STREAM CHANNEL CONDITIONS ASSESSMENT

A Methodology to Evaluate Channel Damage Related to Increased Peak Flow

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INTRODUCTION

This Stream Channel Condition Assessment is designed to identify channel damage resulting from increased peak flows. The methodology is based on in-channel indicators most likely to reflect peak flow-related channel damage. If stream channel damage is revealed using this methodology, however, it does not necessarily follow that the cause of damage was an increase in peak flows. A thorough watershed analysis is necessary to link a probable cause with the observed effects.

The Stream Reach Inventory and Channel Stability Evaluation Procedure (Pfankuch 1978) has been the most popular method for assessing peak flow-related channel damage to date. The Pfankuch procedure provides descriptions of excellent, good, fair, and poor conditions for 15 different items involving the upper banks, lower banks, and channel bottom. The observer chooses the most appropriate description and corresponding score, with poor conditions receiving the highest score. Individual item scores are totalled at the end of the survey to obtain the overall stability rating for the stream reach.

To accurately assess channel damage related to peak flows, revision of the Pfankuch procedure was necessary because it was designed to assess channel stability, which does not necessarily correspond to channel damage. For instance, a wide, shallow channel that allows high flows to spread across the floodplain is rated as having poor channel capacity in the Pfankuch procedure. However, when peak flows overtop the channel banks, energy is dissipated as the water spreads across the floodplain. In-channel damage can thus be avoided or minimized by overbank flows. A poor Pfankuch channel capacity rating actually corresponds to conditions which resist the potential for damage from increased peak flows.

Another difficulty with the Pfankuch procedure is that the observer is often forced to lump several conflicting observations into one rating of excellent, good, fair, or poor. For example, bottom scour and deposition are rated as one item. A reviewer has no way of knowing if a rating of fair was based on extensive deposition or obvious scour within the reach. Instead of providing an accurate portrayal of the observed channel conditions, the Pfankuch procedure integrates the field observations into a subjective evaluation. The problem with this approach is that the original field observations are not recorded, and so it is not possible to re-evaluate the channel condition if a new or revised interpretation is revealed through subsequent research.

This Stream Channel Condition Assessment has been developed: (1) to identify the potential response of the stream reach to increased peak flows; (2) to record information relevant to assessing the present condition of the channel bed and banks; (3) to determine the degree of existing channel damage related to peak flows; and (4) to evaluate the potential for damage from future increased peak flows. Many of the in-channel indicators used in this assessment are expanded or modified versions of similar items in the Pfankuch procedure.

Field testing of the method was performed on streams in the Skagit, Stillaguamish, Raging, Deschutes, White, Grays, and Cowlitz River watersheds in the western Washington Cascade Mountains and Willapa Hills regions. Test streams were generally second through fourth order (Washington Department of Natural Resources Stream Type 2, 3, and 4) in size. Minor modifications may be necessary for application in other areas (eastern Washington) and in smaller or larger streams.

The assessment is designed for application by observers with some background in stream hydrology and an understanding of the basic concepts of fluvial geomorphology. Widely used hydrologic terms and concepts are not defined or explained in detail in this text. Recommended background reading for those not familiar with these terms and concepts includes the chapter on river channels in Dunne and Leopold (1978) and the rivers chapter in Schumm (1977). The quantitative analysis of drainage basin system components prepared by Orsborn (1990) also includes an excellent discussion of channel adjustment to perturbations.

OVERVIEW OF THE METHOD

The format of the assessment allows the observer to objectively record characteristics of the channel prior to making a subjective evaluation on whether these results represent a "damaged" or "undamaged" condition. The observer first records conditions affecting the potential response of the channel to increased peak flows, then classifies the channel into a defined Channel Response Category. The predicted response described for each Response Category helps key the observer into the signals this type of channel would exhibit if it had responded to increased peak flows (i.e., widening through bank cutting, enlargement through downcutting, or little effect and transmission to a lower reach).

After determining the Response Category, the observer records conditions of the channel banks and bottom, as well as other influential factors such as steepness of the upper banks, location of woody debris, and adequacy of culverts and bridges. At the end of the field form there is a list of "red flag" conditions. After completing the survey, the observer goes back through the field form to determine if any of these conditions have been met. Each red flag condition is given a score of 1, applicable to the surveyed reach, or 0, not applicable. The red flag conditions have been separated into indicators of existing damage and indicators of the potential to resist future damage. The total score in each category provides a relative index of the degree of existing damage related to increased peak flows and the potential for damage from future increased peak flows. Once a determination of damage has been made, the individual red flag conditions contributing toward the score should be reviewed and compared to the predicted response described for the Response Category.

It should be noted that not all of the information recorded on the field form is used in the final evaluation of damage. Current knowledge of stream channel conditions is not such that each item can be analyzed. However, these observations are valuable in providing an accurate portrait of the stream channel and may be incorporated into the evaluation in the future as knowledge increases.

WHERE TO CONDUCT THE ASSESSMENT

This assessment is designed to be applied over a channel reach consisting of fairly uniform channel gradient and substrate. Aerial photographs and topographic maps should be used to stratify the stream into segments of similar channel gradient, valley confinement, and sinuosity. If desired, the Cupp (1989) valley segment or Rosgen (1989) channel type classifications can be used as a means of stratification.

Within each segment, the total length of stream that should be walked will depend on the purpose of the survey. For many applications, one subsample of the segment may be adequate if conditions of the bed and banks within the segment appear fairly uniform. To ensure the assessment reflects conditions of the segment, rather than micro-scale indicators, the length of the surveyed reach should be at least 20 times as long as the active channel width. If widely different characteristics of a single item are observed within a reach, the reach should be subdivided to account for the changes.

CHANNEL RESPONSE TO INCREASED PEAK FLOWS

Stream channels achieve a form which is responsive to inputs of water, sediment, and woody debris. Since streamflow is a product of width, depth, and velocity, an increase in flow must be accompanied by an increase in at least one of the other parameters. Schumm (1977) has developed channel response relationships that predict changes in channel form related to changes in flow and sediment. All other inputs being equal, an increase in flow will result in an increase in width, depth, and meander wavelength (distance between the outside of bends), and a decrease in gradient.

The response of natural systems is not quite so simple to predict, however. Channel confinement by valley walls affects the ability of a channel to increase width or meander wavelength, substrate size affects the ability to downcut and increase depth, and woody debris further influences the location and extent of bank cutting and bottom scour. Furthermore, increases in peak flow can trigger an increase in sediment load by eroding the channel bed and banks. On the other hand, accelerated mass wasting can generate an increased sediment load that is not related to increased peak flows. Channel response to a change in sediment load may overwhelm the indicators of a response to increased peak flows.

Therefore, it is difficult to isolate the indicators of damage resulting solely from increased peak flows. The morphological response of a channel to a change in water input will vary depending on the accompanying input of sediment and woody debris. Several of the conditions to be evaluated on the field form are indicative of a sediment-related effect as well as a peak flow effect. The focus of this assessment is to determine whether the channel is in a "damaged" condition. Specific indicators of damage are those most likely to reflect a peak-flow effect. However, the specific cause of the damage can only be determined by analyzing inputs within the contributing watershed. Therefore, it is recommended that this assessment be conducted in conjunction with a thorough watershed analysis.

Information recorded in Part I of the field form should be used in conjunction with the Flow Chart to determine the Response Category. The predicted response for each type is described at the bottom of the Flow Chart. This predicted response provides a context from which to evaluate existing damage and the potential for future damage. The predicted response can also serve as a hypothesis to be tested through monitoring.

