SECTION 11
STANDARD METHODOLOGY FOR CONDUCTING WATERSHED ANALAYIS

Table of Contents

Part 1 Introduction to Watershed Analysis

1.1 Background

The 1974 Forest Practices Act provides authority for state regulation of forest practices on Washington's 12.5 million acres of state and private lands. Regulations are primarily designed to protect public resources by preventing erosion from roads, to protect water quality and provide fish and wildlife habitat with streamside buffers, to protect wetlands and to ensure long-term supply of forests with reforestation requirements. Since 1974, significant changes have been made in the rules, reflecting improved scientific knowledge and efforts to promote efficient regulation and effective resource protection while ensuring industry stability.

Until the cumulative effects rules were adopted, forest practices were considered one activity at a time. Although the regulations provide protection on a site by site basis, there are concerns that the watershed as a whole may be affected by the "cumulative effects" of all of the activities in the basin. Cumulative effects have been defined as "the changes to the environment caused by the interaction of natural ecosystem processes with the effects of two or more forest practices." These changes may be taken to include effects on water quality, wildlife, fish habitat, and other public resources.

Although it is desirable to consider watersheds as a whole in regulations of forest practices, there are practical and conceptual difficulties in doing so. These arise from several sources:

1. Watershed ecosystems involve a complex dynamic between many watershed and biological processes operating at many spatial scales. Scientific understanding of these processes is limited, and comprehensive reliable techniques for evaluating watersheds are lacking.

2. The physical and biological characteristics of a watershed and sub-areas within it reflect the local geology, terrain, climate, vegetation and so on. Consequently, every watershed is unique, with its own distribution of these factors as well as effects due to the history of past disturbance including natural events or land use.

3. Because of these differences in landscape features, the sensitivity of watersheds and sub-areas within them to forest practices also varies from place to place. While one location may generate no likelihood of local or cumulative effects from an activity, the same activity conducted in the same way in another location with heightened sensitivity could have both local and cumulative impacts.

For all of these reasons, there appears to be no simple method that can be uniformly applied to watersheds throughout the state to reliably guide management activities at the basin scale to prevent cumulative effects. When evaluating forest activities one-by-one, it is difficult to adequately weigh all the possible effects of an activity for the entire watershed. Even though local site conditions are taken into account when conditioning forest practices applications for a site, the "one-size-fits-all" approach of forest rules based on "best management practices" that formed the basis for the forest practice regulatory process is not well suited to tailoring practices to local basin-wide situations as needed.

1.2 Recent History of Cumulative Effects Leading To A Policy Framework

In recent years, efforts have been initiated to review regulations to ensure more systematic treatment of cumulative effects.

The Timber/Fish/Wildlife (TFW) Agreement concluded in February of 1987, contained the following summary of a recommended approach to cumulative effects:

1. **State, regional, and basin goal-setting.** Goals and objectives should be developed that reflect local conditions and resource sensitivities. Participants should include TFW cooperators, such as tribes, landowners, and environmental groups.

2. **Use of risk assessment techniques for problem identification.** Methods and techniques should support the setting of goals and objectives. They should anticipate or predict future problems as well as define existing ones.

3. **Implementation of an adaptive management process** in which assessment tools, management and regulation are revised based upon experience and the feedback from monitoring.

4. **Monitoring and evaluation to determine if goals are being met.** Monitoring programs should be developed that are tailored to regional and local landscape variability.

5. **Reevaluation of goals as new information becomes available.**

In 1989, the TFW Policy Group approved a cumulative effects issue paper that recommended development of a system which would focus on individual basins. Problems assessment would address spatial and temporal issues, with efforts to define impact thresholds and recovery rates for affected resources.

The report went on to reinforce the role of the Cooperative Monitoring Evaluation and Research (CMER) Committee in providing the tools needed for addressing cumulative effects. CMER is composed of resource scientists with a number of technical disciplines who represent agencies, landowners, tribes and environmental groups. Their responsibility is to guide the development and application of TFW-sponsored research to improve forest management. In response to the specific recommendations from the policy group, CMER began working on a method that would provide a science-based approach for assessing watershed problems and sensitivities to be used as a basis for developing appropriate prescriptions.

The Sustainable Forestry Roundtable, which met periodically from 1989 through most of 1990, built the concepts on which CMER was working into the proposals that it considered. Even though the negotiations resulted in neither an agreement nor legislation, they did form an important point of reference for later consideration.

In 1991, proposed changes in the state forest practices rules drew upon these efforts, calling for the Department of Natural Resources (DNR) to continue work with CMER in developing a method for use in conditioning proposed forest practices for cumulative effects. The result of the work involving scientists and policy-makers was a recommendation that the Forest Practices Board adopt a process for developing a watershed forest practices plan tailored to each watershed based on scientific understanding. They termed the process "watershed analysis". The method defines areas of sensitivity within each watershed with explicit consideration of resource vulnerabilities based on the potential for specific impacts to public resources. This method was adopted by the Forest Practices Board into regulation in 1992 (chapter 222-22 WAC). (The Forest Practices Board decided not to include wildlife in the current watershed analysis rules.) Watershed analysis is a principle but not an exclusive section of the forest practice rules that addresses cumulative watershed effects.

As part of the watershed analysis rule, the state has been divided into approximately 800 watersheds ranging in size of approximately 10,000 to 50,000 acres. These watersheds are termed Watershed Administrative Units (WAUs). Their boundaries can be found on the DNR Watershed Administrative Unit Map.

1.3 The Washington Approach to Forest Watershed Management - Watershed Analysis

Watershed analysis is a structured approach to developing a forest practices plan for a WAU based on a biological and physical inventory. It is a collaborative process involving resource scientists and managers representing landowners, agencies, tribes and other interested public. Once initiated, the team conducts the assessment within a specific time-frame. (See figure I-1). The forest practices rules provide a policy structure to the process by encoding the steps, operating rules, key linkages and decision requirements for the team. This manual guides the specific technical steps of the process in support of the policy laid out in the rule. The application of the process is expected to evolve as scientific knowledge and experience with the process grows, and those improvements will be included in future versions of the Watershed Analysis Manual. The watershed analysis process can best be viewed as a work in progress.

Components of Watershed Analysis

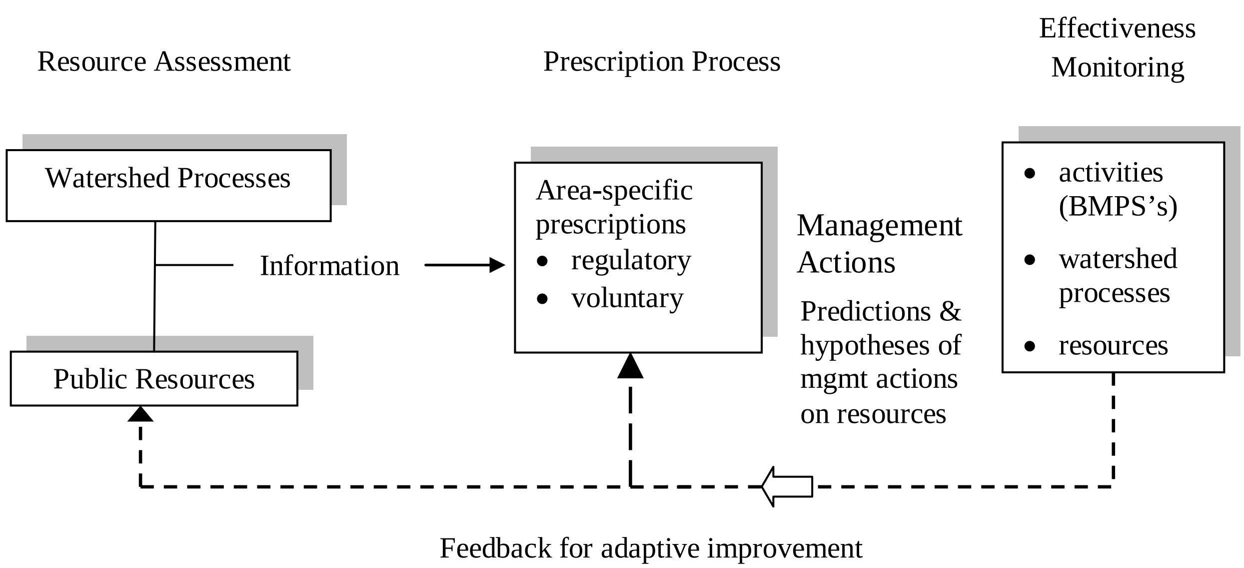


Figure I-1 The Major Components of Watershed Analysis

In watershed analysis, the scientists first develop information and interpretations of resource conditions and sensitivities at a watershed scale guided by a series of key questions. These findings include maps locating sensitive areas (which may include all or parts of the watershed) and reports describing the nature of the sensitivity and its risk to public resources supported with facts and data generated by the team. These then feed into a prescription process where local land managers and agencies develop a tailored management plan for the watershed that responds to the resource concerns identified by scientific investigation. Provisions are made for the public review of the findings of the watershed study and management prescriptions before final acceptance of the plan. Total time to completion is two to five months depending on the size and complexity of the watershed and the chosen level of assessment.

Once the watershed plan is developed, further forestry activities in the watershed must be conducted within the provisions of the watershed analysis prescriptions for each sensitive area, unless an alternative plan is approved, with compliance regulated by the DNR. Products of the watershed analysis are assumed to be valid for a period of five years, at which time the process may be repeated if necessary.

The watershed plan is designed to be adaptive. Provisions are included for design of an optional monitoring plan to be implemented by landowners, agencies, tribes, and others interested in the watershed to track the effectiveness of the prescriptions and the assessments on which they were based. Monitoring is designed to provide feedback on where resources were actually protected or improving as a result of prescriptions.

By encoding into regulations a science-based assessment process rather than a one-size-fits-all set of "Best Management Practices (BMPs)", the watershed analysis process represents a departure from conventional approaches to forest land regulation. The new system not only requires local scientific assessments but relies upon diligent revision as monitoring provides feedback on whether resources are improving or degrading. It also relies on stakeholders within each watershed to make it work.

Some of the important features of the watershed analysis process for regulating forest practices on state and private lands include:

- A recognition that watersheds are different and effects of forest practices are not uniform. Therefore, watershed information is required as part of the process for generating watershed prescriptions.
- Watershed activities are prescribed based on information generated by qualified scientists defining the watershed conditions.
- The plan containing a comprehensive set of prescriptions designed with respect to the landscape is constructed by qualified managers with provisions encouraging all stakeholders to participate in the process.
- The managers and scientists work together on the geography to conduct a watershed analysis.

1.4 Overview of the Scientific Framework and Assumptions

A basic premise of the watershed analysis is that a change in erosion, hydrology, or riparian function resulting from forest practices is significant when it is sufficient to cause an adverse change in a public resource of fish habitat, water quality, or public works. To adequately relate changes in watershed processes (sources or "causes") to effects on public resources they must be linked. Hillslope processes are linked to stream-related resources by the flow of geomorphic products of sediment, water, wood, and energy that shape and determine the stream environment. This linkage is depicted in Figure I-2.

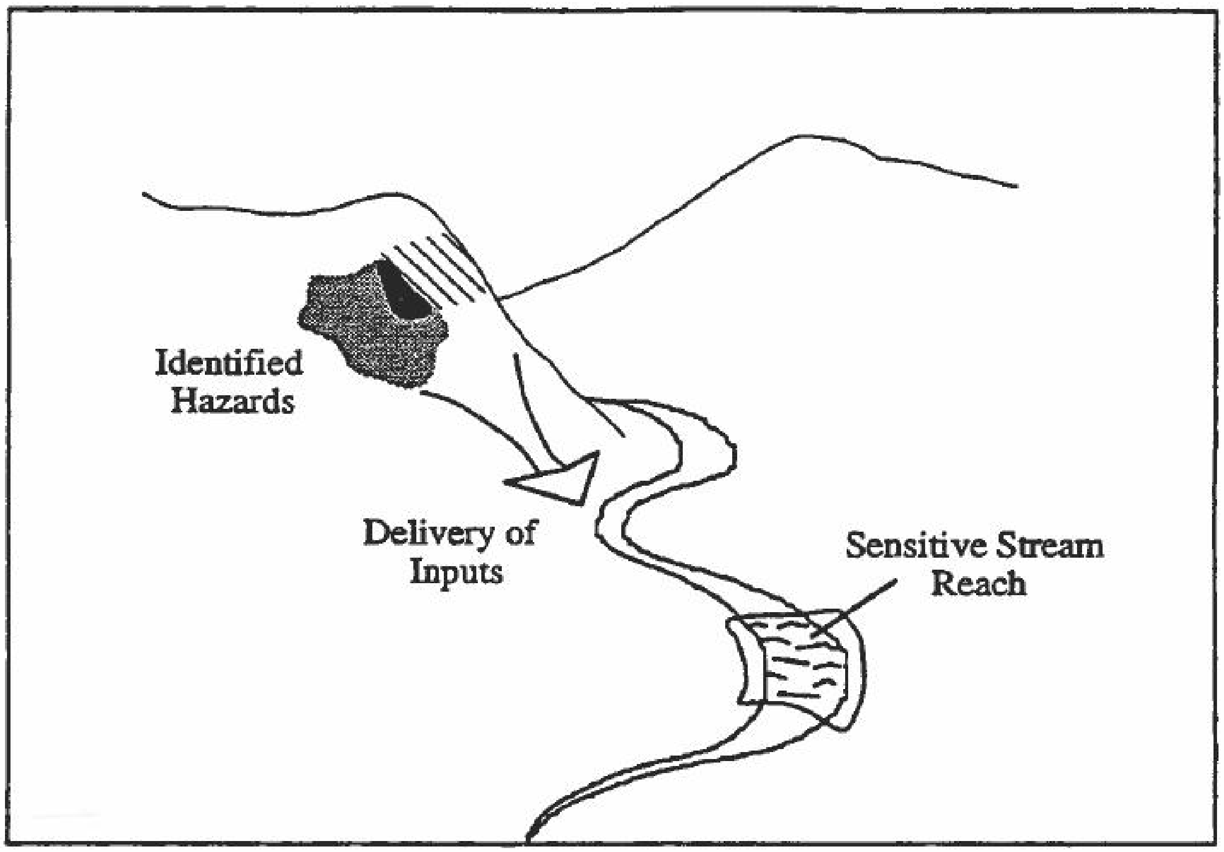


Figure I-2. Watershed analysis perspective of the spatial relationship between hillslope activities and stream effects through changes in input factors of sediment, water, wood or energy.

Forest practices may affect the amount of geomorphic products produced and delivered to streams in an area (i.e., increased erosion, changes in water available for runoff, altering wood loading to streams, or changing the temperature of water by removing shade). The mechanisms determining the effect of forest practices on the rate of input of geomorphic inputs are relatively well understood and approaches for assessing them are straightforward. Since each watershed possesses distinct environmental conditions, resource characteristics, and sensitivities, watershed analysis assessment is premised on the need to define locally active watershed processes that pose a significant risk to public resources. Each of these general processes includes more specific processes, and those addressed explicitly in the current version of watershed analysis are shown in Figure I-3.

Changes in geomorphic inputs, if large enough, may express themselves in stream channels in measurable ways. In turn, these changes in the physical characteristics of streams as they respond to sediment, water, wood and energy may have impacts on the biologic communities inhabiting them or public works located on or near them. Streams and associated resources such as fish habitat may be affected by changes in peak flows and timing of discharge. Higher sediment loading, arising from erosion and mass wasting, may cause pool filling or gravel siltation which may reduce the productive potential of a stream or stream segment. Reductions in large organic debris (LOD) recruited to channels may result in fewer pools and unstable stream beds. Other cumulative watershed effects include changes in stream temperature, nutrient levels and turbidity.

Although mechanisms for response are reasonably well understood, methods for correlating the extent of response of channels and biologic communities to changes in geomorphic factors are not well developed. For determination of impact potential or risk, a link must be made between the resource and a mechanism that can affect it. The procedure provides for this by defining resource vulnerability in terms of a specific susceptibility to change in flows of wood, water, energy, and sediment and the susceptibility is related to the manner in which resource functions respond to changes in physical conditions.

While individual models exist for assessing specific processes, no "off-the shelf" method is available that comprehensively links hillslope processes to resource impacts at a watershed scale. This reflects the inherent complexity of the many processes at work in the forest landscape as well as the immaturity of several of the scientific disciplines. Because of these deficiencies, individual methods and models must be linked in less comprehensive, less quantitative fashion.

Processes, Variables, and Resources Addressed in Watershed Analysis

Watershed Process

- **Erosion**
  - --Debris Torrents
  - --Earthflow
  - --Surface-roads
  - --Surface-hillsopes
- **Hydrology**
  - --Water availability during peak flow events
  - --Water availability during low flow
- **Riparian Function**
  - --LOD recruitment
  - --Shading
  - --Bank stability

Input Variable

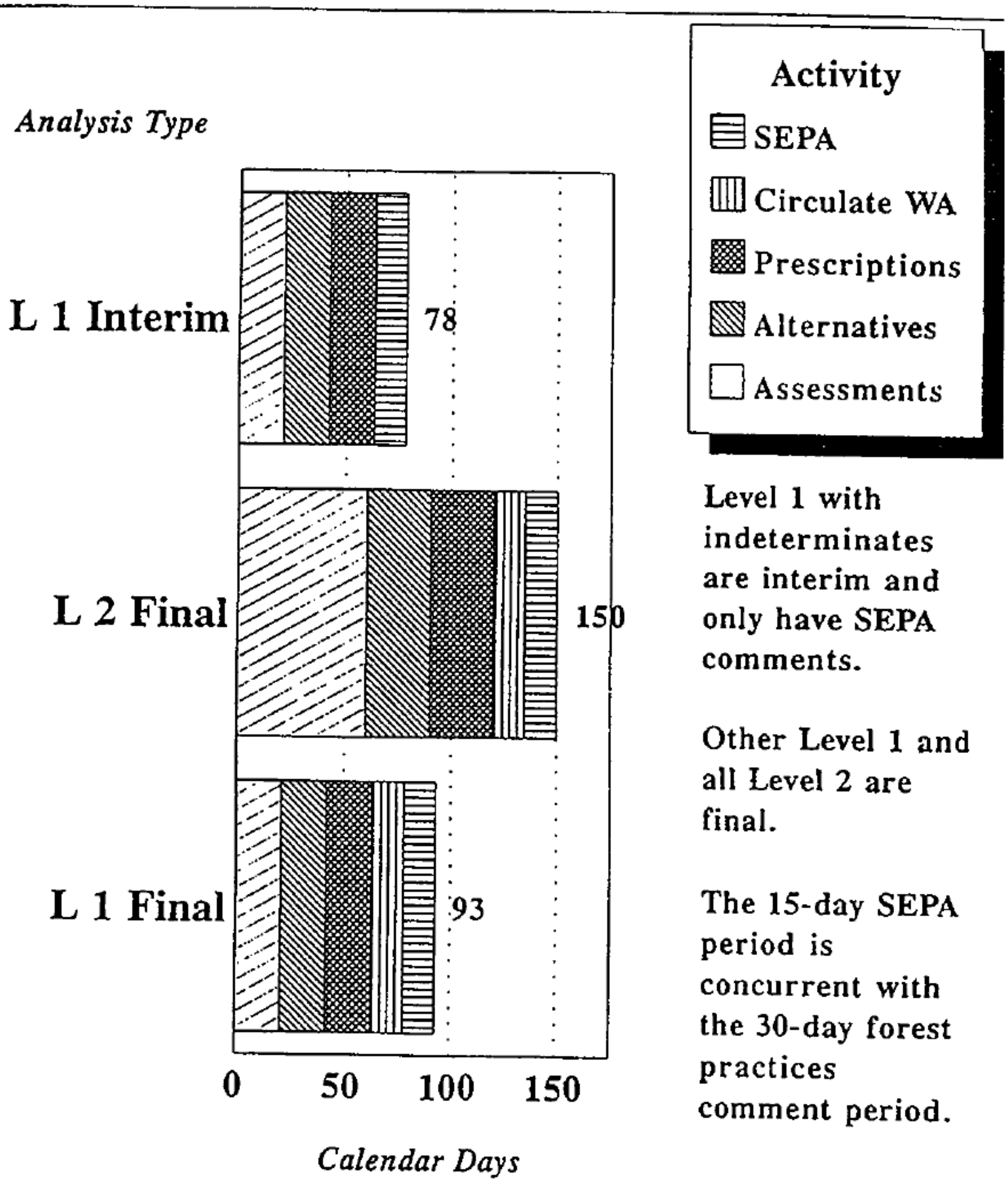
- **Sediment**
  - --Coarse
  - --Fine
  - --Washload
  - --Catastrophic channel damage
- **Water**
  - --Peak flow of large events
  - --Frequency of channel-forming discharge
  - --Annual yield
  - --Low flow
- **Wood**
  - --In-channel obstructions
- **Energy**
  - --Water temperature

Public Resource

- **Fish Habitat**
- **Water Supplies**
  - --Municipal
  - --Domestic
  - --Hatchery
- **Public Capital Improvments**
  - --Roads
  - --Bridges
  - --Reservoirs
  - --Irrigation
  - --Other significant structures

Figure I-3. Processes, Variables and Resources Addressed in Watershed Analysis

Maximum Projected Time by Activity



Level 1 with indeterminates are interim and only have SEPA comments.

Other Level 1 and all Level 2 are final.

The 15-day SEPA period is concurrent with the 30-day forest practices comment period.

Additional time required to assemble data and evaluate SEPA comments.

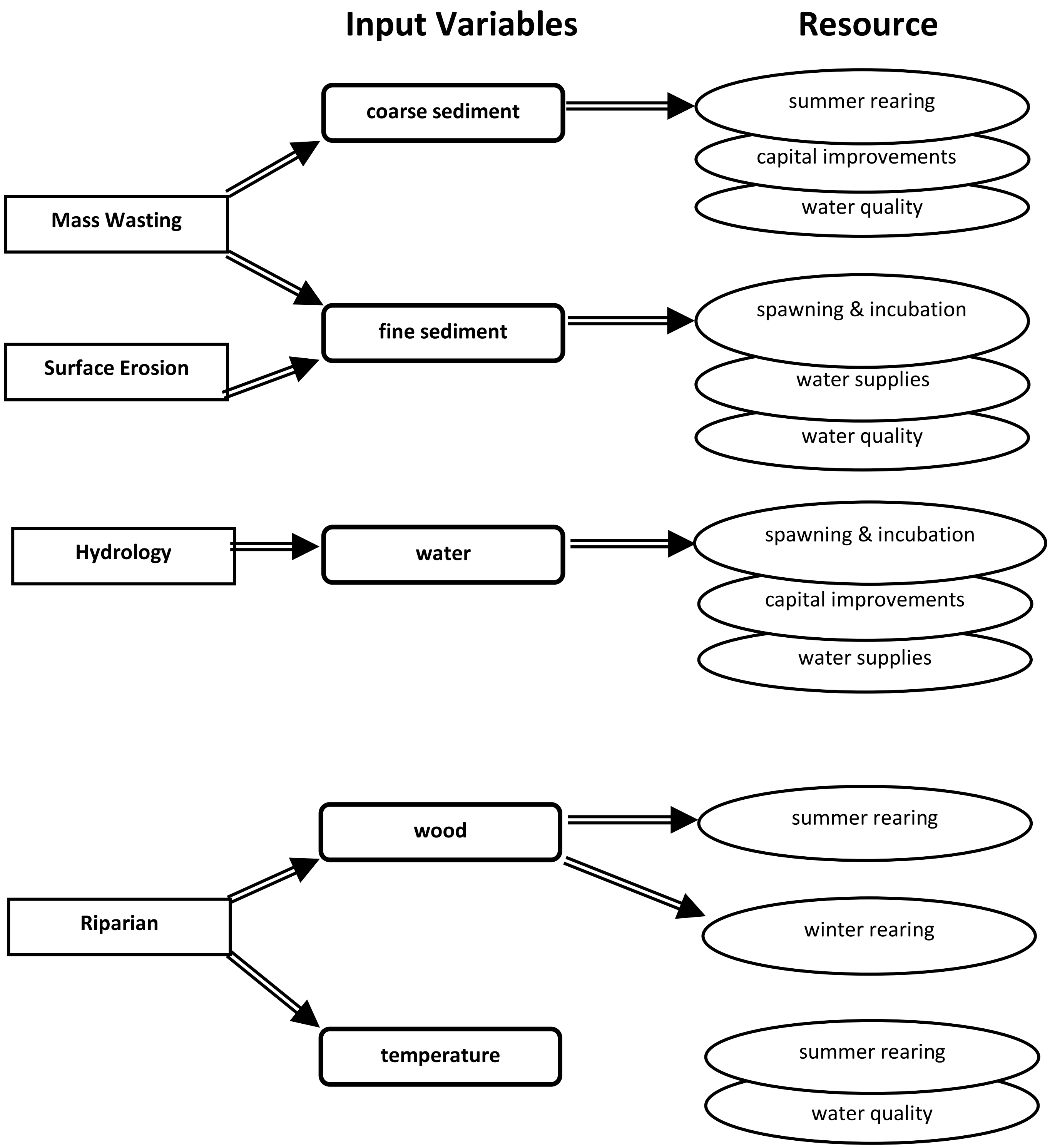


Figure I-4. Relationships among watershed processes, input variables, and effects on public resources.

