Channel Assessment Procedure Field Guidebook

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Authority

> ***Forest Practices Code of British Columbia Act***
> ***Operational Planning Regulation***
> Part 3 (Forest Development Plans)

Contents

Appendices

List of figures

List of tables

Channel Assessment Procedure Field Guidebook

Table of Contents

Introduction

The channel assessment procedure (CAP) consists of both office and field work. The following is restricted solely to field assessments. The objective of the field guidebook is to collect the relevant data required to complete the CAP. Only the text and field forms directly relevant to field assessments are included; all supplemental information on methods, definitions and background context is included in the *Channel Assessment Procedure Guidebook*.

Field assessments are conducted in small and intermediate-sized channels; they are not usually required for large channels except to confirm aerial photograph assessments. Field work is done in all reaches along the mainstem where reaches could not be assessed on the aerial photographs (due to riparian vegetation canopies or shadows).

The CAP field assessment is based on determining the type of channel expected (given its location within the watershed and certain channel attributes), a set of field indicators of disturbance, and a series of diagnostic disturbance keys. In general, for those reaches identified on the aerial photographs as requiring field visits, complete the following steps.

1. Walk the stream reach and determine the average channel gradient (s), depth (d), bankfull width (W_b) and largest stone moved by flowing water (D).
2. Determine the appropriate channel type (based on s, d, W_b and D).
3. Refer to the correct series of diagnostic channel keys.
4. Using the field indicators, identify the types and level of stream disturbance present from the series of diagnostic channel keys.
5. Evaluate the overall disturbance level for the stream, using the keys to determine the specific level of disturbance and the survey lengths to calculate the spatial extent of disturbance.

Field procedure overview

The steps to complete a field assessment (Table 1) are as follows (all forms are located in Appendix 1). Details associated with each step can be found in the sections to follow.

1. Proceed to the downstream (or upstream) end of the reach identified on the aerial photograph as requiring field evaluations.

2. Measure bankfull channel width (W_b) at five locations spaced evenly along the reach and record on Field Form 1.

3. Measure channel depth (d), using a stadia rod, at five locations spaced evenly along the reach and record on Field Form 1.

4. Identify the largest sediment particle (D) on the channel bed at five locations spaced evenly along the reach, and measure the b-axis. Record on Field Form 1.

5. Measure the channel gradient (s), over a distance of several channel widths, at five locations spaced evenly along the reach. Record on Field Form 1.

6. Calculate D/W_b.

7. Calculate D/d.

8. Based on s and the ratios D/W_b and D/d, determine channel morphology using the nomogram. Record on Field Form 1.

9. Determine if large woody debris (LWD) is important to channel structure.

10. Refer to appropriate set of seven channel keys corresponding to the determined channel morphology (Appendix 2). For example, if the morphology is identified as a CP_c-w (cascade-pool morphology with predominately cobble bed and functional LWD), then the appropriate set of keys is found on pages 50 to 56.

11. Attach the hip chain thread at the beginning of the reach and begin the channel inventory, using the list of field indicators of disturbance and appropriate diagnostic keys. Walk upstream (or downstream) along the channel thalweg (deepest point along the cross-section if wading is possible) or along the bar tops if the water is too deep or the stream flow velocities are too fast for safe wading. Record the distance (from the hip chain) corresponding to the channel condition as determined from the list of field indicators of disturbance and appropriate keys. Record data on Field Form 1. For instance, if the reach is a RP_c, the distance corresponding to each level of disturbance is recorded. An example of the field form is as follows:

Distance (m)	Bank type	Channel type and disturbance level	Field indicators S1	S2	S3 ...	D3	Photo roll and frame
0-53	A3/4	RP_c:A2	☐	☑	☐	☑	R3:F7, 8
53-109	A3/4	RP_c:D1	☐	☐	☑	☑	R3:F9, 10

12. Refer to the "Field operational rules" section for directions to follow during the survey.

13. At each recording of channel type and disturbance level, determine predominant bank material type and record on Field Form 1 (see Field Form 1 for bank-type codes).

14. Continue the survey, recording all levels of disturbance to the end of the reach. Continue to refer to the "Field operational rules" section.

15. Repeat the procedure in the next reach.

16. Continue to the end of all reaches requiring field inspection.

Table 1. Summary of the field procedure

Task Field form	Refer to figure(s)	Field form
1. Measure:		
W_b	2	1
d	3	1
D	4	1
s	–	1
2. Calculate:		
D/W_b	5 & 6	–
D/d	5 & 6	–
3. Determine:		
Type of morphology	5 & 6	1

	Importance of LWD	7	–
4.	**Inventory:**		
	Bank material	–	1
	Level and extent of disturbance	8 & Appendix 2	1
5.	**Summarize:**		
	Level of disturbance associated with each reach	–	2

Disturbance level analysis

The steps to assess the level of disturbance are as follows.

1. Summarize the inventory information collected by completing Field Form 2.
2. Calculate the percentage of the reach in each disturbance class.
3. Sum the percentage of the reach in moderate and severe disturbance classes.
4. Weight the percentage of the reach in both moderate and severe disturbance classes by the total length of the reach.
5. Sum the weighted length of disturbed stream channel for each reach assessed in the field and enter the result on Form 8 of the *Channel Assessment Procedure Guidebook*.

Field operational rules

During any field survey there are always numerous decisions to be made; it is important that these decisions are made in a consistent manner. The following operational rules will make field surveys easier by removing procedural ambiguities.

1. Minimum stream survey length is 1 W_b (no change in level of disturbance will be identified and recorded unless the section of channel with a different level of disturbance exceeds 1 W_b).

2. Maximum distance along a channel without an assessment is 10 W_b (even if there is no change in the level of disturbance, an assessment, including the listing of disturbance code, field indicators and photographs looking upstream and downstream, must be made every 10 W_b). This rule is ± 1 W_b; if a distance of 10 W_b has been reached but it is evident that a change in disturbance level occurs at, or before, the 11 W_b distance, then it is acceptable to miss the 10 W_b and proceed to the 11 W_b.

3. It is acceptable to break reaches, as determined from aerial photographs, into shorter reaches, based on field examinations. Because of the resolution of aerial photographs, it is possible that a

reach may need to be divided into two or more shorter segments if field conditions warrant (based on changing s, D, d, W_b). The new reaches should be identified as a subset of the reach that is being subdivided (e.g., Reach ;B is broken into Reach B.1 and B.2).

4. As in Rule 1, if a different *type* of channel is encountered (e.g., changing from a RP_g to a RP_c, or from a RP_c to a CP_c), it must extend for more than 1 W_b to be included as a distinct type (i.e., if the different channel type is <1 W_b it will not be inventoried).

5. If a different type of channel is encountered (e.g., changing from a RP_g to a RP_c, or from a RP_c to a CP_c), and it extends for more than 3 W_b, then a new reach must be designated.

6. If a channel type not considered in the assessment is encountered (e.g., a bedrock waterfall–drainage network classification code CB3aii), and it is -3 W_b in length, it is listed as such on Field Form 1. The total stream length includes these entries (i.e., the total length of the channel used to calculate the percentage of disturbed channel morphology includes lengths of channel not assessed by this procedure). The level of disturbance assigned to these channels is "none" so they will not influence the overall reach rating.

7. If, as in Rule 5, a channel type not assessed by the CAP (e.g., CB3aii) extends beyond 3 W_b in length, a new reach must be designated and assigned a channel class according to Figure 1.

8. If a survey proceeds from a single channel into zones with multiple channels, the survey is to follow the thalweg (follow the branch with the deepest channel, and usually highest discharge).

Figure 1. Drainage network classification (details are presented in Appendix 3).

Field measurements and diagrams

The main field measurements required for the CAP are channel gradient, bankfull channel width, and depth and size of the largest stone on the bed that is moved by flowing water. The relative channel size and morphological type are based on these measures. Morphological type is determined by the relative roughness (D/d), relative width (D/W_b), and slope of the channel. Measurements are made at five locations spaced evenly along the reach (i.e., at the begining and end of the reach with three locations between). Fewer measurements may be made if the assessor is an experienced geomorphologist with extensive knowledge of fluvial forms. If competent professional judgement is used to determine the morphological type, the number of field measurements is left up to the assessor.

Channel slope

To measure channel gradient:

- Use a hand-held inclinometer (e.g., Suunto level) and measure the slope (±0.5%) over the longest length of channel possible (greatest distance visible between field workers); a minimum length of several channel widths should be used for each measurement.

