APPENDIX I
Routing Assessment Module

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Introduction

Many physical processes operate simultaneously within a watershed. They deliver material or energy such as water, sediment, woody debris, nutrients and heat from the surrounding landscape and atmosphere to the stream system. Watershed conditions dictate the rate of materials transfer to the stream system, and changes in their input rates raise many of the concerns associated with forest management activities. As these materials and energy are processed, stored, or transported downstream, they influence channel morphology and the suitability of streams for fish habitat and water quality.

Watersheds and the series of stream segments in a drainage system are linked systems. Materials, once introduced to the stream, are transferred from segment to segment or are stored in and released from segments episodically as a function of water flow regimes and sediment transport capacities of segments. In this module, only the fluvial transport of materials are considered; other transport processes, such as debris flows, are treated as sediment-generating processes. See the Mass-Wasting Module.

Coupling the rate of input with transport and storage within a stream system will be critical elements of relating stream characteristics with basin-wide erosion or hydrologic processes. For example, sediment budgets need to be coupled with estimates of transport and indices of channel response. Although detailed accounting of sediment or water budgets are probably not possible in all watersheds, more qualitative or general estimates are still of value. They provide some discrimination of the significance of potential changes. Adjustment of channels to moving material will reflect both amounts introduced upstream as well as locally.

Critical Questions

Critical questions addressed by this module are:

Is the potential impact (sediment or peak flow) transported or routed to the indicator segment of concern?

Is the amount of material or energy transported to the segment sufficient to cause a significant change in channel or habitat conditions?

Answers to the following second order questions will help determine if the potential impact is routed to the indicator segment.

Is the segment directly or indirectly linked to the potential impact source?

Is the potential impact active or inactive?

Is there evidence of an effect from the potential impact?

Can potential impacts be routed to segment?

Level l and 2 Analysis

This module is designed to address questions concerning the linking or routing of sediment and peak flow impacts from hillslope processes to stream segments. The module is a subroutine of synthesis; therefore it is not performed during the hillslope process and resource assessment phase of watershed analysis. Information needed to perform the routing assessment is derived from the modules. All required information, however may not be available from the Level l analysis. In some cases, answers to specific questions (e.g., downstream transport efficiency) will most likely require Level 2 channel analysis.

Qualifications

Analyst qualifications required to perform the routing assessment are equivalent to the skills, education, and experience required for the channel assessment.

Analysis Procedure

The routing assessment is performed for the indicator areas selected for synthesis. Only segments that have resource characteristics vulnerable to one or more of the potential hillslope impacts (i.e., fine sediment, coarse sediment, or peak flows) are evaluated.

Linkages between each potential hillslope hazards and vulnerable resource characteristics are examined by answering a set of questions. The questions are organized in a logical stepwise format (Figures I-1 and I-2). Decision criteria for each impact variable are used to determine the appropriate response to each question (Tables I-1 to I-3). Responses to each question and the specific criterion (if more than one applies) are recorded on Worksheet I-1.

The routing analysis is performed for each potential impact and each indicator area where routing is in question. The hillslope impact area closest to the indicator area is evaluated first. Additional hillslope areas that may impact upstream vulnerable resource characteristics are evaluated sequentially. The process continues until all impact areas that may be linked to a specific indicator area are examined. If evidence of effect is used to confirm delivery of an impact from more than one hillslope impact area there is a possibility that there is unequal contribution from each area. In these cases, the magnitude of the effect from each impact area needs to be weighed against the signal from observed effects to determine if a routing connection exists.