ASSESSMENT OF CHANNEL CONDITIONS

During the initial testing of the Pfankuch procedure and subsequent testing of early versions of this methodology, a common thread was discovered among observers. No one wanted to carry a lengthy explanatory text into the field. Even when the text was handed out in the field, observers focused solely on the field form and never referred to the text. Therefore, the item by item discussion has been dropped from this narrative and replaced with longer, more descriptive comments on the field form.

Appendix A contains color plates illustrating most of the conditions described on the field form. Appendix B contains example forms that illustrate the evaluation system. These appendices should be reviewed prior to conducting an assessment in the field.

The field form and flow chart, a sharp pencil, and a clinometer or hand level for measuring stream gradient are the only required field equipment. Valley bottom and active channel widths may be estimated or measured with a tape.

CITATIONS

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Dunne, T., and L.B. Leopold. 1978. Water in environmental planning. W.H. Freeman and Company. San Francisco, CA.

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Field Form

FIELD ASSESSMENT OF STREAM CHANNEL CONDITIONS

Stream: ____________________ WRIA#: ________ Sub-WRIA#: ______ WAU: _______ Reach #: ________
Surveyors: ____________________ Reach length: ________ ft/m Average wetted width: _ ft/m
____________________ Date: ___________ Flow today is: High Moderate Low

Reach location: ____
____

Walk the study reach and observe the conditions of the channel bed and banks (length of the study reach should be at least 20 times the active channel width). If conditions such as confinement of the channel, stream gradient, or dominant channel bed or bank material change significantly, then a new reach should be described.

After walking the reach, fill in the blanks and circle the letter responses to describe conditions within the channel. If none of the descriptions fit, do not circle any responses, but supply comments to describe the condition. If applicable, more than one response can be circled for an item.

I. FACTORS AFFECTING CHANNEL RESPONSE

A. Channel Constraint

Average active channel width = _______ feet/meters
Average valley bottom width = _________ feet/meters VBW/ACW = __________

Sinuosity: a. straight (= 1) b. slightly sinuous (1.1-1.3) c. sinuous (1.4-1.7) d. meandering (>1.7)

B. Resistance of Channel Bank Material

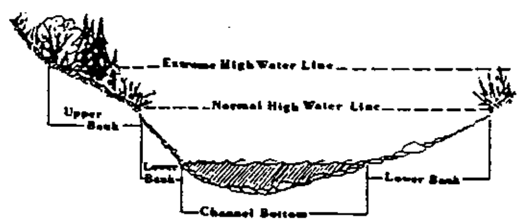
Source of material: alluvial glacial till colluvial lacustrine sediments bedrock unknown
other ________________

Can the stream move the majority of the bed material sizes during high flows? Yes No

Can the stream erode the banks during high flows? Yes No Only in a few places

C. Influence of Upper Banks

Average upper bank slope = ______ %
Can the stream undercut the upper banks? Yes No
If yes, would this result in mass wasting? Yes No



D. Stream Energy

Average channel gradient = _______ %
Is the profile "stairstepped"? Yes No
If yes, what forms the steps? Bedrock Boulders Woody debris
Do the steps appear stable? Yes No
Position in drainage network: a. 1st order headwater stream c. 4th order mainstem
b. 2nd or 3rd order tributary d. 5th order or larger river

From flow chart, response category is:
Type A: unconstrained
Type B: slightly constrained, unconsolidated bottom
Type C: laterally constrained, unconsolidated bottom
Type D: constrained, bedrock/large boulder
Type E: boulder/bedrock stairstep
Type F: woody debris stairstep

II. CONDITION OF CHANNEL BANKS

A. Channel Capacity

1. Response Category Type A or B (channels with floodplains):
   - a. active channel carries average annual flood, larger events spread across floodplain
   - b. active channel has downcut or widened, so peak flows rarely spread over the floodplain
   - c. active channel has downcut and/or widened to the extent that peak flows never spread over the floodplain; an inner terrace has developed within the "blownout" channel area, marking a new active channel
   - d. a major flood has passed through and caused obvious damage in this channel

2. Response Category Type C, D, E, F (channels without floodplains)
   a. active channel area appears adequate to carry average annual flood; streamside vegetation comes down to the active channel margin
   b. active channel area shows signs of enlargement, raw banks indicate some widening or downcutting; there is a flood-disturbed area that is greater than the active channel width
   c. channel appears "blownout"; active channel area is much smaller than the flood-disturbed area within the valley bottom
   d. a debris flow or flood has obviously come down this channel and caused damage

B. Degree of Existing Bank Cutting

1. Length of reach affected:

a. none	e. 51-75%
b. 1-10%	f. 75-90%
c. 11-30%	g. >90%
d. 31-50%	

2. Location of bank cutting:
   a. nowhere in reach
   b. in expected places, such as outside of corners and constrictions
   c. in unusual places, such as straight stretches and inside of bends

3. Angle of banks exposed by cutting:
   a. vertical: |_| b. angled back: _/ c. undercut: /_\

C. Degree of Bank Protection

1. Predominant type of vegetation along the banks: (circle more than one if mixed)
   a. mature coniferous trees
   b. mature hardwood trees
   c. immature conifers 20-60 feet tall
   d. immature conifers 10-20 feet tall
   e. immature conifers 5-10 feet tall
   f. recent clearcut, trees <5 feet tall
   g. immature hardwood trees
   h. shrubs
   i. grass

2. Vegetation density:
   a. banks are well protected by a deep, dense root network, which is inferred from the dense, mature (well-established) forest
   b. banks are fairly well protected by deep roots with several open areas
   c. banks are protected by a dense but shallow root network, inferred from the dense, young trees or shrubs
   d. banks are poorly protected by a shallow root network with numerous openings
   e. banks receive little or no protection from roots

D. Resistance of Lower Bank Material

1. Bank rock content:

a. 90-100% rock	d. 20-40% rock
b. 65-90% rock	e. <20% rock
c. 40-65% rock	

2. Bank cohesion (kick the bank!)
   a. resistant bedrock
   b. erodible bedrock
   c. cohesive silt/clay resistant to erosion
   d. cemented matrix of fine material containing rock particles
   e. cohesive but erodible silt/clay
   f. noncohesive assortment of mostly cobble and larger sizes
   g. noncohesive assortment of mostly cobble to gravel-size rocks
   h. noncohesive assortment of mostly gravel-size rocks
   i. noncohesive assortment of mostly fine material

Particle Size Classes:

Large boulder: >24"
Small boulder: 12-24"
Cobble: 3-12"
Gravel: 0.2-3"
Fines: <0.2"

E. Flow Deflection into Banks (focus on thalweg)
   a. little or no deflection of flows into banks
   b. a few areas where flow is deflected into the banks by logs, boulders, or the channel pattern
   c. numerous areas where flow is deflected into channel banks by logs, boulders, or the channel pattern

III. CONDITION OF CHANNEL BOTTOM

A. Deposition

1. Extent of bottom affected (consider active channel area, not just wetted area):
   a. very few fresh deposits
   b. 5-20% of bottom affected by deposition, mostly isolated pockets behind large boulders or small point bars
   c. 20-50% of bottom covered with fresh deposits, such as several small point bars or pockets behind boulders or woody debris
   d. 50-75% of bottom covered with fresh deposits, such as large mid-channel or point bars
   e. >75% of bottom covered with fresh deposits

2. Size of dominant material in deposits:
   a. most particles cobble-size and larger
   b. most particles are gravel to cobble-size
   c. particles are mostly gravel with some finer material
   d. particles are mostly fines (sand and smaller sizes)