- Level shots should be taken between two field workers, each standing at the water's edge and sighting on the point of the other individual, with the same distance to the ground (eye to eye for individuals of same height, eye to chin for individuals 10 cm different in height, etc.).

- The distance between individuals, over which the gradient is being measured, should be approximately the same for each of the five measurements.

Channel width

To determine the channel bankfull width (Figure 2), measure W_b using a fibre tape and measuring to ±0.1 m.

Figure 2. Identifying bankfull width (after Church 1992). In this schematic, the lower limit of perennial terrestrial vegetation is used to define the left banktop while the right banktop is defined by a terrace (old elevated floodplain surface).

A number of standard criteria can be used to determine W_b in the field (after Leopold 1994). Only those relevant to the field site need be used. Look for:

- a change in vegetation from bare ground with no trees to vegetated ground with trees, from no moss to moss-covered ground, or from bare ground to grass-covered ground, particularly in range lands

- a topographic break from vertical bank to flat floodplain

- a topographic break from steep bank to more gentle slope

- the highest elevation below which no fine woody debris (needles, leaves, cones or seeds) occurs

- a change in texture of deposited sediment from clay to sand, or sand to pebbles, or boulders to pebbles.

Channel depth

To determine the channel depth:

- Measure the depth (using a stadia rod) at five locations along the reach (measurements are made at a riffle-pool or step-pool break; see Figures 3a and 3b).

- Place the stadia rod on the channel bed at the break (between either riffle or step) and, holding the stadia rod vertical, estimate the height of bankfull stage using the hand level to sight off the bank (read the stadia rod at the point that corresponds to level from bankfull height).

- Measurement should be to the nearest 10%. For instance, if the channel depth is 1 m, then measurement to ±10 cm is appropriate. If the depth is only 10 cm, then the measurement should be ±10 mm.

- Channel depth should be measured at the thalweg (generally, the deepest portion of the channel).

Figure 3. Locations used to determine channel depth. (a) Illustration of step-pool morphology and location to determine channel depth (d). Depth is estimated at the step-pool break from the thalweg to the height of bankfull conditions. Note that D/W_b in this schematic is approximately equal to 0.3.
(b) Illustration of riffle-pool morphology and location to determine channel depth (d). Depth is estimated at the riffle-pool break from the thalweg to the height of bankfull conditions. Note that D/W_b in this schematic is 0.01.

Largest stone moved by flowing water

To determine the size of the largest sediment particle on the channel bed:

- Locate the five largest stones at a cross-section and measure the b-axis (intermediate length) diameter of each (see Figure 4). Select the median value for analysis.

- Measurements need be to the nearest 10%. For instance, if the largest stone is 1 ;m in b-diameter, measurement to ±10 cm is appropriate. If the largest stone is 10 cm, the measurement should be ±10 mm.

- The largest stone does not include large lag boulders deposited during periods with very different streamflow regimes (e.g., immediately post-glacial) or those that have fallen into the channel from surrounding glacial moraines or colluvial fans/cones.

- The largest stone should not be covered in old moss and organic stains and should be rounded or sub-rounded but not angular. It should have evidence of movement by flowing water during the past decade, that is, it should be incorporated into the channel bed (other sediment knitted around the larger stones) and not be an isolated stone distinctly different than all others in the near vicinity (within several bankfull widths, upstream and downstream). Note, however, that in extremely stable CP or SP morphologies (i.e., the channel has not reformed in the last century), the entire bed may be covered in moss.

Figure 4. Illustration of the largest stone moved by flowing water, relative width, and relative roughness used to determine channel size.

Channel Assessment Procedure Field Guidebook

Table of Contents

Determining the type of channel morphology

The seven channel types used in the CAP are summarized in Table 2. The type of morphology is determined by using the field measures, nomogram (Figure 5), and by referring to Figure 6. First, the relative width is calculated by entering the measured values of D and W_b on Graph 1 of Figure 5. Second, the relative roughness is determined by entering the measured values of D and d on Graph 2. Third, the respective D/Wb and D/d values are transferred onto Graph 3, which calculates their product. Finally, the product of D/W_b and D/d is transferred onto Graph 4, with the intersection of this value and s giving the type of channel morphology. If the point of intersection between s and $(D/W_b)(D/d)$ does not lie on the diagonal line, follow the shortest line distance back to the shaded band.

Table 2. Channel types and associated characteristics

Code	Morphology	Sub-code	Bed material	LWD
RP	riffle-pool	RP_g-w	gravel	functioning
RP	riffle-pool	RP_c-w	cobble	functioning
CP	cascade-pool	CP_c-w	cobble	present, minor function
CP	cascade-pool	CP_b	boulder	absent
SP	step-pool	SP_b-w	boulder	present, minimal function
SP	step-pool	SP_b	boulder	absent
SP	step-pool	SP_r	boulder-block	absent

Figure 5. Nomogram used to determine channel morphology.

Figure 6. Channel morphologies of small- and intermediate-sized channels.

As an example of the use of Figure 5, use:

D = 10 cm

d = 120 cm

Wb = 20 m

s = 1.5%

Following the lines in the nomogram produces a riffle-pool morphology with predominately gravel-textured materials (RP_g). Large woody debris (LWD) is important in these channel types (see Figure 7).

Figure 7. Determining the influence of LWD on channel morphology.

If either the CP or SP morphologies are determined from Figure 5, it is necessary to determine if LWD is expected in the particular channel. The importance of LWD to channel functions depends on the width of the channel (also stream power, but this is considered implicitly in Figure 5). The functional role of LWD is given in Figure 7. For instance, if a channel is determined to be cascade-pool morphology, from Figure 7 it is apparent that when the channel is less than 30 m wide, LWD should be present. When the channel is wider than 30 m, LWD is present but not functioning. (Note that since LWD characteristics are to be used as field indicators of disturbance, it is necessary to know when LWD should, or should not, be present in channel.)

The nomogram is a tool to assist in determining the type of channel morphology. If, in the field, the nomogram indicates a type of morphology that appears incorrect, the field measures should be re-taken. For instance, if a step-pool morphology is determined from Figure 5, but the channel is clearly a riffle-pool morphology, the field values used (with emphasis on channel slope) should be checked.

Evaluating channel disturbance

Each of the three main channel morphologies assessed in the field (step-pool, cascade-pool, riffle-pool) respond differently to disturbances caused by changes in streamflow discharge and sediment/debris loads. In general, the nature of the morphological disturbance expected is associated with channel degradation and aggradation (Figure 8 and Appendix 2).

Figure 8a. Small-sized channel morphology matrix showing levels of disturbance (degradation and aggradation).

Figure 8b. Intermediate-sized channel morphology matrix showing levels of disturbance (degradation and aggradation).

Field indicators

Field evidence of channel degradation and aggradation is summarized in Figure 9. The changes in sedimentological characteristics are related to both sediment supply and transport limitations. Bank impacts are related to recent erosion as evidenced by collapsing or freshly removed materials. Morphological features considered are primarily the relative abundance of pools and steps or riffles.

Disturbances associated with LWD are assessed by considering the functional role of debris in controlling the morphology (see Hogan et al., in press, for additional details concerning LWD functions). In certain channels, LWD controls the patterns of sediment erosion and deposition within the channel zone. The channel will adjust to any change if LWD is altered in its dimensions, orientation, or storage patterns. LWD plays an insignificant stream-forming role in other channel types (Figure 7).

Figure 9a. Field indicators of channel disturbance-sedimentological features.
Figure 9b. Field indicators of channel disturbance-bank features.
Figure 9c. Field indicators of channel disturbance-morphological features.
Figure 9d. Field indicators of channel disturbance-LWD features.

Channel keys

The field indicators of disturbance described in Figure 9 are used together with the diagnostic keys (Appendix 2) to determine the level of disturbance present along a reach of a particular channel type. The keys integrate all the individual properties of disturbance and incorporate the field indicator evidence to show the overall disturbance pattern. Without the keys it would be necessary to physically measure the attributes of disturbance (many of which are problematic due to streamflow stage dependency), and then compile these in some statistically rigorous way to determine the overall level of channel disturbance.

