true flies, but you are likely to recognize three main groups or families. Midge larvae (or chironomids) are very small, often C-shaped, and have a spastic squirming movement. They are often attached to debris by their tiny legs. Blackfly larvae (or simuliids) are dumb-bell shaped and soft. They attach themselves to the substrate and prefer soft sediment. Cranefly larvae (or tipulids) are large and fleshy with very short "tentacles" at one end.

Aquatic worms

planaria

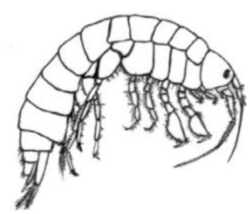
nematode



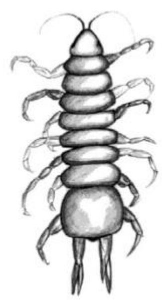
oligochaete

Flatworms (planaria), roundworms (nematodes), and freshwater earthworms (oligochaetes) are properly called worms; but don't confuse them with the soft-bodied larvae of flies, which are not. Nematodes and oligochaetes are long and thin and writhe like snakes. Note that these animals do not have legs.

Crustaceans



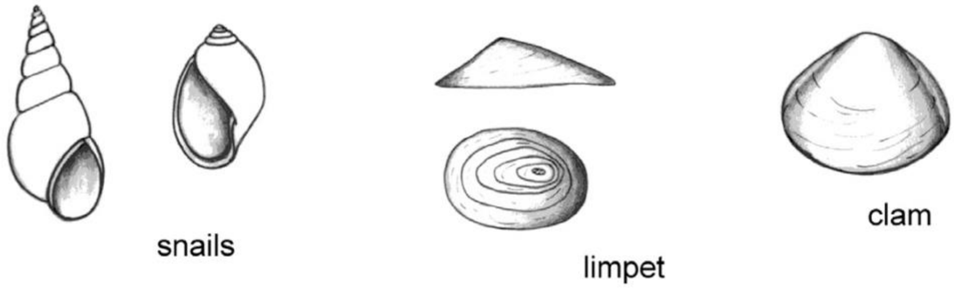
amphipod



isopod

Amphipods (or "scuds") are very fast swimmers that look like shrimp. They have many appendages and look fuzzy. High proportions of these animals are present in very degraded sites. Isopods (or sowbugs) are usually found creeping through leaf litter.

Mollusks (Classes Gastropoda & Pelecypoda)



Most snails and limpets eat algae they scrape from rocks. Check to see if the animal is still in the shell. As larvae, freshwater mussels (or clams) may hitch a ride by attaching themselves to migrating fish. Mussels are very sensitive to sediment because they feed by filtering stream water through their shells. Mature mussels indicate an undisturbed site and may be up to 40 years old.