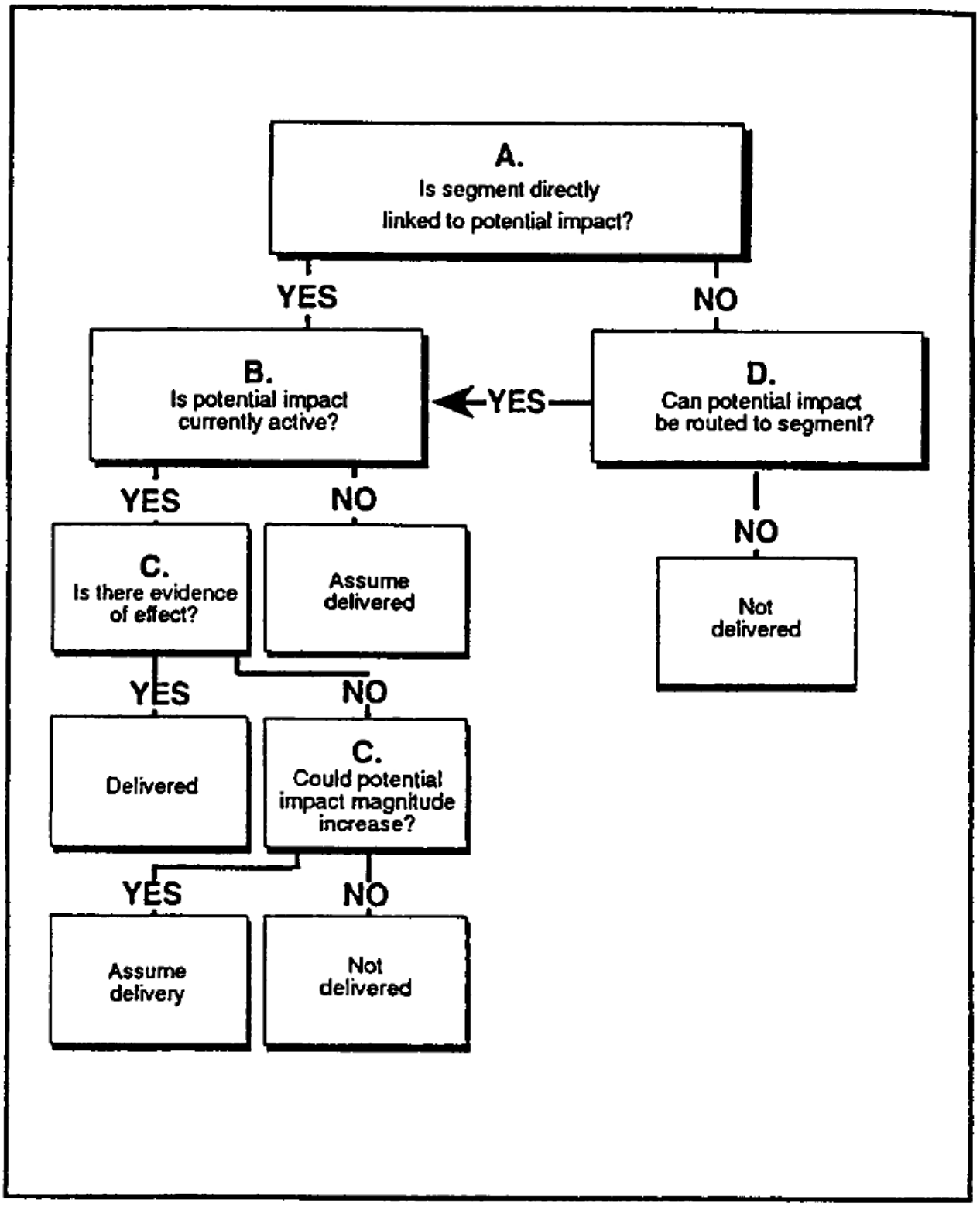

Figure I-1: Fine and coarse sediment routing analysis.