B. Evidence of Recent Bed Mobility

a. in all but channel thalweg, rocks are "dull"; bed materials show definite staining, algae growth, or have clinging vegetation; bed materials are never or only rarely mobile
b. throughout the channel, there is a mix of "bright" and "dull" rocks; staining or algae growth or clinging vegetation is evident in some places
c. mostly "bright" rocks; some staining or algae growth or clinging vegetation is evident in sheltered backwater areas
d. nearly all "bright" rocks; there is no evidence of staining, algae growth, or clinging vegetation; majority of bed materials appear to be quite mobile during high flows

C. Armoring (pick up some rocks and look at subsurface particles)

Within the wetted channel, are surface particles distinctly larger than subsurface particles?
Yes No

On bars, are surface particles distinctly larger than subsurface particles?
Yes No

D. Particle Size Distribution

a. substrate sizes are typical for the size of stream and position in the drainage network, large and small materials present
b. slight reduction in distribution of smaller particles
c. smaller particles are absent or present only in fresh deposits on bars

E. Dominant Particle Sizes

a. bedrock/large boulder
b. large and small boulders
c. large and small boulders, some cobble
d. mostly cobble with some boulders
e. cobble/gravel
f. mostly gravel
g. mostly fines

F. Angularity

a. substrate consists mostly of flat or angular rocks resistant to rolling
b. substrate consists mostly of subangular rocks, some flat or rounded rocks present
c. substrate consists mostly of rounded rocks that have little resistance to rolling

G. Particle Packing (kick the bottom!)

a. larger particles are surrounded by smaller or overlapping ones, creating a tightly packed substrate resistant to scour
b. some overlap and particle packing, larger rocks can be moved with your foot but smaller particles create a tightly packed matrix resistant to erosion
c. larger particles are surrounded by a loose matrix of smaller particles
d. bottom is very loose, most particles can be moved with your foot

IV. OTHER INDICATORS

A. Location of Woody Debris

a. individual logs within or adjacent to the wetted channel area
b. clumps or jams within or adjacent to the wetted channel area
c. clumps or jams along the outer margin of the active channel area
d. individual logs along the outer margin of the active channel area
e. most of the logs have been deposited above and outside of the active channel area
f. a debris jam blocks the channel
g. numerous debris jams block the channel
h. most logs have been transported to a lower reach of the channel
i. numerous logs have been deposited within this reach from upstream
j. there are no logs in or adjacent to the channel

B. Culverts and Bridges

Describe culverts or bridges within or near the study reach (size, condition, location of rust line on culvert, capability for handling flood flows and debris)

C. Channel Controls

Describe riprap or levees that have been constructed along the channel (which bank, length, height, effectiveness)

D. Known History of Flooding or Debris Flows

Note date, magnitude of flood event, probable cause, source of information

E. Other Observations

EVALUATION OF CHANNEL CONDITIONS

Using the Field Assessment, score each item: 1 = applicable to the surveyed reach, or 0 = does not apply. Record the score in the column indicated.

"Red Flag" Conditions	Existing	Potential
I. Response Category Type = A, B, or C		____
II. Channel Banks		
A. Channel Capacity = b, c, or d	____	
B. Bank Cutting		
1. (1. Length) >30% <u>and</u> (2. Location) = c	____	
2. (1. Length) >50%	____	
C. Degree of Bank Protection		
1. (2. Density) = c, d, or e <u>and</u> banks are not predominantly resistant bedrock		____
D. Resistance of Bank Material		
1. (1. Rock content) = d or e <u>and</u> (2. Cohesion) = d, e, g, h, or i		____
2. (1. Rock content) = b or c <u>and</u> (2. Cohesion) = g or h		____
E. Flow Deflection = c		____
III. Channel Bottom		
A. Deposition		
1. (1. Extent) = c <u>and</u> (2. Size) = d	____	
2. (1. Extent) = d or e	____	
B. Recent Bed Mobility = d	____	
C. Armoring "yes" for either wetted channel or bars	____	
D. Particle Size Distribution = c	____	
E. Particle Size = e or f or g		____
F. Angularity = c		____
G. Particle Packing = c or d		____
IV. Other Indicators		
A. Woody Debris		
location = e, h, or i	____	
location = f, g		____
B. Culverts or Bridges Appear Inadequate		____
Total Score =	____	____

Interpretation - "Existing" Column

≤1 Channel conditions indicate little or no existing damage related to increased peak flows

2-3 Channel conditions indicate a moderate degree of existing damage, further investigation should be used to determine the specific cause of items scored above

≥4 Channel conditions indicate significant channel damage has occurred

Interpretation - "Potential" Column

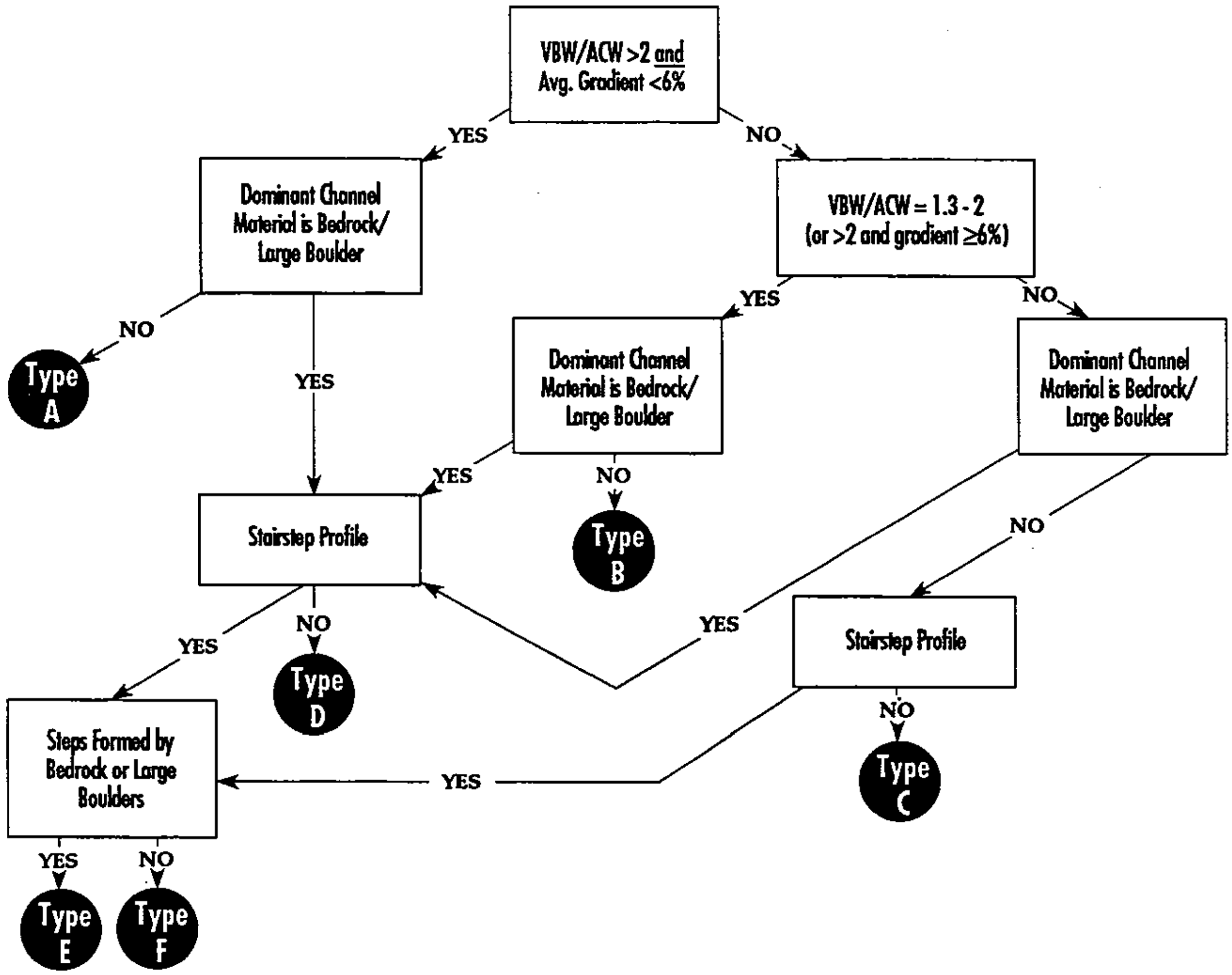
≤1 Channel conditions indicate the channel has a low potential for damage if peak flows increase