1.5 Overview of the Operational Approach to Watershed Analysis

Cumulative effects may occur in two ways. Cumulative effects may result from the accumulation of the small effects of many forest practices that are insignificant at any one site, including practices conducted over time or space. This mechanism of cumulative effects may be most relevant for hydrologic changes and for some aspects of erosion from forest roads and stream-side buffers. Cumulative effects may also result from changes in dominant watershed processes, even when activities triggering effects are limited in spatial extent. This mechanism is operative in "sensitive areas" where watershed processes are particularly susceptible to change based on the local conditions. Cumulative effects are most likely for sensitive areas dominated by mass wasting, hillslope surface erosion, and some aspects of forest roads and streamside riparian zones.

A fundamental assumption of watershed analysis is that by applying standard forest practices in less sensitive areas and managing sensitive areas appropriately, the overall watershed condition will be protected and cumulative effects will not occur. The mission of the scientific assessment is to identify sensitive areas, which may include the entire watershed or sub-areas within it. (An area may be sensitive to a type or a rate of activity, and both are examined in watershed analysis.) Resource specialists gather information and interpret watershed processes and conditions. This information is used to identify resource sensitivities that require special management prescriptions to solve potential or existing problems not normally handled by standard forest practices. An assumption of watershed analysis is that resource sensitivities can be identified by qualified individuals at a scale appropriate for developing a sound watershed plan.

Once sensitivities are identified the field managers team develops prescriptions for the area with the justification that they are likely to solve the identified problem. An assumption of watershed analysis is that management plans should be developed by those with the skills and experience to conduct forest management activities. In addition, those with the responsibility to implement prescriptions should be involved in their development. It is a fundamental philosophy of the process that the best solutions will result when the scientists that develop the information for a geography work collaboratively with the resource managers responsible for developing and implementing the plan for the area.

1.6 Overview of the Watershed Analysis Team Process

Once a watershed analysis is started, the team process progresses through a series of steps beginning with resource assessment, followed by prescription writing, and concluding with wrap-up steps that assure a handoff of responsibilities for monitoring and voluntary activities to stakeholders in the watershed. This manual provides instructions and guidelines on how to perform each step of watershed analysis.

Startup

Watershed analysis is initiated with startup. In this step, the maps, photographs and data are collected. The various teams are formed, responsibilities are defined, and notifications are distributed. The resource assessment team also develops a plan for performing the required evaluations of the watershed.

Resource Assessment

The resource assessment takes an interdisciplinary team approach that requires inventories of watershed processes and resources following a structured approach to problem definition that is framed by a series of critical questions. Team members possessing skills in forestry, forest hydrology, fisheries, forest soils science or geology, and geomorphology locate and map sensitive areas, evaluate potential impacts of delivery, and assess the potential or existing impacts on resources. The inventories and subsequent interpretations provide a basis for area-specific problem statements and rule calls linking forest practices, watershed processes, and resource effects.

Prescription Process

Based on the findings of the resource assessment, a field managers team made up of managers and analysts determines the required and voluntary forest practices for each identified area of resource assessment. Managers and resource specialists visit the sensitive areas and identify one or more practices or strategies for each that are likely to prevent, avoid, or minimize problems. Problems associated with non-forest activities are referred to the appropriate agency. Prescriptions are included in the watershed analysis report. The report is provided to the Department of Natural Resources, which manages the public review.

Wrap-up

Once the watershed analysis report is complete, the watershed analysis team may perform one last task - develop a plan to measure the effectiveness of the prescriptions. The group identifies appropriate monitoring variables and protocols to test the effectiveness of the plan using the information gathered in the assessments as a basis. These will depend on (1) the findings of the watershed analysis, (2) the variables most useful for determining whether long-term resource goals are met, and (3) the financial and personnel resources available. Two steps are useful: a prognosis step, in which the team hypothesizes their expectation of likely future conditions, given management prescriptions; and a monitoring selection step, in which specific characteristics are selected for tracking whether those expectations are met. These are passed on to stakeholders in the watershed for implementation.

1.7 Watershed Analysis Products

The watershed analysis team produces a number of products during the assessment. The resource specialists produce:

- Resource condition reports describing watershed conditions;
- Maps of sensitive areas requiring prescriptions;
- Causal Mechanism reports describing the sensitive area and the nature of potential problems; and
- Rule calls based on resource vulnerability that determine standards of performance for the rule call.

The field managers produce:

- Prescriptions with justification for each mapped sensitive unit.

The entire team produces the final watershed report and may develop a monitoring proposal for the watershed to be handed off to stakeholders in the watershed.

Part 2 Process Overview

2.1 Introduction

This manual is designed to provide a step-by-step approach for performing watershed analysis. The manual includes steps which are required, as well as suggestions that may improve the watershed analysis process. It leads the members of the team through the steps to create the resource assessment for a watershed, define problems and sensitivities, produce management prescriptions, and monitor effectiveness. Individuals leading and/or participating in a watershed analysis should be familiar with the appropriate rules and regulations (chapter 222-22 WAC) in addition to the information contained in this manual.

The process includes assessments of current and potential watershed and resource conditions by resource specialists. Assessments identify existing and potential hazards and their relationship to resource vulnerabilities. Subsequently, the field managers team develops prescriptions based on information generated in the resource assessment. (Figure 1 indicates the general steps involved in the watershed analysis process, and Table 1 provides an overview of the specific steps.)

2.2 Start-up

Watershed analysis begins with start-up. Whether the watershed analysis is initiated by the DNR or by a private landowner, identification of all landowners in the WAU is a key starting point. The maps, photographs and available data are collected, the working teams are formed, responsibilities are defined, and required notifications are distributed. The resource assessment team then develops a plan for performing the required evaluations of the watershed.

Prior to actual start-up, it can be useful to call an initial "scoping" meeting for landowners and other interested parties so that they may understand what watershed analysis entails and the team may determine the landowner's abilities to participate and provide helpful input.

Resource Assessment

Once underway, the scientific team follows a two-phase process for performing resource assessment. In the inventory phase, data is gathered and interpreted for individual watershed processes and resources, with analysts working relatively independently from one another. In the synthesis stage, the analysts work together to develop a watershed scale perspective of cause and effect linkages between hillslope and stream processes. They identify resource sensitivity areas requiring additional prescriptions reported in the causal mechanism report.

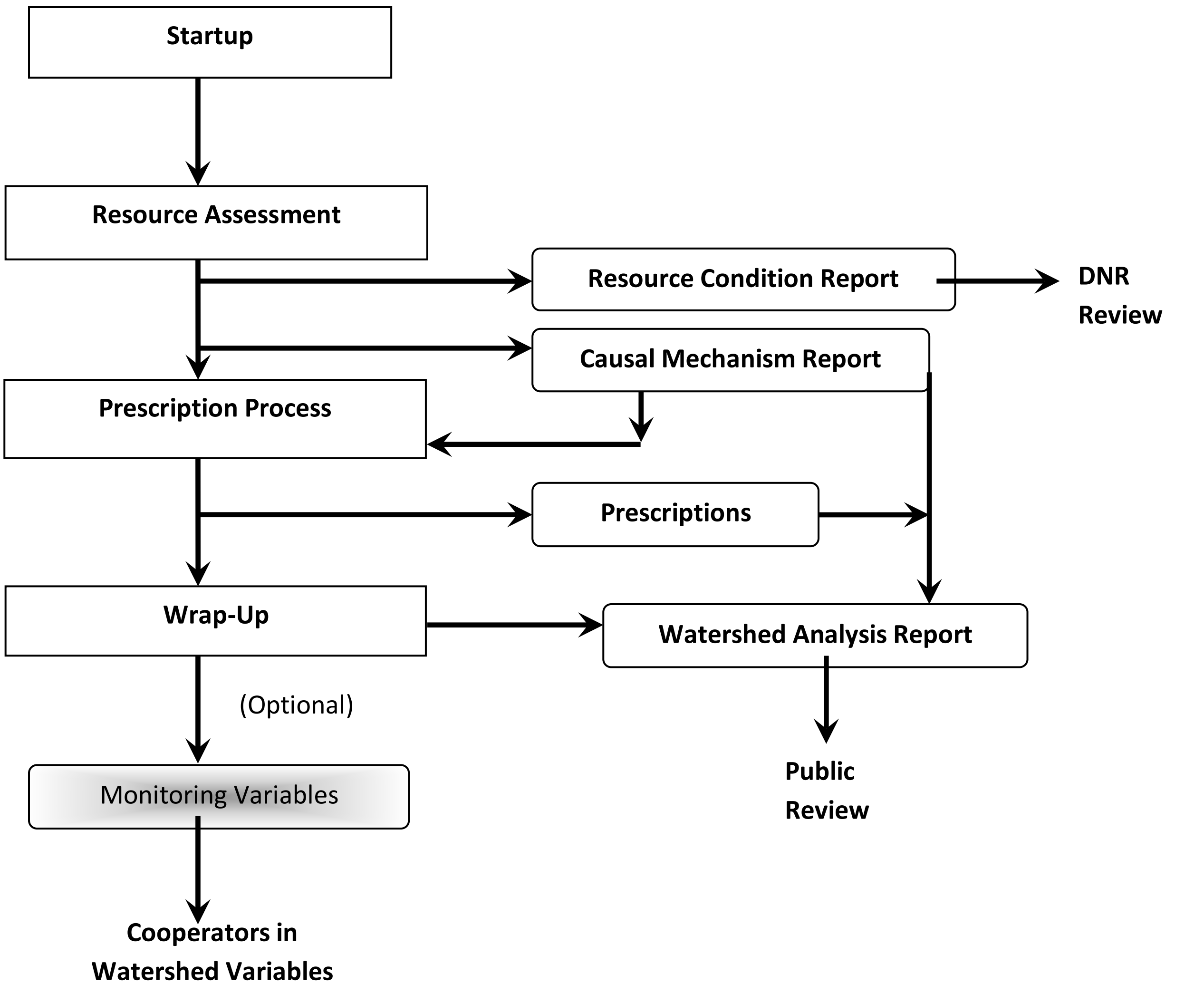


Figure 1. Watershed Analysis Team Process Steps

2.3 Prescription Process

Based on the findings of the resource assessment compiled in the causal mechanism report, a field managers team made up of managers and analysts determines the required or voluntary forest practices for each identified area of resource sensitivity. For each area, the team should prescribe one or more practices or strategies that are likely to avoid, prevent, or minimize problems. When necessary, managers and resource specialists should visit the sensitive areas. Voluntary enhancement opportunities can be noted at this point. Problems associated with non-forest practice related activities are referred through the DNR to the appropriate agency. Prescriptions are reviewed with the resource assessment team to assure that the correct resource sensitivities are addressed and are included in the watershed analysis report.

2.4 Final Steps

Report

Watershed analysis for the WAU is completed when the team produces the watershed analysis report. Prescriptions are attached to each resource sensitivity identified in the causal mechanism report. The proposed monitoring plan is also attached.

Review

The team leader must also complete the environmental checklist, as required under the State Environmental Policy Act (SEPA).

The full report and checklist is forwarded to the responsible official (DNR Resource Protection and Service Assistant Regional Manager) for Threshold Determination.

The DNR will coordinate review as specified in WAC 222-22-080.

Wrap-up

Once the watershed analysis is completed, the entire watershed analysis team may perform one last task. The group may select appropriate monitoring variables and protocols to measure the effectiveness of the prescriptions and resource response. These will depend on (1) the findings of the watershed analysis, (2) the variables that are likely to be most useful for determining whether long-term resource goals are met, and (3) the financial and personnel resources available. Two steps are useful: a prognosis step, in which the team hypothesizes their expectation of likely future conditions, given management prescriptions; and a monitoring selection step, in which specific characteristics are selected for tracking whether those expectations are met.

Forms and Worksheets

Various data forms and worksheets are provided in the manual to assist the assessment team and field managers team. Use of these forms is encouraged in that they provide some tracking and accountability to the data gathering and interpretation. It is expected that these forms can be used in place of lengthy written documents, encouraging the team to spend time writing only where judgment or deviations from methods are used and brief narratives are useful. The use of forms and worksheets will need to be flexible, especially for Level 2. Analysts may be using different methods than those for which the forms were designed.

It is recommended that some narrative be included in the final report for the benefit of land managers and others who become involved with the watershed several years after the original analysis is completed.

Table 1. Overview of the Specific Steps of Watershed Analysis.

1. Startup

   Identify leader(s). An overall project manager is recommended in addition to the required team leaders.

   - Identify and notify landowners in the WAU.
   - Notify affected Indian tribes, county and city governments in the WAU, and the public (prior to starting the analysis).
   - Hold a "scoping" meeting, if desired.
   - Appoint qualified individuals to perform assessments and fill team roles.
   - Notify DNR of intent to start watershed analysis (as set forth in WAC 222-22-040(3)); the analysis may begin within thirty (30) days after this notification is received by the DNR.
   - Gather starting information (maps, aerial photographs, management history).
   - Schedule first meeting.
     - Develop team schedule and responsibility list.
     - Develop plan for common sampling and coordination of fieldwork.

2. Resource Assessment
   - Qualified analysts (Level 1) or specialists (Level 2) implement inventory modules of resource assessment.
   - Team meets (preferably with field managers present) to perform synthesis of watershed information gathered in inventory.
   - Team completes causal mechanism report for identified watershed sensitivities and resource condition reports describing watershed conditions.
   - Team makes recommendations on indeterminates and the need for Level 2 if appropriate.
   - Schedule hand-off of resource assessment to field managers.
   - Schedule Level 2 if necessary (can occur immediately or at a later time).
   - Circulate the products (including supplying copies to the DNR region when the assessment is completed).

- If no consensus see WAC 222-22-050(3), -060(4).

3. Prescription Process
   - Convene field managers team (managers, engineers, and analysts as needed).
   - Develop prescriptions for each identified resource sensitivity.
   - Attach prescriptions to causal mechanism report.
   - Review with the assessment team (recommended).
   - Complete compilation of watershed analysis report.
   - Complete the environment (SEPA) checklist.
   - Forward the report to the responsible official (DNR Resource Protection and Service Assistant Regional Manager).

4. Wrap-up
   - Reconvene resource analysts and managers.
   - Develop prognosis for watershed considering current conditions and hypothesized condition given management prescriptions.
   - May recommend monitoring program considering useful measures and financial resources.
   - Pass on to watershed stakeholders.

Part 3 Start-up

3.1 Overview

Start-up of the watershed analysis team involves administrative functions of notification of other landowners, the DNR, other state agencies, local governments, Indian tribes, and the public; identification of the assessment and field manager teams; and assembly of the maps, aerial photographs, and management history required by the resource assessment team. Whether conducted by a landowner-sponsored team or the DNR, the efficiency of watershed analysis is affected by the openness of the process, landowner support and involvement, availability of local knowledge, team composition and function, GIS capabilities and prior assembly of required information.

It is recommended that a scoping meeting be held with other landowners in the watershed analysis unit and affected agency and tribal representatives prior to official startup. The intent of this meeting is to explain the process and outcome of watershed analysis and solicit their participation, if appropriate.

This is also the time to hold the first meeting with the teams, preferably both resource assessment and field managers. Prior to this first team meeting, team leaders should ensure that their team has an approved WAU base map with the updated WAU boundary, and all maps and aerial photos they will need. At this first meeting, the team should develop a schedule and recognize the importance of staying on that schedule.

3.2 Watershed Analysis Initiation

A watershed analysis for a WAU is initiated either by landowners whose lands comprise 10% or more of the watershed or by the DNR according to its priority based on the DNR watershed screening. The WAU boundaries are determined by DNR and are available in digital form. These boundaries were pre-delineated at 1:100,000 scale. Prior to official start-up, the WAU boundary needs updating to 1:24,000 scale and approval from DNR. Updates to this larger scale may be provided by either landowners or DNR. These boundary corrections require approval from DNR Forest Practices prior to further data acquisition.

Landowners may initiate either a Level 1 or Level 2 assessment and are responsible for arranging for the appropriate analysts or specialists and field managers required to complete the process. A list of qualified analysts and specialists is available from the DNR, Forest Practices Division, (360) 902-1400. Qualification requires that an individual have appropriate skills, experience and education and has completed the DNR training in watershed analysis. (A Level 1 team has 21 calendar days to complete the assessment while a Level 2 team has 60 calendar days.)

Retraining is advisable if substantial revisions are made to the watershed analysis manual.

Team Roles and Expertise
There are a variety of functions that must be performed for a team to successfully and efficiently accomplish watershed analysis. These include administrative, scientific, management decision-making, and support functions.

The success of the team may be determined by the energy and skills of the team leader.

The project manager's job is to complete the watershed analysis. The project manager acts as a facilitator between the assessment team and the field managers team and keeps the entire process on the time track that has been established.

Weekly status reports from the module leaders to the team leader may be an effective way of keeping track of their progress. It is recommended that the team leader not assume the role of a module leader.

Observers may be allowed in the watershed analysis process. Their presence is up to the initiator of the watershed analysis. If they are allowed, their roles should be clearly defined during the start-up procedure.

Project Manager
- Notifies landowners and requests start-up information, including official basemap;
- Appoints qualified members to the team (forest landowners conducting watershed analyses are encouraged to include available, qualified expertise from state and federal agencies, affected Indian tribes, other landowners, local government entities, and the public.) Early notification will facilitate securing qualified personnel;
- Notifies DNR that a watershed analysis is to be performed;
- Obtains list of landowners and other interested/affected parties in the WAU, sends letter of notification, and requests start-up information.
- Sets up contacts with local expertise and requests other additional information;
- Monitors timelines for notification/products; coordinates meetings; and
- Completes environmental (SEPA) checklist.

Assessment Team Leader
- Schedules first team meeting; and
- Oversees team performance and ensures quality of completed product.

Resource Assessment Analysts and Specialists

- Implement the inventory modules (see Resource Assessment section of this manual):
  - Mass Wasting
  - Surface Erosion
  - Hydrology
  - Riparian Function
  - Fish Habitat
  - Water Quality
  - Public Capital Improvements
- Conduct watershed synthesis identifying resource sensitivities and rule calls described in the causal mechanism report.

Field Managers Team

- Produce prescriptions for areas of resource sensitivity; team may include members with expertise in the following disciplines:
  - Forestry
  - Forest Engineering
  - Fisheries
  - Forest Hydrology and/or Water Quality

Data Technician (Optional, *Recommended*)

- Produces or acquires official basemap, assists with compiling other maps and photographs for start-up.
- Acquires digital datasets from the DNR of other GIS compatible sources.
- Assimilates 'canned' computer programming for use in map and report generation.
- Provides special GIS/Cartographic products and analysis in support of management decision-making, time management, and prescription writing.
- Compiles digital data for ARS's (Areas of Resource Sensitivity).
- Helps produce the watershed analysis report.

Landowners

- Participate in watershed analysis process through qualified representation on resource assessment and/or field managers teams;
- Facilitate assessment process by providing information and materials;
- Ensure access to area; and
- May submit prescriptions to field managers team.

Tribal Representative

- Participate in watershed analysis process through qualified representation on resource assessment and/or field managers teams;
- Facilitate assessment process by providing information and materials; and

- Can cooperatively implement watershed analysis with the department depending on tribal resources.

Observers (Optional)
- Observe watershed analysis process and/or may perform field work under supervision of qualified analysts or specialists.
- Additional participation is at the option of the project manager.

Start-up Materials
Timelines for completion of Level 1 and Level 2 watershed analysis are set forth in the rule (WAC 222-22-070, -080). The availability and quality of materials and data at the start of the analysis are keys to meeting required timelines. A common set of maps and aerial photographs is needed by all of the resource assessment modules and must be gathered by the team or project leader prior to the team's first start-up meeting. If this is done, the team will be able to begin field assessment immediately and will be more likely to meet the time requirement for producing a causal mechanism report. Table 2 lists the information, maps, and aerial photographs that should be produced prior to assembling the assessment team. The notification letter should request landowners to provide the key management information specified in the table. If possible, the information from all landowners should be consolidated onto the official basemap.

Table 2. Startup Materials for Each WAU

What	Detail to be included	Where obtained
Official DNR Base Map 1:24,000 scale 1:2,000 ft.)	• Official base map with township and ranges • WAU study area boundary • All streams and surface water typed according to the DNR water type map	• Forest Practices Division, Department of Natural Resources (Olympia)
Topographic Map	• USGS 7.5 minute topographic maps (or better) **Note:** Digitized elevation data from the USGS is usually of insufficient resolution.	• USGS or • DNR Photo and Map Sales • Local vendors
Vegetation Age Maps	• Forest stand age map in 10-year increments • Hydrologic maturity map	• Landowners • DNR GIS Group
Road Map	• Complete road map color coded according to the attached table	• Landowners
Soil Erosion Map	• Soil erosion potential map for the WAU	• DNR maps and cartography
Aerial Photographs	• All available photography, with a special emphasis on the (1) oldest and (2) most current photo sets **Note:** Flight lines for all photo series should be clearly keyed to location in the study area.	• Landowners or • DNR Photo and Map Sales
Management Activities	• Logging history by logging type (with general areas of tractor, highlead, or railroad logging noted) • Areas of INTENSE burns (natural or prescribed) • Known locations of splash-damming • Known locations of stream cleaning	• Landowners • Landowners • Landowners or anecdotal information • Landowners or Dept. of Fish & Wildlife personnel
Other	• Fish distribution questionnaires • Local expertise familiar with the watershed	• Local agency representatives for Dept. of Fish & Wildlife and • Tribal representative • Leader and team's familiarity

GIS Support

Although all of the resource assessment methods are designed to be performed with standard maps and photography, these assessments are facilitated by accessing information through a Geographic Information System (GIS). The GIS database can greatly ease the time and effort in capturing and mapping information. The DNR GIS has most, if not all, of the information requested in Table 2.

For watershed analyses conducted by parties other than the DNR, the initiating parties are solely responsible for obtaining the GIS start-up kit from the DNR Forest Practices Division. Indicate types of software and media to be used in the analysis.

Specific information for the GIS team members:

Provide each resource analyst with:

- Copies of team base map
- Copy of specific module base map
- Mylar overlays with new WAU boundary at 1:24,000 scale, USGS 7.5' corner tics, quad boundaries, township and range boundaries, map # and label (i.e., C-1 Hydrology base map) standard map legend for each module

Information on GIS products and official WAU boundaries may be obtained from the Forest Practices Division at (360) 902-1400.

3.3 Level of Assessment

Resource assessment can begin at either Level 1 or 2. It may have only Level 1 or Level 2 assessment or a combination of both. Level 1 is a reconnaissance assessment, relying predominantly on maps and remotely sensed information with some field checking. The assessment is designed to take one to two week's effort by the team. Level 2 may be similar but results in a more detailed assessment of the overall watershed, or it may be focused on specific resource issues identified by Level 1. More experience and education is required for Level 2 specialists and more time may be needed to perform a Level 2 analysis.

Begin at Level 1:

If the assessment begins at Level 1, then the analysts complete the assessment as specified in this manual and determine the resource sensitivities and the rule calls. If the Level 1 assessment contains any areas in which the delivered hazard or resource vulnerability are identified as indeterminate, or if the Level 1 methodology recommends it, then a Level 2 team may be assembled. The uncertainties can only be resolved by a Level 2 team.

Begin at Level 2:
If resource assessment begins at Level 2, then the specialist must complete the standard products required of Level 1, except that the Level 2 team shall not have any indeterminates in the calls. Level 2 products may vary somewhat in detail or substance from Level 1 products.

Level 1 followed by Level 2:
If the Level 1 assessment results in any indeterminate ratings, then Level 2 analysis may be assembled for the primary task of resolving the uncertainties. The Level 2 specialists have flexibility in methods which allows the team to develop and test hypotheses, responding to the findings of the Level 1 assessment. The manual allows the specialists to exercise judgment in selecting methods to answer the critical questions and asks for justification of their use. The Level 2 team in this situation may not have the full complement of resource analysts to perform each method.

Level 1 followed by Level 2 for review:
A Level 2 team may be convened to review all or part of the Level 1 assessment. The team may revise the ratings as appropriate.

3.4 Specific Start-up Steps

Before actually beginning a watershed analysis, interested parties should consider updating stream types for the WAU. Stream types should generally **not** be updated **during** analysis because parts of the analysis depend on the stream type. Prescriptions often hinge on stream type, so it is advantageous to all concerned to have a good idea of correct stream types **prior to analysis**.

Identify leader(s).
A representative of the DNR or private landowner initiating the watershed analysis must be identified as project manager or the team leader (although the task can be reassigned after the team has been convened). This person is responsible for conducting the initial steps before the full team is convened.

Identify landowners in the WAU.
If there are few landowners in the WAU, the team leader/initiating landowner, or local DNR forester may be sufficiently familiar with them to compile the appropriate list.

If there is uncertainty of ownership, the county tax assessor may be a good source for this information. If the assessor's forest tax information base is computerized, it may be queried according to township/ranges to yield an ownership list.

Notify landowners in the WAU and request information/participation.
A reasonable attempt will be made to notify landowners in the WAU. The project manager should send out a letter to the landowners with the purpose of (1) notifying them that a watershed analysis is to be conducted, (2) inviting them to participate or observe, (3) requesting the information listed in Table 2, and (4) defining the official starting date and contact person.

Provisions should be made for the team to obtain access to all lands within the WAU.

Notify DNR in writing of intent to start a watershed analysis (as set forth in WAC 222-22-040(3)).

Send out the fisheries and capital improvements questionnaire.
A list of state and tribal representatives is available for each WAU from DNR regional offices.