APPENDIX 3. ROOTING DEPTH OF COMMON SPECIES IN THE PACIFIC NORTHWEST

PLANTS FOR DRY, SUNNY AREAS		
TREES		
Plant Species	**Cultural Requirements**	**Root Depth**
Abies grandis, grand fir	dry to moist soil, full to partial sun	deep roots
Abies lasiocarpa, subalpine fir	dry soil, full sun	deep roots
Abies procera, noble fir	dry to moist soil, full sun	deep roots
Acer macrophyllum, big-leaf maple	dry to wet soil, full sun	deep roots
Arbutus menziesii, Pacific madrone	dry soil, full sun	deep roots
Cornus nuttallii, Pacific dogwood	dry to moist soil, full to part sun	deep roots
Picea sitchensis, sitka spruce	dry to moist soil	deep roots
Pinus contorta, shore pine	dry soil, full sun	seep roots
Pinus contorta var. latifolia, lodgepole pine	dry soil, full sun	deep roots
Pinus ponderosa, western ponderosa pine	dry soil, full sun	deep roots
Populus tremuloides, quaking aspen	dry to moist soil, full sun	deep roots
Prunus virginiana, chokecherry	dry soil, full sun	deep roots
Pseudotsuga menziesii, Douglas fir	dry to moist soil, full sun	deep roots
Quercus garryana, Oregon white oak	dry to moist soil, full sun	deep roots
Sambucus cerulea, blue elderberry	dry to moist soil	deep roots
Thuja plicata, western red cedar	dry to wet soil, full sun	deep roots
Tsuga mertensiana, mountain hemlock	dry soil, full sun	deep roots
SHRUBS		
Plant Species	**Cultural Requirements**	**Root Depth**
Amelanchier alnifolia, serviceberry/Saskatoon	dry to moist soil, full sun	medium depth
Arctostaphylos uva-ursi, kinnikinnik	dry soil, full sun	medium depth
Baccharis pilularis, coyote brush	dry soil, full sun	deep to medium depth
Ceanothus integerrimus, deer brush	dry soil, full sun	deep roots
Holodiscus discolor, oceanspray	dry to moist soil, full sun to full shade	deep roots
Mahonia aquifolium, tall Oregon grape	dry to moist soil, full sun to full shade	medium depth
Mahonia repens, creeping Oregon grape	dry to moist soil, full sun to full shade	medium depth
Myrica californica, Pacific wax myrtle	dry soil, full sun	deep roots
Philadelphus lewisii, mock orange	dry to moist soil, full sun	medium depth
Rhus glabra, smooth sumac	dry to moist soil, full sun	medium depth
Ribes aureum, golden currant	dry to moist soil, full sun	medium depth
Ribes sanguineum, red flowering current	dry to moist soil, full sun to part shade	medium depth
Rosa gymnocarpa, baldhip rose	dry to moist soil, full sun to part shade	medium depth
Rosa nootkana, nootka rose	dry to wet soil, full sun	medium depth
Rosa pisocarpa, clustered rose	dry to moist soil, full sun	medium depth
Spiraea betulifolia var. lucida, birch-leaf spirea	dry to moist soil, full sun	medium depth
spiraea densiflora, subalpine spirea	dry to moist soil, full sun	medium depth
LOW-GROWING PLANTS		
Plant Species	**Cultural Requirements**	**Root Depth**
Achillea millifolium, common yarrow	dry soil, full sun	shallow roots
Anaphalis margaritacea, pearly everlasting	dry soil, full sun	shallow
Asclepias speciosa, showy milkweed	dry soil, full sun	shallow

Aster subspicatus, Douglas aster	dry to moist soil, full sun	shallow
Epilobium angustifolium, fireweed	dry soil, full sun	shallow
Festuca idahoensis, Idaho fescue	dry soil, full sun	shallow
Fragaria chiloensis, coastal strawberry	dry to moist soil, full sun to part shade	shallow
Fragaria virginiana, wild strawberry	dry to moist soil, full sun	shallow
Juncus effusus, common rush	dry to wet soil, full sun to part shade	shallow
Lonicera hispidula, chaparral honeysuckle	dry to moist soil, full sun to part shade	shallow
Lupinus rivularis, streambank lupine	dry to wet soil	shallow
Solidago canadensis, goldenrod	dry soil, full sun	shallow
Sisyrinchium bellum, blue-eyed grass	dry to moist soil, full sun	shallow
PLANTS FOR DRY, SHADY AREAS		
TREES		
Plant Species	**Cultural Requirements**	**Root Depth**
Rhamnus purshiana, cascara	dry to wet soil, full to part shade	deep roots
SHRUBS		
Plant Species	**Cultural Requirements**	**Root Depth**
Gaultheria shallon, salal	dry to moist soil, full to part shade	medium depth
Holodiscus discolor, oceanspray	dry to moist soil, full sun to full shade	deep roots
Mahonia nervosa, Cascade Oregon grape	dry to moist soil, full to part shade	medium depth
Oemlaria cerasiformis, Indian plum	dry to moist soil, full to part shade	medium depth
Symphoricarpos albus, common snowberry	dry to wet soil, full to part shade	medium depth
Symphoricarpos mollis, creeping snowberry	dry to moist soil, full to part shade	medium depth
Vaccinium ovatum, evergreen huckleberry	dry to moist soil, full to part shade	medium depth
Vaccinium parvifolium, red huckleberry	dry to moist soil, full to part shade	medium depth
LOW-GROWING PLANTS		
Plant Species	**Cultural Requirements**	**Root Depth**
Achlys triphylla, vanilla leaf	dry to moist soil, full shade	shallow roots
Aquilegia formosa, western columbine	dry to moist soil, full to part shade	shallow
Aruncus sylvester, goatsbeard	dry to moist soil, full to part shade	shallow
Asarum caudatum, wild ginger	dry to moist soil, full to part shade	shallow
Dicentra formosa, Pacific bleeding heart	dry to moist soil, full to part shade	shallow
Fragaria vesca, woods strawberry	dry to moist soil, full to part shade	shallow
Heuchera chlorantha, meadow alumroot	dry to moist soil, full to part shade	shallow
Heuchera micrantha, small-flowered alumroot	dry to moist soil, full to part shade	shallow
Hydrophyllum tenuipes, Pacific waterleaf	dry to moist soil, full to part shade	shallow
Luzula parviflora, small-flowered wood rush	dry to moist soil, full to part shade	shallow
Montia parvifolia, small-leaved montia	dry to moist soil, full to part shade	shallow
Montia siberica, candyflower	dry to moist soil, full to part shade	shallow
Polystichum munitum, sword fern	dry to wet soil, full to part shade	medium depth
Tolmiea menziesii, piggy-back plant	dry to moist soil, full to part shade	shallow
Vancouveria hexandra, inside-out flower	dry to moist soil, full to part shade	shallow
PLANTS FOR WET, SUNNY AREAS		
TREES		
Plant Species	**Cultural Requirements**	**Root Depth**
Acer macrophyllum, big-leaf maple	dry to wet soil, full sun	deep roots
Alnus rubra, red alder	wet to moist soil, full sun	deep roots
Crataegus douglasii, black hawthorn	wet to moist soil, full sun	deep
Fraxinus latifolia, Oregon ash	wet to moist soil, full sun	deep
Populus balsamifera var. trichocarpa, black cottonwood	wet to moist soil, full sun	deep