2-3 Channel conditions indicate the channel has a moderate potential for damage if peak flows increase

≥4 Channel conditions indicate the channel has a high potential for damage if peak flows increase

Flow Chart

Flow Chart for Determining Response Category Type



RESPONSE CATEGORY TYPE		POTENTIAL RESPONSE TO INCREASED PEAK FLOW
Type A:	Unconstrained	Increased width and meander wavelength through bank cutting; may also downcut
Type B:	Slightly constrained, unconsolidated bottom	Increased width through bank cutting; this may result in undercutting of the upper banks and accelerated mass wasting; may also enlarge by downcutting
Type C:	Laterally constrained, unconsolidated bottom	Most likely to downcut; may also increase width through bank cutting, which could trigger accelerated mass wasting of upper banks
Type D:	Constrained, bedrock/large boulder bottom and banks	Cannot enlarge through downcutting, may widen slightly where banks can erode; will transmit water, sediment, and debris to lower reaches
Type E:	Boulder/bedrock stairstep	High stream energy will transport water, sediment, and debris to lower reaches; if upper banks are not bedrock, may widen slightly and accelerate mass wasting
Type F:	Woody debris stairstep	If "steps" are stable, will respond as Type E, or may trigger debris flow/dam break flood if debris recruitment is high and "steps" fail

Appendix A. Color Plates

Appendix A. Color Plates

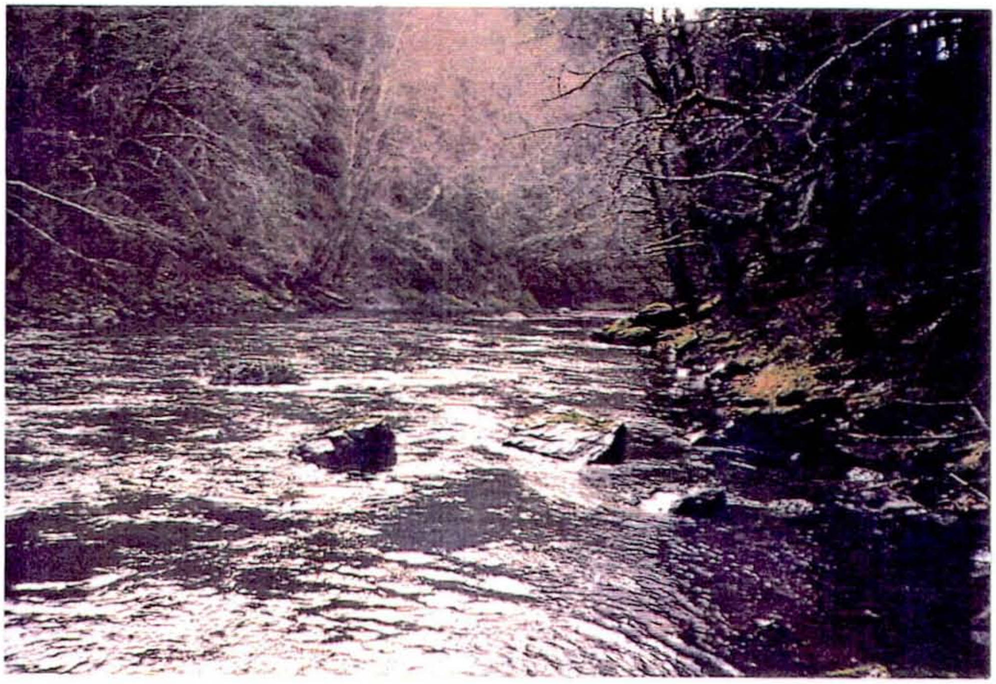
These photographs are presented to illustrate channel conditions to be rated during the field assessment. The captions refer to specific items on the field form. Please refer to the field form when reviewing the photographs.

Kiona Creek is a relatively low gradient channel with an associated valley bottom that is more than twice as wide as the active channel. It is classified as Response Type A (unconstrained). The stream can cut into its banks and migrate laterally across the valley floor. While widening is the typical response of a Type A channel to increased peak flows, downcutting could also occur.

Response Type

In this Response Type B (slightly constrained, unconsolidated bottom) segment, Milky Creek flows through a relatively narrow valley bottom, between 1.3 and 2 times as wide as the active channel. While the stream has room to meander or migrate laterally, the degree of movement is limited by the valley walls. The stream may widen or downcut in response to increased peak flows. Channel widening could undermine the upper banks and result in accelerated mass wasting.

Response Type



In a Response Type C (laterally constrained, unconsolidated bottom) channel, lateral movement is severely restricted by the valley walls. The valley bottom is approximately equal to the active channel width, as shown on this stretch of the Grays River. The stream is most likely to downcut in response to increased peak flows. Some channel widening is also possible in Type C channels. Widening could trigger accelerated mass wasting of the upper banks.

Response Type

This Response Type D (constrained bedrock/large boulder bottom and banks) channel cannot enlarge through downcutting because the bed consists of resistant bedrock. Such channels are usually tightly confined by the valley walls. In response to increased peak flows, the channel may widen slightly where the banks are erodible. If the banks are mostly resistant bedrock, it may be difficult to detect a response to increased peak flows in Type D channels; the effects will be more apparent in downstream reaches.

Response Type

East Fork Silver Creek is a Response Type E (boulder/bedrock stairstep) channel: stream gradient is greater than 6% and boulders create a stairstep profile. The channel may widen slightly where banks are erodible, but in-channel impacts of increased peak flows are more likely to occur in lower gradient reaches.

Response Type

Response Type F (woody debris stairstep) channels are similar to Type E except that the steps are formed primarily by woody debris. The expected response to increased peak flows is also similar, unless the debris forming the steps is unstable. A peak flow event could trigger failure of the steps and result in large volumes of debris being transported downstream to lower gradient reaches.