Gather starting information (maps, aerial photographs, management history).
Start-up materials specified in Table 2 should be assembled. If maps or aerial photographs or GIS data are to be obtained from the DNR, an order should be placed several weeks prior to assembling the team. The team leader is ultimately responsible for securing all information and for adherence to mapping and data standards.

The official DNR base map WAU boundary is the boundary for the watershed analysis. This map can be obtained by acquiring the start-up ARC/INFO macro package from the DNR Forest Practices Division. It is important that standards established within these macros be maintained since the data sets prepared by watershed analysis will be entered into the DNR GIS and used to track ARS's and related prescriptions.

Be certain you are using the official WAU boundary by contacting DNR Forest Practices Division in Olympia at (360) 902-1400. Use of an incorrect boundary may result in delays in completion and approval of the analysis.

Official start-up GIS macros (ARC/INFO) generating products at 1:24,000 and 8.5 x 11 includes:
- Team base maps aml
- Hydro module aml
- Contour aml
- Landsat aml
- Soil erosion module aml
- and related reports

Official Start-up data sets (ARC/INFO export format) include: WAU boundary (1:24,000 scale)

		___	Storm 2, 5, 10, 25, 50, 100
___	Hydro	___	Precipitation Zones
___	Trans	___	Slope morphology
___	Soils	___	Stream temperature
___	POCA	___	303d (Department of Ecology)
___	Canopy	___	FPWET
___	Annual precipitation	___	LAT75 (DEM's)

- Topographic maps - USGS 7.5'
- Aerial photos

It may be useful to prepare mylar overlays for the basemap to be used by each of the resource analysts:

- Transfer boundaries of the WAU onto each.
- Put register marks on the map layers and transfer onto mylars.
- Label mylar layers with map number and title.
- Decide where the legend will go on all maps and what the legend design will be.

Identify resource assessment team and other participants in the process.
It is recommended that the field managers team also be identified early in the process. Complete the team information form.

Schedule first meeting:

- Develop team schedule and responsibility list.
- Develop plan for common sampling and coordination of fieldwork.

Begin Resource Assessment.

3.5 Products of Start-up

- Notification sent by DNR or initiating landowner.
- Official WAU boundary map at 1:24,000 scale.
- Work map identifying landowners who need to be notified of watershed analysis and contacted for access.
- Team schedule.
- Team Information Form(s) 1 lists members of the Resource Assessment Team; Form 2, the Field Manager's Team. The WAU, date of notification, and initiating landowner should be clearly identified on each form.

Form 1. Team Information Form

WAU: _____________ Start Date: ___________ Initiated by:_________

Position	Name	Address	Phone Home/FAX	Cert. ? Y/N
Team Leader				
Administrator				
Resource Specialist				
• Mass Wasting				
• Surface Erosion				
• Hydrology				
• Fish Habitat				
• Riparian Function				
• Stream Channel				
• Water Supply Public Works				
Data Technician				
Landowner Representatives				
Tribal Representatives				

Form 2. Field Manager's Team Information

WAU: ___________ Start Date: __________ Initiated by: __________

Position	Name	Address	Phone Home/FAX	Cert. ? Y/N
Team Leader				
Participant				
Participant				
Participant				
Participant				
Participant				
Participant				
Observer				
Observer				
Observer				
Observer				

Part 4 Resource Assessment

4.1 Overview

The resource assessment takes an interdisciplinary team (ID) approach with team members possessing skills in forestry, forest hydrology, fisheries, forest soils science, geology, and geomorphology. The primary objectives of the scientific team are: (1) to develop an understanding of the past and present factors influencing watershed condition and a comprehensive view of the cumulative effects of practices, and overall vulnerabilities of the watershed as a whole, and (2) to locate any areas sensitive to erosion, hydrologic change and riparian functions, establishing the level of sensitivity based on the risk to public resources, for which prescriptions must be developed. The inventories and subsequent interpretations provide a basis for area-specific problem statements and rule calls, linking forest practices, watershed processes, and resource effects. The expectation is that the team can construct a complete picture of a watershed and how it works at a scale appropriate for guiding land use decision-making.

To accomplish this, the various TFW cooperators envisioned a watershed resource assessment method that meets the following specifications:

Comprehensive: a framework appropriate for the assessment of a variety of watershed processes and potentially affected public resources, including fish, water quality, water supply, and public capital improvement. The framework should be compatible with wildlife assessment needs, even though a wildlife component is initially excluded.

Area-Specific Focus of Analysis: methods should confront problems of scale, resolution, and natural variability of landscapes. The method should be designed for more detailed and intensive focus (at higher resolution) when so dictated by processes under evaluation.

Scientific Grounding: evaluations should be based on the best science available.

Repeatability: methods should be specified to ensure that the same conclusions and results could be reached by independent reviewers.

Explicit Treatment of Uncertainty: key assumptions should be displayed; potential for error should be clearly defined.

Accountability: all assessments and determinations should be supported by a written record that provides a basis for decisions and interpretations.

Delivering the expected products while satisfying these criteria poses a challenge for design of the resource assessment method since none of the watershed assessment or cumulative effects methods currently available satisfy all of them. To meet the specifications as closely as possible, the resource assessment procedure included in this manual includes a mixture of analytical and qualitative assessments performed by the individual scientific disciplines and the team as a whole.

4.2 Basic Features and Design of Resource Assessment

To comprehensively address the sensitivity of multiple watershed processes to forest practices, and to determine the current condition and vulnerability of a variety of public resources, a two-stage process was developed.

In the first stage, the interdisciplinary team members develop data, observations, and interpretations for each watershed and public resource component. This stage of resource assessment is termed the "Inventory Stage" (see Figure 2). Assessing multiple watershed processes is accommodated by analysts first working relatively independently from one another, with each focusing on a particular aspect of watershed function and identifying conditions at whatever scale is appropriate for that process. Thus, during the inventory stage each analyst takes an area-specific focus using a "top-down" approach. Data is gathered and interpreted for individual watershed processes and resources with the intent of identifying and mapping specific areas of sensitivity or resource concern (these areas can include the entire watershed).

Most of the time spent in resource assessment will be taken up accomplishing the various inventories and most of the data that will be collected for the watershed is done during this stage. The inventory stage provides the preliminary identification of sensitive areas, contributing forest practices, and resource vulnerabilities. Assessment products and interpretations completed during the inventory stage are passed along to later phases for integration at the watershed scale.

Once the individual watershed processes have been evaluated, the collective team considers the individual locations and potential impacts in a broader spatial and temporal context in the second stage of resource assessment -- "Synthesis". During this stage, the team considers a "bottom up" perspective of the watershed. They view the potential for changes in watershed processes to affect specific stream segments or resource locations, thus allowing the consideration of cumulative watershed effects on specific public resources. Based on the information gathered in inventory, the assessment team confirms the existence of resource sensitivities by linking the identified potential impacts (causes) to the identified or existing or potential resource vulnerabilities (effects).

Although the resource assessment is presented as a staged process, the boundary between phases will not necessarily be sharp. Although most interdisciplinary dialogue occurs during the synthesis or second stage, it should be recognized that interteam dialogue may be very helpful during the inventory stage as well. In addition, even though most of the data used by the team is generated during the inventory stage, the group may find it necessary to gather additional data during the synthesis stage to resolve uncertainties that arise during watershed hypothesis building.

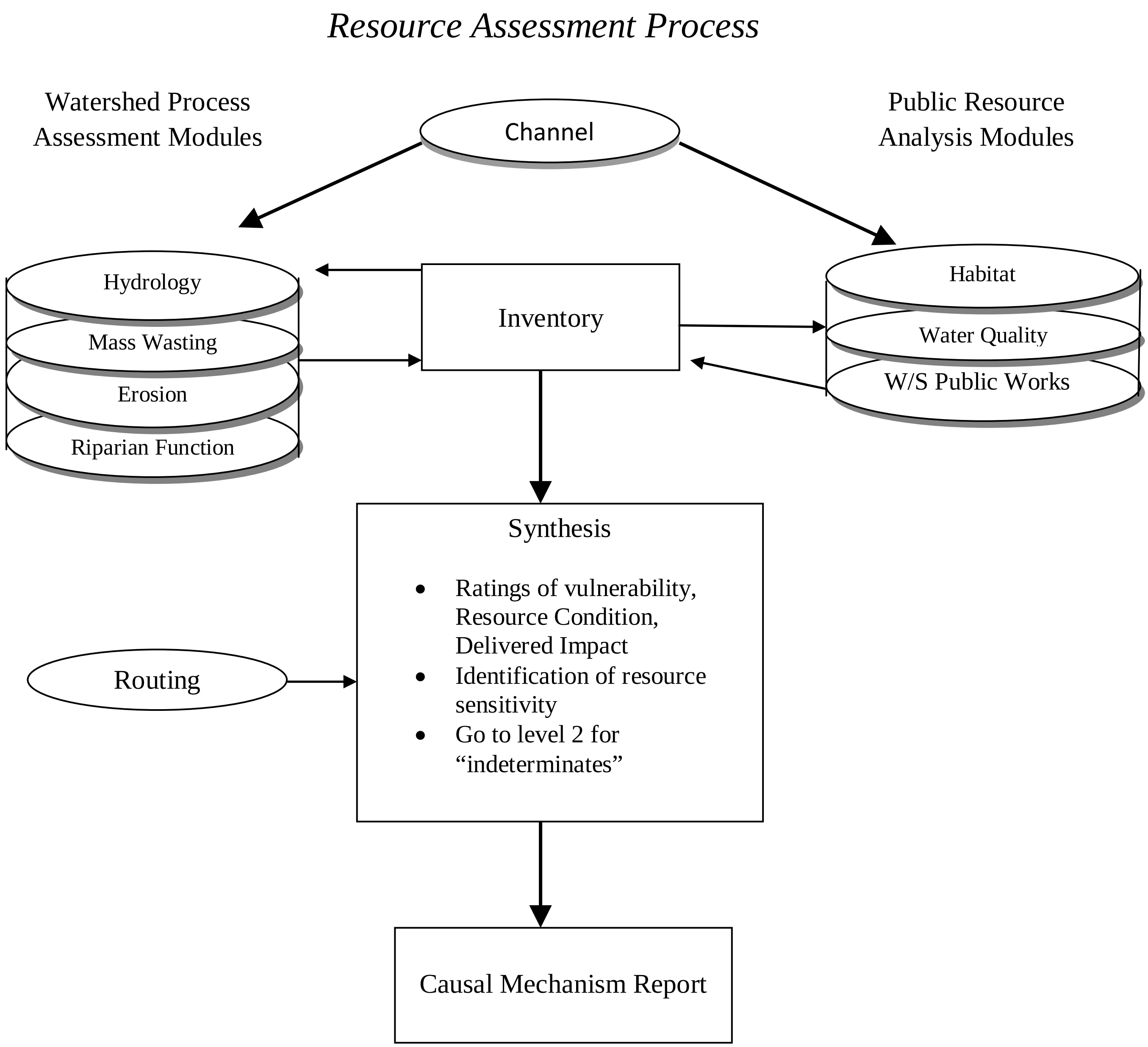


Figure 2. Diagram of the Principle Elements of Resource Assessment

4.3 Scientific Structure

The status of scientific knowledge today is such that we cannot say we know all of the answers leading to full interpretation of all of the watershed processes to be included in watershed analysis. We do feel reasonably certain, however, that science has identified the appropriate questions to ask, so that if they were answered with data from a watershed, its status would be reasonably well understood. Therefore, all of the methods for individual processes and the watershed as a whole that are described in this manual have a question based framework, where critical questions define what is to be addressed by the assessment team. The questions are framed at an overview conceptual level and establish important points of understanding that should be established if sound interpretations are to be made. These questions, rather than the methods, are probably the best representation of the scientific understanding of watershed processes that CMER believes would yield correct watershed interpretations.

The methods provided in the manual reflect a CMER consensus on the best techniques currently available that are recommended for answering the critical questions given our current knowledge, as well as personnel and time allocations. It is assumed that as better techniques are developed for answering each of the critical questions, they can be replaced in future versions of the manual. Adhering to the critical questions as a framework allows such improvements to be made without fundamentally altering the intent and structure of the watershed assessment.

Methods that address the critical questions suffer from the immaturity of some of the scientific disciplines and lack of experience with analyzing processes on the watershed scale. The mechanisms determining potential for forest practices to change the rate of geomorphic inputs are relatively well understood and the module methods for mass wasting, surface erosion, hydrology and riparian function are semi-quantitative. Methods for correlating the extent of response of channels and biologic communities to changes in geomorphic inputs are not as well developed, even though mechanisms for response are reasonably well understood. Therefore, methods for determining resource vulnerabilities (fish habitat, channels, public works) are necessarily more qualitative. Furthermore, the systematic linkage of multiple processes, practices, and resources at the watershed scale in a reliable process has no precedent in the scientific literature. Because of these deficiencies, individual methods and models must be linked in less comprehensive, less quantitative fashion. However, it appears that qualitative interpretations supported by observations are likely to be informative at the scale appropriate for land use decision-making in the watershed.

Although the methods are designed to be as quantitative as possible, nearly all of the methods included in the manual rely heavily on the ability of the scientists and managers to use a scientific process of hypothesis development tested by observation, rather than a "cookbook recipe" approach. The critical questions guide the line of inquiry, no matter what the qualifications of the analyst or level of assessment. The standard methods described in detail in Appendices A-I direct the analyst to develop a minimum set of data to address the critical questions. The modules are designed to provide as much flexibility as possible to the resource assessment team, by allowing them to suggest alternative methods and to spend more time addressing particular critical questions as appropriate in a particular watershed.

Despite the flexibility allowed in the assessments, a reasonable degree of repeatability of a scientific interpretation and products is ensured by (1) the critical question framework, (2) the description of techniques provided in each module, (3) the explicit requirements of certain analysis products, and (4) the retention of records, observations and methods used for analysis of variance from manual methods.

4.4 Explicit Treatment of Uncertainty

The reliability of the resource assessments is dependent on the quality of the specified procedures, the skills of the assessment team members, and the time and resources provided for the assessment. It is expected that the assessment methods provide problem determinations with reasonable confidence, although it is recognized that errors can be made. Reliability can be expressed in terms of the potential or likelihood for correct and incorrect calls. Two types of errors (or incorrect calls) are possible:

1. **False positives** - concluding that a problem exists or condition is present, or a cause effect linkage exists when it really doesn't.

2. **False negatives** - concluding that a problem doesn't exist when it does.

Although greater reliability is ordinarily attained through more intensive analysis providing greater resolution, the widespread application of such intense procedures is not practical given personnel and financial limitations (Figure 3). The proposed methodologies attempt to strike a balance between certainty requirements and the resources available to achieve them. Where considerable uncertainty exists, the methods are designed to err on the side of a decision conservative for the public resource.

Watershed analysis confronts this tradeoff by allowing for two different levels of analysis.

Level I - about three weeks for the assessment by a team of five or six; emphasis on remote analysis with limited field work. Cooperators have indicated that Level 1 should be within the capability of current TFW ID teams whose skills would be augmented with additional training. A typical Level 1 team would possess college degree level expertise.

Level 2 - three to eight weeks, with greater emphasis on field work; analysis designed to resolve Level 1 indeterminate calls and offer greater resolution and certainty. A Level 2 team would possess higher skill levels and greater experience in each of the individual disciplines. A typical Level 2 team would possess Bachelor's and probably advanced degrees in relevant disciplines.

In developing and testing hypotheses, the Level 1 team will attempt to reduce the potential for either type of error. The assessment teams are expected to attempt to resolve uncertainties as much as possible. In cases where significant residual potential exists, the team will conclude that a situation is "indeterminate," warranting clarification through a Level 2 analysis. The specific likelihood threshold for making a call that a situation is "indeterminate" has not been developed, although guidance is provided in the manual for when indeterminate calls may be appropriate.

To date, the reliability of the procedures provided in the manual have not been determined. It is the hope that the CMER research program will provide improved scientific knowledge so that gaps can be bridged, eventually leading to more balanced but simultaneously reliable decisions.

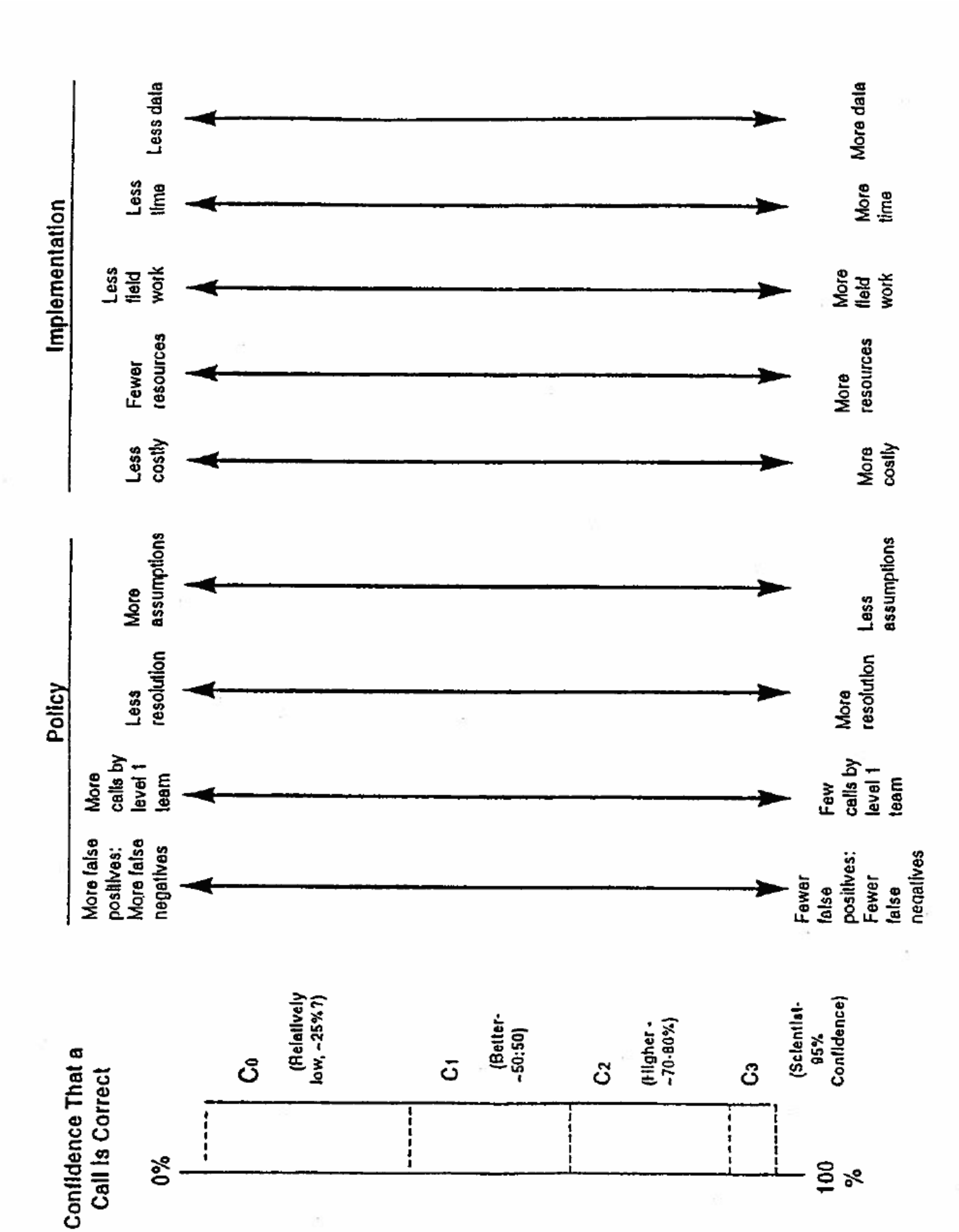


Figure 3. Tradeoffs Among Cost, Resolution and Certainty

4.5 Accountability

Accountability is accomplished by specification of a number of analysis products. These include maps, worksheets recording data and key observations leading to interpretations, and brief narratives summarizing findings. It is recognized that the time limitations imposed by the rule prevent elaborate report writing. The required products allow the resource assessment team to convey key findings systematically but efficiently.

4.6 Resource Inventory

Overview

With basic background information assembled, the team begins the assessments, applying methods identified in the resource assessment modules (Appendices A-H). Inventory calls for assessing the watershed processes (mass wasting, surface erosion, hydrology and riparian function) that generate wood, water, energy, and sediment and the condition of resource characteristics shaped by them (stream channels, fish habitat, water quality, and public works). The scientific investigation includes assessments of current and potential watershed and resource conditions. Existing and potential sensitive areas and their relationship to resource vulnerabilities are identified. Each of the process assessments results in maps, data sheets and narratives. These are used during synthesis to support the ratings of resource vulnerability, resource condition and delivered potential impact and form the basis for causal mechanism reports forwarded to the prescription team.

Each module is organized around a series of primary questions designed to identify the important scientific issues relevant to the process or resource condition under assessment. Generally, it will be possible to answer the module questions without a great deal of interdisciplinary dialogue. Answers are based upon decision criteria specified in each of the modules, resulting in maps, forms, and worksheets that provide an accounting trail and support the integration that occurs under synthesis. Although the inventory assessments will generally be conducted independently, team members may choose to interact to define areas and issues of mutual concern.

Inventory assessments require a mix of office and field work guided by the methods specified in the individual assessment modules. The specific steps to be followed in each of the assessments to answer the critical questions are defined within the modules. The methods provided in the modules represent the standard methods for watershed analysis. That is, all teams regardless of specified level produce the standard set of products and address each critical question. The expectations of the teams differ in the degree of resolution each achieves in answering the questions. Level 1 assessments are likely to have less field work and less quantitative products and more indeterminate calls. Level 2 assessments are likely to have greater resolution, more quantitative supporting data, and additional products that they generate to address uncertainties.

The timing of the resource assessment can be important to gathering good data and could affect the certainty of the results. For example, especially in the higher elevations, much of the landscape is covered by snow during the winter months, possibly hiding some of the information needed for thoroughly analyzing the resources. However, it is not expected that all assessments should be done in the summer months.

Critical questions, assessment methods and interpretations differ between watershed processes (causes) and public resources (effects).

4.7 Watershed Processes

Watershed Process critical questions are designed to identify sources of sediment, water, and wood; the conditions under which processes are activated; reference conditions; and delivery to streams. Although the questions in each module are specific to the watershed process being evaluated, the questions generally address:

- Locations and descriptions of hazard areas for each process based on mapped landscape potential.
- Management activities associated with the process (e.g., road building).
- Delivery of materials to the stream system.
- Geomorphic inputs potentially affected by the process (e.g., coarse or fine sediment, wood, etc.).
- Baseline or reference conditions for each process that provide a basis for potential impact evaluation. (Note that this is not consistent among the modules.)

4.8 Public Resources

Resource questions establish existing conditions, reference conditions, and sensitivities of segments to potential changes in inputs of wood, water, heat energy and sediment. Public Resource assessments are guided by questions that address the following:

- Channel locations susceptible to changes in inputs of wood, water, energy, and sediment (response segments);
- Current channel conditions and sensitivities (e.g., transport capacity);

- Resource potential of segments (fish habitat module only);
- Current resource conditions; and
- Sensitivity (or responsiveness) of resource conditions to changes in inputs of wood, water, energy and sediment.

Public resource assessment teams gather facts and data to characterize resource characteristics sensitivities. Maps are developed locating resources that may be susceptible to changes in flows of fine and coarse sediment, wood, water, and energy (response segment identification). The team then evaluates current conditions based on defined indicators. For fish habitat, these indicators include spawning gravel condition and pool: riffle ratio. Resource analyses also relate current conditions to segment potential which takes into account physical characteristics of segments (e.g., gradient and confinement). Each of the public resource assessments results in maps and data sheets that are used by the team in synthesis and support the rule matrix calls.

4.9 Procedure

Detailed methods for conducting the resource assessments are provided in modular form in Appendices A-I of this manual.

1. **Mass Wasting Module (*Appendix A*)**
   - shallow rapid landslides
   - undifferentiated debris torrents
   - deep-seated mass movements

2. **Surface Erosion Module (*Appendix B*)**
   - surface erosion from roads
   - surface erosion from hillslopes

3. **Hydrology Module (*Appendix C*)**
   - change in channel forming flows

4. **Riparian Function Module (*Appendix D*)**
   - riparian wood recruitment
   - riparian shade provisions

5. **Stream Channel Module (*Appendix E*)**
   - Effects of regimes of wood, water, coarse sediment, and fine sediment

6. **Fish Habitat Module (*Appendix F*)**

7. **Water Quality Module (*Appendix G)***

8. **Water Supplies/Public Works Module (*Appendix H*)**

4.10 Module Project Management

This section describes the steps in an inventory module of the resource assessment from a project management perspective. It is directed primarily to the module leader who is working with others to complete the module, especially in the situation where the team may consist of observers or guest analysts from different organizations. We encourage all module participants to read this section, however, since it may help them to understand project tasks and timelines and clarify expectations of the module leader regarding their involvement. Careful attention to project management considerations will greatly facilitate review and consensus on module products in later stages. Module products and team support will be superior when the team is able to fully and effectively participate in their development.

The module leader must be technically qualified to complete the module assessment according to the criteria listed in the manual and by the DNR official process of skills review and training. Ensuring that the products are complete and as technically correct as possible is the primary responsibility of the module leader. S/he is also the primary representative of the team in communicating analysis results and interacting at later stages of assessment and prescriptions in watershed analysis. The module leader may call upon team members to assist in those efforts.