Thuja plicata, western red cedar	dry to wet soil, full sun	deep
Salix sp., willows	wet to moist soil, full sun	deep
SHRUBS		
Plant Species	**Cultural Requirements**	**Root Depth**
Cornus stolonifera, red osier dogwood	moist to wet soil, full sun to part shade	deep roots
Philadelphus lewisii, mock orange	dry to wet soil, full sun	medium depth
Physocarpus capitatus, Pacific ninebark	wet to moist soil, full sun to part shade	deep roots
Rosa nootkana, nootka rose	dry to wet soil, full sun	medium depth
Rosa pisocarpa, clustered rose	dry to wet soil, full sun	medium
Spiraea douglasii, Douglas spirea	dry to wet soil, full sun	medium
LOW-GROWING PLANTS		
Plant Species	**Cultural Requirements**	**Root Depth**
Camassia leichtlinii, great camas	wet to moist soil (likes to dry out in summer)	shallow roots
Camassia quamash, common camas	wet to moist soil (likes to dry out in summer)	shallow
Carex deweyanna, dewey sedge	wet to moist soil, full sun	shallow
Carex obnupta, slough sedge	wet to moist soil, full sun to part shade	shallow
Deschampsia caespitosa, tufted hairgrass	wet to moist soil, full sun	shallow
Eleocharis palustris, creeping spikerush	wet to moist soil, full sun	shallow roots
Geum macrophyllum, large-leaved avens	wet to moist soil, full sun to part shade	shallow
Juncus balticus, baltic rush	wet to moist soil, full sun	shallow
Juncus effusus, common rush	dry to wet soil, full sun to part shade	shallow
Juncus ensifolius, dagger-leaved rush	wet to moist soil, full sun to part shade	shallow
Juncus patens, spreading rush	wet to moist soil, full sun to part shade	shallow
Scirpus acutus, hard-stem bulrush	wet to boggy soil, full sun	shallow
Scirpus microcarpus, small-fruited bulrush	wet to moist soil, full sun to part shade	shallow
Sisyrinchium californicum, yellow-eyed grass	wet to moist soil, full sun to part shade	shallow
Typha latifolia, common cattail	boggy soil, full sun	shallow
Sagittaria latifolia, wapato	wet to boggy soil, full sun	shallow
PLANTS FOR WET, SHADY AREAS		
TREES		
Plant Species	**Cultural Requirements**	**Root Depth**
Acer circinatum, vine maple	wet to moist soil, full to part shade	deep roots
Rhamnus purshiana, cascara	dry to wet soil, full to part shade	deep roots
SHRUBS		
Plant Species	**Cultural Requirements**	**Root Depth**
Rubus spectabilis, salmonberry	wet to moist soil, full to part shade	medium depth
Symphoricarpos albus, common snowberry	wet to moist soil, full to part shade	medium
LOW-GROWING PLANTS		
Plant Species	**Cultural Requirements**	**Root Depth**
Athyrium felix-femina, lady fern	wet to mist soil, full to part shade	medium depth
Blechnum spicant, deer fern	dry to wet soil, full to part shade	shallow roots
Dryopteris austriaca, wood fern	wet to moist soil, full to part shade	shallow
Maianthemum dilatatum, false lily-of-the-valley	wet to moist soil, full to part shade	shallow
Polypodium glycyrrhiza, licorice fern	wet to moist soil, full to part shade	shallow
Polystichum munitum, sword fern	dry to wet soil, full to part shade	medium depth

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