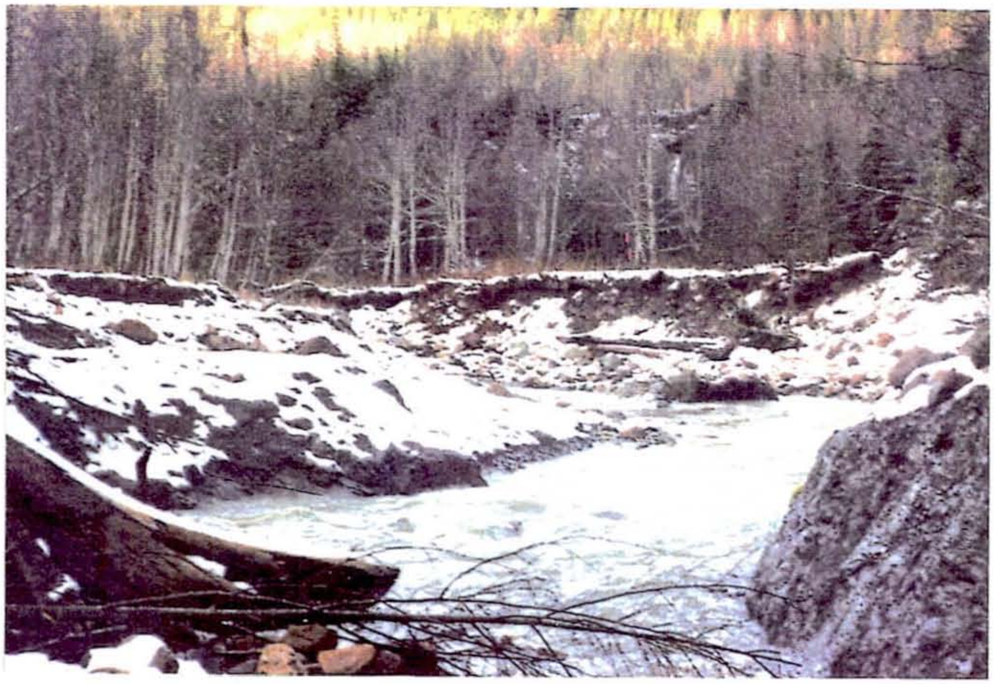
Response Type

In this Response Type B channel (shown at a fairly high flow), the active channel is adequate to carry the average annual flood. Larger flood events overtop the lower banks and spread across the floodplain where energy is dissipated by the dense forest (channel capacity rating = a). Other notable features of the banks include protection by a deep, dense root network, which can be inferred from the dense, mature alder lining the banks. There is little flow deflection into the banks and no bank cutting occurs in this reach.

Condition of Channel Banks

Channel capacity of this Response Type A channel has been enlarged primarily by widening. Peak flows would rarely overtop the banks and spread onto the floodplain (channel capacity rating= b).

Condition of Channel Banks



This Response Type B channel has downcut and enlarged to the extent that peak flows will never reach the old floodplain. An inner terrace is developing within the recently enlarged active channel area (channel capacity rating = c).

Condition of Channel Banks

A debris flow or flood event has caused obvious damage in this channel. The channel has both widened and downcut, resulting in a greatly enlarged cross-sectional area (channel capacity rating = c and d).

Condition of Channel Banks

On this reach of the East Fork Grays River, bank cutting occurs in expected places, such as on the outside of this bend. Exposed banks are vertical or slightly overhanging. Predominant bank vegetation is immature conifers (20-60 feet high) which have deep roots interspersed with several open areas. Bank rock content is 40-65% and banks consist of a noncohesive assortment of mostly gravel to cobble-sized rocks. While these conditions do not indicate existing damage from increased peak flows, there is a moderate potential for damage if peak flows are increased in the future. Bank cohesion may be insufficient to withstand increased erosive energy.

Condition of Channel Banks

Appendix A

Bank cutting in upper Deer Creek occurs on the inside as well as the outside of bends. Exposed banks are mostly angled back, indicating less internal cohesion than a vertical bank. Bank vegetation is predominantly immature hardwoods which have a shallow root network and numerous openings along the bank. Bank rock content was rated as 20-40% overall. Bank materials include both a cemented matrix of fine material containing rock particles, and cohesive but erodible silt/clay. The condition of the channel banks indicate that significant channel damage has occurred.

Condition of Channel Banks

In this segment of Finney Creek, 20-50% of the bottom is covered with fresh deposits, including these point bars. The deposited material is mostly gravel to cobble-size. The extent and size of deposited material does not indicate that there has been significant damage related to increased peak flow.

Condition of Channel Bottom

This upturned rock displays algal staining, evidence that the channel bottom is rarely mobile.

Condition of Channel Bottom

These angular rocks are resistant to rolling; larger particles are surrounded by smaller particles, creating a tightly packed matrix that is resistant to scour.

Condition of Channel Bottom

The bottom of Camp Creek consists mostly of subangular rocks. The larger rocks can be moved with little resistance, but they are surrounded by a tightly packed matrix of smaller particles.

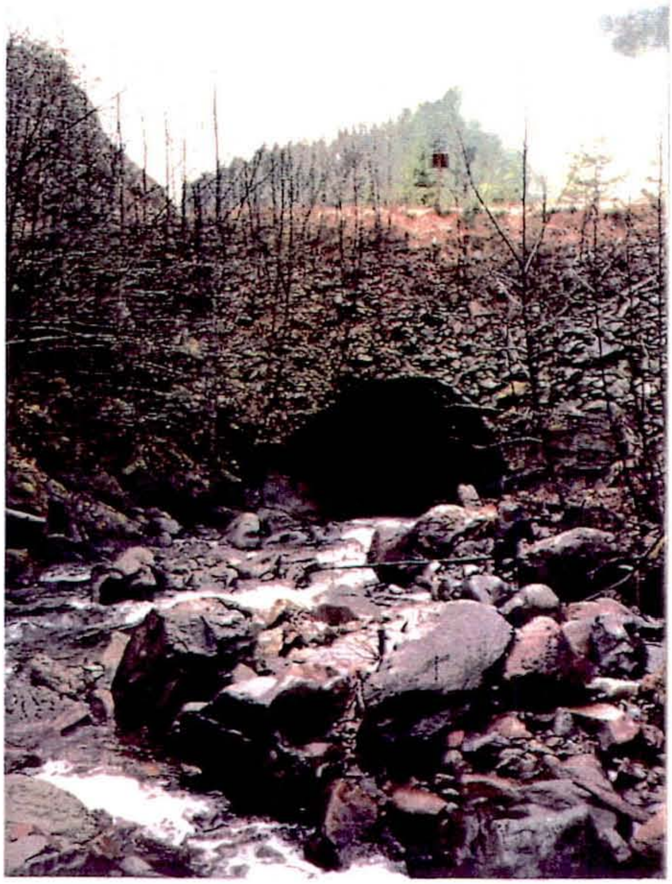
Condition of Channel Bottom

Woody debris in this widened channel has been moved to the outer margin of the active channel area during a high flow event. The wetted channel area now consists of a long, shallow riffle with little cover or holding habitat for fish.

Other Indicators

A debris jam blocking the channel can become a temporary dam during a high flow. This jam consists mostly of small material that is not embedded or tightly packed. When pressure builds behind the dam during high flow, it is likely to fail.

Appendix A



This culvert on East Fork Silver Creek probably has adequate capacity to handle peak flows. The rust line, visible on the left side of the culvert, is well below one-quarter the height of the culvert and there is no indication of erosion around the culvert inlet.

Other Indicators

This culvert in Milky Creek was obviously inadequate to handle the water, sediment, and debris load transported down the channel.

Other Indicators

Appendix B. Examples of Field Forms

FIELD ASSESSMENT OF STREAM CHANNEL CONDITIONS

Stream: Silver Creek WRIA#: 26 Sub-WRIA#: - WAU: upper Cowlitz Reach #: 1
Surveyors: J. Mehler Reach length: 500 ft/m Average wetted width: 20 ft/m
J. Cate Date: 1/22/92 Flow today is: High Moderate Low

Reach location: Upstream of FS Road 85 bridge crossing

Walk the study reach and observe the conditions of the channel bed and banks (length of the study reach should be at least 20 times the active channel width). If conditions such as confinement of the channel, stream gradient, or dominant channel bed or bank material change significantly, then a new reach should be described.

After walking the reach, fill in the blanks and circle the letter responses to describe conditions within the channel. If none of the descriptions fit, do not circle any responses, but supply comments to describe the condition. If applicable, more than one response can be circled for an item.