Managing the module team through the assessment process is also an important function of the module leader, especially where there are observers or qualified analysts participating on a full or part-time basis. The module leader must facilitate review of the products within the team and help to resolve concerns as the assessment proceeds. It is important that team members understand how and when intermediate and final work products are developed and when critical review points are reached so that they can effectively participate in the assessment. The module leader will need to be clear about the team's certainty and level of agreement on the key findings of the assessment as they carry their results forward. Specific tasks and milestones are provided in a Module Project Task checklist provided in each module. We suggest that the module leader review the module methods and expected products with the team at the outset of the assessment, and that the team complete the schedule together so that expectations are clear.

Startup

The module leader's tasks begin during preparatory steps preceding watershed analysis. S/he should be sure that information needs such as aerial photographs and maps are accessible as early as possible. At the startup meeting, the module leader should identify the interested participants, if s/ he has not already done so. S/he will review the module methods with the team, explain when and what critical reviews will occur and schedule the sequence of project tasks.

Resource Assessment
The module leader may enlist team members to help conduct office and field work, or may involve team members primarily in review of the products as they are developed. Regardless of the approach the team chooses, scheduling will be critical to timely delivery of module products within the short time frames that the team must work.

The checklist identifies a number of points during the assessment where various interim products are completed and interpretations and decisions are made. It is strongly recommended that the module leader ensure that all module team members are invited to participate at these critical points and that all products necessary to complete the interim review are available for review. The module team should recognize that once these checkpoints are passed and the team moves on, the team will not entertain additional discussion unless later stages of the assessment reveal uncertainties that the module team was not aware of. Team members and observers are strongly encouraged to bring forth questions and concerns at these checkpoints where the team can most effectively address them. Questions or concerns not brought forward in a timely fashion may undermine the effectiveness of the team's process.

The module leader should ensure that all the products are completed and contacts with other modules are established. The module leader will serve as the primary representative of those products and team discussions during the synthesis stages of the resource assessment.

4.11 Prescriptions

If resource sensitivities are identified in the resource assessment, there may be a need for technical expertise to advise the field managers team during the prescription phase of watershed analysis. The module leader serves as the primary contact to provide that expertise to the team as requested.

If you have been assigned responsibility for a resource assessment,

Go to the Pertinent Assessment Module and Perform the Assessment.

If you are not performing the assessment, but are interested in knowing the specific procedures and products of each module, you may want to read the

Overview of Assessment Methods and Products section of each module which provides a brief summary of what is done in each module.

Part 5 Synthesis

5.1 Overview

Once the module analysts have worked through the methods addressing the critical questions, they will reach a point where they cannot go much further in developing a more comprehensive picture of the watershed and linkages between sources, channels and public resources without interaction with other team members. This begins the second major stage of resource assessment where the team works together to complete the watershed interpretation. Like the inventory stage where modules are completed, synthesis is a stepped and iterative process that may require inter-module and full group meetings, and could include additional data gathering if the team finds it necessary to test hypotheses. The primary qualities that distinguish the synthesis stage of resource assessment is the inter-disciplinary nature of the dialogue and the focus of the group at the watershed scale.

The purpose of synthesis is to bring together the information gathered in the inventory stage (resource assessment modules) to link resource effects to existing or potential hazards and to consider the existing and potential cumulative effects of forest practices. To determine whether the contributing activities in the sensitive area will cause significant changes in the stream, a watershed assessment team must work both ends of an input pathway (Figure 4), defining the likelihood of a change in an input and the effect on a resource if a change occurs. This development of watershed scale linkages and hypotheses is currently performed qualitatively by the interdisciplinary resource assessment team. It is the hope that future versions of this manual will be able to include more quantitative methods for establishing linkages and testing hypotheses. Level 2 teams are encouraged to attempt more quantitative assessments but must provide rationale and justification.

As with the resource assessment modules, the team is guided by a series of critical questions as they attempt to synthesize the results of the individual module assessments into a comprehensive watershed story:

- What and where are the potential impacts altering the input variables?
- Are the inputs delivered to the response segments of concern and if so in what quantity?
- What is the channel sensitivity to the inputs?

- What is the habitat or public resource vulnerability to the inputs? The team answers the questions with empirical evidence developed primarily in the inventory modules. The evidence will include:

- Presence of activities are altering (or may alter) inputs related to the process under consideration (e.g., logging road failures generating coarse materials).

- Input reaching the stream system (or is likely to).

- Routing through the stream system to locations of vulnerable resources.

- Public resources sensitive to the input are present in the reach under consideration (e.g., rearing habitat is sensitive to inputs of coarse sediment).

- Resource conditions in a stream segment that can be adversely affected or the current rate of inputs is such that an already affected/degraded condition will not improve (the coarse material that is generated is likely to accumulate in pools with expected reduction in pool volume).

The team focuses on representative indicator areas selected as likely locations of resource effects. The initial delineation of areas is provided by the Fish and Channel teams. Watershed processes and resource conditions are linked along common themes of the effects on or responses to the five input variables (i.e., coarse and fine sediment, wood, water, and heat energy).

Confirmation procedures establish what is required in terms of evidence and indicators; these are used to establish cause and effect with reasonable confidence. The team uses an iterative approach of hypothesis development and testing based on the strength of the supporting evidence; alternative hypotheses are developed if the signals of cause and effect are present but weak. The team may decide to generate more information to resolve uncertainties.

A confirmed hypothesis results in the identification of a sensitive area. The problem statement is referred to as a situation sentence which has supporting evidence; the "sentence" is a statement or paragraph that summarizes key processes and relationships. This is captured in a causal mechanism report that describes location, impact mechanisms, linkage to vulnerable resources and the rule call. The rule matrix is performed to determine the Rule Call, which sets the standard of performance in preventing changes in watershed processes for the prescriptions to be developed for the sensitive area. The sensitive areas are the mapped units resulting from the Mass Wasting, Surface

Erosion, Hydrology and Riparian Function Modules. The units are termed "sensitive areas" once an effect on public resources is established. The causal mechanism report is given to the field managers team to develop appropriate prescriptions.

A problem statement for each resource sensitivity includes identification of active processes (e.g., surface erosion), contributing management activities, channel effects, and effects on a resource characteristic (e.g., loss of spawning habitat). Synthesis also produces the ratings of resource vulnerability, resource condition, and delivered hazard required under the cumulative effects rules (WAC 222-22-050).

The team may conclude that insufficient evidence is available from the Level 1 analysis to make a rating of vulnerability or hazard for a given area. In this case, Level 2 problem solving would be initiated to answer the unresolved questions. When a Level 1 or Level 2 assessment is complete, the products of resource assessment are forwarded to the DNR and to the watershed field managers team for prescription setting and monitoring.

5.2 Procedure

The general approach for conducting synthesis is qualitative, where key data and observations from the individual assessments are brought together to determine the strength of the signal in determining the likelihood of a cause and effect linkage between hillslope and stream conditions. This process is intended to be a guide for this key component of the analysis. Importantly, synthesis is not a cookbook approach. Synthesis is an iterative process requiring repeated questioning and evaluation of watershed processes by the assessment team.

Synthesis includes the steps of resource assessment that require interdisciplinary dialogue. There is a logical sequence for performing tasks and producing products, but there is no set recipe for how a team works this process. A general sequence that the team may follow includes:

1. **Individual modules present results to the rest of the team**. This will get everyone up to speed on the general stories for each watershed process in the watershed.

2. **Inter-team dialogues** resolving any linkage products they have been assigned responsibility for, and to fill in any gaps.

   Fish Vulnerability: Fish habitat/Stream channel teams.

Public Works Vulnerability: Public works/hydrology, mass wasting, riparian function.

Others as needed: The need for other inter-team dialogue should become apparent when module products are presented.

3. **Watershed Condition Hypothesis Development and Testing**
   The entire team works together to establish the watershed condition and cause and effect linkages. The resource condition reports are produced.

4. **Resource Sensitivities**
   Once the overall functioning of the watershed is understood and cause and effect linkages established, the team needs to formally designate the sensitive areas from the module unit maps and use the rule matrix to determine the rule call. The causal mechanism reports are completed and prepared for forwarding to the field managers team.

5. **Resource Assessment Report Completion**
   Complete products and package them in reviewable fashion.

6. **Prepare for the Hand-off Meeting with the field managers.**

Presentation of Module Products
Synthesis begins with reporting of the findings from each of the inventory modules to a full group meeting. Assessment products (i.e., maps, summary data, and text) are reviewed and explained among the team. Potential hazard areas are displayed for each watershed process. A clear description of what, if any, components of forest management activities affecting hazards are identified. The location and vulnerability of each important resource (e.g., fish habitat or capital improvements) is identified and described.

If appropriate, each presentation includes a discussion of why and where indeterminate calls were made and what additional information may be needed to resolve these calls. The confidence in work products is discussed.

5.3 Inter-Team Dialogue

There are a number of points specified in the modules where the analysts are expected to interact in order to mutually develop some of the interpretations and rule calls. Since most of these calls occur at or near the completion of the module products, these discussions may be conducted either prior to any group interaction during synthesis or during its early stages. They are discussed as a second step here because it may be useful for the analysts to learn what the other modules have discovered prior to assigning calls. Modules will also benefit from conferring among teams as resource assessment proceeds.

In particular, most of the resource vulnerability calls are made as a product of team dialogue. The public works module specifies that the analyst should consult with the hydrology, mass wasting, and riparian function module analysts to determine the vulnerability call. Fish habitat vulnerability is determined by dialogue between the fish habitat and stream channel teams. Because of the complex nature of fish habitat, the procedure for establishing vulnerability is described in detail.

5.4 The Fish/Channel Linkage-Making Vulnerability Calls

Prior to the synthesis steps that involve all of the assessment modules, the information and maps from the channel and fish habitat assessments must be brought together in order to define the habitat vulnerability calls. The following steps describe the general process by which the two resource assessments are used to create the vulnerabilities. It is important to bear in mind that habitat issues not covered in this manual may arise. The analysts must then rely on the data describing the situation and their knowledge of fluvial geomorphology and fish biology to create vulnerability calls.

The channel assessment produces a summary report which presents the results of the channel assessment. The report provides the context for interpreting the causes of historic channel change, identifies current channel condition, and presents a diagnosis of how current channel condition may react to changes in the various input factors. For each geomorphic unit (defined as a group of segments that respond similarly to the inputs), the relative potential for the channel to respond to each of the input factors will be rated. Accompanying this report will be a geomorphic unit response map which compliments the summary report by showing the spatial context of the potential channel responses.

The fish habitat assessment identifies the existing and historical distribution of the various fish species in the WAU. In addition, the assessment produces four maps showing areas of concern from the standpoint of fish habitat. Each of the maps will focus on one of the four life history stages (upstream migration, spawning and incubation, summer rearing and winter rearing). Each map will display reaches that have been identified as areas of concern (areas of degraded habitat, limiting habitats, refuge areas, etc.). Accompanying each map will be narrative descriptions of each area of concern and summaries of habitat conditions in the WAU.

Typically these two summaries will be organized at different spatial scales. For example, an area of resident cutthroat trout may encompass a large portion of a WAU that includes portions of a number of geomorphic units. It is recommended that the vulnerability calls be organized around the species distribution, and that within each zone of the species distribution the analysts review the results of the two assessments for each geomorphic unit and identify processes influencing habitat formation.

Proceeding through geomorphic units one at a time, the channel analyst describes the potential response ratings and any relevant historical and current condition information. The fish habitat analyst describes the distributions of fish species and life history stages and emphasizes areas of special concern in the unit. Together, the analysts work through combinations of life history stage and channel sensitivity (Table 3) and identify the input factors that influence habitat formation in the unit. For each sensitivity rating, the analysts review the general and special habitat concerns for each life phase to determine if the fish habitat is or could potentially be vulnerable to an input factor in the geomorphic unit. The fish habitat analyst is responsible for reviewing the channel sensitivity calls and for determining whether the potential response ratings to each of the input variables are appropriate for protection of fish habitat. In some cases the habitat vulnerability may need to be raised or lowered from the channel response rating depending on fish habitat interpretations. Fish habitat is considered vulnerable if there is a causal linkage between the channel response and life history stage (e.g., Table 3) for input factor.

In many cases the level of habitat vulnerability to an input factor will be equivalent to the potential channel response rating. For example, if there is an area of special habitat concern due to spawning gravel degradation from sediment that corresponds to a geomorphic unit with a high sensitivity to fine sediment, then the habitat vulnerability to sediment is high. If a potential impact to a life history stage cannot be linked to a channel response for a specific input factor, then the habitat for the life stage is not vulnerable to the input factor.

In some cases, the fish habitat information and potential channel response rating will be inconsistent with respect to making vulnerability calls. This may occur in several ways:

1. Habitat conditions are poor due to the influence of an input factor for which the channel response has been rated low or moderate.

2. A unit rated as low or moderately sensitive to an input factor is an area of concentrated fish use (e.g., an area of high density spawning).

3. A unit rated as low or moderately responsive to an input factor is a habitat of limited availability (e.g., off channel refugia are a limiting habitat in the WAU).

These and other inconsistencies may arise in a watershed analysis and must be addressed. The biologist and the channel module leader will need to work together to identify factors causing the inconsistency. Based on this evaluation, the problems may be discovered and the appropriate corrections made. In all cases, the fish biologist is responsible for determining whether the channel sensitivity rating appropriately describes the habitat vulnerability. If the cause of an inconsistency cannot be explained and resolved, the biologist will make the final vulnerability call. The biologist will rely on the results of the fish habitat diagnostic evaluation as a basis for the call. The relative condition of the habitat for a life phase and the parameter responsible for this condition is evident from the diagnostic evaluation. Habitat vulnerability would be determined from the relative condition indices.

Note: In some cases it may be possible to empirically determine the amount of an input that causes an adverse change in a resource condition. This additional information may be used to qualify the vulnerability call. For example, the use of a diagnostic sediment budget may allow the channel and fish habitat assessments to determine amount of coarse sediment that degrades summer rearing habitat.

Combinations of life history stage and input factors must be addressed in creating vulnerability calls. Table 3 presents a list of the most commonly encountered situations that must be addressed in each watershed analysis. Other combinations of channel sensitivity and life history stage may be addressed in addition to these.

Table 3. Combinations of Life-history Stage and Input Factors

Life-history Stage	**Potential Channel Response**
Upstream Migration	Coarse sediment (holding ponds)
Spawning and Incubation	fine sediment (incubation environment) peak flows (redd scour)
Summer Rearing	coarse sediment (pool filling) wood debris (pool formation and cover) temperature (appropriate temperature ranges)
Winter Rearing	woody debris (in channel refuge and cover) coarse sediment (pool filling) factors that create and maintain off-channel refugia

5.5 Watershed Condition Assessment

The next steps of synthesis are performed by the team as a whole. The team first develops the comprehensive watershed picture by examining the linkage between hillslope processes and resources for the indicator areas selected by the team. (The geomorphic units supplied by the stream channel assessment will serve as a basis for these units, although they may be modified.) The team will systematically work through the critical synthesis questions for each geomorphic input factor (change in coarse or fine sediment, change in peak flows, recruitment of large woody debris, or change in energy loading) for the indicator areas. It is strongly recommended that the field managers team observe the synthesis sessions of the assessment team. This will help them to understand how the resource sensitivity calls are made.

If the team is large, they may wish to use a facilitator for this part of the assessment. If so, it is strongly recommended that the facilitator be a knowledgeable resource specialist given the hypothesis development/testing nature of this exercise.

Questions are designed to capture the following:

1. Activities generating an input (e.g., coarse sediment).

2. Process triggered by activities (e.g., mass wasting associated with logging road failures).

3. Delivery to the stream.

4. Delivery of an effect - whether an input can be transported to a sensitive segment (and whether a material effect can be registered).

5. Public resources impact - whether resources can be or will be degraded.

Data and interpretations relevant to each of these points has been developed within the assessment modules as critical questions are addressed. Tables 4 to 8 list each of the primary synthesis questions and identify the associated questions and information that were asked and answered during inventory assessments. Sources of information to address the synthesis questions can therefore be found in the products of the assessment modules. The specified work products provide the evidence weighed by the team to answer the associated synthesis questions. The resource assessment team will find it useful to have the module summary reports and products in hand, and to have interim work products available for reference.

Table 4. Key Questions and Information Relating to Fine Sediment Processes

Primary Synthesis Questions	Primary Inventory Questions	Required Information	Module
What is the channel sensitivity to fine sediment?	Are there locations sensitive to changes in inputs of fine sediment?	Form E-5	Channel
	What do the current channel conditions indicate about existing levels of fine sediment inputs?	Sediment supply/transport capacity relationship	Channel
	Is there evidence that channel conditions relative to fine sediment are changed from historic conditions?	Supplemental Information	Channel
What is the habitat sensitivity to fine sediment?	What is the production potential rating for spawning and incubation?	Good, Fair, Poor calls from Worksheet F-4	Habitat
	What is the current habitat condition?	% fine sediment content of spawning gravels and other supplemental information. (Worksheet F-1)	Habitat
	Is there evidence that habitat conditions have changed from historic?	Supplemental information (Worksheet F-2)	Habitat
What and where are the potential impacts producing fine sediment?	Is there potential for shallow rapid failures?	Maps and Descriptions Map A-1	Mass Wasting
	Is there potential for debris torrents?	Map A-1	Mass Wasting
	Is there potential for deep-seated movement?	Map A-1	Mass Wasting
	Is there potential for road surface erosion?	Road surface erosion worksheet	Surface Erosion
	Is there potential for hillslope surface erosion?	Hillslope erosion worksheet	Surface Erosion
	Is fine sediment generated by management activities?	Maps A-1, B-1, B-2	Mass Wasting & Surface Erosion
Is fine sediment delivered to segment of concern?	Is fine sediment routed from the contributing impact to a susceptible location?	Worksheet I-1	Routing
	Will the delivery of fine sediment change the channel or habitat conditions?	Form E-5 Map F-3	Habitat or Channel

Table 5. Key Questions and Information Relating to Coarse Sediment Processes

Primary Synthesis Questions	Primary Inventory Questions	Required Information	Module
What is the channel sensitivity to coarse sediment?	Are there locations sensitive to changes in inputs of coarse sediment? What do the current channel conditions indicate about existing levels of coarse sediment inputs? Is there evidence that channel conditions relative to coarse sediment are changed from historic conditions?	Form E-5 Sediment supply/transport capacity relationship Supplemental Information	Channel Channel Channel
What is the habitat sensitivity to coarse sediment?	What is the production potential rating for summer rearing? What is the current habitat condition? Is there evidence that habitat conditions have changed from historic?	Good, Fair, Poor calls from Worksheet F-4 See percent pools and other supplemental information. (Worksheet F-1) Check supplemental information (Worksheet F-2)	Habitat Habitat Habitat
What and where are the potential impacts producing coarse sediment?	Are there potential shallow rapid failures? Are there potential debris torrents? Are there potential deep-seated failures?	Maps and Descriptions Map A-1 Map A-1 Map A-1	Mass Wasting Mass Wasting Mass Wasting
	How much coarse sediment is generated naturally for each impact? How much coarse sediment is generated by management activities for each impact?	Map A-1	Mass Wasting
Is coarse sediment delivered to segment of concern?	How much coarse sediment is generated naturally from all impacts in this basin? Is coarse sediment routed from the contributing impact to a susceptible location? Will the delivery of coarse sediment change the channel or habitat conditions?	Worksheet I-1 Form E-5 Map F-2	Routing Routing Channel & Habitat

Table 6. Key Questions and Information Relating to Peak Flow Processes

Primary Synthesis Questions	Primary Inventory Questions	Required Information	Module
What is the channel sensitivity to changes in flood frequency and magnitude?	Are there locations sensitive to changes in peak flows? What do the current channel conditions indicate about existing flow conditions? Is there evidence that channel conditions are changed from historic conditions?	Form E-5 Transport capacity (Form E-5) Supplemental Information (Form E-5)	Channel Channel Channel
What is the habitat sensitivity to changes in flood frequency and magnitude?	What is the production potential rating for spawning and incubation? What is the current habitat condition? Is there evidence that habitat conditions have changed from historic?	Good, Fair, Poor calls (from Worksheet F-4) Supplemental Information (from Worksheet F-1) Supplemental Information from (Worksheet F-2)	Fish Habitat Fish Habitat Fish Habitat
What and where are the potential impacts producing changes in flood frequency and magnitude?	Where are potential rain-on-snow impact areas? What % of each potential impact area is hydrologically immature?	Watershed hydrologic condition map	Hydrology Hydrology
Are increased flows delivered?	What is the magnitude of the 2-year flood under mature forest conditions? What is the magnitude of the 5-year flood under mature forest conditions? Is increased water delivered to indicator segments during storm events?	Hydrographs for 2-year, 5-year, and 10-year floods	Hydrology

Table 7. Key Questions and Information Relating to LOD Recruitment Processes

Primary Synthesis Questions	Primary Inventory Questions	Required Information	Module
What is the channel sensitivity to changes in the size or frequency of large organic debris?	Are there locations sensitive to changes in LOD?	Map (Form E-6, Map E-2)	Channel
	What do the current channel conditions indicate about existing levels of LOD?	Counts of LOD, size or volume information by channel width (from Form E-5)	Channel
	Is there evidence that channel conditions relative to LOD are changed from historic conditions?	Bilby and Ward target LOD loading levels (from form E-5)	Channel
What is the habitat sensitivity to changes in LOD size or frequency?	What is the production potential rating for summer rearing?	Good, Fair, Poor calls (from Worksheet F-4)	Habitat
	What is the current habitat condition?	Percent pools and other supplemental information (Worksheet F-1)	Habitat
	Is there evidence that habitat conditions have changed from historic?	Supplemental Information (Worksheet F-2)	Habitat
What and where are potential impacts impairing the recruitment of large organic debris to the channel?	Does the riparian zone stand age tree density, and species composition indicate current and continued supply of LOD?	Maps and Descriptions (Map D-1)	Riparian Function

Table 8. Key Questions and Information Relating to Temperature Regulating Processes

Primary Synthesis Questions	Primary Inventory Questions	Required Information	Module
What is the channel sensitivity to increased water temperature? Is this different from habitat module?	Are there locations sensitive to changes in heat energy? What do the current shade conditions indicate about existing stream temperatures? Is there evidence that channel conditions relative to heat energy have changed?	Map D-2 Shade conditions relative to target conditions (Form D-2) Supplemental Information (Form D-2)	Riparian Function
What is the water quality sensitivity to changes in heat energy inputs?	What is the production potential rating for summer rearing? What is the current maximum stream temperature relative to water quality standards? Is there evidence that temperature conditions have changed from historic?	Good, Fair, Poor calls (from Worksheet F-4) Maximum temperature value from Ambient Monitoring Supplemental Information (Worksheet F-2)	Habitat Habitat Habitat
What and where are the potential riparian shade impacts?	Is existing shade less than target shade?	Comparative shade values (Map D-2)	Riparian Function
Is warmer water delivered to the segment of interest?	Is temperature delivered from upstream segments?	Temperature data and/or shade conditions 1,000 ft. (305 m) above the response segment	Riparian Function

Identify Indicator Areas

Due to limitations of time and resources, the team will not be able to directly evaluate the potential cumulative effects on all stream segments, especially for widely distributed public resources such as fish habitat or water quality. They will need to select representative areas that are appropriately distributed in the watershed as indicators of local or watershed scale responses. The stream channel module has determined geomorphic units that include stream areas with similar condition and sensitivity to changes in geomorphic inputs. These units should provide the nucleus for synthesis of watershed scale cause and effects, although the full team may wish to modify them somewhat to accommodate other factors.

Develop Watershed Process Hypotheses

Information from the inventory work products is used to develop understanding of the existing or potential effects of management activities on watershed processes and resource characteristics. Linkages among management activities, watershed processes, stream segments, and vulnerable resources are established through a hypothesis development process. Empirical evidence, process theory, or both are used during this assessment to confirm or examine the acceptability of each hypothesis.
The team begins the assessment by assuming the perspective of field investigator at an indicator area. Maps, tabular data and summary reports are available from the habitat, channel and process modules. Routing considerations are of primary importance.

The team now attempts to integrate and associate the information to produce hypotheses for watershed processes. This process is similar to the way a medical team might diagnose a patient's condition, utilizing tests, and historical workup that are coupled with the skills and knowledge of specialists and generalists.

For reliable results, the watershed analysis team should identify competing hypotheses for each segment. Through team dialogue and association of current and historical data, it should be possible to dismiss certain hypotheses while defining others as more likely. For each segment, the existing channel conditions are characterized by the channel and habitat modules. Supporting data is recorded on appropriate forms (e.g., pool/riffle ratio, levels of coarse sediment loading). Points in the photographic record are noted where stream channel conditions may have changed. Before evaluation of causal mechanisms, the team should reach common understanding on current and recent trends in channel and habitat conditions. This will help focus the evaluation and facilitate hypothesis development and testing. A dialogue between the habitat analyst and the channel analyst is essential.

As hypotheses begin to form, the team should be aware of the potential for either erroneous acceptance or rejection of the hypotheses. For example, limited pools and aggradation may not necessarily be derived from management activities. The cause may be a natural sediment source. The team should qualitatively analyze alternative explanations. Using the module information, they should identify the most likely hypothesis or explanation. If the team does not reach agreement on cause and effect, an indeterminate call may be appropriate (Level 1).