Several points should be noted concerning the channel keys. First, the keys are organized so that the undisturbed channel is located in the middle of each set of channel types. Three levels of aggraded channels are found in front of the undisturbed channel and three levels of degraded channels are located after the undisturbed channel. This series shows the progression of channel changes that occur if sediment and/or water quantity are increased (aggrading, for example, downstream of a landslide entry point to the channel) or decreased (degrading, for example, downstream of a barrier to sediment transport, such as a landslide-dammed channel). This series is given in Appendix 2. The three levels represent degrees of disturbance severity.

Second, the text associated with each channel disturbance level often indicates that a feature is becoming "more," "less," "coarser," "finer," etc. These terms refer to the progression of changes away from the undisturbed state (e.g., see title page of each channel type in Appendix 2). They indicate the sequence of changes that make up the disturbance.

Third, the keys provide generalized, typical examples of channel conditions along a reach. They are not intended to be exact duplicates of the conditions encountered (do not expect your field situation to be exactly the same as conditions shown in the keys). Finally, the "typical field indicators" listed in the keys do not have to be found in every case for that particular level of disturbance to be assigned. The indicators are included to show which indicators should, but not must, be present for the level of disturbance.

In the field, the morphology of each reach is determined according to the channel attributes measured in the field and with Figure 5. The level of disturbance is then assessed by inventorying the field indicators of channel disturbance and reviewing the deviation from the stable state, as shown in Appendix 2. All data are recorded on Field Form 1, and the proportion of each reach with disturbed morphology is calculated on Field Form 2. Finally, the information summarized on Field Form 2 is transferred to Form 8 of the *Channel Assessment Procedure Guidebook*.

Field equipment

Recommended field equipment for conducting the CAP include:

- map and aerial photographs showing channel reaches to be evaluated in the field
- field guidebook and notebook
- chest waders
- 50 m fibre tape measure
- pocket tape measure
- surveyor's hip chain
- hand-held level (e.g., Suunto clinometer)
- stadia rod
- 35 mm camera and 400 ASA (or faster) film
- channel "types" and "keys" (Figure 8 and Appendix 2).

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Channel Assessment Procedure Field Guidebook

[Table of Contents]

Appendix 1.

Field forms

The blank field forms that follow are to be used to make copies for field use. These should be copied onto water-proof paper with enough copies to complete the assessment.

Field Form 1. Field data.
Field Form 2. Disturbance summary.

Channel Assessment Procedure Field Guidebook

[Table of Contents]

Appendix 2.

Diagnostic channel keys

Riffle-pool: RP_g-w

Degraded	Stable	Aggraded
Morphology:		
Extensive riffles and runs	Repeating riffle-bar-pool sequences	Extensive riffles, runs and bars
Small shallow pools(due to erosion of riffle crests)	Diverse pool size, shape, and depth	Small, shallow pools (due to depositional infilling)
Pools represent approximately 15% of the channel	Pools represent 50-70% of the channel	Pools represent approximately 15% of the channel
One main channel	One or two main channels	Multiple channels on braided bed surface
Simple, uniform riffle and run shapes	Diverse riffle shapes	Simple, uniform riffle and run shapes (minimal depth variability)
Limited side-channel bars	Mainly diagonal and point bars	Mainly mid-channel bars elevated above surrounding bank tops
Bed sediment:		

Mainly cobbles and coarser textures	Gravel and cobble	Mainly gravel and finer textures
Banks:		
Mainly cobbles and gravel	Mainly cobbles, gravel, and sand	Mainly gravels, sand, and cobbles
Banks primarily sloping and/or overhanging	Large proportion of vegetated undercut or overhanging banks	Extensive bank erosion (commonly complete absence of undercut banks)
LWD:		
Limited. Any LWD present is small, oriented parallel to the banks, and elevated above the channel	Abundant. Most LWD is incorporated into the channel and oriented perpendicular to the banks	Absent or buried. Any LWD present is small and oriented parallel to the banks

Channel Assessment Procedure Field Guidebook

[Table of Contents]

Appendix 3.

Drainage network classification

This appendix includes a modified version of Appendix 11 in the fifth report of the Scientific Panel for *Sustainable Forest Practices in Clayoquot Sound, Sustainable Ecosystem Management in Clayoquot Sound: Planning and Practices* (Anon, 1995). Several physical dimensions have been altered to be consistent with other Forest Practices Code documents. The classification units changed here are intended to avoid some of the operational difficulties encountered in the field. Wherever possible, the original definitions used in the Clayoquot Sound report are retained.

Bases for classification (from the Clayoquot Sound report 5)

The hydroriparian classification in the Clayoquot Sound report 5 has been modified for use with the CAP and is referred to here as the drainage network classification (Figure 1).

The most basic division is defined by the nature of the water body, because this fundamentally determines the nature of the associated ecosystems. Lotic (streams), lentic (standing fresh water), and marine are the basic units; the latter is not considered here.

Within stream channels, the most basic division is between erodible and non-erodible channels. Erodible channels flow through either their own alluvium deposits or materials erodible by flowing water, such as lacustrine, marine and certain colluvium deposits. Non-erodible channels are non-alluvial channels — those flowing on bedrock or on sediments not normally eroded by the contemporary stream flow. This corresponds with the criterion of confinement, because an unconfined channel always flows with at least one erodible (alluvial) bank. The next most important criterion is stream gradient, because this determines important aspects of fluvial processes and morphology. A third criterion is entrenchment; entrenched channels are confined within fluvially eroded gullies or valleys of some depth. A final criterion is stream size, which influences some of the physical and biological processes.

Within the class of erodible stream channels, the definition of a "floodplain" presents some difficulty. The generic definition — the surface of a body of sediment deposited by the stream — ignores whether a change of stream regime has led to degradation and consequent development of a terrace (which is not subject to inundation). The difference is ecologically significant. A definition based on the possibility of inundation occurring needs some qualification about the frequency of inundation, but it is not practically applicable in terrain analysis procedures. The best discriminators probably are the presence of indicator plant species in the understorey and immature cumulic soils, which can be decided definitively at the stage of field checking. Adopting such discriminators requires local guidelines.

Lentic freshwater environments are divided according to whether the environment is permanently open water more than 1 m deep (a lake) or is a wetland. A second distinction is the nature of the lacustrine ecosystem: oligotrophic lakes have relatively poor nutrient status. Wetlands are further classified as fen, marsh, swamp, or bog. Another criterion is water body size. As in streams, this determines some of the physical and biological processes between the water body and adjacent land.

Classification

Stream (lotic environment)

C — Stream channels

A. Erodible channels
An erodible channel has a flanking floodplain, including estuarine channels in deltas, and alluvial fans (also called fluvial fans):

1. gradient less than 8 per cent

(i) channel width less than 1.5 m
(ii) channel width between 1.5 m and 20 m
(iii) channel width greater than 20 m

Notes: Channels with gradient less than 8 per cent (4.6°) have primary morphological units consisting of pools separated by riffles or extended rapids. Anadromous salmonids are found in these channels. Channels with gradients greater than 8 per cent, up to 20 per cent (5-11.3°), have step-pool morphology. Resident fish may be present.

2. gradient greater than 8 per cent
(i)-(iii) width criteria as in Al.

Operational rules:

1. A channel with one erodible bank and one non-erodible bank is classified as erodible. The bed need not be erodible, but a non-erodible bed with contemporaneously active erodible bank will be rare.

2. A channel with non-erodible banks but erodible bed is classified as erodible. The intent is to identify channels that can be disturbed by forestry activities. Channels that clearly cannot be disturbed are non-erodible. Those that clearly can or could undergo changes (step-pool sequences) are erodible.

3. If a reach is classified as erodible, but a non-erodible segment is encountered along the reach, the reach class will not change if the non-erodible segment is $\leq 1W_b$. If the non-erodible channel extends for between 1 and 3 bankfull widths, the segment is noted, but the reach class remains

erodible. If the segment extends for $\geq 3W_b$, then the reach class is changed to non-erodible for the extent of the segment.

4. In Type 1 (C1), many channels less than 1.5 m wide will be secondary channels on floodplains, which will be incorporated into the unit defined by the main channel. Type 2 (C2) will usually be alluvial fans; in Type 2 (C2), width criterion (iii) is rare.

B. Non-erodible channels

1. gradient less than 8 per cent

a) not entrenched

(i)-(iii) width criteria as in Al.

b) entrenched

(i)-(iii) width criteria as in Al.