I. FACTORS AFFECTING CHANNEL RESPONSE

A. Channel Constraint

Average active channel width = 45 feet/meters
Average valley bottom width = 70 feet/meters VBW/ACW = 1.6

Sinuosity: a. straight (= 1) b. slightly sinuous (1.1-1.3) c. sinuous (1.4-1.7) d. meandering (>1.7)

B. Resistance of Channel Bank Material

Source of material: alluvial glacial till colluvial lacustrine sediments bedrock unknown
other ______

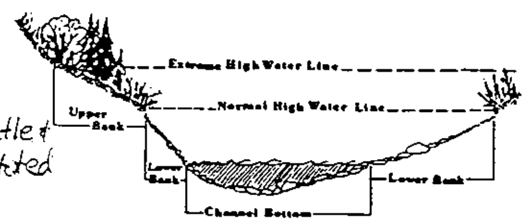
Can the stream move the majority of the bed material sizes during high flows? Yes No

Can the stream erode the banks during high flows? Yes No Only in a few places

C. Influence of Upper Banks

Average upper bank slope = 0-40 %
Can the stream undercut the upper banks? Yes No
If yes, would this result in mass wasting? Yes No

Slopes are fairly gentle & very well vegetated



D. Stream Energy

Average channel gradient = 4 %
Is the profile "stairstepped"? Yes No
If yes, what forms the steps? Bedrock Boulders Woody debris
Do the steps appear stable? Yes No
Position in drainage network: a. 1st order headwater stream c. 4th order mainstem
b. 2nd or 3rd order tributary d. 5th order or larger river

From flow chart, response category is:
~~Type A:~~ unconstrained
Type B: slightly constrained, unconsolidated bottom
Type C: laterally constrained, unconsolidated bottom
Type D: constrained, bedrock/large boulder
Type E: boulder/bedrock stairstep
Type F: woody debris stairstep

II. CONDITION OF CHANNEL BANKS

A. Channel Capacity

1. Response Category Type A or B (channels with floodplains):
   a. active channel carries average annual flood, larger events spread across floodplain
   b. active channel has downcut or widened, so peak flows rarely spread over the floodplain
   c. active channel has downcut and/or widened to the extent that peak flows never spread over the floodplain; an inner terrace has developed within the "blownout" channel area, marking a new active channel
   d. a major flood has passed through and caused obvious damage in this channel

2. Response Category Type C, D, E, F (channels without floodplains)
   a. active channel area appears adequate to carry average annual flood; streamside vegetation comes down to the active channel margin
   b. active channel area shows signs of enlargement, raw banks indicate some widening or downcutting; there is a flood-disturbed area that is greater than the active channel width
   c. channel appears "blownout"; active channel area is much smaller than the flood-disturbed area within the valley bottom
   d. a debris flow or flood has obviously come down this channel and caused damage

n/a

B. Degree of Existing Bank Cutting

1. Length of reach affected:

a. none	e. 51-75%
b. 1-10%	f. 75-90%
c. 11-30%	g. >90%
d. 31-50%	

2. Location of bank cutting:
   a. nowhere in reach
   b. in expected places, such as outside of corners and constrictions
   c. in unusual places, such as straight stretches and inside of bends

3. Angle of banks exposed by cutting:
   a. vertical: |_| b. angled back: _/ c. undercut: /_\

C. Degree of Bank Protection

1. Predominant type of vegetation along the banks: (circle more than one if mixed)
   a. mature coniferous trees
   b. mature hardwood trees - red alder
   c. immature conifers 20-60 feet tall
   d. immature conifers 10-20 feet tall
   e. immature conifers 5-10 feet tall
   f. recent clearcut, trees <5 feet tall
   g. immature hardwood trees
   h. shrubs
   i. grass

2. Vegetation density:
   a. banks are well protected by a deep, dense root network, which is inferred from the dense, mature (well-established) forest
   b. banks are fairly well protected by deep roots with several open areas
   c. banks are protected by a dense but shallow root network, inferred from the dense, young trees or shrubs
   d. banks are poorly protected by a shallow root network with numerous openings
   e. banks receive little or no protection from roots

D. Resistance of Lower Bank Material

1. Bank rock content:

a. 90-100% rock	d. 20-40% rock
b. 65-90% rock	e. <20% rock
c. 40-65% rock	

Particle Size Classes:

Large boulder: >24"
Small boulder: 12-24"
Cobble: 3-12"
Gravel: 0.2-3"
Fines: <0.2"

2. Bank cohesion (kick the bank!)
   a. resistant bedrock
   b. erodible bedrock
   c. cohesive silt/clay resistant to erosion
   d. cemented matrix of fine material containing rock particles
   e. cohesive but erodible silt/clay
   f. noncohesive assortment of mostly cobble and larger sizes
   g. noncohesive assortment of mostly cobble to gravel-size rocks
   h. noncohesive assortment of mostly gravel-size rocks
   i. noncohesive assortment of mostly fine material

E. Flow Deflection into Banks (focus on thalweg)
   a. little or no deflection of flows into banks
   b. a few areas where flow is deflected into the banks by logs, boulders, or the channel pattern
   c. numerous areas where flow is deflected into channel banks by logs, boulders, or the channel pattern

III. CONDITION OF CHANNEL BOTTOM

A. Deposition

1. Extent of bottom affected (consider active channel area, not just wetted area):
   a. very few fresh deposits
   b. 5-20% of bottom affected by deposition, mostly isolated pockets behind large boulders or small point bars
   c. 20-50% of bottom covered with fresh deposits, such as several small point bars or pockets behind boulders or woody debris
   d. 50-75% of bottom covered with fresh deposits, such as large mid-channel or point bars
   e. >75% of bottom covered with fresh deposits

2. Size of dominant material in deposits:
   a. most particles cobble-size and larger
   b. most particles are gravel to cobble-size
   c. particles are mostly gravel with some finer material
   d. particles are mostly fines (sand and smaller sizes)

B. Evidence of Recent Bed Mobility

a. in all but channel thalweg, rocks are "dull"; bed materials show definite staining, algae growth, or have clinging vegetation; bed materials are never or only rarely mobile
b. throughout the channel, there is a mix of "bright" and "dull" rocks; staining or algae growth or clinging vegetation is evident in some places
c. mostly "bright" rocks; some staining or algae growth or clinging vegetation is evident in sheltered backwater areas
d. nearly all "bright" rocks; there is no evidence of staining, algae growth, or clinging vegetation; majority of bed materials appear to be quite mobile during high flows

C. Armoring (pick up some rocks and look at subsurface particles)

Within the wetted channel, are surface particles distinctly larger than subsurface particles?
Yes No

On bars, are surface particles distinctly larger than subsurface particles?
Yes No

D. Particle Size Distribution

a. substrate sizes are typical for the size of stream and position in the drainage network, large and small materials present
b. slight reduction in distribution of smaller particles
c. smaller particles are absent or present only in fresh deposits on bars

E. Dominant Particle Sizes

a. bedrock/large boulder
b. large and small boulders
c. large and small boulders, some cobble
d. mostly cobble with some boulders
e. cobble/gravel
f. mostly gravel
g. mostly fines

F. Angularity

a. substrate consists mostly of flat or angular rocks resistant to rolling
b. substrate consists mostly of subangular rocks, some flat or rounded rocks present
c. substrate consists mostly of rounded rocks that have little resistance to rolling

G. Particle Packing (kick the bottom!)

a. larger particles are surrounded by smaller or overlapping ones, creating a tightly packed substrate resistant to scour
b. some overlap and particle packing, larger rocks can be moved with your foot but smaller particles create a tightly packed matrix resistant to erosion
c. larger particles are surrounded by a loose matrix of smaller particles
d. bottom is very loose, most particles can be moved with your foot