The linking or routing of impacts from hillslope processes to stream segments is a critical element of the hypothesis development process. The team members need to define how routing processes work within the various response segments. The evaluation of these linkages for sediment and peak flow impacts requires an assessment of the evidence and processes affecting routing. The application of routing to potential hazards is fundamental in reading the landscape; the result is a translation of data into useful information used directly in the rule matrix. Beyond the regulatory context, the information may have other valuable uses for voluntary or cooperative actions. A routing assessment for these input variables is described in Module I: Routing. At this time, this routing assessment is very qualitative. It is hoped that this may become more quantitative in the future with sediment and water budgeting.

Because impacts from riparian processes are not likely to be routed downstream and are directly adjacent to the stream segment of concern, these impacts do not require a routing analysis.

The plausibility or strength of the signal for the hypotheses should be evaluated by a qualitative certainty assessment. For example, for some impacts, such as delivery, channel conditions and habitat conditions, there will be clear correlation (Figure 5). In other cases the connections will be less clear; this is the result of natural variability, level of resolution of the assessment methodology, and other factors. Here, potential problems may still be identified and hypotheses may still be constructed, but at a lower level of certainty. Lower levels of certainty will dictate Level 2 analysis.

		Observed Habitat Sensitivity	
		YES	NO
Observed Impacts	YES	*HIGHER CERTAINTY* Clear impacts and clearly discernable habitat effect.	*LOWER CERTAINTY* Clearly active impact with no discernable habitat effect.
	NO	*LOWER CERTAINTY* No discernable potential impact, but unexpected habitat effect present.	*HIGHER CERTAINTY* No discernable potential impact and no discernable habitat effect.

Figure 5. Simplified example circumstances which result in higher or lower certainties in hypothesis development. When the certainty is low, the watershed analysis team will usually go to Level 2 analysis.

This hypothesis generating process yields an interpretation of resource conditions within the watershed. This is discussed in the Resource Condition Report, which focuses on describing the watershed from the stream system view. This is a narrative describing the public resource(s) condition and vulnerabilities, and the interpretation of watershed processes affecting it.

The suggested format for the Resource Condition Report for each analysis unit is provided in Form 3.

An Example from the Tolt River

A resource condition report for the Lynch Creek indicator area is provided at the end of this section illustrating a compilation of information for the area. This area was one of 14 identified in the WAU. The format on this report is flexible. This example represents one team's interpretation of how to present the appropriate information.

Form 3. Suggested Resource Condition Report format. Alternative formatting should address the key points indicated.

I. Location Information
- A map indicating the area
- Watershed Location Information
- Streams Observed
- Applicable to Other Streams

II. Resource Condition
(This section is a narrative describing key watershed interpretations)
- Public Resources Situation
- Overall Interpretation
- Confidence
- Discussion Points or Remaining Questions

III. Key Observations and Notes
This section captures some of the key observations contributing to the interpretations presented above). These observations are drawn from all of the modules.
- Coarse sediment
- Fine Sediment
- Peak Flows
- Large Woody Debris
- Temperature

IV. Discussion of Vulnerability Call

Resource Sensitivities

When existing or potential hillslope hazards can be linked to their existing potential effect on resource characteristics then a resource sensitivity is established. The evidence is compiled and interpreted in Synthesis; hypothesis testing supports the team's conclusion.

Linking Mapped Units to Public Resources

Generally, the hazards are mapped areas or "polygons" within the watershed where specific watershed processes are found likely to be significantly affected by the management practices. Each hazard area is differentiated by a unique "triggering mechanism." That is, potential changes in specific watershed processes are isolated to a reasonable degree. Examples could include the following: shallow debris flows within valley inner gorges; ancient deep-seated earthflows from a glacial terrace; surface erosion from road cut and hillslopes; increased available water from rain-on-snow; or lack of shade from past harvest of riparian stands. Differentiating hazard areas by triggering mechanisms related to specific processes (not activities) facilitates the development of appropriate management prescriptions for the area.

Hillslope impacts that may affect vulnerable resources are identified by superimposing the resource vulnerability maps (Maps F-2 to F-6, H-I & H-2) on the hillslope impact maps (Maps A-2, B-1 & B-2, C-1, D-1 & D-2). Working with one impact map and the corresponding vulnerable resource map (e.g., for coarse sediment, use mass wasting impact Map A-2 and fish habitat Map F-2), identify the stream segments that are least likely to be affected by the impact.

Consider this step to be a coarse screen with the objective of removing mapped units and blocks of segments from further consideration. Areas and segments not excluded are examined further for potential cumulative effects.

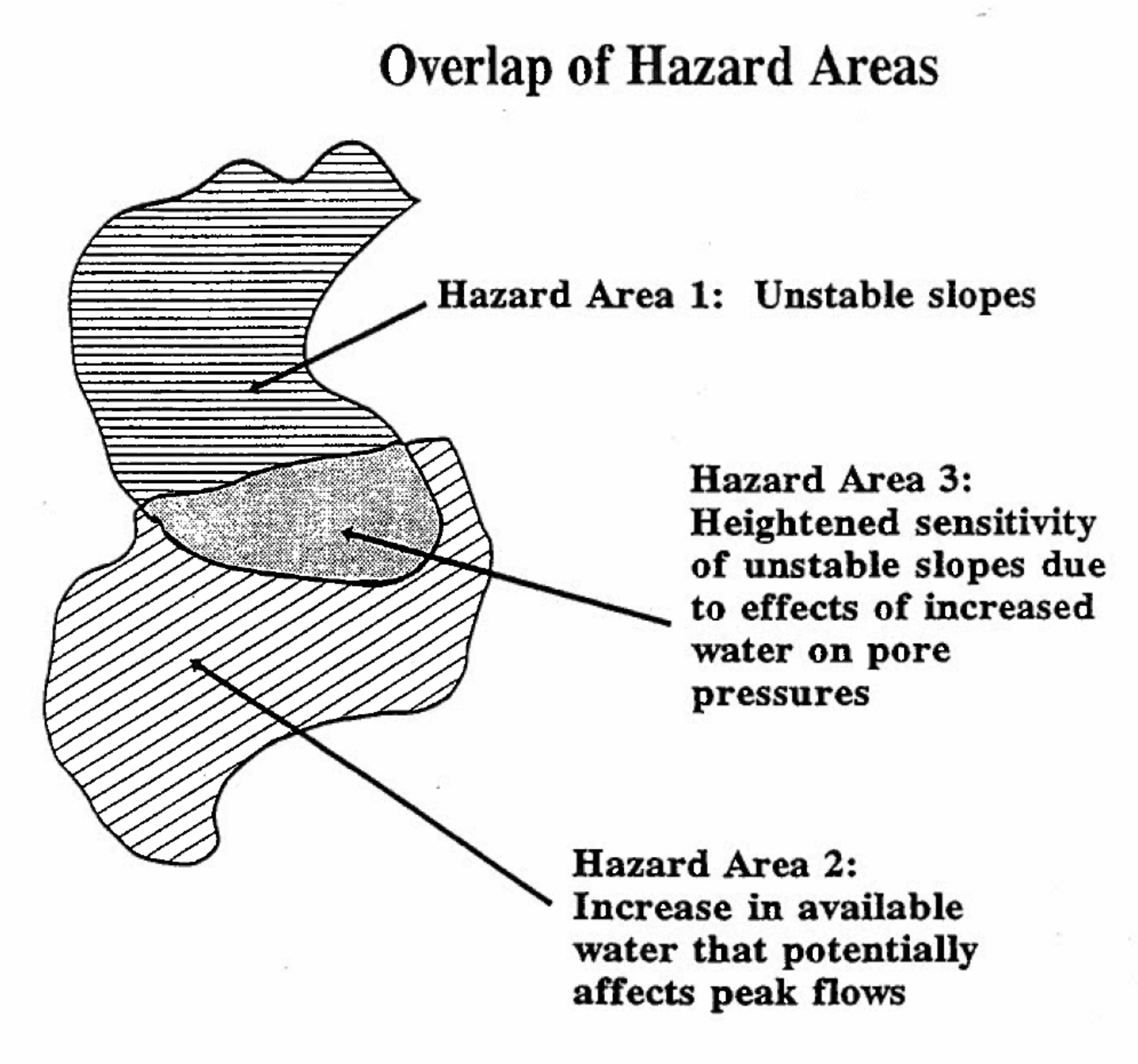


Figure 6. Overlap of Hazard Areas

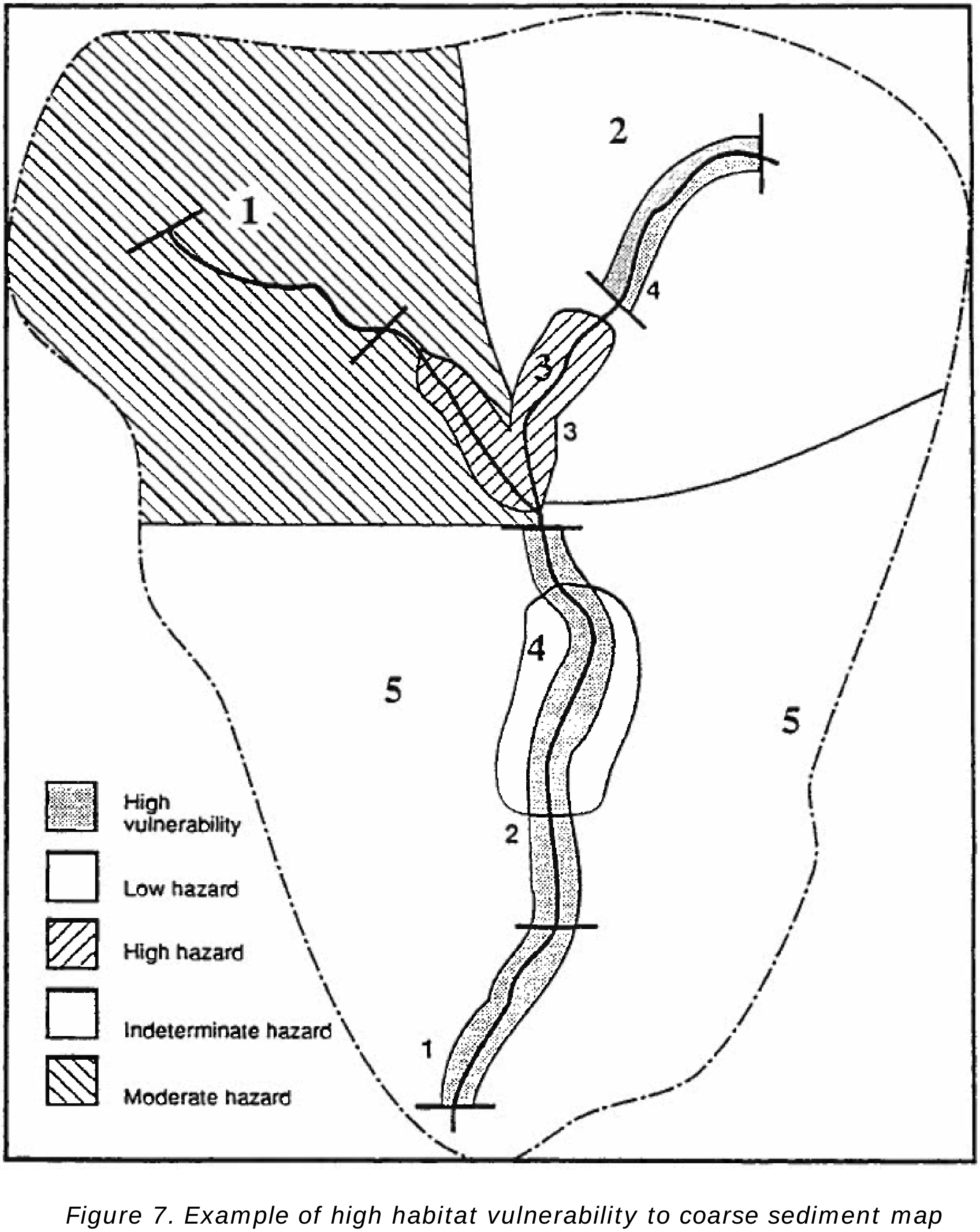


Figure 7. Example of high habitat vulnerability to coarse sediment map (from Appendix Fig. F-3) superimposed on mass wasting impact potential map (from Appendix Fig. A-4)

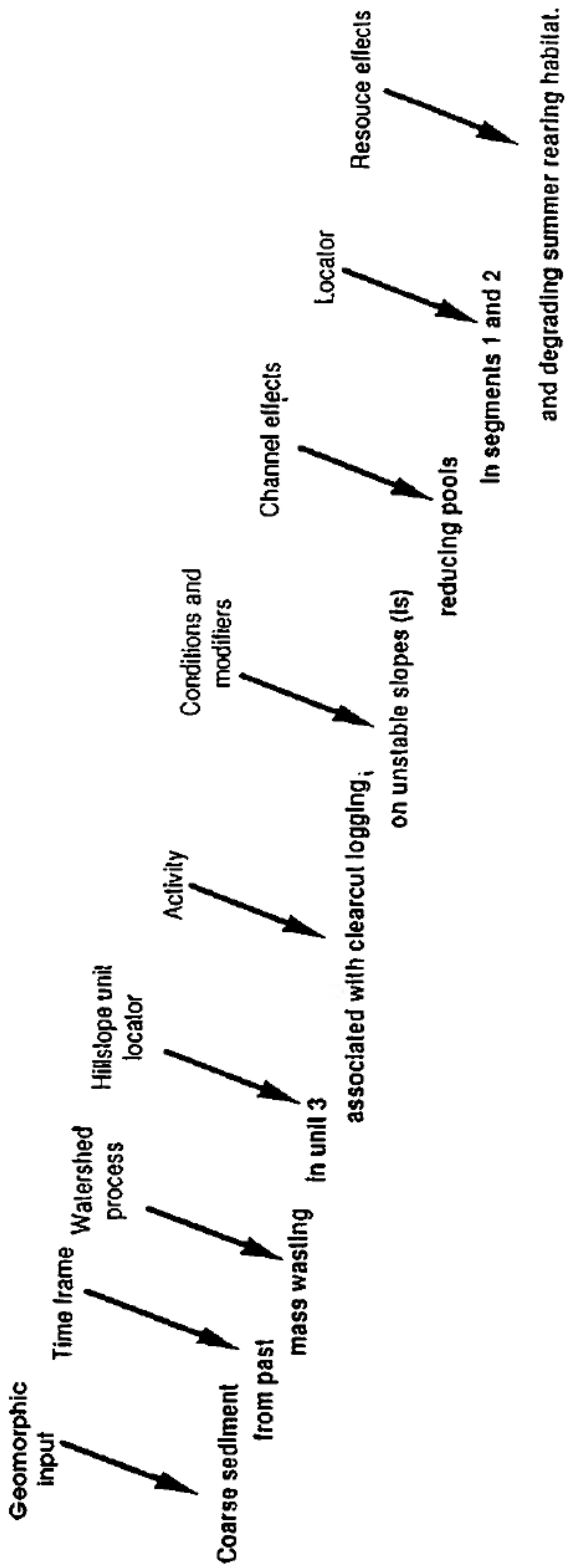


Figure 8. Situation Sentence Syntax

For example, the resource, fish habitat, can be divided into rearing habitat and reproduction habitat. Good spawning habitat demands high quality spawning gravels. A risk to the resource is present when spawning gravels are degraded (or placed at risk) because of fine sediment loading associated with forest practices. A rearing sensitivity or risk arises when forest practices result in (or heighten the potential for) pool filling and reduction in summer rearing habitat.

The team should also consider the overlap of hazard areas to determine whether changes in more than one watershed process in that geographic area may heighten the potential hazard. Figure 6 illustrates this point. For example, if a change in available water in the rain-on-snow zone (hydrology unit 1) heightens the probability of shallow debris flow on unstable slopes (mass wasting unit 2) then a new area (3) enveloping the overlap in triggering mechanisms should be identified as a separate resource sensitivity. If the two hazards do not directly interact, then no additional differentiation is needed; they remain and are treated as separate hazards.

Resource Sensitive Areas
If a mapped area can produce delivered changes in coarse or fine sediment, water, wood or energy resulting in significant adverse impacts on stream and habitat conditions, then the mapped area is termed a "resource sensitive area." Some hazard areas identified in the inventory modules may not become resource sensitive areas if significant impacts cannot be delivered. It is important to note that the resource sensitive area is designated relative to the hazard area rather than to the stream segments with which it is associated.

As depicted in Figure 7, a resource effect may arise when a change in hillslope process (e.g., a road failure) generated material (e.g., coarse sediment) that can affect channels or otherwise impair resource function. The evaluation of effect must include an assessment of delivery to a stream and the responsiveness or vulnerability of resources to the input. Various stream segments will respond differently to each of the inputs. The method must recognize this by defining conditions under which responses are registered.

To provide accountability, the team compiles key summarized information for each resource sensitivity; each such sensitivity must have demonstrated that the linkages between sources, routing, channels, and habitat or water quality have been evaluated. These linkages and their rationale are accounted for in the Resource Condition report.

Although this background information is useful for accounting for how the resource sensitive area was identified, the information needed by the field managers team to address the sensitivity must be focused on the processes and mechanisms by which forest practices can influence the area. This information is provided in a Causal Mechanism Report, which briefly states the problem and elaborates more fully on its potential causes.

The problem statement for each resource sensitive area is termed a "situation sentence." The team confirms each of the key elements of the sentence with reasonable certainty based on the evidence (Figure 8 Situation sentence syntax). Each sentence is constructed based on the empirical or process theory evidence used to justify the linkages; the linkages are clearly documented in the routing, watershed process, and resource modules. The completion of all of the elements of the sentence represents a confirmed hypothesis of hazard linked to a vulnerable resource. Therefore, the existence of the situation sentence signals that the team has compiled enough evidence to identify a resource sensitivity and the content of the sentence expresses the nature of the problem. If one of the key sentence elements is not present, or of insufficient magnitude to be of concern, then that situation component is not confirmed; here, the linkage of hazard to vulnerable resources is not established, the sentence is not completed, and a problem is not found to exist for the purposes of the watershed analysis rules. In this case, the identified hazard area is not considered a resource sensitivity.

The key information developed by the scientists that will help the field managers team to develop appropriate prescriptions is the triggering mechanism. This is as good a description as possible of what the analyst believes is the factor that contributes to the potential to change a watershed process sufficiently to create the sensitivity. The analyst is encouraged to be as specific and detailed as possible. Simply saying that logging causes problems is incomplete. A clear articulation of what aspects of logging (e.g., soil displacement associated with high lead logging), is important in the development of appropriate prescriptions.

Rule Calls

For decision making within the rule, the resource assessment team also makes a rule call that determines the standard of performance for prescriptions based on the risk to resources. In the synthesis stage, the team has the relevant information with which to establish with reasonable certainty the relative likelihood of an adverse change in watershed processes associated with particular practices and the relative vulnerability of the public resources to changes in those processes. This qualitative determination sets the performance standard for prescriptions according to Figure 9.

The Washington Forest Practices Rules (WAC 222-22-050) specify that data from the assessments determines the appropriate management response, the rule call. The rule call, the management response, is defined by the rule matrix in Figure 9. To correctly use the rule matrix, potential hazards must be capable of being routed to a vulnerable resource. This is the question of deliverability. Deliverability is defined in the rules as the likelihood that a material amount of wood, sediment, or energy will be delivered to fish, water, or capital improvements of the state. This definition of deliverability has three conditions that must all be satisfied before an impact is delivered: (1) an impact is likely to occur, (2) the magnitude or size of the impact is sufficient to have a significant adverse effect on the resource characteristic, and (3) the impact is likely to be delivered to a stream segment with a vulnerable resource.

Each hillslope impact identified by the situation sentences must be evaluated for deliverability. Information needed to assess deliverability is derived from the data supporting the situation sentences. The likelihood of the event and its magnitude are elements of the module impact ratings. The likelihood of impacts reaching vulnerable resources is derived from the routing assessment. Because riparian impacts are not likely to be routed downstream and are directly adjacent to the stream, these impacts are assumed to be delivered and no further analysis is required. For sediment and peak flow impacts, the linkages between impacts and vulnerable resources must be established to determine deliverability.

Deliverability is determined for each input variable by examining linkages between the hillslope and the indicator areas. Beginning with the indicator areas closest to the potential impact, the team determines deliverability. This is repeated for each successive indicator area, for each impact area, and for each input variable. Impacts that are delivered to indicator areas are recorded by unit, map number, and rating on Worksheet 1.

Cumulative Effects Rule Matrix

RESOURCE VULNERABILITY	Likelihood of Adverse Change and Deliverability: L	M	H
L	Standard	Standard	Prevent
M	Standard	Minimize	Prevent
H	Standard	Prevent	Prevent

Figure 9. Matrix Used to Produce Management Response Call for a Given Basin Problem Statement (from WAC 222-22-050)

Delivered potential impact and vulnerability determinations are combined to produce prescribed management responses (Figure 9). The X axis refers to potential impact from changes in watershed processes delivered to resources, and the Y axis refers to resource vulnerability.

The rule matrix produces three possible management responses:
1. Standard rules
2. Minimize
3. Prevent or avoid

The causal mechanism report is a compilation of the synthesis results. To condense this information into a readily usable format, the situation sentence products and supporting data are summarized on the causal mechanism report Summary (number it Form xx) using the format suggested in Figure 4. This form is prepared for each resource sensitivity that was developed in the synthesis phase. A causal mechanism report should be completed for each resource sensitive area, although parts of it may be completed by the resource assessment teams prior to synthesis.

This format is designed to assist the team to develop an understandable report without extensive written documentation; the team is encouraged to include observations or discussions in an appropriate level of detail, that increase clarity or justification of the conclusions.

Form 4. Suggested Format of the Causal Mechanism Reports.

Causal Mechanism Report Summary

WAU:____

Resource Sensitivity Number:____________________________________

Situation Sentence:____

____

____

____

____

Triggering Mechanism(s) (Be as precise as possible):___________________

____

____

____

____

Rule Call for Management Response:________________________________

Additional Comments: ____

____

____

____

An Example from the Tolt River - Causal Mechanism Report

Form 4. Causal Mechanism Report Summary

WAU: TOLT

Resource Sensitivity Number:
Mass Wasting Hazard Unit #1

Situation Sentence:
Coarse and fine sediment from past landslides in Unit #1 associated with roads and timber harvest within inner gorges has reduced pools and degraded cutthroat (and possibly dolly varden and bull trout) spawning, and summer and winter rearing habitat in the North Fork braided reaches (Segments 13, 15, and 17). Sediment from this unit is also routed downstream and can affect depositional areas such as segments 1, 2, 3 and 5.

Triggering Mechanism(s) (Be as precise as possible):
Failures are mainly associated with roads, both side cast failures and fill failures. Stream crossing failures are the result of the active transport of wood debris and bedload down these channels, causing plugged culverts. Harvest of the very steep slopes adjacent to streams has accelerated mass wasting. This is due to root strength deterioration and changes in groundwater hydrology. The larger melt rates and volumes due to clearcut harvest may lead to an increase in saturated thickness causing failure. Given the elevation and rock type, root strength is the more important of the two.

Rule Call for Management Response:
Prevent or Avoid

Additional Comments:
Dolly varden and rainbow may be present. Unit #1 is a naturally unstable area. Delivery associated with Segments 13, 15 and 17.

Resource Assessment Report

The majority of the Watershed Analysis Report for the WAU will consist of the resource assessment products. It is recognized that producing a full written report for the watershed would be a very time consuming effort for the team and is not possible within the time constraints of the watershed analysis regulation. The report consists of a compilation of key products produced during the course of the assessment. Once the prescriptions are completed by the field managers team, they can be added to report to complete the watershed analysis products. It may be most useful for review purposes to append each prescription to the appropriate causal mechanism report.

Watershed Characteristics

The watershed characteristics information is recorded on Form 5. Most of the information for this form will be derived from the startup phase.

Resource Condition Reports

These reports provide the watershed interpretations for each of the geomorphic units of the watershed. They convey in narrative form findings of the team including public resource condition, contributing hazards, and routing assumptions. They also record the resource vulnerability calls with supporting evidence.

Causal Mechanism Reports

The situation sentence is recorded along with the triggering mechanism and rule call. In addition, the specific supporting information (e.g., input variable and the resource affected) and source of the information (e.g., map or source data) are recorded. The actual maps, data, and worksheets are included as appendices.

The contents and format of this report are listed in Figure 11. Because landowners, agencies, and other interested parties will be using and reviewing watershed information for more than one WAU, a common report format is necessary to facilitate easy reference.

Resource Assessment Report

A. Watershed Characteristics (Label Form 5)
Team Personnel (Form 1)

B. Resource Condition Report - one for each indicator area (Form 3)

C. Causal Mechanism Report - one for each resource sensitive area (Form 4)
Situation Sentence
Rule Call
Trigger Mechanism
Confidence Discussion
Supporting Data

D. Module Summary Reports (see each module)

E. Maps

Appendices

A. Assessment Module Products

B. Synthesis Products

Figure 11. Suggested format for the Resource Assessment Report

Hand-off

Although the field managers team is encouraged to attend in the Synthesis stage of Resource Assessment, and therefore may be familiar with the scientific findings, it is important for the resource assessment team to formally hand off their product to the field managers team. This should be accomplished in a meeting setting with the focus on explaining the causal mechanism reports. This will ensure that the field managers fully understand their contents. It may also be useful for resource analysts to consult with the field managers during prescription writing.