Notes: These may include fairly large channels that have degraded and now flow between terraced banks on lag armour (unconsolidated material — typically cobbles or boulders — that the stream cannot move and that is not alluvial in the current regime). An entrenched channel, as the result of fluvial erosion, is continuously confined within banks sufficiently high that overflow may not occur. Gullies, ravines, and bedrock gorges are typical entrenchment landforms.

2. gradient in the range 8-20 per cent

a) not entrenched

(i)-(iii) width criteria as in A1.

b) entrenched

(i)-(iii) width criteria as in Al.

Notes: Class (a) streams will principally have steep alluvial fans. In this gradient range, width class (iii) streams probably are non-existent. Most debris flows stop in this gradient range.

3. gradient greater than 20 per cent

a) not entrenched

(i) seasonal or perennial

(ii) ephemeral

b) entrenched

Notes: Although streams in class (3) are steep, they maintain water quality downstream and serve as animal travel routes and the site of riparian herbs and shrubs-including some with otherwise limited distribution. Fish are not normally present. Gradient is usually bedrock-controlled. In (a), one will classify mainly seasonal to ephemeral rills on hillsides. In (b), one will classify mainly gullies but could include sizable rivers cascading down bedrock-controlled channels from hanging valleys. Stream width is usually less than 1.5 m. Gully floor width is more significant than channel width, but usually will not be critical for processes. Debris flows may start and will be maintained on these gradients. An upper limit for stream channel gradients (other than cascades and waterfalls on bedrock) is 60 per cent.

Operational rules:

1. Both channel banks and the bed must be non-erodible for the stream to be classed as such. If one bank is erodible (alluvial) and one bank non-erodible, or the banks are non-erodible but the bed is erodible, then the reach is classified as erodible.

2. If a reach is classified as non-erodible, but an erodible segment is encountered along the reach, it will not change the reach class if the erodible segment is $\leq 1W_b$. If the erodible channel extends for between 1 and 3 bankfull widths, the segment will be noted but the reach class remains non-erodible. If the segment extends for $\geq 3W_b$, then the reach class is changed to erodible for its extent.

C. Artificial channels

Artificial channels have been modified by engineering works. This commonly involves channelization, rip-rap bank protection, long culverts or other human activity.

Operational rules:

1. The artificial channel must extend for $\geq 3W_b$ to be classed as such. If a reach is classified as either erodible or non-erodible, but an artificial channel segment is encountered along the reach, it will not change the reach class if the non-artificial segment is $\leq 1W_b$. If the artificial channel extends for between 1 and 3 bankfull widths, the segment will be noted but the reach class remains unchanged. If the segment extends for $\geq 3W_b$, then the reach class is changed to artificial for its extent.

Standing waterbodies and wetlands (lentic environment)

L - Lakes

A. Oligotrophic

(i) sand or gravel beach
(ii) low, rocky shore
(iii) cliffed or bluffs
(iv) wetland shore

B. Non-oligotrophic

W - Wetlands

(i) shallow open
(ii) marsh
(iii) fen
(iv) swamp

(v) shrub-carr
(vi) wet meadow

Notes: Shallow open water denotes ponds and sloughs with submerged aquatic plants, and water less than 2 m deep in midsummer.

A marsh has free-standing water with emergent vegetation or remains waterlogged throughout the growing season.

A fen (minerotrophic mire) is a wetland with limited peat accumulation, maintained by groundwater and runoff. Fens often occur as shoreline wetlands peripheral to lakes, ponds, and low-gradient streams.

A swamp is a forest or high shrub mineral wetland or peat land that is periodically flooded. Swamps include sparse, open-canopy to closed-canopy forests of mixes of western redcedar, red alder, and shore pine (the latter is more commonly associated with bogs). Most of the surface is usually submerged, but there are periods when the soil may be dry and aerated.

Very poorly drained, sparsely forested swamps are characterized by western redcedar, yellow-cedar (increasingly at higher montane to subalpine elevations), red alder, crabapple, salmonberry, stink currant, skunk cabbage, and giant horsetail, all of which are culturally important. The poorly drained, closed-canopy forested swamps vary less, with predominant western redcedar and an understorey of western hemlock, both growing on raised microsites of accumulated rotting wood.

Minor vegetation includes skunk cabbage growing in wet, mucky organic materials in depressions between the drier hummocks. On the minor hummocks grow minor vegetation similar to that of mesic sites-Vaccinium spp., Comus canadensis, Hylocomium spiendens, Rhytidiadelphus loreus, etc. This latter type is properly classified as a western redcedar swamp forest, but is not generally recognized as such.

Shrub-carr is a shrub-dominated wetland, developed on mineral soils, that is periodically saturated, but rarely inundated.

A wet meadow is a herbaceous wetland that is rarely inundated. The latter two types are not waterlogged in the growing season. All foregoing types (i) to (vi) are fed by inflowing surface or groundwater.

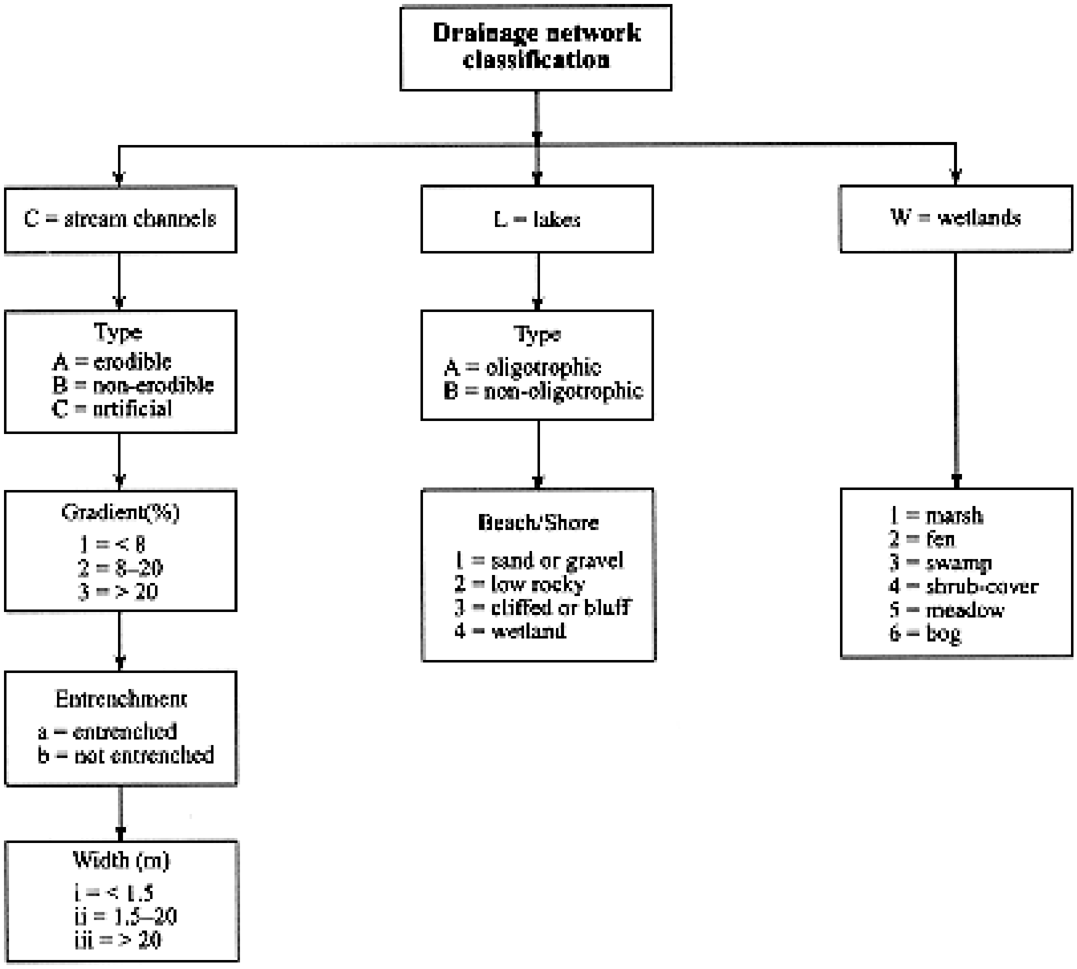
A bog (ombrotrophic mire) is a peat accumulation that has grown above the local water table, so that the water in the upper peat is sustained by precipitation.

These definitions are consistent with the *Proposed Wetland Classification System for British Columbia* (Kistritz and Porter 1993).