IV. OTHER INDICATORS

A. Location of Woody Debris

a. individual logs within or adjacent to the wetted channel area
b. clumps or jams within or adjacent to the wetted channel area
c. clumps or jams along the outer margin of the active channel area
d. individual logs along the outer margin of the active channel area
e. most of the logs have been deposited above and outside of the active channel area
f. a debris jam blocks the channel
g. numerous debris jams block the channel
h. most logs have been transported to a lower reach of the channel
i. numerous logs have been deposited within this reach from upstream
j. there are no logs in or adjacent to the channel

B. Culverts and Bridges

Describe culverts or bridges within or near the study reach (size, condition, location of rust line on culvert, capability for handling flood flows and debris)

Bridge appears adequate - straight approach & >20ft clearance above bankfull height

C. Channel Controls

Describe riprap or levees that have been constructed along the channel (which bank, length, height, effectiveness)

none

D. Known History of Flooding or Debris Flows

Note date, magnitude of flood event, probable cause, source of information

unknown

E. Other Observations

Root wads & logs have been cabled into channel upstream of bridge - fish habitat improvement project by USFS. It also appears that some streamside alders have been blasted or pushed into creek. There are no mature conifers in riparian area for future LWD recruitment - all logged ~40 years ago.

EVALUATION OF CHANNEL CONDITIONS

Using the Field Assessment, score each item: 1 = applicable to the surveyed reach, or 0 = does not apply. Record the score in the column indicated.

"Red Flag" Conditions	Existing	Potential
I. Response Category Type = A, B, or C		1
II. Channel Banks		
A. Channel Capacity = b, c, or d	0	
B. Bank Cutting		
1. (1. Length) >30% and (2. Location) = c	0	
2. (1. Length) >50%	0	
C. Degree of Bank Protection		
1. (2. Density) = c, d, or e and banks are not predominantly resistant bedrock		0
D. Resistance of Bank Material		
1. (1. Rock content) = d or e and (2. Cohesion) = d, e, g, h, or i		0
2. (1. Rock content) = b or c and (2. Cohesion) = g or h		1
E. Flow Deflection = c		0
III. Channel Bottom		
A. Deposition		
1. (1. Extent) = c and (2. Size) = d	1	
2. (1. Extent) = d or e	0	
B. Recent Bed Mobility = d	0	
C. Armoring "yes" for either wetted channel or bars	0	
D. Particle Size Distribution = c	0	
E. Particle Size = e or f or g		1
F. Angularity = c		0
G. Particle Packing = c or d		0
IV. Other Indicators		
A. Woody Debris		
location = e, h, or i	0	
location = f, g		0
B. Culverts or Bridges Appear Inadequate		0
Total Score =	1	3

Interpretation - "Existing" Column

≤1 Channel conditions indicate little or no existing damage related to increased peak flows

2-3 Channel conditions indicate a moderate degree of existing damage, further investigation should be used to determine the specific cause of items scored above

≥4 Channel conditions indicate significant channel damage has occurred

Interpretation - "Potential" Column

≤1 Channel conditions indicate the channel has a low potential for damage if peak flows increase

2-3 Channel conditions indicate the channel has a moderate potential for damage if peak flows increase

≥4 Channel conditions indicate the channel has a high potential for damage if peak flows increase

Could erode bed or banks if peak flows increased

FIELD ASSESSMENT OF STREAM CHANNEL CONDITIONS

Stream: Kiona Creek WRIA#: 26 Sub-WRIA#: - WAU: Upper Cowlitz Reach #: 1
Surveyors: J. Metzler Reach length: 1,000 ft/m Average wetted width: 15 ft/m
T. Getz Date: 1/22/92 Flow today is: High Moderate Low

Reach location: downstream of State Hwy 12 bridge crossing

Walk the study reach and observe the conditions of the channel bed and banks (length of the study reach should be at least 20 times the active channel width). If conditions such as confinement of the channel, stream gradient, or dominant channel bed or bank material change significantly, then a new reach should be described.

After walking the reach, fill in the blanks and circle the letter responses to describe conditions within the channel. If none of the descriptions fit, do not circle any responses, but supply comments to describe the condition. If applicable, more than one response can be circled for an item.

I. FACTORS AFFECTING CHANNEL RESPONSE

A. Channel Constraint

Average active channel width = 50 feet/meters
Average valley bottom width = 100+ feet/meters VBW/ACW = 2+

Sinuosity: a. straight (= 1) b. slightly sinuous (1.1-1.3) c. sinuous (1.4-1.7) d. meandering (>1.7)

B. Resistance of Channel Bank Material

Source of material: alluvial glacial till colluvial lacustrine sediments bedrock unknown
other ______

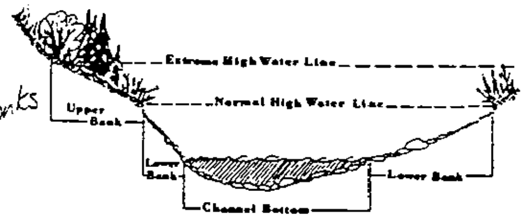
Can the stream move the majority of the bed material sizes during high flows? Yes No

Can the stream erode the banks during high flows? Yes No Only in a few places

C. Influence of Upper Banks

Average upper bank slope = 0 %
Can the stream undercut the upper banks? Yes No
If yes, would this result in mass wasting? Yes No

NA - flat upper banks



D. Stream Energy

Average channel gradient = 2 %
Is the profile "stairstepped"? Yes No
If yes, what forms the steps? Bedrock Boulders Woody debris
Do the steps appear stable? Yes No
Position in drainage network: a. 1st order headwater stream c. 4th order mainstem
b. 2nd or 3rd order tributary d. 5th order or larger river

From ~~flow chart~~, response category is:
Type A: unconstrained
Type B: slightly constrained, unconsolidated bottom
Type C: laterally constrained, unconsolidated bottom
Type D: constrained, bedrock/large boulder
Type E: boulder/bedrock stairstep
Type F: woody debris stairstep

II. CONDITION OF CHANNEL BANKS

A. Channel Capacity

1. Response Category Type A or B (channels with floodplains):
   a. active channel carries average annual flood, larger events spread across floodplain
   b. active channel has downcut or widened, so peak flows rarely spread over the floodplain
   c. active channel has downcut and/or widened to the extent that peak flows never spread over the floodplain; an inner terrace has developed within the "blownout" channel area, marking a new active channel
   d. a major flood has passed through and caused obvious damage in this channel

2. Response Category Type C, D, E, F (channels without floodplains)
   a. active channel area appears adequate to carry average annual flood; streamside vegetation comes down to the active channel margin
   b. active channel area shows signs of enlargement, raw banks indicate some widening or downcutting; there is a flood-disturbed area that is greater than the active channel width
   c. channel appears "blownout"; active channel area is much smaller than the flood-disturbed area within the valley bottom
   d. a debris flow or flood has obviously come down this channel and caused damage

n/a

B. Degree of Existing Bank Cutting
1. Length of reach affected:
   a. none
   b. 1-10%
   c. 11-30%
   d. 31-50%
   e. 51-75%
   f. 75-90%
   g. >90%

2. Location of bank cutting:
   a. nowhere in reach
   b. in expected places, such as outside of corners and constrictions
   c. in unusual places, such as straight stretches and inside of bends

3. Angle of banks exposed by cutting:
   a. vertical: |_|
   b. angled back: _/
   c. undercut: /__\

C. Degree of Bank Protection
1. Predominant type of vegetation along the banks: (circle more than one if mixed)
   a. mature coniferous trees
   b. mature hardwood trees
   c. immature conifers 20-60 feet tall
   d. immature conifers 10-20 feet tall
   e. immature conifers 5-10 feet tall
   f. recent clearcut, trees <5 feet tall
   g. immature hardwood trees
   h. shrubs
   i. grass