An Example from the Tolt River Resource Condition Report
Indicator Area: Lynch Creek

Watershed Location Information:
Major tributary to the South Fork Tolt River below the dam.

Streams Observed:
Lynch Creek and Crazy Creek (Segments 119, 122, 124) were visited by the Channel and Fish Teams.

Applicable to other streams:
Entire Lynch Creek. (Segments 112-117); Crazy Creek (118-124); and Segment 125, a tributary to Lynch Creek.

Macro Story

Public Resources Situation:
Lynch Creek is presently inhabited by resident cutthroat trout. Anadromous species are prevented from moving into Lynch Creek by perched culverts at the pipeline road. An old stringer bridge downstream of the pipeline road was apparently a blockage in the past but is not a barrier today. A shotgun culvert in Segment 116 may become a barrier if not maintained. Beaver dams at several locations in the system may also form barriers.

The channel gradients and confinements characteristic of the system create good spawning and rearing potential. Current conditions are rated as at or near potential in most locations. The spawning habitat is sensitive to fine sediment contamination. Free-flowing reaches are sensitive to wood loss because LOD is an important pool forming agent in these areas. The abundance of beaver ponds in some segments of this system are probably warmer than free flowing reaches in the system. This may heighten sensitivity to temperature increases in these areas.

Crazy Creek is notably different than Lynch Creek. Large slides in headwater segments (122-124) dominate stream characteristics now and will into the future. Fish habitat in Segments 119-124 is off potential due to (1) high levels of fines in gravels and pools, (2) continuously turbid water from exposed clays in slide areas, (3) extremely low pool to riffle ratio (4-10% pools) due to filling by sediments, (4) continuous channel shifts in Segment 120, and (5) a potential fish migration barrier at the upstream end of Segment 118.

An Example from the Tolt River Resource Condition Report

Overall Interpretation:
A number of landslide hazards throughout the sub basin chronically contribute both coarse and fine sediment to Crazy Creek. Elsewhere in the Lynch Creek basin is relatively benign except in incised portions of the channels where bank erosion is (Segment 112) or may become (Segment 116) problematic. Active mass wasting processes include road and non-road related shallow debris flows and ancient deep-seated landslides. The contact between hard rock walls and glacial till deposits are the location of significant mass wasting concerns is not a problem. The roads have a few problem erosion locations but generally are in good condition. Channels in active landslide locations of Crazy Creek are active and destabilized. Beaver ponds occur in the lower alluvial channels providing storage for sediment. Target shade conditions are generally reached except for some locations.

Fish habitat conditions for spawning and rearing are good in the basin, although access for anadromous species is currently blocked by a culvert barrier at the lower end of the basin. The main pipeline culverts are perched, preventing fish movement.

Confidence: Confidence in hazard identification and channel condition is good based on the methodology and field observations. It is assumed that removing the migration block would allow steelhead use of available habitat.

Discussion points or Remaining Questions:

- Did sockeye salmon use Lynch Lake at one time? Are they present in the lake now?

- What is the seasonality of the hydraulic connection of Lynch Creek to the South Fork Tolt?

An Example from the Tolt River Resource Condition Report

Coarse Sediment

Channel Condition:

- Crazy Creek Segments 121 and 122 of Crazy Creek flow across the earth flow area. The channel there is characterized by loose boulder stair steps and appears to be very active and destabilized.
- Upper reaches are zones of transport bringing coarse and fine sediments down to the alluvial reaches.
- Headwaters shifting, unstable, milky color during high flow events. Non-cohesive banks.
- Where streams leave the slide area and flow only the glacial tills, the channel is initially lost and then re-emerges and flows into beaver pond channels.
- Lower Lynch Creek cuts down through sheer vertical walls of clean sand.

Public Resource Effects and Sensitivity:

There are some good spawning gravels available in the system. No evidence of coarse sediment problems relative to fish habitat.

Habitat n Segments 119-124 of Crazy Creek are seriously off potential due to:

- High incidence of fines in gravels and pools.
- Continuously turbid water due to input from exposed clays in slide areas.
- Extremely low pool to riffle ratio (4 to 10% pools) in most segments. Pool filling with both coarse and fine material.
- Recent and continued shifts in Segment 120.
- Fish migration barrier at Old Stringer Bridge/Beaver Dam at upstream end of Segment 118.

Barriers:

- Stringer bridge downstream of Pipeline Road did in the past and may in the future be a barrier, but it currently is not a passage barrier.
- Culverts at Pipeline Road are a barrier.
- Beaver dam at Lynch Lake outlet is probably a barrier.
- Beaver dam on Lynch bank tributary and Lynch proper may form barrier.
- Shotgun culvert in Segment 116 is partially plugged causing water to flow down roadway during min or high flow events.
- Beaver dam at Stringer Bridge in 118 and 119 may be a barrier.

An Example from the Tolt River Resource Condition Report

Coarse Sediment *Continued*

Vulnerability Rating:
MODERATE: good potential and good existing habitat conditions in Lynch Creek proper. High vulnerability in Crazy Creek. It currently has good habitat potential in its alluvial reach and currently has poor habitat condition.

Contributing Hazards:
General
- Edge of continental glaciation.
- There is a problem area associated with a precipitous rock wall. Ancient landslide mixed between rock and old till is related to ice margin sediments. These slip off the hard rock walls.
- Recent road and non-road related slides related to an ancient landslide. There has been a lot of recent slide activity, especially in upper Crazy Creek.
- The rest of Lynch Creek on the glacial plain is not a problem.
- Roading is tricky.
- Landslides chronically generate both coarse and fine sediments.

Specific Areas
- Mass wasting Units 4-2 and 4-3 (rock slopes) (HIGH).
- Mass wasting Units 20-22 and 20-23 (ancient landslides) (HIGH).
- Mass wasting Unit 3 (fault trace) (HIGH).

Identified Fish passage barriers.
Routing Considerations:
Routing from upstream to downstream low gradient reaches occurs.

Confidence:
Good confidence on hazard identification and channel response based on method and field observations.

An Example from the Tolt River Resource Condition Report

Fine Sediment

Channel Condition:

- Fine sediments from landslides were observed trapped in beaver dam areas of Crazy Creek.
- Very high V* of silts and sands behind beaver dams (40-80% fill with yellow cake sediments). The source appears to relate to mass wasting, based on observations that sediment color matches the geology.

Public Resource Effects and Sensitivity:

- Segment 112 has some spawning gravel but only fair potential according to default call.
- No sediment sampling was conducted, but there appeared to be fine sediments stored in this segment. Elsewhere in Lynch Creek proper, spawning habitat appears to be in good condition.

Vulnerability Rating:

HIGH: based on current deposition of fines and good potential for rearing and spawning habitat.

Contributing Hazards:

- Bank erosion in Segments 112 and 116 are major sources for Lynch Creek proper.
- Landslides a major source of fines in Crazy Creek.
- No evidence of surface erosion from hill slopes related to soil or terrain.
- There were some trouble spots on roads (see map and list).
- Wind throw of riparian vegetation has uprooted trees, creating some erosion exposure in a location in Lynch Creek.
- Beaver dam failures could pose problem -- see catastrophic events section.

Routing Considerations:

Sediments routed from upper watershed to lower watershed and stored in beaver ponds.

Confidence:

Good, based on method and observations by field team.

An Example from the Tolt River Resource Condition Report

Peak Flow

Channel Condition:

- Channels are very unstable in the upper reaches of Crazy Creek and could be affected by flows.
- Wide low gradient sections in the middle reaches are probably not affected by flows.

Public Resource Effects and Sensitivity:

If fall spawning salmon occur in the Crazy Creek now or in the future they will be vulnerable to peak flows. No evidence of past effects.

Vulnerability Rating:

HIGH: based on vulnerability of channels to peak flows

Contributing Hazards:

General

- Most of the basin is in the rain dominated zone.
- Some of the vegetation is in sparse category but most is in small dense and large dense.
- Susceptibility to enhanced flows is inherently low and the vegetation is now in a favorable situation.
- Estimated Q2 increase is 6%.

Specific Areas

None identified.

Routing Considerations:

None

Confidence:

Upper reaches of Crazy Creek could be affected by peak flows, but the channel is so active that it's difficult to determine the influence of peak flows separate from the influence of sediment loading. Peak flows are probably not dominant, however.

An Example from the Tolt River Resource Condition Report

Large Woody Debris

Channel Condition:

- Lynch Creek channels have moderate wood volumes in areas not influenced by beaver dams.
- Crazy Creek channels are generally low in wood. Where present, wood functions in trapping sediment and forming stair steps in the steeper sections.
- Boulders are also functioning in forming pools.
- Moderate levels of LOD functioning to create pools in free flowing segments of Lynch Creek proper.
- Low amounts in Segment 112.
- Sensitive to loss of in channel LOD or interrupted recruitment.
- Low gradient channel nature means most of the wood remains within the system.
- Lack of LOD in Crazy Creek above Segment 118 -- sensitive to further loss where beaver dams don't form pools.

Public Resource Effects and Sensitivity:

- There is good rearing habitat in the beaver dam reaches and elsewhere in Lynch Creek proper.
- There are not many pools and not much LOD in the upper reaches of Crazy Creek but there is a lot of wood in the beaver pond segments.

Vulnerability Rating:

HIGH: based on function in providing pools and trapping sediments.

Contributing Hazards:

General

- Harvest within the last 10 years has left many stands in young conditions. About 70% of the system is rated as situation category RF1 (see maps dd-2 and dd-5).
- Most of the riparian area below Lynch Lake, except along the beaver ponds, are low in recruitment potential.

Routing Considerations:

None

Confidence:

Good based on method and field observations.

An Example from the Tolt River Resource Condition Report

Catastrophic Events

Channel Condition:

- Evidence that the channels in the upper reaches have experienced debris flows entering them in the past.
- Lower reaches are too low in gradient to pass debris flows through them.

Public Resource Effects and Sensitivity:

Immediate effects disastrous, indirectly affect spawning and rearing conditions in downstream areas of Crazy Creek and in Lynch Creek (Segment 112) where materials may be routed.

Vulnerability Rating:

HIGH, if occur.

Contributing Hazards:

- The old Stringer Bridge is now a beaver pond. It could pose erosion hazard and fish migration problems.
- Dam break floods from this or other beaver ponds in Crazy Creek could devastate downstream reaches in Lynch Creek.

Routing Considerations:

Confidence:

Good

An Example from the Tolt River Resource Condition Report

Temperature

Channel Condition:
Shade in beaver pond areas is achieved through alder, vine maple and willows covering most wetted areas, even when overstory shade is below target.

Public Resource Effects and Sensitivity:
May exceed water quality standards in reaches with low shade. Beaver ponds may be particularly susceptible to increased temperatures.

Vulnerability Rating:
HIGH

Contributing Hazards:
- There is adequate shade along much of the stream.
- Target shade is not being met in some locations (see map d-4).
- Depending on temperatures in Lynch Lake and its associated wetlands, the influence of this lake on downstream temperatures may be positive or negative.

Routing Considerations:
Inflow from Lynch Lake and associated wetlands may increase water temperature in segments below.

Confidence:

MODERATE. Based on TFW temperature method. Offsite influences could affect temperature not considered in method. Temperature monitoring would improve confidence

Form 5. Watershed Characteristics Format

Watershed Administrative Unit:

Drainage System:____

Location:____

Basin Area (acres):____

Climate:_______________ Mean Annual Precipitation:_______________

Elevation Range: ____

Geology: ____

Stream Density (mi/mi^2):____________Road Density (mi/mi^2):________

Vegetation (dominant): ____

Vegetation (sub-dominant): ______________________________________

Land Use: ____

Major Land Owners: ____

Water Supplies: ____

Major Capital Improvements: _____________________________________

____

Fisheries Resources: ____

____

____

____

Part 6 Prescription Writing Process

6.1 Watershed Analysis Management Response

The watershed analysis management response follows watershed assessment by using its products as the basis for writing prescriptions. Prescriptions are appropriate solutions to the issues or problems identified during the assessment processes and documented within the causal mechanism report(s) for individual watershed administrative units. Characteristics of the system include:

- Performed by a team of qualified field managers with appropriate expertise and training;
- Considers the assessment maps and causal mechanism reports from the Level 1 analysts or the Level 2 specialists plus the management response calls from the rule matrix;
- Provides flexibility for land owners in the form of options designed for specific situations;
- Provides protection for public resources through prescriptions for regulatory application;
- Provides opportunities for resource enhancement or restoration through actions that may be used voluntarily outside of regulations;
- Identifies problems or events not regulated by forest practices and forwards them in the report.

6.2 Basic Features

Prescription writing takes the products of watershed assessment and develops management solutions for use on the ground. The basic goal of watershed analysis is to protect and restore specific public resources, i.e., fish, water and capital improvements of the state or its political subdivisions, and the productive capacity of fish habitat, while maintaining a viable forest products industry. The role of prescriptions is to protect and allow the recovery of these resources. In areas of resource sensitivity as set forth in the rule, prescriptions must minimize, or prevent or avoid, the problems identified by the assessment. Since assessment is done on individual watersheds, prescriptions will address individual watershed problems generally on a resource specific basis.

Regulatory use of prescriptions in areas of resource sensitivity will be required for selected forest practices activities and situations identified by each watershed assessment (WAC 222-22-070(3)). Ideally, a number of prescriptions will be developed for each area of resource sensitivity, and landowners may select from a list of options, including alternate plans (WAC 222-12-040). Each prescription will appropriately address the stated problem(s).

Voluntary mitigation measures, initiated by landowners, are encouraged for resource enhancement or restoration. Voluntary actions may be used by the landowner to improve or restore resource conditions. Such voluntary actions may provide the foundation for cooperative projects.

Level 1 prescriptions and Level 2 prescriptions should be similar and the process should be the same. However, a Level 1 analysis with "indeterminate" findings leads to interim prescriptions, whereas a Level 2 (or a Level 1 that does not need Level 2) will lead to final prescriptions. Level 2 should provide for more site and sensitivity-specific prescriptions. The greater detail and understanding resulting from a Level 2 assessment will provide additional information that is transferred to the prescription process. In some cases, this information will require additional detail in the prescription process as well. Different prescriptions for each situation may be possible at Level 2 due to more specific assessment products.

Watershed analysis and the prescriptions process are based on the concept of adaptive management. Experience will help improve the process. A flow chart of the process is provided in Figure 12.

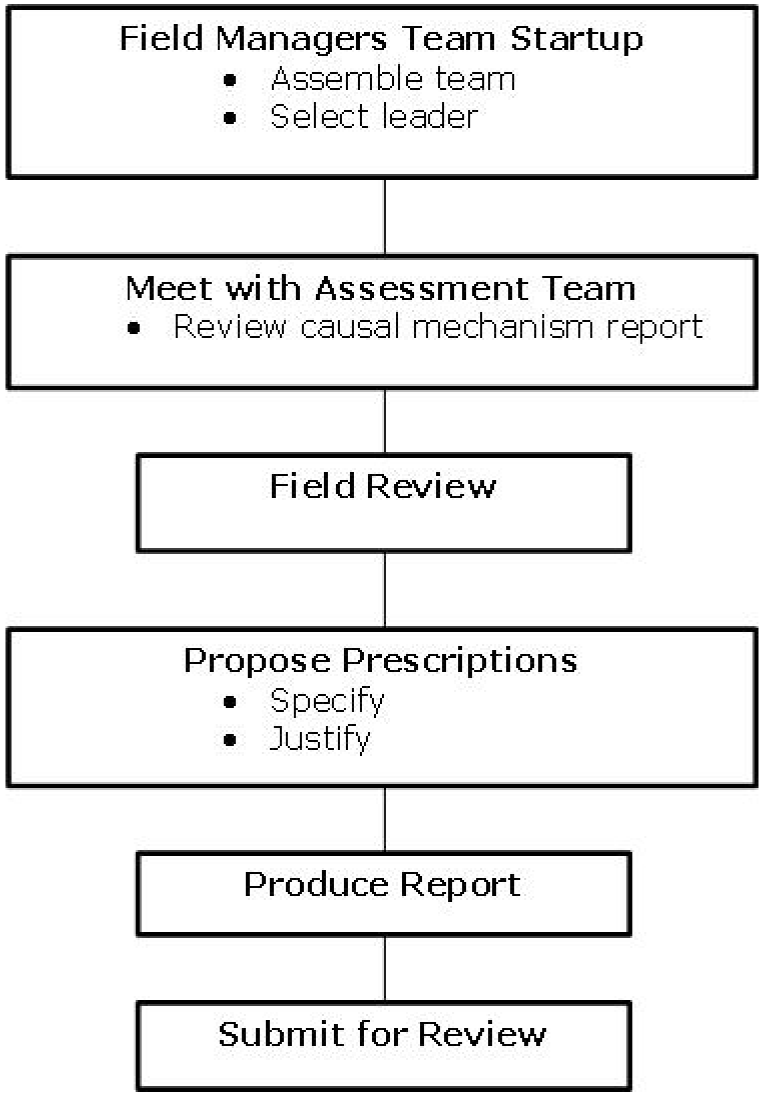


Figure 12. Field Manager's Team's Prescription Writing Process

6.3 Prescription Writing

1. ***Assemble the field managers team.*** Tentative assignments to the field managers team can be made when the assessment team is being formed. The final field managers team composition should reflect issues brought out in the causal mechanism reports from the assessment. The team composition should generally include expertise in forest management, engineering, hydrology, and fisheries science. Composition may vary depending on resource conditions and the watershed processes identified in the analysis. Individuals from a cross-section of qualified TFW or other participants, with local knowledge, are preferred as team members. Assessment files and information should be gathered and available to the prescription team. Photos, maps and field notes should be included.

2. ***Select a team leader.*** The team leader should be responsible for setting work schedules and completing the prescription package.

3. ***Meet with the assessment team.*** It is beneficial for members of the field managers team to observe the synthesis sessions of the assessment team. This helps the field managers understand how the various modules work together to identify problems contained in the causal mechanism reports. In addition, when the assessment phase is complete, it is essential for the assessment team to meet with the field managers team for a complete face-to-face hand-off of the assessment products. This provides a complete overview of all modules, and ensures that all reports are understood. Information gathered and developed during the assessment will be the basis for prescription writing. The watershed analysis team may have recommendations for prescriptions to be reviewed by the field managers. The involvement of the assessment team is to ensure the development of prescriptions that adequately address the areas of resource sensitivity.

4. ***Clarification of the causal mechanism reports, as needed.*** In some cases, the reports may have multiple underlying causal mechanisms which could be separated; prescriptions for the multiple mechanisms would be developed. Mapping may also provide some opportunity for refinements. Where the assessment identifies impacts caused by nonforestry related activities, the prescription team must take these into account and develop prescriptions only for those contributions related to forest practices. This is especially important in areas of mixed use. The management team should include those nonforestry related impacts in the final report for notification to the proper jurisdictional authorities.

5. ***Field review.*** Field review of resource sensitive areas may be necessary. Appropriate members of the field team should be on site for this review. The team should identify whether areas are resource specific (limited to identifiable sites) or basin wide.

6. ***Propose prescriptions.*** Each previously identified area of resource sensitivity will have causal mechanism reports. For each, there will be an assigned management response call from the rule matrix (Figure 13) and WAC 222-22-070(3). The team's task is to determine if and how specific forest practices and activities can be conducted consistent with the standard of protection required in the rule. Prescriptions must address the issues and processes identified in the causal mechanism reports and meet the rule standard.
   Where a proposed voluntary action would lead to a different set of prescriptions than those that would be necessary without the voluntary action, the team should describe, if possible, two (or more) alternative

series of actions: a prescription that is necessary if the voluntary action is not taken, and another prescription that is made possible by taking the voluntary action.

Prescriptions must be reasonably designed to meet the standard set forth in the rules (WAC 222-22-050(2)(d) or WAC 222-22-070(3)); they must either minimize or prevent or avoid as specified in the causal mechanism report based on the resource assessment, the likelihood of adverse change and deliverability that has the potential to cause a material, adverse effect to resource characteristics. In other words, prescriptions are to work on the "hazard" side of the equation. They are designed to minimize, or prevent or avoid, additional contributions to an existing problem or new contributions where a problem does not currently exist, but has the potential to exist; such potential needs to have been identified during the assessments. It is important to note, however, that the prescriptions are not required to minimize, or prevent or avoid, any further or potential contribution, but only those that have the potential to cause a material, adverse effect to a resource characteristic (e.g., damage to spawning habitat). These prescriptions are intended to create conditions in which these resources are allowed an opportunity to recover.

Where the matrix requires "minimize," the intent is to minimize the likelihood of those events or chronic circumstances identified in the causal mechanism report that have a potential for material, adverse impacts to resource characteristics; the intent is not to minimize the adverse impacts to the resource characteristics.

Cumulative Effects Rule Matrix

		Likelihood of Adverse Change and Deliverability		
		L	M	H
RESOURCE VULNERABILITY	L	Standard	Standard	Prevent
	M	Standard	Minimize	Prevent
	H	Standard	Prevent	Prevent

Figure 13. Matrix used to produce management response calls for a given problem statement within a causal mechanism report (same as Figure 9 in Resource Assessment).

Where the matrix requires "prevent or avoid," the intent is to prevent or avoid events or chronic circumstances identified in the causal mechanism report that have the potential for material, adverse effects. One of the solutions may be to avoid or defer activities such as harvesting, road construction or use, salvage, that may contribute to the problems identified in the causal mechanism report. Other solutions could include technological solutions that prevent or avoid the effects of the forest practices identified as potential problems in the causal mechanism report.

The team's responsibility is to develop various ways to address the processes and issues identified in the causal mechanism report. Consideration should be given to all relevant factors. The team is encouraged to develop more than one prescription for each causal mechanism report. This allows landowners to select from a variety of options.

Each landowner in the watershed is entitled to submit draft prescriptions for its lands to the team. A landowner need not be qualified under WAC 222-22-030 to submit draft prescriptions for its lands. The team should compile all those prescriptions and discard those that are not reasonably expected to work. The team can use the various proposed prescriptions to prepare alternatives for each situation. Prescriptions will generally be resource specific, but may include broad responses such as road maintenance and abandonment plans. If the causal mechanism report requires, prescriptions might include a verification step, such as determination if an identified field condition actually exists on the site of the proposed forest practice. They should also include a mechanism for applying prescriptions to recognized land features identified in the WAU as areas of resource sensitivity but not fully mapped.

Currently utilized practices that are successful, versus standard forest practices as defined by rule or past practices, should be encouraged. Prescriptions might include an operational monitoring component or landowner plan to verify compliance. Staged operations are a possibility when there are appropriate prescriptions implemented consistent with the staging. Creative problem solving is essential for prescription writing and the inherent variation of assessment products.

Time frames for implementation of the prescriptions will be required where appropriate. For example, time frames with expected start and completion dates for road maintenance plans should be required.

7. ***Potential subjects.*** For issues identified in the causal mechanism report, the follow issues may need to be addressed:

I. Harvest

A. Method of harvest

1. even age or uneven age

2. yarding method (linked to roads)

3. designated skid trails

B. Harvest size limitation, if any, for rain-on-snow or other purposes

C. Timing of harvest activities (e.g., summer v. winter)

D. Wet-weather restrictions

E. Buffers

1. stream type

2. stream reach

3. wetland type

F. Hydrologic maturity

G. Possibility of no harvest

II. Road construction, maintenance, abandonment, and use

A. Construction

1. Location (including avoidance)

2. **Grade**
3. **Sidecast/endhaul**
4. **Drainage structures-design for 50- or l00-year storms**
   a) **Bridges, fords**
   b) **Culvert size, spacing, intake, outfall, skew**
   c) **Waterbars**
   d) **Outsloping**
   e) **Ditch size, depth, gradient, shape**
   f) **Vegetative protection or buffers**
5. **Road width control**
6. **Compaction**
7. **Rip-rap anchoring toe, retaining walls**
8. **Revegetating cuts and fills**
9. **Berms, dikes, debris racks, overflow channel**
10. **Surface material**
11. **Water management-gullies, natural drainage, cross-drains, wetland protection**
12. **Abandonment as a design standard**

B. Maintenance
1. **Frequency and timing**
2. **Drainage structures**
3. **Surface-crowned, insloped, outsloped**
4. **Emergency maintenance (e.g., storm events)**
5. **Monitoring, sampling**

C. Abandonment
1. **Water management**
   a) **natural drainage**
   b) **culverts**
   c) **bridges, fords**
   d) **cross-ditch size, location, spacing**
   e) **water bars**
2. **Surface treatment**
   a) **outslope**
   b) **inslope**
3. **Fill and sidecast**
4. **Revegetation**

5. **Landing**

D. **Road Use**

1. **Timing**
2. **Activities**

8. ***Support for prescriptions.*** Prescriptions must be expected to work. Sufficient rationale, based on local operational expertise or information from appropriate scientific literature, should be provided. This is not a literature review exercise but rather a reasonable demonstration that the proposed prescription will adequately address the specific processes and issues identified by the causal mechanism report. The explanation of the proposed prescriptions can be in several forms. Logic and reasoning relative to the causal report may be sufficient justification. Science and research reports that support the proposed prescription, or examples of successful prescriptions from past operations rather than avoidance as a prescription should be provided. The team shall document their technical rationale for selecting prescriptions.

9. ***Voluntary actions.*** The watershed analysis rules do not require restoration projects; however, there may be opportunities to identify such projects for voluntary implementation. The team should look for these restoration and enhancement opportunities and report on their scope and feasibility. Identification of these opportunities will be helpful to landowners and other resource managers in forming cooperative projects for specific watersheds. If used to justify alternative prescriptions, proposed restoration and enhancement projects must be proven to be successful (see previous section).