Channel Assessment Procedure Field Guidebook

[Table of Contents]

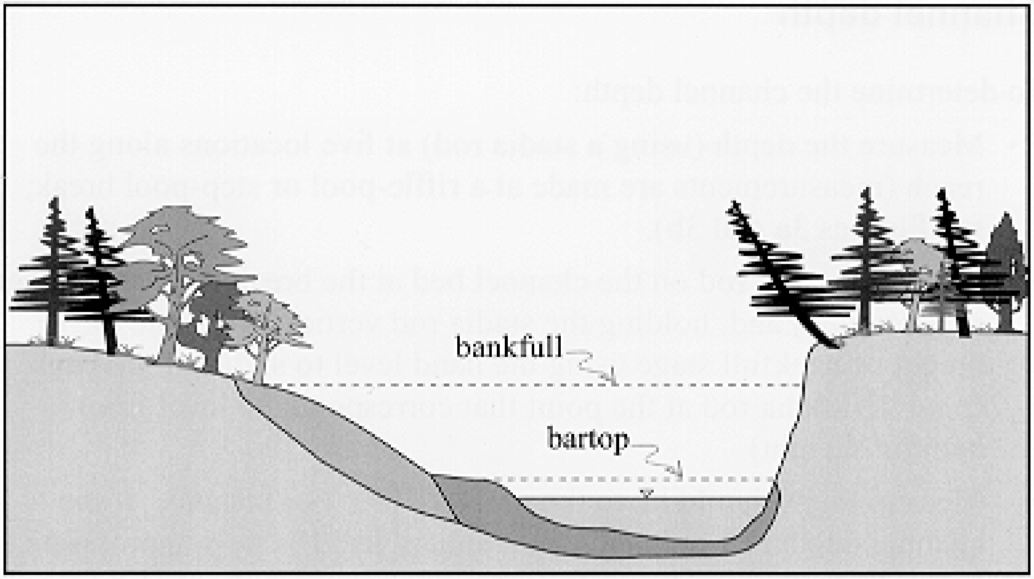
Figure 1. Drainage network classification (details are presented in Appendix 3).



Channel Assessment Procedure Field Guidebook

[Table of Contents]

Figure 2. Identifying bankfull width (after Church 1992). In this schematic, the lower limit of perennial terrestrial vegetation is used to define the left banktop while the right banktop is defined by a terrace (old elevated floodplain surface).



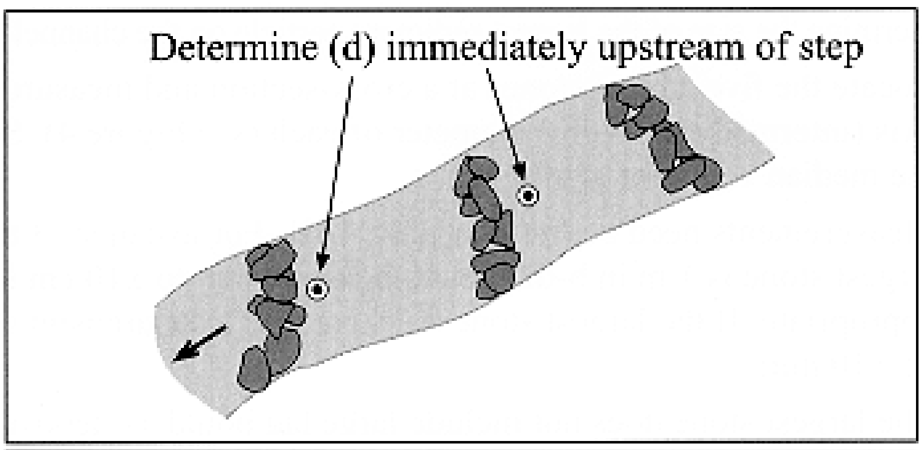
Channel Assessment Procedure Field Guidebook

[Table of Contents]

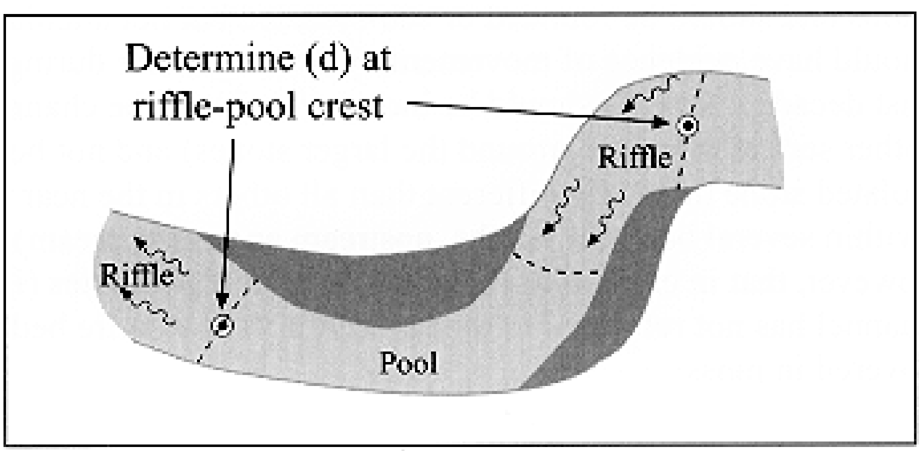
Figure 3. Locations used to determine channel depth.

(a) Illustration of step-pool morphology and location to determine channel depth (d). Depth is estimated at the step-pool break from the thalweg to the height of bankfull conditions. Note that D/W_b in this schematic is approximately equal to 0.3.
(b) Illustration of riffle-pool morphology and location to determine channel depth (d). Depth is estimated at the riffle-pool break from the thalweg to the height of bankfull conditions. Note that D/W_b in this schematic is <0.01.

(a) Step-pool morphology



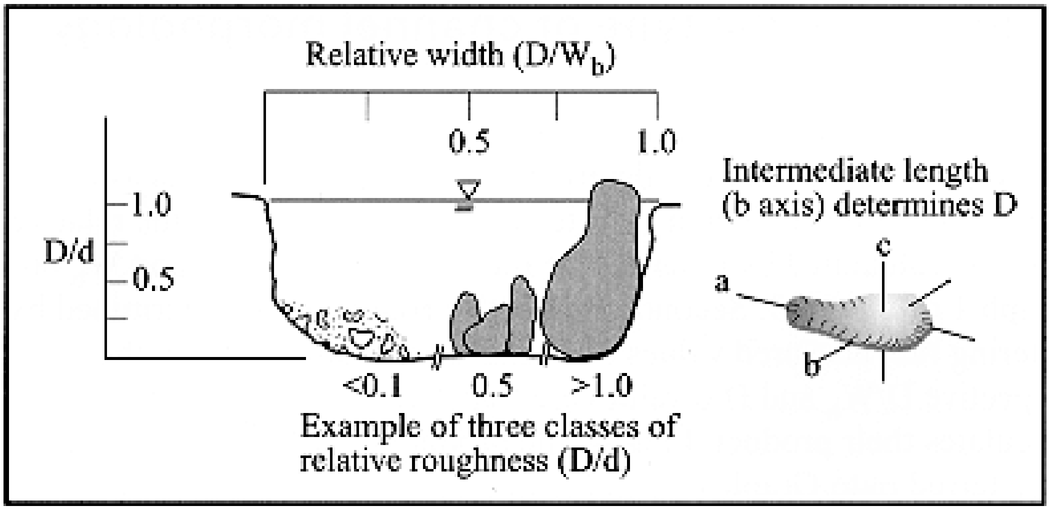
(b) Riffle-pool morphology



Channel Assessment Procedure Field Guidebook

[Table of Contents]