2. Vegetation density:
   a. banks are well protected by a deep, dense root network, which is inferred from the dense, mature (well-established) forest
   b. banks are fairly well protected by deep roots with several open areas
   c. banks are protected by a dense but shallow root network, inferred from the dense, young trees or shrubs
   d. banks are poorly protected by a shallow root network with numerous openings
   e. banks receive little or no protection from roots

D. Resistance of Lower Bank Material
1. Bank rock content:
   a. 90-100% rock
   b. 65-90% rock
   c. 40-65% rock
   d. 20-40% rock
   e. <20% rock

Particle Size Classes:

Large boulder: >24"
Small boulder: 12-24"
Cobble: 3-12"
Gravel: 0.2-3"
Fines: <0.2"

2. Bank cohesion (kick the bank!)
   a. resistant bedrock
   b. erodible bedrock
   c. cohesive silt/clay resistant to erosion
   d. cemented matrix of fine material containing rock particles
   e. cohesive but erodible silt/clay
   f. noncohesive assortment of mostly cobble and larger sizes
   g. noncohesive assortment of mostly cobble to gravel-size rocks
   h. noncohesive assortment of mostly gravel-size rocks
   i. noncohesive assortment of mostly fine material

E. Flow Deflection into Banks (focus on thalweg)
   a. little or no deflection of flows into banks
   b. a few areas where flow is deflected into the banks by logs, boulders, or the channel pattern
   c. numerous areas where flow is deflected into channel banks by logs, boulders, or the channel pattern

III. CONDITION OF CHANNEL BOTTOM

A. Deposition

1. Extent of bottom affected (consider active channel area, not just wetted area):
   a. very few fresh deposits
   b. 5-20% of bottom affected by deposition, mostly isolated pockets behind large boulders or small point bars
   c. 20-50% of bottom covered with fresh deposits, such as several small point bars or pockets behind boulders or woody debris
   d. 50-75% of bottom covered with fresh deposits, such as large mid-channel or point bars
   e. >75% of bottom covered with fresh deposits

2. Size of dominant material in deposits:
   a. most particles cobble-size and larger
   b. most particles are gravel to cobble-size
   c. particles are mostly gravel with some finer material
   d. particles are mostly fines (sand and smaller sizes)

B. Evidence of Recent Bed Mobility
   a. in all but channel thalweg, rocks are "dull"; bed materials show definite staining, algae growth, or have clinging vegetation; bed materials are never or only rarely mobile
   b. throughout the channel, there is a mix of "bright" and "dull" rocks; staining or algae growth or clinging vegetation is evident in some places
   c. mostly "bright" rocks; some staining or algae growth or clinging vegetation is evident in sheltered backwater areas
   d. nearly all "bright" rocks; there is no evidence of staining, algae growth, or clinging vegetation; majority of bed materials appear to be quite mobile during high flows

C. Armoring (pick up some rocks and look at subsurface particles)

Within the wetted channel, are surface particles distinctly larger than subsurface particles?
Yes No

On bars, are surface particles distinctly larger than subsurface particles?
Yes No

D. Particle Size Distribution
   a. substrate sizes are typical for the size of stream and position in the drainage network, large and small materials present
   b. slight reduction in distribution of smaller particles
   c. smaller particles are absent or present only in fresh deposits on bars

E. Dominant Particle Sizes
   a. bedrock/large boulder
   b. large and small boulders
   c. large and small boulders, some cobble
   d. mostly cobble with some boulders
   e. cobble/gravel
   f. mostly gravel
   g. mostly fines

F. Angularity
   a. substrate consists mostly of flat or angular rocks resistant to rolling
   b. substrate consists mostly of subangular rocks, some flat or rounded rocks present
   c. substrate consists mostly of rounded rocks that have little resistance to rolling

G. Particle Packing (kick the bottom!)
   a. larger particles are surrounded by smaller or overlapping ones, creating a tightly packed substrate resistant to scour
   b. some overlap and particle packing, larger rocks can be moved with your foot but smaller particles create a tightly packed matrix resistant to erosion
   c. larger particles are surrounded by a loose matrix of smaller particles
   d. bottom is very loose, most particles can be moved with your foot

IV. OTHER INDICATORS

A. Location of Woody Debris

a. individual logs within or adjacent to the wetted channel area
b. clumps or jams within or adjacent to the wetted channel area
c. clumps or jams along the outer margin of the active channel area
d. individual logs along the outer margin of the active channel area
e. most of the logs have been deposited above and outside of the active channel area
f. a debris jam blocks the channel
g. numerous debris jams block the channel
h. most logs have been transported to a lower reach of the channel
i. numerous logs have been deposited within this reach from upstream
j. there are no logs in or adjacent to the channel

B. Culverts and Bridges

Describe culverts or bridges within or near the study reach (size, condition, location of rust line on culvert, capability for handling flood flows and debris)

Bridge under highway is adequate - no sign of damage

C. Channel Controls

Describe riprap or levees that have been constructed along the channel (which bank, length, height, effectiveness)

Upstream of highway (above this reach) the channel has been riprapped & banks are graded into a trapezoidal X-C

D. Known History of Flooding or Debris Flows

Note date, magnitude of flood event, probable cause, source of information

unknown

E. Other Observations

Channel appears widened - cause could be related to sediment - mass wasting evident upstream off of logging roads on west side of Kiona Peak

EVALUATION OF CHANNEL CONDITIONS

Using the Field Assessment, score each item: 1 = applicable to the surveyed reach, or 0 = does not apply. Record the score in the column indicated.

"Red Flag" Conditions	Existing	Potential
I. Response Category Type = A, B, or C		1
II. Channel Banks		
A. Channel Capacity = b, c, or d	1	
B. Bank Cutting		
1. (1. Length) >30% and (2. Location) = c	1	
2. (1. Length) >50%	1	
C. Degree of Bank Protection		
1. (2. Density) = c, d, or e and banks are not predominantly resistant bedrock		1
D. Resistance of Bank Material		
1. (1. Rock content) = d or e and (2. Cohesion) = d, e, g, h, or i		0
2. (1. Rock content) = b or c and (2. Cohesion) = g or h		1
E. Flow Deflection = c		0
III. Channel Bottom		
A. Deposition		
1. (1. Extent) = c and (2. Size) = d	0	
2. (1. Extent) = d or e	1	
B. Recent Bed Mobility = d	0	
C. Armoring "yes" for either wetted channel or bars	0	
D. Particle Size Distribution = c	0	
E. Particle Size = e or f or g		1
F. Angularity = c		0
G. Particle Packing = c or d		0
IV. Other Indicators		
A. Woody Debris		
location = e, h, or i	1	
location = f, g		0
B. Culverts or Bridges Appear Inadequate		0
Total Score =	5	4

Interpretation - "Existing" Column

≤1 Channel conditions indicate little or no existing damage related to increased peak flows

2-3 Channel conditions indicate a moderate degree of existing damage, further investigation should be used to determine the specific cause of items scored above

≥4 Channel conditions indicate significant channel damage has occurred -Extensive bank erosion, channel has widened

Interpretation - "Potential" Column

≤1 Channel conditions indicate the channel has a low potential for damage if peak flows increase

2-3 Channel conditions indicate the channel has a moderate potential for damage if peak flows increase

≥4 Channel conditions indicate the channel has a high potential for damage if peak flows increase

-Could continue to widen or downcut through extensive gravel deposit.