10. ***Report.*** The team should compile the prescriptions in an interim final draft report for the watershed. The format shall be consistent with the assessment report and products, with linkage between the products and prescriptions as needed. For each area of resource sensitivity, prescriptions should be clearly stated and complete. Maps and drawings may be helpful. Include appropriate definitions or explanations as needed.

11. ***Timing.*** Upon departmental acceptance of the assessments, the field managers team shall submit the prescriptions to the department within 21 days for Level 1 Analysis or 30 days for Level 2 Analysis (see WAC 222-22-070(4)).

12. ***Agency, tribal and public review of prescriptions.***
    a. *Final Watershed Analysis, Level 1 or Level 2*. The field managers team shall submit the final draft watershed analysis report to the

department (DNR). The department shall circulate the draft to appropriate divisions in the departments of fisheries, wildlife, and ecology, affected Indian tribes, local governments, affected landowners in the WAU and the public for their review and comments (see WAC 222-22-080(1)). This is a 30-day circulation period.

b. *Interim Watershed Analysis, Level 1 Only*. Before submitting recommended interim prescriptions to the department, the field managers team shall review the recommended prescriptions with available representatives of the jurisdictional management authorities of the fish, water, and capital improvements of the state. This includes, but is not limited to the departments of fisheries, ecology, and affected Indian tribes. The team shall provide for a reasonable period of time for comments; such comments must occur within the 21 days required by rule. See number 11 (Timing) above.

A copy of the draft report should also be provided to the relevant watershed analysis team. The team may, when consistent with existing laws, rules and methods, incorporate agency and tribal input for the development of an interim/final report.

13. ***Interim/Final Watershed Analysis Report.*** The field managers team attaches the prescriptions for each identified resource sensitivity (recorded on Form 6) to the Causal Mechanism Report. This combined report is termed the Watershed Analysis Report for the WAU. The report will be considered interim if there are indeterminates within the resource assessment (Level 1). The report will be considered final when the indeterminates have been resolved by Level 2 analysis and prescriptions. Include non-forest practice related contributing activities.

14. ***The interim or final report will be submitted to the department.***

a. *In WAUs* that contain no areas of resource sensitivity or no indeterminate ratings, Level 1 Analysis is considered final after approval by the department.

b. *In WAUs* that contain indeterminate ratings, Level 1 Analysis is considered interim after approval by the department. It is anticipated that such WAUs will receive Level 2 Analysis, converting the interim into final.

c. *Level 2 Analysis* is considered final after approval by the department.

Review Process

1. ***Review of watershed analysis.***
   a. *Final Watershed Analysis.*
   The department shall circulate copies of the final watershed analysis (assessments plus prescriptions, if any) to other relevant state and federal resource management agencies, affected Indian tribes and local governments, forest landowners, and the public for their review and comment according to the rules. The department shall review the comments and revise the watershed analysis as appropriate, and approve or disapprove the analysis within 30 days of the receipt of the watershed analysis report (WAC 222-22-080(1)).
   b. *Interim Watershed Analysis.*
   Interim Level 1 watershed analysis products are not circulated (see WAC 222-22-080(1)) but comments to the department are encouraged, subject to the timing mandates established by WAC 222-22-050(5) and WAC 222-22-070(4). Copies will be available for review at the regional office.

2. ***State Environmental Policy Act.*** The Forest Practices Board has directed the department to consider the approval of a watershed analysis as a governmental action subject to SEPA. The responsible official is the RP&S Assistant Regional Manager, DNR.
   a. *The field managers team* for any watershed analysis shall prepare an environmental checklist. Parties conducting watershed analysis shall prepare the SEPA documents at their sole expense.
   b. *The responsible official* shall review the checklist for adequacy and make a draft threshold determination.
   c. 15-day SEPA Comment Period.
      i. Final Watershed Analysis. The determination shall be circulated for a 15-day commentary period during the same time period that it circulates the draft watershed analysis under WAC 222-22-080(1).
      ii. Interim Watershed Analysis. There is no 30 day circulation period required under the forest practice rules (WAC 222-22-050(5)). The department shall circulate the interim watershed analysis environmental checklist threshold determination for a 15-day SEPA review.
   d. *Subsequent to the evaluation* of the comments, the responsible official may approve, modify or deny the watershed analysis. In some circumstances, an EIS may be required.

Form 6. Suggested Format for Prescription Writing

WAU:____

Resource Sensitivity Number:____________________________________

Situation Sentence for the Area (from causal mechanism report):

____
____
____

Triggering Mechanism (from causal mechanism report):________________
____
____
____

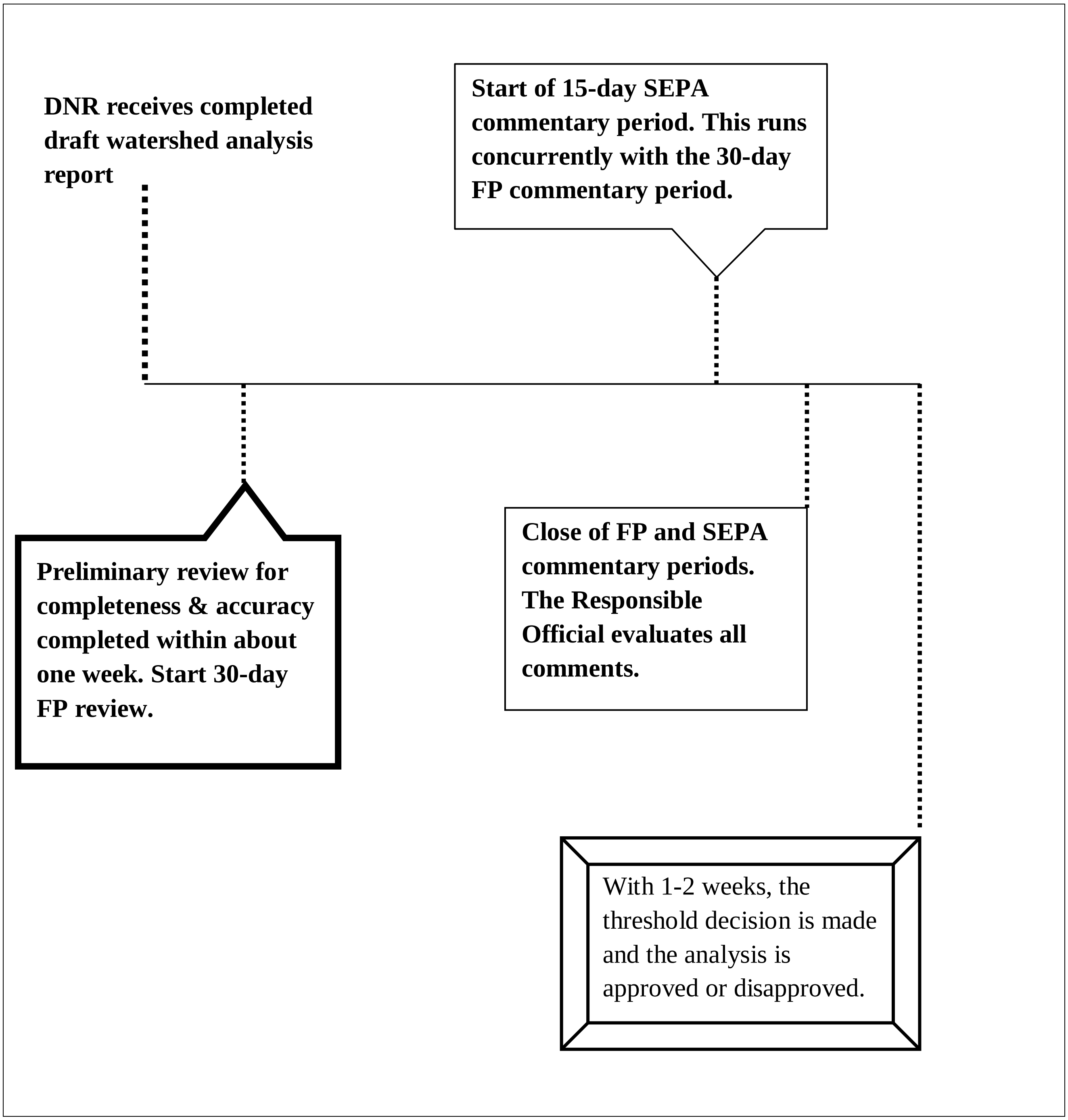
Rule Call for Management Prescriptions (from causal mechanism report):___

Field Observations:____
____
____

Prescriptions:____
____
____
____
____

Justification for Prescriptions:___________________________________
____
____
____

Review of Watershed Analysis by the Department of Natural Resources



Part 7 Monitoring Program Identification Process

7.1 Introduction

After completion of the assessment and prescription process, management practices developed by the prescription team will be applied in the sensitive areas identified. The managers of the forest, fish and water resources need to know whether these prescriptions are working and if resource goals are being achieved. Monitoring information can play an important role in evaluating the effectiveness of watershed analysis, determining trends in the conditions of resources and providing direction for future resource management. (See Figure I-1 in the Introduction to Watershed Analysis section).

The purpose of the monitoring module is to provide guidance for monitoring programs to evaluate the effectiveness of watershed analysis in achieving watershed-specific objectives. Monitoring must answer two questions in order to be useful in the context of watershed analysis: 1) are the prescriptions effective in preventing cumulative effects; and 2) how are the resources of concern responding to the protection provided by watershed analysis?

The effectiveness of forest practices prescriptions can be determined by monitoring the response of triggering mechanisms and input processes. Monitoring the status of stream channel, fish habitat and water quality conditions can determine if the resource objectives of the watershed analysis are being met.

The formal mechanism for using monitoring information in evaluation of watershed analysis and adaptive management is provided by WAC 222-22-090 *(4) of the forest practices rules. This section requires DNR to evaluate the effectiveness of prescriptions in providing for protection and recovery of resources in cases where the condition of resource characteristics or indices of resource conditions is fair or poor. If resource conditions are found to be fair or poor, information gathered through monitoring will be critical for evaluating whether the trend in resource condition is improving consistent with the intentions of the WAC.

In addition, monitoring information can be used to guide local management decisions and cooperative efforts for additional resource benefits. Monitoring can provide adaptive management feedback to help refine and improve the analysis over time.

The monitoring module is based on several underlying principles. Watershed analysis monitoring uses a watershed-based approach that examines the relationships between prescriptions, triggering mechanisms, input processes and associated channel, habitat and water quality effects. These linkages provide a context for interpretation of monitoring results. Monitoring plans are developed and implemented locally (for each watershed) and cooperative monitoring efforts are encouraged to reduce costs and share responsibilities. Monitoring parameters are chosen to be consistent with local conditions, processes, and resources based on watershed-specific information from the causal mechanism, resource assessment, and prescription reports and the knowledge of people familiar with the watershed. Standard methods will be available.

This module provides guidance so people with different backgrounds and skills can develop monitoring plans that will produce consistent and useful monitoring information.

7.2 Critical Questions

Watershed analysis monitoring is designed to answer two fundamental questions:

Are the prescriptions effective in controlling identified trigger mechanisms and maintaining related input processes within acceptable ranges?

Are the conditions of the channel, fish habitat, water quality, water supply or public works responding as expected?

7.3 Assumptions

Watershed analysis monitoring is based on the following assumptions:

1. Cause and effect linkages exist between forest practices (prescriptions), triggering mechanisms, input processes and channel, fish habitat, water quality, water supply and public works conditions.

2. The Causal Mechanism Reports identify the key linkages and provide testable hypotheses that can be used to test the effectiveness of watershed analysis.

3. Changes in the condition of stream channels, fish habitat and water quality, water supply and public works can be detected and measured.

4. Trends in resource conditions over space and time can be distinguished from natural variability.

7.4 Overview of Procedure and Products

The following is a listing of when the major steps occur in the watershed analysis process for preparing a monitoring plan and implementing a cooperative monitoring program. The product produced is a Monitoring Plan Report for filing with DNR and for use during cooperative implementation efforts.

Start-up

- Project manager instructs each resource assessment team leader and prescription team leader to identify potential monitoring objectives.

Resource Assessment

- Assessment teams identify potential monitoring objectives.

Synthesis

- Assessment team leaders discuss potential monitoring objectives during the module report presentations.

Prescription

- Prescription teams identify potential monitoring objectives.

Wrap-up

- Wrap-up team discusses potential monitoring objectives.
- Team selects final monitoring objectives for inclusion in the monitoring plan.
- Prepare the monitoring plan report for filing with DNR.

Voluntary Implementation

- Project manager convenes stakeholders to discuss monitoring plan report.
- Identify participants volunteering for monitoring implementation.
- Select a coordinator from volunteering participants.
- Develop a cooperative monitoring implementation workplan.
- Implement the workplan.

7.5 Qualifications

Participating resource analysts, managers, and members of assessment and prescription teams are qualified to participate in the development of a monitoring plan.

7.6 Background Information

Much of the information needed to prepare a watershed analysis monitoring plan is found in the watershed analysis documents. The team will need a copy of the resource assessment, causal mechanism, and prescription reports. Maps showing areas of resource sensitivity and channel response segments will be needed. Other useful information includes past monitoring data and sources of standard methods, such as the TFW Ambient Monitoring Program Manual.

7.7 Procedure

The procedure for the Watershed Analysis Monitoring Module is presented in two sections. The first section describes how to develop a monitoring plan. The second section discusses cooperative implementation of the plan and procedures for collecting, interpreting and using monitoring data.

Section 1. Developing a Watershed Analysis Monitoring Plan

Each monitoring plan is developed during the wrap-up phase by representatives of the resource assessment and prescription teams. The plans are tailored to watershed-specific conditions and concerns documented in the resource assessment, causal mechanism, and prescription reports. The monitoring module does not generate the local information needed to develop a monitoring plan. Instead, it provides guidance for using information gathered during watershed analysis along with other local sources to develop an effective monitoring plan.

Step 1: Initial Discussion

During the start-up phase of watershed analysis the project manager should discuss the issue of monitoring with participating organizations and stakeholders, informing them that a monitoring plan will be developed during wrap-up and that a decision on whether to cooperatively implement the monitoring plan will need to be made following the completion of watershed analysis.

The project leader should also remind leaders of the assessment teams and the prescription team that they should document information on situations that would benefit from monitoring and record that information in module write-ups. At synthesis, the assessment module team leaders should discuss potential monitoring ideas as part of the assessment module presentations.

Step 2: Identifying Watershed-Specific Monitoring Objectives

One of the most important tasks is to clearly identify specific monitoring goals to provide the focus needed for a successful monitoring plan.

The primary goal of watershed analysis monitoring is to determine if watershed analysis has been effective in achieving resource management objectives. This section provides guidance for translating this general goal into specific monitoring objectives for each watershed.

Developing specific monitoring objectives is a critically important step in putting together an effective monitoring program. Specific monitoring objectives will keep the monitoring program focused and efficient, and help ensure that the information collected serves a useful purpose. The procedure in this section provides a means of identifying, evaluating and prioritizing potential watershed-specific monitoring objectives.

Identifying potential monitoring objectives
The causal mechanism reports are the main tools used to identify monitoring objectives relating to effectiveness of watershed analysis. Each causal mechanism report identifies a cause and effect relationship between forest practices, input processes and resource effects that can be evaluated with monitoring data. The resource assessment reports and prescriptions are additional sources of useful information for identifying monitoring objectives when used in conjunction with the causal mechanism reports.

Using the monitoring objective work sheet
Form M-1 provides a suggested format to assist in the process of identifying and evaluating potential monitoring objectives, and organizing information useful in evaluating each monitoring objective. As you examine the information discussed above and identify potential monitoring issues or situations, use the suggested format to develop a narrative discussion of each potential monitoring objective. The following section describes the information that should be included in each narrative. However, feel free to include additional applicable information not specified below.

Monitoring objective. There are several potentially useful alternative approaches for identifying monitoring objectives. One approach is to base the monitoring objectives on the cause and effect relationships between input processes and resource conditions described in the causal mechanism reports.

In these cases the monitoring objective will often be to evaluate the effect of the prescriptions on triggering mechanisms, input processes and resource conditions over time. Monitoring to achieve this objective is recommended in cases where the condition of the resource characteristics is determined to be fair or poor as measured by indices of resource condition in the resource assessment reports. An example of a monitoring objective derived from a causal mechanism report (and the relevant prescriptions) might read:

"To evaluate the effectiveness of the road maintenance prescription for Surface Erosion Mapping Unit (SEMU) 2 in reducing fine sediment levels in spawning and incubation habitat in Channel Segment 6."

Another approach used to identify monitoring objectives (which may be faster) begins with identifying a critical resource objective(s). Then the resource assessments and causal mechanism reports are used to identify what input processes are affecting the resource. Work through the relevant cause-effect pathways to identify potential parameters related to the resource of concern. This type of monitoring objective may capture the effect of multiple input processes on a critical resource. A monitoring objective of this type may state:

"To monitor the status of older age-classes of resident cutthroat trout in Segment 10 as a means of evaluating whether the combination of prescriptions affecting LWD recruitment, coarse sediment input and catastrophic events are improving rearing habitat for those age-classes."

Finally, monitoring of the biological resource itself, such as fish populations, may provide a means of truly understanding the biological response to input processes and channel conditions.

Source. List the source of information that each monitoring objective is based on, such as a specific causal mechanism report, resource assessment report, assessment or prescription team suggestion, etc.

Monitoring hypothesis. The next question requires formulation of a hypothesis for each monitoring objective. Where the monitoring objective is based on a causal mechanism or resource assessment report, the cause and effect relationship needed to develop a monitoring hypothesis has already been identified. For example, a hypothesis based on a causal mechanism report might state:

"The road maintenance prescription for SEMU 2 will reduce sediment delivery to the stream system, reducing fine sediment levels in spawning and incubation habitat in Channel Segment 6."

Current status. Describe the current situation using information in the causal mechanism and resource assessment reports, and the knowledge of team members. Discuss the past effects of natural events, forest practices and other activities that have contributed to current conditions. An example of a description of current status may state:

"Surface erosion from roads in SEMU 2 has been delivering moderate amounts of fine sediment to the stream system for the last ten years. A large storm event in 1989 deposited large amounts of fine sediment from upstream bank erosion and mass wasting. Spawning gravel fine sediment levels in channel segment 6 are elevated (mean of 16.1% <0.85 mm)."

Future prognosis. The future prognosis should be developed by assessment team members based on the current situation, the expected response to future management, and natural disturbance/recovery cycles. Watersheds are dynamic physical systems subject to natural or management-induced disturbances that create cycles of disturbance and recovery over time so a variety of future outcomes are possible. The time-frame required for recovery from disturbance depends upon factors such as the magnitude of disturbance, the frequency of disturbance, distribution of the disturbance over the stream network, the type of process involved, and inter-relationships with other processes. To determine if a system is responding as predicted in the monitoring hypothesis, it is important to know the time-frame over which changes, such as recovery from past disturbance, are expected to occur. It is also important to identify other factors that could affect the rate or direction of change over time. This information will help in the evaluation of resource recovery in WAC 222-22-090 *(4) by establishing realistic expectations for resource response. An example of a future prognosis might read:

"Implementation of the road maintenance prescription in SEMU 2 is expected to result in a decrease in fine sediment delivery to the stream channel. Reduction in the spawning gravel fine sediment levels in Segment 6 is expected to occur over the next 5-10 years, at which time levels should stabilize at a mean of less than 12% <0.85mm. Mass wasting and/or bank erosion associated with a large peak flow event could temporarily reverse or slow the recovery process."

This is also a place to capture critical uncertainties which arise due to the fact that we may not have a thorough knowledge of a watershed process, or we cannot accurately predict the probability of disturbance or the rate of recovery.

Potential monitoring parameters and their feasibility. The next part of the work sheet provides spaces to record potential monitoring parameters and comments about their feasibility and applicability to the monitoring objective. This is an identification of the basic "how to's" for possible monitoring. Detailed plans will be developed during cooperative implementation for selected objectives.

A parameter is defined as a variable used as an indicator to gage in a quantitative manner whether there has been a change to part of a system. Be specific when identifying parameters, keeping in mind what data needs to be generated and how it will be analyzed and used. For example, pool habitat is too general to be a useful monitoring parameter. More specific parameters are used to measure pool habitat depending on the linkage to input processes that are being monitored. Examples of parameters to measure pool habitat include: pool surface area as a percentage of total surface area, channel widths per pool, and residual pool depth.

Spaces are provided for parameters related to input processes, triggering mechanisms, channel effects, habitat effects and water quality effects. All types of parameters will not be relevant in each case so fill out only the appropriate ones for each monitoring objective.

Use the comment section to record factors such as relevance or feasibility that make certain parameters better choices than others for inclusion in the monitoring plan. For example, measuring changes in stream flow may be very expensive and require a long period in order to produce a meaningful data set.

Appendix A shows a variety of possible parameters for triggering mechanisms, channel, and fish habitat effects and the input processes that they are associated with. See MacDonald et al. (199l) and the TFW Ambient Monitoring Program Manual for additional information on monitoring parameters related to forest practices and their effects.

Step 3: Determining monitoring objectives

The next step is to finalize and prioritize the potential monitoring objectives. This step involves winnowing through the possible objectives and narrowing the field to those which will be most efficient, useful and informative, and eliminating those not meeting these criteria.

Selection of final monitoring objectives is a judgment of the team about the relative importance of the objectives and their ability to answer the key questions. The worksheet information is useful for evaluating and comparing potential monitoring objectives, but does not provide a formula for final selection among objectives. Use Form M-3 to document the selected objectives. If priorities are determined among final monitoring objectives, note relative importance as a comment.

Step 4: Prepare a Monitoring Plan Report

Once the final monitoring objectives have been identified and prioritized, the team assembles this information in written form. The monitoring plan is not part of the final Watershed Analysis Report submitted to DNR for approval, however it should be filed with DNR as a separate report for future reference. The monitoring report should include the selected monitoring objectives and document the process used to identify and select these parameters.

Section 2. Cooperative Implementation of Watershed Analysis Monitoring
Implementation of the monitoring plan is done through cooperative efforts by stakeholders. As such, the actual monitoring done depends on resources available through various stakeholders and their commitment of those resources to a monitoring program. There will be cases where no monitoring is done, cases where some of the plan is done and cases where the plan is done as designed.

Step 1: Determine the amount of cooperative commitment for implementation of monitoring
The project manager for the watershed analysis convenes a meeting of interested stakeholders to discuss the monitoring plan report and determine the level of interest in cooperative implementation of a monitoring program. The monitoring plan report provides guidance for monitoring to answer the key questions. Additional monitoring goals may be discussed. Stakeholders should be encouraged to help implement the developed plan first, before adding additional objectives.

Determine the commitment of cooperative resources to a monitoring program. Determine any specific commitments to individually identified objectives. Based on the level of cooperative commitment of resources, decide whether to proceed with detailed development of a monitoring program.

Select a coordinator from volunteering cooperators to manage the development of a monitoring workplan and coordinate its implementation. The coordinator works with cooperators, ensuring that monitoring is carried out on schedule and according to plan. A feedback loop is recommended to provide for review and revision of the monitoring workplan to ensure that program objectives are being met. The coordinator structures meetings as needed to share results, review progress and distribute data. The coordinator should be experienced in project management with some knowledge in operational monitoring and quality assurance.

Step 2: Develop a cooperative monitoring workplan
The actual design of monitoring activities needs to be done with utmost care. The goal is credible data that answers the key questions. Use standard methods, such as those developed by the TFW Ambient Monitoring Steering Committee or other recognized available methods, to provide the needed consistent quality of data. Poorly designed monitoring will not provide answers to the questions being asked. It is recommended that special expertise be recruited to assist in this effort. Experience in natural resources monitoring and statistical design of sampling programs is recommended. The TFW Ambient

Monitoring Steering Committee has experience and knowledge in this area and could be called on for assistance and advice.

Based on the commitments made in Step 1, develop a detailed workplan for the selected objectives. For each selected objective, the details for parameters to sample are defined. Sampling design should include such factors as sampling location, sampling intensity, sampling methods, sampling schedule and quality control/quality assurance. Data analysis needs should be considered. Completion of the module includes a report developed cooperatively by the participants that summarizes results. Form M-4 provides a possible format for organizing the elements of the monitoring workplan.

Step 3: Implement the workplan
The actual implementation of the monitoring workplan is done by participating cooperators as agreed on during the development of the monitoring program. Each cooperator assumes the operational responsibility for their respective portion of the program. It is essential that all cooperators follow through with their commitment, ensuring that procedures, schedules and quality controls are carried out as designed. Individuals taking the samples should be adequately trained in the field procedures assigned. The TFW Ambient Monitoring Steering Committee provides training in proper field procedures for many parameters and additional methods are being developed. Cooperators will work with the coordinator during implementation of the workplan.

Table M-2. Monitoring Module Task Checklist

Review	Task	Schedule	Complete
	Project manager instructs each resource assessment team leader and prescription team leader to identify potential monitoring objectives.		
	Assessment teams identify potential monitoring objectives.		
X	Assessment team leaders discuss potential monitoring objectives during the module report presentations.		
	Prescription teams identify potential monitoring objectives.		
	Wrap-up team discusses potential monitoring objectives.		
	Wrap-up team selects final monitoring objectives for inclusion in the monitoring plan.		
X	Prepare the monitoring plan report for filing with DNR.		