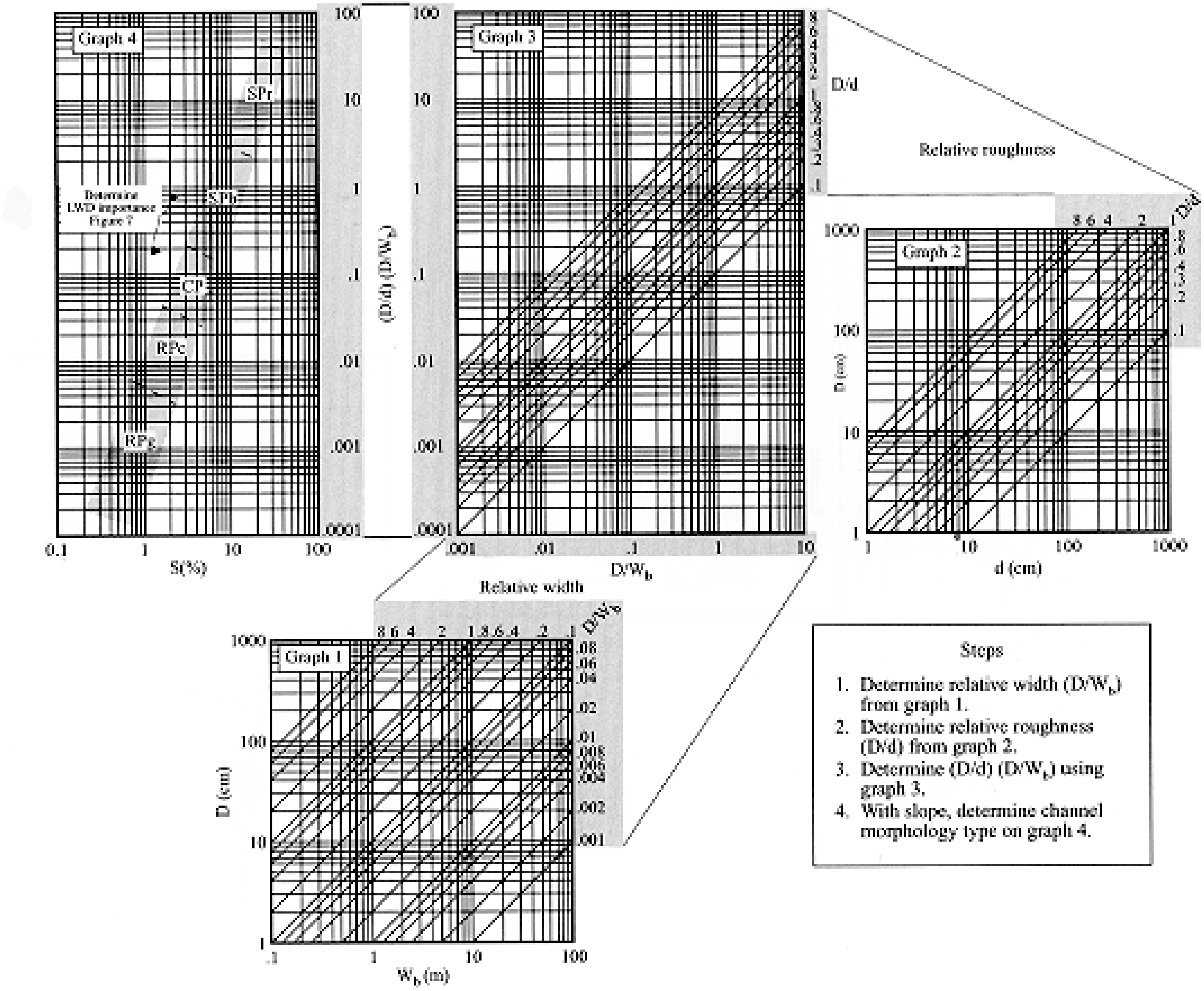
Figure 4. Illustration of the largest stone moved by flowing water, relative width, and relative roughness used to determine channel size.



Channel Assessment Procedure Field Guidebook

[Table of Contents]

Figure 5. Nomogram used to determine channel morphology.

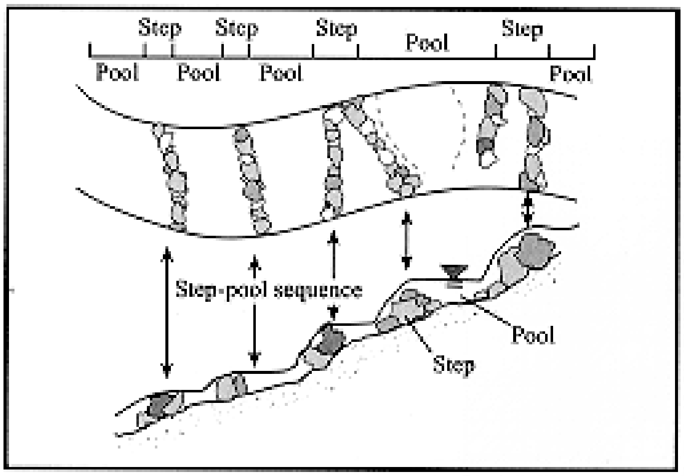


Channel Assessment Procedure Field Guidebook

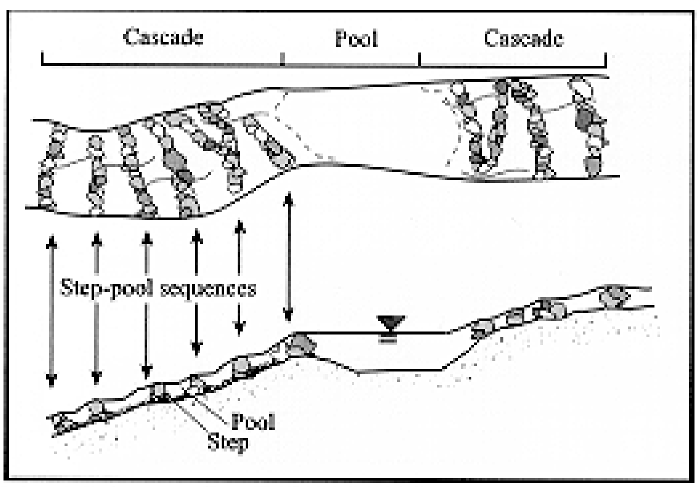
[Table of Contents]

Figure 6. Channel morphologies of small- and intermediate-sized channels.

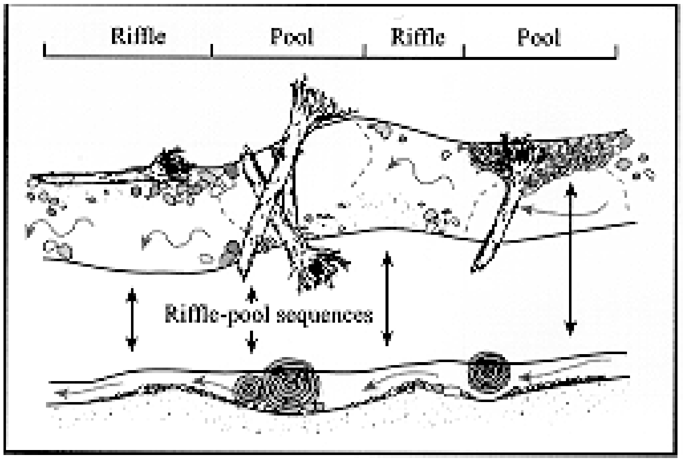
a) Step-pool morphology (SP_r SP_b and SP_b-w; after Church 1992)



b) Cascade-pool morphology (CP_c and CP_b; after Grant *et. al.* 1990)