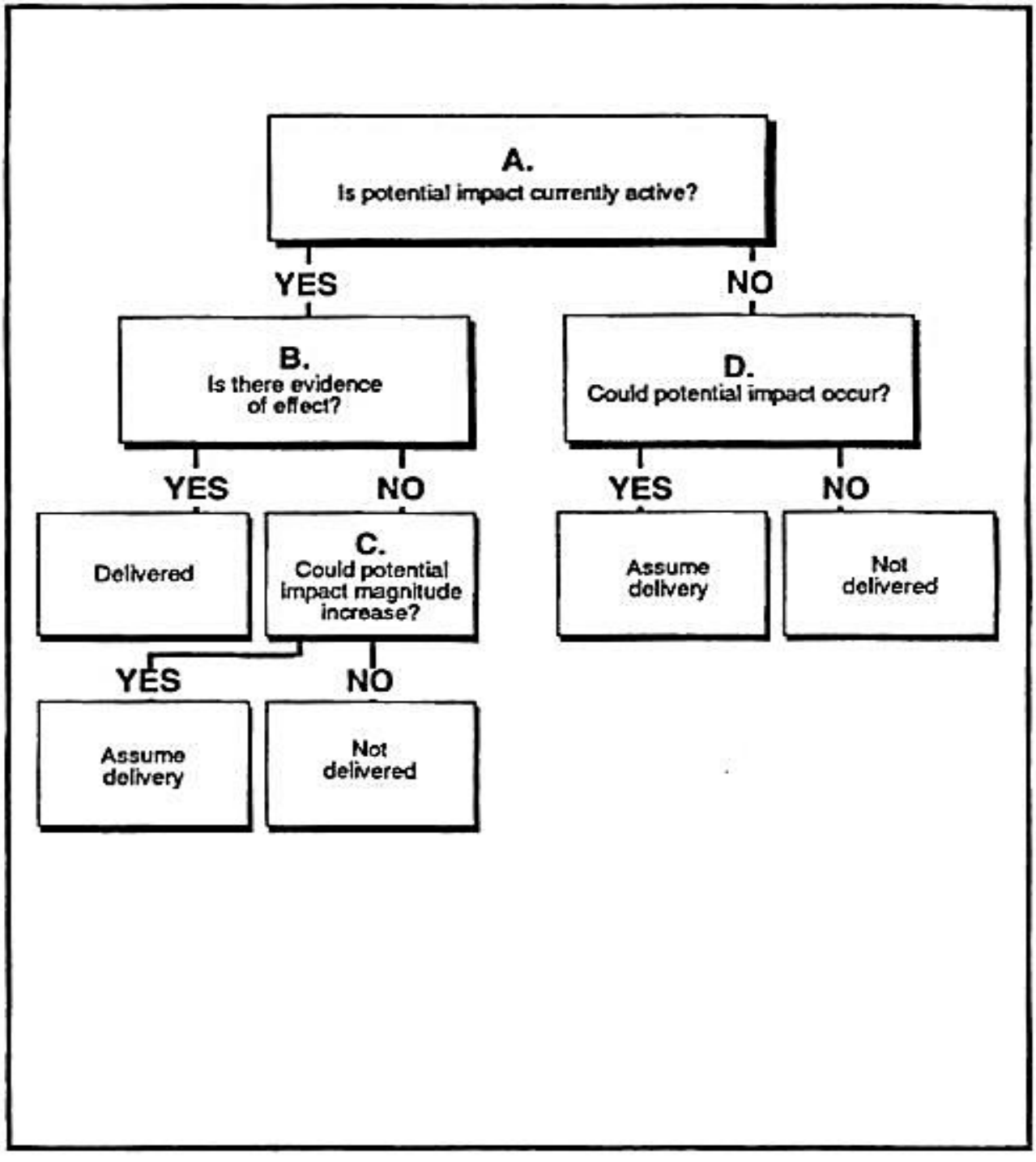

Figure I-2: Peak flow routing analysis.

Table I-1: Decision criteria for fine sediment routing analysis

Question	Response	Criteria
A. Is segment directly linked to potential impact?	Yes	Potential impact immediately adjacent to segment
	No	Potential impact not adjacent to segment
B. Is potential impact active?	Yes	Mass wasting events, or hillslope surface erosion, or road surface erosion currently generating fine sediment
	No	Mass wasting potential impacts, or hillslope surface erosion potential impacts, or road surface erosion potential impacts not generating fine sediment
C. Is there evidence of fine sediment effect?	Yes	• Spawning gravel fines rated as fair or poor • No stream bed armoring • Sand in stream bed • Decreased pool capacity • Channel module sensitivity • rating medium or high
	No	None of the above
D. Can potential impact be routed to segment?	Yes	• Intervening stream channel • conducive to transport of fine sediment • Sediment flushing flows likely • Upstream sediment storage capacity saturated
	No	• Upstream sediment storage available and inputs attenuated • Sediment flushing flows unlikely

Table I-2: Decision criteria for coarse sediment routing analysis

Question	Response	Criteria
A. Is segment directly linked to potential impact?	Yes	Potential impact immediately adjacent to segment
	No	Potential impact not adjacent to segment
B. B. Is potential impact active?	Yes	Mass wasting event generating coarse sediment
	No	Mass wasting event not generating coarse sediment
C. Is there evidence of fine sediment effect?	Yes	• No stream bed armoring • Decreased pool capacity • Channel module sensitivity rating medium or high • Channel widening
	No	None of the above
D. Can potential impact be routed to segment?	Yes	• Intervening stream channel conducive to transport of coarse sediment • Sediment flushing flows likely • Upstream sediment storage capacity saturated
	No	• Upstream sediment storage available and inputs attenuated • Sediment flushing flows unlikely

Table I-3: Decision criteria for peak flow routing analysis

Question	Response	Criteria
A. Is potential impact active?	Yes	• Moderate or high peak flow impact potential rating for the sub-basin
	No	• Low peak flow impact potential rating
B. Is there evidence of effect?	Yes	• Bank cutting obvious • Evidence of recent bed mobility • Bed armoring • Small particles only present on bars • Evidence of redd scouring
	No	None of the above
C. Could potential impact increase?	Yes	• Hydrologic maturity of vegetation could be decreased by timber harvest
	No	• Hydrologic immaturity is at maximum
D. Could hazard occur?	Yes	• Timber harvest could increase peak flow impact potential rating to moderate or high
	No	• Not possible to increase peak flow impact potential rating above low

Worksheet I-1: Record of routing decisions linking hillslope potential impacts to stream segments

River Basin _____ Date _____ Page _____ of _____

WAU _____ Analyst _____

Impact / Vulnerability Variable	Indicator Segment Number	Hillslope Impact Area			Routing Response and Criteria			
		Map Number	Unit Number	Rating	A	B	C	D