7.8 Acknowledgments

The Watershed Analysis Monitoring Module is the product of a concerted effort by the Ambient Monitoring Steering Committee and the TFW Ambient Monitoring Program. This version of the module was written by Dave Schuett-Hames, with revisions by Bob Gustavson and Blake Rowe. It incorporates many concepts and suggestions from the Ambient Monitoring Steering Committee and other reviewers including Stan Donda, Hans Ehlert, Mark Hunter, Jeff Light, Randy MacIntosh, George Pess, Allen Pleus, Ed Rashin, Ed Salminen, and Julie Thompson. Dennis McDonald assisted in editing this document.

The Northwest Indian Fisheries Commission and the Washington Forest Protection Association provided funding for development of this version of the monitoring module.

7.9 References

MacDonald, L.H., A.W. **Smart** and R.C. **Wissmar**. 1991. Monitoring guidelines to evaluate the effects of forestry activities on streams in the Pacific Northwest. EPA/910/9-91-001. Environmental Protection Agency. Seattle.

Schuett-Hames, D., A. **Pleus**, L. **Bullchild** and S. **Hall**. 1993. TFW Ambient Monitoring Program Manual. Northwest Indian Fisheries Commission. Olympia.

Schuett-Hames, D. and G. **Pess**. 1994. A strategy to implement watershed analysis monitoring. Northwest Indian Fisheries Commission. Olympia.

Form M-1. Outline for Cooperative Monitoring and Objective Worksheet

WAU____

Date____

Potential Monitoring Objective

Source

Monitoring Hypothesis

Current Status

Future Prognosis

Potential Monitoring Parameters

Input Process

Triggering Mechanisms

Channel Effects

Habitat Effects

Water Quality Effects

Form M-2. Prioritizing Cooperative Monitoring Objectives Worksheet

Priority Number/ Objective Number	Monitoring Objective	Reasoning/Comments

Form M-3. Outline for Watershed Analysis Cooperative Monitoring Objective Description

WAU________________________________ Date_____________________

Monitoring Objective Priority Number _____

Monitoring Objective

Source

Monitoring Hypothesis

Current Status

Future Prognosis

Monitoring Parameters Selected

Form M-4. Outline for Watershed Analysis Cooperative Monitoring Workplan Parameter Description

WAU________________________________ Date___________________

Monitoring Objective Priority Number _____

Parameter

Type of Parameter

Sampling Location

Data Collection Methods

Sampling Design and Procedures

Data Analysis Procedures

Quality Assurance Plan

Products

Roles and Responsibilities of Participants

Lead Organization:

Project Leader:

Phone:

Address:

7.10 Possible Parameters for Watershed Analysis Cooperative Monitoring

The following parameters have been identified from existing Watershed Analysis Causal Mechanism Reports. Currently the only CMER approved standard methods are in the TFW Ambient Monitoring Program Manual (July 1993). Additional parameters will be added to the list as identified in the future. When developing standard methods for each parameter it is desirable to consider both high and low methods for stakeholders to be able to choose from. Development and adoption of additional standard methods for other parameters is dependent upon future efforts and/or funding. (A Strategy to Implement Watershed Analysis Monitoring 1994)

Triggering mechanisms

- Aerial photo landslide inventory
- Slope stability analysis
- Deep-seated landslides
- Road assessment procedure
- Surface erosion survey
- Fine sediment delivery
- Aerial photo survey of riparian vegetation
- LWD recruitment
- Aerial photo survey of rain-on-snow (ROS) zone vegetation
- Site-specific peak flow runoff monitoring

Channel effects

- Channel substrate size (fining or coarsening)
- Channel aggradation or degradation
- Channel widening, braiding, lateral migration and bank erosion
  - Aerial photo method
  - Field methods
- Sediment storage features

Fish habitat effects

- Spawning gravel scour
- Redd de-watering
- Spawning gravel sedimentation and redd entombment **(TFW AM Manual)**
- Spawning gravel availability
- Water temperature **(TFW AM Manual)**
- De-watered habitat (sub-surface flow) **(TFW AM Manual)**
- Macro-invertebrates
- Pool rearing habitat

(TFW AM Manual)

- Overhead/instream cover
- Pool refuge habitat
- Interstitial refuge habitat
- Large woody debris (LWD) refuge cover
- Off-channel refuge habitat
- Adult holding pools
- Passage blockage

Part 8 Review and Reanalysis of Watershed Analysis

Flooding and landslides associated with the 2007 storm events in western Washington led the Forest Practices Board (Board) to request a review of watershed analysis rules . The Board questioned the effectiveness of watershed analyses (WAS) prescriptions associated with approved watershed analyses (WSA) and their ability to provide necessary protection to public resources. Consequently, the Board directed the Adaptive Management Program to develop recommendations for change if needed. This led to the Department of Natural Resources (DNR) developing a watershed analysis review and a revised WSA mass wasting prescription reanalysis process (see Appendix K).

This part of the Watershed Analysis Board Manual contains guidance for completing a review and reanalysis on an approved watershed analysis. The guidance supplements chapter 222-22 WAC, which regulate forest practices on forest lands with approved watershed analyses.

8.1 Review Overview

DNR will perform a review on approved watershed analyses (WSA) to determine if a reanalysis is necessary in order to maintain current prescriptions. The WSA reviews occur when specific criteria are met and specific steps must be followed during performance of the reviews. The criteria and steps are outlined below.

1. Periodic WSA review is required and is based on WAC 222-22-090 which provides the following criteria:
   - A review will take place five years after the date the watershed analysis is final, and every five years thereafter; or
   - The occurrence of a natural disaster; or
   - Deterioration in the condition or no improvement of a resource characteristic in the watershed administrative unit (WAU).

2. DNR will notify forest landowner(s) in the WAU when a review is conducted on their approved watershed analysis and DNR has determined that reanalysis is necessary.

3. For any approved watershed analysis, the DNR will determine which WSA prescriptions and modules will be reanalyzed, if applicable.
   - DNR will provide opportunities for stakeholder input regarding prescriptions for reanalyzed WSAs.

4. Forest landowners must either accept the reanalysis or give up existing WAU prescriptions.

5. If the landowner chooses not to conduct a reanalysis DNR will initiate a nonproject State Environmental Policy Act (SEPA) checklist to eliminate the identified WSA prescriptions.

Forest landowners with habitat conservation plans (HCP) are exempt from DNR watershed analysis reviews per WAC 222-12-041, if watershed analysis prescriptions have been incorporated into their HCP. Reviews of privately-sponsored watershed analysis associated with an approved federal HCP are on schedules established through their HCP agreement. All reanalysis of WSA prescriptions on HCP covered lands will continue to be reviewed in cooperation with DNR.

8.2 Reanalysis Overview

When a DNR review determines that a reanalysis is necessary and landowners in the WAU decide they would like to retain their approved watershed analysis prescriptions the subsequent steps will be followed:

1. DNR will solicit forest landowners with 10% or greater forest land ownership within a WSA area to determine who may be willing to sponsor, co-sponsor, or assist in a reanalysis. A schedule for reanalysis will be established once the landowner(s) responds. This schedule will incorporate input from the forest landowners regarding their level of participation.

2. Once the landowner commits their resources to completing a reanalysis, DNR in consultation with the departments of ecology and fish and wildlife, affected Indian tribes, forest landowners, and the public shall establish a timeline for the reanalysis. DNR will work with individual forest landowners who are sponsoring or participating in reanalyses to consider appropriate schedules.

3. DNR may request a meeting to gather new information and concerns from interested parties pertaining to the specific module(s) included within the reanalysis.

4. DNR will notify the forest landowner(s) they have the following options:
   a. Sponsor or co-sponsor a reanalysis, or
   b. At any time during the reanalysis process, DNR, in consultation with the forest landowner(s), can rescind the WSA prescriptions and use the applicable forest practices rules for the module being reanalyzed (i.e., target module).

8.3 Reanalysis Start-up

1. DNR notifies the landowner, the departments of ecology and fish and wildlife, affected Indian tribes, relevant federal agencies and local governmental entities, and the public that a reanalysis is necessary.

2. DNR will provide the specific prescription(s) and target module(s) needing reanalysis.

3. DNR will determine the degree of expertise required to conduct the reanalysis.

4. DNR will provide necessary training for module(s) being reanalyzed.

5. DNR will determine the geographic area(s) being reanalyzed.

6. DNR in consultation with the departments of ecology and fish and wildlife, affected Indian tribes, forest landowners, and the public will develop a reanalysis timeline.

7. Supportive Documentation
   DNR with the landowner's assistance will provide the required start-up maps and supportive documentation. Reference Table 2 located in Start-up, Appendix A located at http://www.dnr.wa.gov/Publications/fp_wsa_manual_section02.pdf.
   - Map of previous years forest activities prior to initial watershed analysis.
   - Map of Forest Practices Applications (FPAs) completed in the WAU in the past five years - include all applicable FPA numbers.
   - Map of known restoration projects completed in the WAU in the past five years.
   - Any reports about the area written since the last review.
   - Any monitoring data collected since the last review.
   - There are established maps, tables, and report requirements that are

- standard WSA products, and many of these should be included in a reanalysis document.
- Aerial photos, LiDAR, and other appropriate tools are encouraged to be
- used.

8. Critical Questions

The objective of each watershed analysis module is to guide development of information necessary to address questions critical to understanding the natural and anthropogenic processes in a watershed.

- DNR in consultation with stakeholders will develop critical questions for the reanalysis based on an assessment of the questions from the current approved watershed analysis, taking into account any changes that have occurred in the watershed. Pertinent involvement by stakeholder groups will be encouraged while developing these critical questions.
- Mass Wasting Reanalysis Critical Questions (Appendix K).

9. Assumptions

- A number of fundamental assumptions are outlined in each current
- approved watershed analysis module. It is important to review these assumptions and determine if they remain valid in relation to current scientific knowledge, new rules that may render them obsolete, and/or innovative field or assessment methods.
- New assumptions can be established by the landowner if they are supported by new data and/or science, documented and shared with stakeholders, and approved by DNR before the reanalysis begins.

10. Qualifications

- DNR, per WAC 222-22-030, will determine the qualifications for participation in both the resource assessments and prescription teams for reanalyses. DNR will provide training to explain the resource assessment and reanalysis process to prescription teams.
- The State of Washington requires an Engineering Geologist license for assessing and making recommendations for forest practices activities associated with potential unstable slopes and landforms (Appendices A and K). DNR established that Qualified Experts for FPA review of unstable slopes requires 3 years of experience evaluating unstable slopes in the forested environment (WAC 222-10-030(5)).
- Modules other than mass wasting may require different qualifications. DNR will determine the qualifications for participants in reanalysis of these modules and prescriptions for these modules.

8.4 Reanalysis Process

1. Flow chart for the reanalysis process

    - The sponsors of the reanalysis are encouraged to create a flow chart of the assessment process and assign tasks. DNR in consultation with forest landowner(s), and analysts will determine timelines and milestones such as field work and report writing. DNR will identify reviewers and a schedule for the completion of the reanalysis will be outlined.

2. Maps
    - DNR will provide background maps for the reanalysis of the target module(s). Many of these resources are available to download from DNR's spatial GIS layers at http://www.dnr.wa.gov.
    - Forest landowner(s) assessment maps will follow map standards provided by DNR. Reanalysis maps pertinent to each target module(s) and resource assessment(s) will maintain the current approved watershed analysis maps' naming conventions and include new dates.

3. Resource Inventory
    - The target module(s) will drive the assessment requirements for the reanalysis. Maps or tables from the current approved analyses will be updated by the sponsor(s). Attribute requirements should follow the current approved WSA in order to be comparable and show changes in the condition of the watershed. Use the same numbering, classifying, and protocols outlined in the current approved analyses. DNR recommends using the current approved WSA mapping standards for reanalysis maps. Modern techniques such as LiDAR or higher resolution aerial photography, if available, should be used.

4. Field reconnaissance
    - The current board manual process for the target module(s) in Parts 2 and 3 will guide the appropriate level of field and or office review. Procedures and field protocols should be comparable with the current approved WSA and current version of the WSA Board Manual.

5. Review of historic and present conditions
    - The reanalysis should include a thorough review of the background information in the current approved module data. This data should inform the analyst on how to supplement that information for the period of time since the last current approved watershed analysis was completed. Analysts should review the entire WSA Report to gain an understanding of the watershed overall.

6. Tables and Matrices to update
   - The reanalysis of a module will update existing data sheets, attribute and summary tables, and any other scientific monitoring or collection records used in the current approved module assessments.
   -
7. New Scientific Considerations
   - Generally use literature published since the approval date of the current
   - approved watershed analysis (DNR has the approval date of all of the approved watersheds). The reference sections for each current approved module are a starting point for literature searches.
   - Consider pertinent literature relevant to critical questions.
   - Consider relationships to other Resource Modules (see causal mechanism reports within each current approved WSA).

8.5 Synthesis

Evaluate and compare the approved watershed analysis causal mechanism reports to the reanalysis modules to determine the reanalysis prescription's relationship to other modules.

1. Hazards, Resources, and "Triggers"
   a. Triggers, in the context of watershed analysis, are the cause for resource degradation. Look at the relationships between the new hazard assessments, resource sensitivities and triggers (i.e. synthesis report).
   b. Within the target module, complete the necessary reanalysis products (e.g., for mass wasting reanalysis, complete an updated landslide inventory; for riparian conditions, complete an updated shade hazard report using current stream typing information, etc.)
   c. For each necessary resource sensitivity reanalysis, compare current conditions to previous conditions (e.g., has fish habitat changed or have public works changed?).

2. Results
   a. Answer key questions pertaining to resource conditions, forest practices, and synthesis per Part 4 *Synthesis* within the current watershed analysis board manual.
   b. Map Products used during assessment (i.e. current landslide inventory, Mass Wasting Map Units, Riparian Shade Units, RMAP accomplishments, monitoring station locations, updated Timber Age Classes, etc.) should be consistent with the current approved WSA products for comparison.

8.6 Evaluate and Compare

Evaluate and compare the current approved watershed analysis prescriptions. Ask what worked and what did not work within the WSA.

1. Does the assessment incorporate the current science and methods?
   - Would new methods substantially change results of the assessment?
   - Would the new results likely affect prescriptions?

2. Was the resource assessment sound?
   - Did the assessment correctly identify and map problems related to forest practices, agricultural practices, and other human influences?
   - Did the assessment correctly identify cause-and-effect linkages related to identified problems?
   - Did the module correctly interpret effects of the situations identified?
   - Was there a cause-and-effect relationship between extreme natural events and observed resource affects?

3. Causal Mechanisms
   - Should causal mechanism reports (CMRs) be created or significantly altered as a result of this new assessment?

4. Have there been FPAs within the current approved WSA mapped units?
   - Were prescriptions or standard rules implemented?
   - Were prescriptions or standard rules effective at protecting public resources?

5. Prescription Modifications Needed?
   - Do prescriptions incorporate current science?
   - Is there new information challenging the adequacy of prescriptions?
   - Are there new causal mechanisms that result in new prescriptions or can they be incorporated into existing prescriptions?
   - Do the resource sensitivity maps need to be updated?

8.7 Reanalysis Prescription Modifications

If prescription amendments or new prescriptions are needed, a prescription team will be convened. Prescriptions will be written and submitted to DNR for review. DNR will approve or disapprove the prescriptions to include in the final report.

1. Completion of Final Report
   a. Watershed analysis for the WAU is completed when the team produces the watershed analysis report, including associated causal mechanism reports, and prescriptions, if applicable.
   b. Prescriptions are attached to each target module(s) assessment.
   c. The final reanalysis report will require the sponsors to complete a SEPA nonproject environmental checklist and submit it to DNR.
   d. The proposed monitoring plan (if required) will also be attached.

2. Criteria for determining the completeness of reanalysis are:
   a. All critical questions were answered.
   b. Causal mechanism reports and statements on triggering mechanisms have been completed, if applicable.
   c. Final prescriptions were developed for each area of resource sensitivity, if applicable.
      - If final prescriptions were not developed, an explanatory statement discussing this decision will be added to the final report.
   d. Required maps have been finalized.
   e. Completion of the target module report.

3. SEPA and Approval Process
   a. When DNR determines that the reanalysis is complete, they will accept or disapprove the watershed analysis within thirty days of receipt.
   b. DNR makes a threshold determination of the nonproject SEPA checklist, submits it to the SEPA center, and the SEPA checklist will be distributed for stakeholder review.
   c. SEPA comments will be accepted and evaluated for 30 days. DNR will issue a final threshold determination.
   d. The final watershed analysis will be distributed to landowners and implemented per WAC 222-22-090.

Glossary

Note: Although an attempt has been made to conform to proper usage of technical terms, many of the words and phrases defined below are terms of art with meanings specific to the watershed analysis process. Sources of the definitions are not cited, except for terms defined in the Forest Practices Rules, Title 222 WAC: Chapter 222-16 WAC, General Definitions, and Chapter 222-22 WAC, Watershed Analysis.

channel-forming discharge. Stream flow of magnitude sufficient to mobilize significant amounts of bed sediments.

channel indicator. Characteristic of streambed, banks, and floodplains used to interpret the effects of changes in sediment, water, or wood.

channel sensitivity. Capacity to respond to physical disturbance.

CMER. Cooperative, Monitoring, Evaluation and Research Committee established by the Timber/Fish/Wildlife Agreement.

critical question. Fundamental question, based on scientific process considerations, addressed in one of the modules of this manual.

cumulative effects. Changes to the environment caused by the interaction of natural ecosystem processes with the effect(s) of two or more forest practices (WAC 222-16-010).

dam-break flood. Downstream surge of water caused by the sudden breaching of an impoundment in a stream channel; a form of debris torrent. The rapid failure of the dam(formed by a landslide , the deposit of a debris flow, or a debris jam) can cause a flood up to two orders of magnitude larger than normal storm-run off floods. These extreme hyperconcentrated (water>sediment) floods can occur in 1st- through 6th-order valleys, in both natural and managed landscapes.

debris flow. Highly mobile slurry of soil, rock, vegetation, and water that can travel many miles down steep (>5°) confined mountain channels; a form of debris torrent. While generally occurring in colluvium-filled 1st- and 2nd-order streams, debris flows can deposit sediment in streams of any order, typically at tributary junctions.

debris torrent. Debris flow or dam-break (or other hyperconcentrated) flood, undifferentiated. The effects of debris flows and dam-break floods can appear superficially similar (particularly on air-photos), although the two processes differ in initiation, composition, and travel characteristics. This term is used when it is not possible to distinguish between the two, either because of poor resolution on air-photos or inconclusive evidence in the field.

deep-seated failure. Landslide involving deep regolith, weathered rock, and/or bedrock, as well as surficial (pedogenic) soil. As used here, deep-seated landslides commonly include large (acres to hundreds of acres) slope features, associated with geologic materials and structures. ***In watershed analysis, they are divided into***:

large-persistent deep-seated failures, commonly slump-earthflows involving large areas of hillside; found in natural and managed landscapes, recognizable over long periods of time, and almost without exception predate land use;
small-sporadic deep-seated failures, commonly smaller slumps that can be triggered at irregular time intervals (by storms or earth movement), and can decay to the point where they are indiscernible.

Because movement of deep-seated failures is hydrologically controlled (at least in part), land use can influence movement insuitable situations.

deliverability. Likelihood that, as a result of one or more forest practices or by cumulative effects, a material amount of wood, water, sediment, or energy will be delivered to fish habitat, streams, or capital improvements; three conditions must all be satisfied: 1) an impact is likely to occur; 2) the magnitude or size of the impact is sufficient to have a significant effect on the resource characteristic(s); and 3) the impact is likely to be delivered to a stream segment with a vulnerable resource.

delivered hazard, or potential impact. Adverse change in the amount or location of wood, water, sediment, or energy being delivered to fish, water quality, or capital improvements.

dry ravel. Down slope movement of dry, non cohesive soil or rock particles under the influence of gravity; a form of soil creep.

earthflow. Deep-seated landslide of broken soil and rock, dominantly by slow flow; produces linear areas of hummocky, disjointed terrain. Earth flow activity is favored in deep, cohesive soil, clay-rich bedrock, or slumped material, and is largely controlled by seasonal (or longer) fluctuations of pore-water pressure.

erosion. The removal of rock and soil from the land surface, by a variety of processes: by gravitational stress, through mass wasting; or by the movement of a medium (e.g. water, in solution or by overland or channel flow).

flood-frequency curve. Graph showing the relationship between recurrence interval(or exceedance probability)and peak discharge (volume flux of water per unit time).

geomorphic processes. Landscape-modifying processes such as erosion, mass wasting, and stream flow.

GIS. A computerized geographic information system.

gully erosion, gullying. Advanced stage of surface erosion in which rills, carved by channelization of overland flow, coalesce into larger channels in soil or soft rock.

habitat value. Characteristic of the environment in which an organism (e.g., fish) lives.

hydrologic maturity. Condition of a forest stand in which hydrologic processes operate as they do in a mature or old-growth forest. In particular, snow accumulation is typically lower in thick, dense forest (at middle and lower elevations) than in openings, due to interstorm melt of snow caught in the canopy; and snow melt is slower, due to decreased wind-aided flux of sensible and latent heat.

indicator area. Particular area or stream reach, adopted as representative of a response segment.

input variable. Amount of sediment (coarse and fine), water, wood, and/or energy delivered to a stream segment.

landslide. Any mass-movement process characterized by downslope transport of soil and rock, under gravitational stress, by sliding over a discrete failure surface; or the resultant landform. In common usage, can also include other forms of mass wasting not involving sliding (rockfall, etc.)

LWD recruitment. Large woody debris delivered by the fall of streamside trees, or delivery from upstream sources by stream transport.

mass wasting. General term for the dislodgement and downslope transport of soil and rock under the direct application of gravitational stress (i.e., without major action of water, wind, or ice); mass movement. In watershed analysis, this class of erosion processes is divided into three categories: shallow-rapid landslides, deep-seated failures, and debris torrents (see definitions).

mass-wasting map unit (MWMU). Landscape element for application of hazard ratings, defined in the mass-wasting assessment module. MWMUs are delineated on the basis of physical (geologic, climatic, etc.) characteristics, susceptibility to mass-erosion processes, sensitivity to forest practices, and potential for delivery of sediment to public resources.

peak flow event. Maximum instantaneous stream discharge during runoff, commonly caused by an individual rainstorm, rain-on-snow, or spring snow-melt.

rain-on-snow zone. Area (generally defined as an elevation zone) where it is common for snowpacks to be partially or completely melted during rainstorms several times during the winter.

resource characteristic. specific, measurable characteristic of fish, water, and capital improvements of the state or its political subdivisions:

For fish and water -
physical fish habitat, including temperature and turbidity;
turbidity in hatchery water supplies;
turbidity and volume for areas of water supply;
For [public] capital improvements:
Physical or structural integrity.
(From WAC 222-16-010.)

resource vulnerability. Likelihood of material adverse effects on resource characteristics. Criteria may include (but are not limited to) current resource conditions.

response segment. Location (segment) of the stream channel that is susceptible to changes in inputs of wood, water, energy, and/or sediment.

rill erosion. Development of many closely-spaced channels, caused by the removal of soil by concentrated overland flow; a form of surface erosion, intermediate between sheet erosion and gullying.

riparian function. Activity relating to the LOD-recruitment and stream-shading functions provided by riparian vegetation.

riparian zone. Area surroundinga stream, in which ecosystem processes are within the influence of stream processes.

sediment budget. Accounting of the sources, movement, storage, and disposition of sediment produced by a variety of erosion processes, from its origin to its exit from a basin; includes sediment types, amounts, and routing to specific locations of analysis.

shallow-rapid landslide. Landslide produced by failure of the soil mantle (typically to a depth of one or two meters, sometimes including glacial till and some weathered bedrock), on a steep slope; includes debris slides, soil slips, and failures of road cut-slopes and sidecast. The debris moves quickly (commonly breaking up and developing into a debris flow), leaving an elongate, spoon-shaped scar.

sheet erosion. Removal (more or less evenly) of surface material from sloping land, by the action of broad sheets of overland flow; a form of surface erosion.

slump. Deep, rotation all and slide, generally producing coherent movement (back-rotation) of blocks over a concave failure surface. Typically, slumps are triggered by the build up of pore-water pressure in mechanically weak materials (deep soil or clay-rich rock).

slump-earthflow. Landslide exhibiting characteristics of both slumps and earth-flows: typically the upper part moves by slump (rotation of blocks), while the lower portion moves by flow (hummocky terrain). For purposes of hazard assessment, discrimination between slumps and earthflows is preferred, if possible and appropriate.

snow-water equivalent (SWE). Amount of liquid water (expressed as depth) derived by melting a snowpack.

surface erosion. Movement of soil particles down or across a slope, as a result of exposure to gravity and a moving medium such as rain or wind. The transport of sediment depends on the steepness of the slope, the texture and cohesion of the soil particles, the activity of rainsplash, sheetwash, gullying, and dry ravel processes, and the presence of buffers.

transport capacity. Ability of the flow to carry the sediment delivered to the stream; indicated by the stream power.

watershed administrative unit (WAU). Basic geographic unit for watershed analysis. An area shown on the map specified in WAC 222-22-020(1) (WAC 222-16-010).

watershed analysis. For a given WAU, the assessment completed under WAC 222-22-050 or 222-22-060, together with the prescription selected under WAC 222-22-070, including assessments completed under WAC 222-22-050 where there are no areas of resource sensitivity(WAC 222-16-010).