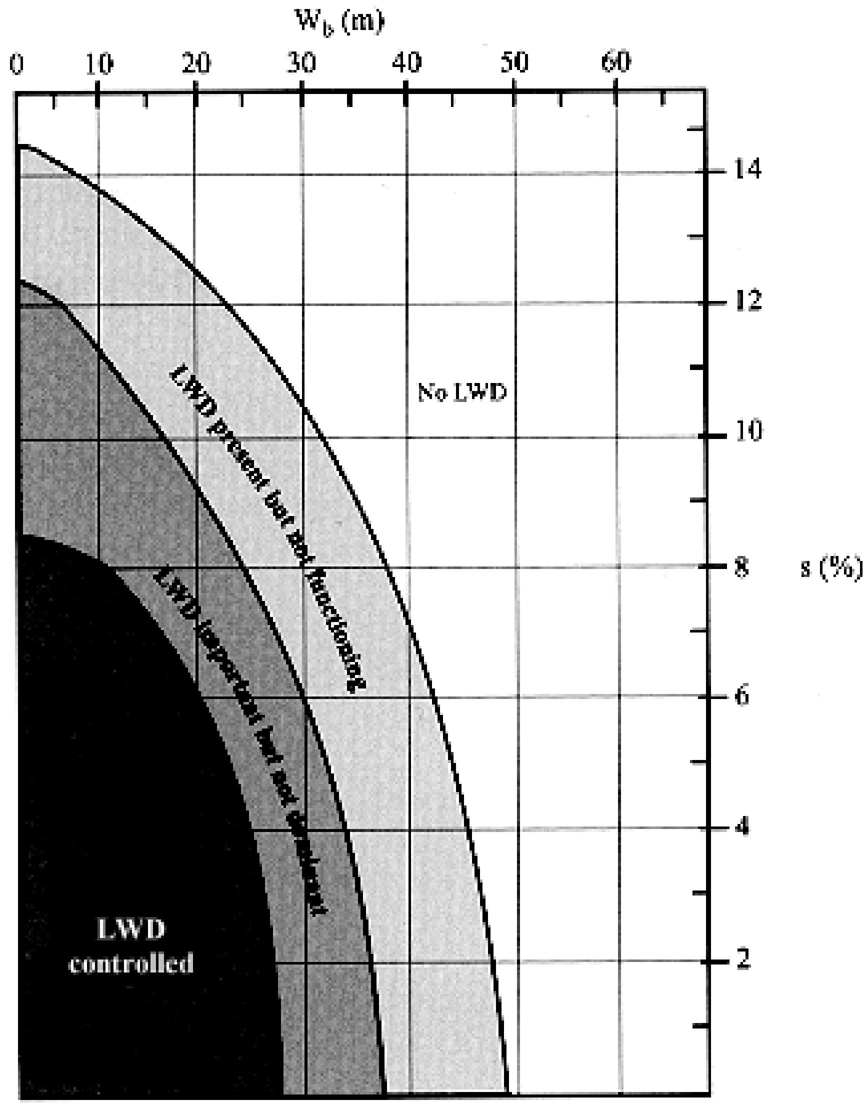
c) Riffle-pool morphology (RP_g and RP_c)


Riffle
Pool
Riffle
Pool
Riffle-pool sequences

Channel Assessment Procedure Field Guidebook

[Table of Contents]

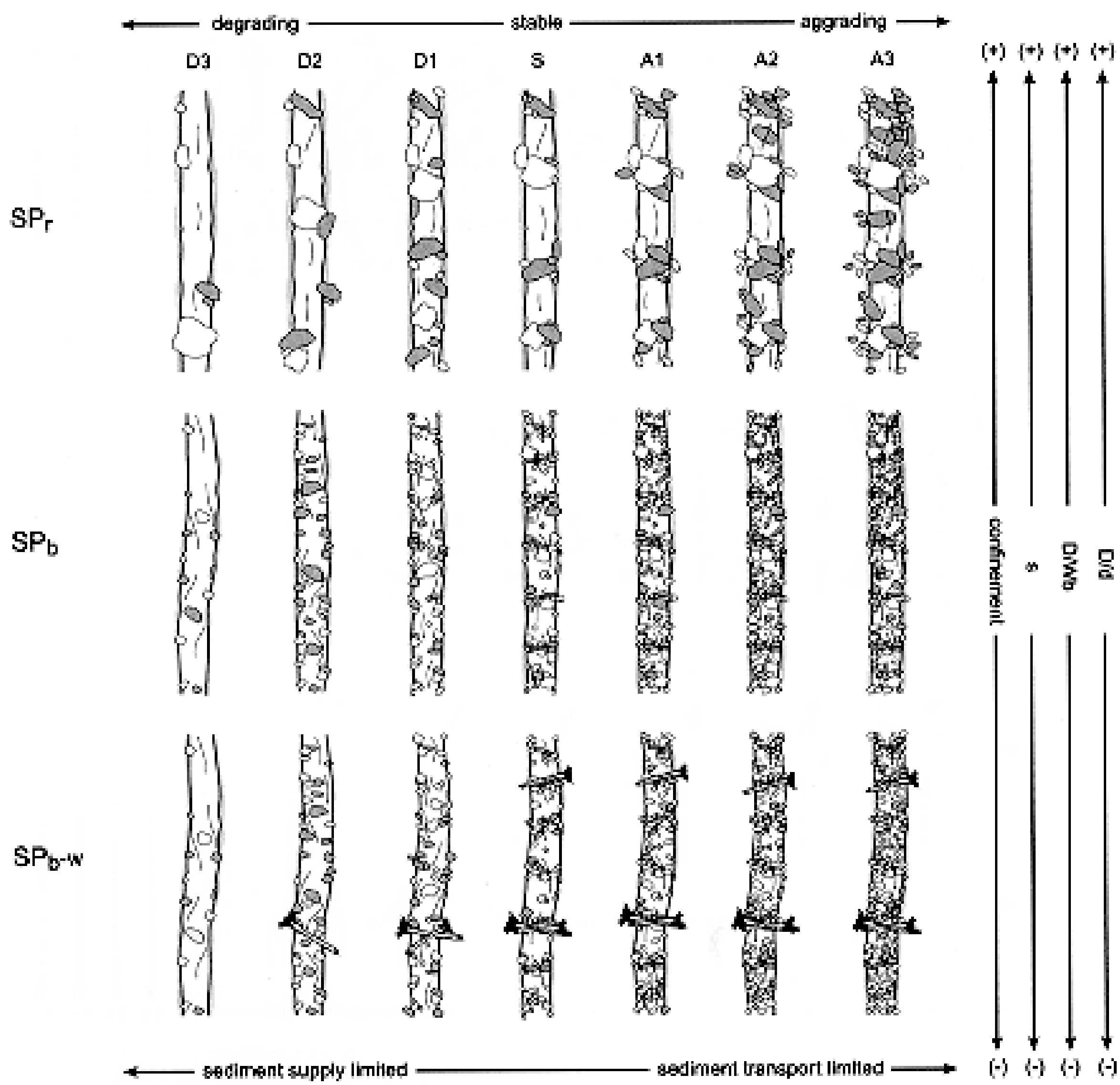
Figure 7. Determining the influence of LWD on channel morphology.



Channel Assessment Procedure Field Guidebook

[Table of Contents]

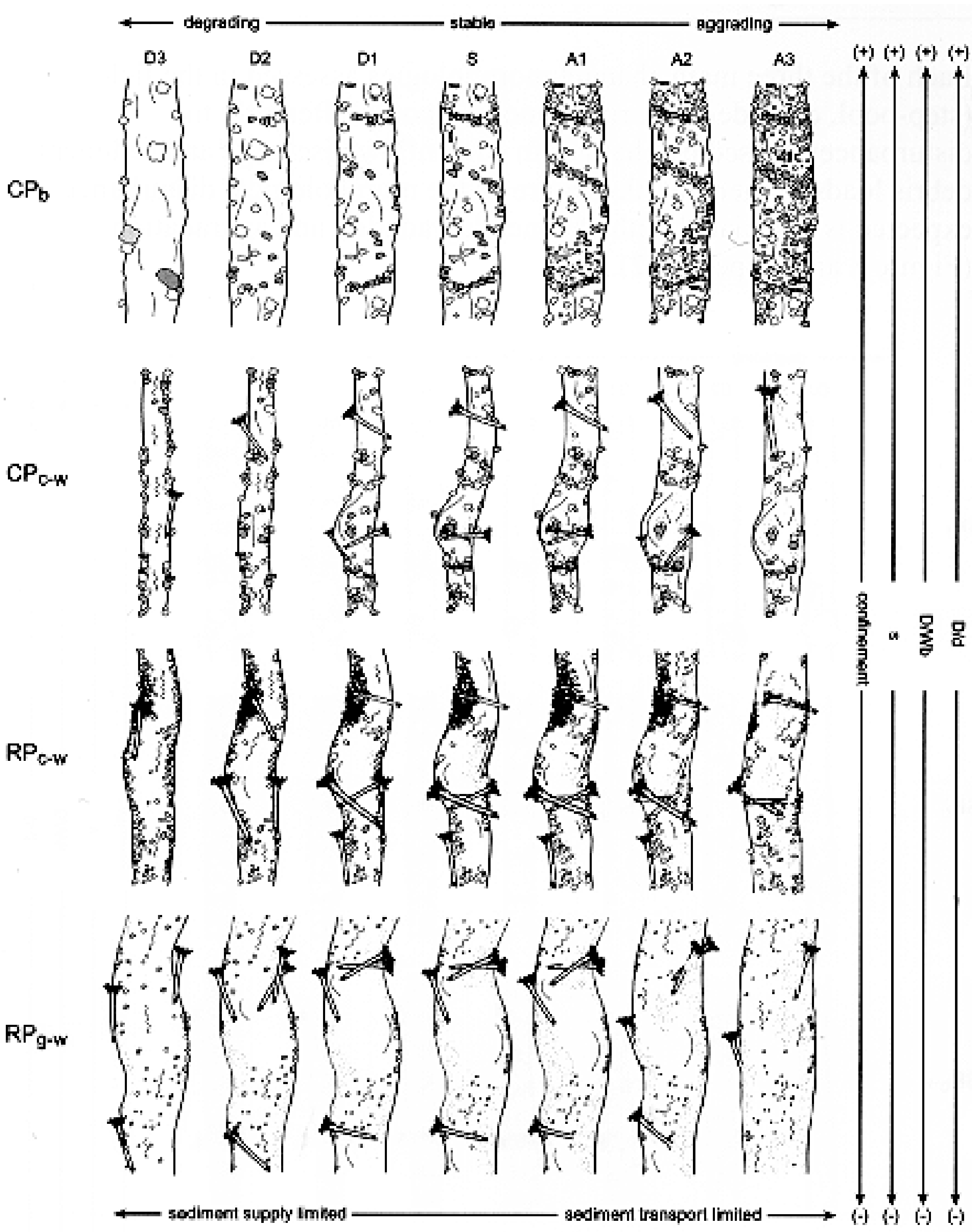
Figure 8a. Small-sized channel morphology matrix showing levels of disturbance (degradation and aggradation).



Channel Assessment Procedure Field Guidebook

[Table of Contents]

Figure 8b. Intermediate-sized channel morphology matrix showing levels of disturbance (degradation and aggradation).



Channel Assessment Procedure Field Guidebook

[Table of Contents]

Figure 9a. Field indicators of channel disturbance-sedimentological features.

Field code	Description	Typical photograph
Field indicators: sedimentation		
S1	Homogeneous bed texture. The channel bed and bars exhibit minimal sediment textural variability. (Sediment sorting is influenced by changes in LWD characteristics —low variability means that sediment is all similarly sized, regardless of actual texture.) Occurs in both aggrading and degrading channels (typical of RP morphologies).	
S2	Sediment fingers. Long linear fingers or stripes of fine-textured sediment (commonly coarse sand in cobble-gravel bed streams) extend longitudinally along the channel bed. Typical of aggrading intermediate and large channel morphologies.	
S3	Sediment wedges. The channel develops extensive wedges of sediment. In extreme cases, the channel can be completely de-watered. Occurs in all morphologies in aggrading channels (associated with channel bends, bedrock outcrops, LWD jams, or large pieces of LWD or root wads). Sediment wedges may occur in degrading channels when a supply-limited channel begins to erode an old wedge surface.	

S4 Extensive bars. Areas of bar extend throughout the entire channel reach and consist primarily of bed material with minimal flowing water during low flows (the extreme is a de-watered channel and may develop in association with individual sediment wedges). Usually occurs in aggrading channels and is typical of all morphologies.

S5 Extensively scoured zones. The majority of bed and bar material is absent due to scouring flows, typical of degrading channel beds. Occurs in all morphologies.

Channel Assessment Procedure Field Guidebook

[Table of Contents]

Figure 9b. Field indicators of channel disturbance-bank features.

Field code	Description	Typical photograph
Field indicators: banks		
B1	Abandoned channels. Abandoned and/or isolated back or side channels that show signs of colonization by riparian vegetation and have accumulated some forest litter. Typical of degrading channels with an RP morphology (although may occasionally occur in CP morphology).	
B2	Eroding banks. Recently exposed bank material or lack of undercut associated with the bank. Typical of aggrading RP and CP morphologies.	
B3	Avulsions. Similar to B1 although mainstem channels are abandoned and/or isolated when the channel shifts laterally. Typical of aggrading RP and CP morphologies.	

Channel Assessment Procedure Field Guidebook

[Table of Contents]

Figure 9c. Field indicators of channel disturbance-morphological features.

Field code	Description	Typical photograph
Field indicators: morphology		
C1	Extensive riffles or cascades. In intermediate and large channel morphologies, the channel is dominated by riffles and relatively shallow pools or glides. In small channel morphologies, extensive riffles are replaced with extensive cascades. Occurs in all morphologies and both aggrading and degrading channels.	
C2	Minimal pool area. Pools are limited in frequency and extent and are often only associated with individual pieces of LWD. Occurs in all morphologies and both aggrading and degrading channels.	
C3	Elevated mid-channel bars. Channel bars have aggraded with bar-tops at equal elevations or higher than adjacent bank-tops. Typically, such bars have relatively steep downstream faces. Occurs in aggrading CP and RP morphologies.	

C4 Multiple channels or braids. Multiple channels develop as the channel aggrades and shifts from past single thread to recent multiple channels. Typical of CP and RP morphologies, and occurs in aggrading channels.

C5 Disturbed stone lines. Steps associated with step-pool morphologies are disturbed (stone lines are no longer intact and water flows around individual stones, rather than cascading over actual stone lines). Occurs in SP and CP morphologies, typically in degrading channels (although may occasionally be present in aggrading channels).

Channel Assessment Procedure Field Guidebook

[Table of Contents]

Figure 9d. Field indicators of channel disturbance-LWD features.

Field code	Description	Typical photograph
Field indicators: large woody debris		
D1	Small woody debris. Abundant small-sized woody debris pieces (commonly logs with saw-cut ends and detached root wads and branches). Typical of aggrading channels.	
D2	Function of LWD. The majority of LWD does not span the channel width as the orientation of individual LWD pieces shifts from perpendicular to parallel (relative to the channel banks). Typical of both aggrading and degrading channels in RP and CP morphologies.	
D3	Recently formed LWD jams. Typical of aggrading channels (but can occur in degrading channels) in RP and CP morphologies.	

Channel Assessment Procedure Field Guidebook

[Table of Contents]

Field Form 1. Field data.

Sub-basin:		**Date:**	
Reach:		**Crew:**	
		Weather:	

Station	W_b (m)	d (cm)	s (%)	D (cm)	Morphology from nomogram (Figure 5)
				Modal morphological type	

Distance (m)	Bank type†	Channel type and disturbance level	Check any field indicators present S1 S2 S3 S4 S5 C1 C2 C3 C4 C5 B1 B2 B3 D1 D2 D3	Photo roll & frame
			❑❑❑❑❑ ❑❑❑❑❑ ❑❑❑ ❑❑❑	
			❑❑❑❑❑ ❑❑❑❑❑ ❑❑❑ ❑❑❑	
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			❑❑❑❑❑ ❑❑❑❑❑ ❑❑❑ ❑❑❑	

S1 Homogeneous bed texture
S2 Sediment fingers
S3 Sediment wedges
S4 Extensive bars
S5 Extensively scoured zones
C1 Extensive riffles or cascades
C2 Minimal pool area
C3 Elevated mid-channel bars
C4 Multiple channels or braids
C5 Disturbed stone lines
B1 Abandoned channels
B2 Eroding banks
B3 Avulsions
D1 Small woody debris
D2 LWD function
D3 Recently formed LWD jams

†A (Erodible): 1 = silt, 2 = sand, 3 = gravel, 4 = cobble, 5 = boulder (A4/5 = Alluvial, gravel over boulder)
N (Non-erodible): 1 = Till, 2 = colluvium, 3 = bedrock (see WAP Appendix 11 for bedrock types)

Channel Assessment Procedure Field Guidebook

[Table of Contents]

Figure 8a. Small-sized channel morphology matrix showing levels of disturbance (degradation and aggradation).

Figure 8b. Intermediate-sized channel morphology matrix showing levels of disturbance (degradation and aggradation).

Channel Assessment Procedure Field Guidebook

[Table of Contents]

Field Form 2. Disturbance summary.

Sub-basin:	Reach:
	Morphology:

Survey distance (m)	Disturbance level	Stream length in each class (m)			
		None (S or other)	Low (A1, D1)	Moderate (A2, D2)	Severe (A3, D3)
Σ =				Σ =	Σ =

Sum moderate and severe = ______________________ (m)

Sum % moderate and severe = ______________________ %

Channel Assessment Procedure Field Guidebook

[Table of Contents]

Figure 9a. Field indicators of channel disturbance-sedimentological features.

Figure 9b. Field indicators of channel disturbance-bank features.

Figure 9c. Field indicators of channel disturbance-morphological features.

Figure 9d. Field indicators of channel disturbance-LWD features.

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