2.0 Planning and Inventory

2.1 Introduction

Every watershed contains its own unique set of physical attributes in terms of geomorphology, hydrology, topography and climate. Many also feature roads, landslides, gullies and stream channels that require varying degrees of restoration as a consequence of land uses (Figures 2.01 and 2.02). Successful watershed restoration depends on three fundamental procedures: identifying watershed restoration planning objectives; building an inventory of all the areas requiring treatment to meet those objectives; and developing a comprehensive plan to treat those areas.

Fig. 2.01 *Portion of the Gordon River watershed, Vancouver Island.*

Fig. 2.02 *Portion of the Bowron River watershed, north-central B.C.*

Establishing objectives is key to the restoration planning process. Objectives guide the restoration plan and are determined by outlining the most beneficial watershed restoration results that can be achieved with the funding available to accomplish the work.

Once the objectives are identified, an inventory can be created consisting of relevant data regarding the watershed features to be treated. From this inventory, an organized plan for restoration can be developed. The plan will include a sequence for undertaking treatments based on a comparison of the benefits to the watershed, and making the most beneficial activities the first priority. An effective plan will also be flexible. In some cases, lower priority sites may be treated because of logistical considerations. It may be prudent, for example, to deactivate a lower priority secondary spur trail along with a higher priority road if the road deactivation will eliminate access to that spur trail.

Benefits to a watershed are typically determined by an assessment of risk. Risk is the likelihood of an event (hazard) occurring combined with the effect (consequence) that event will have on the resources in the watershed, or, Risk = Hazard x Consequence (see the Forest Road Engineering Guidebook for a full definition of risk). Treatment feasibility may be evaluated with risk factors to determine treatment priority. Therefore, if treatment is neither practical nor cost effective, it may not be prescribed and/or implemented.

In all restoration projects, some degree of experienced and/or professional judgment is required. Figure 2.03 presents a flowchart that illustrates a typical planning process. This section will follow the structure of the flowchart

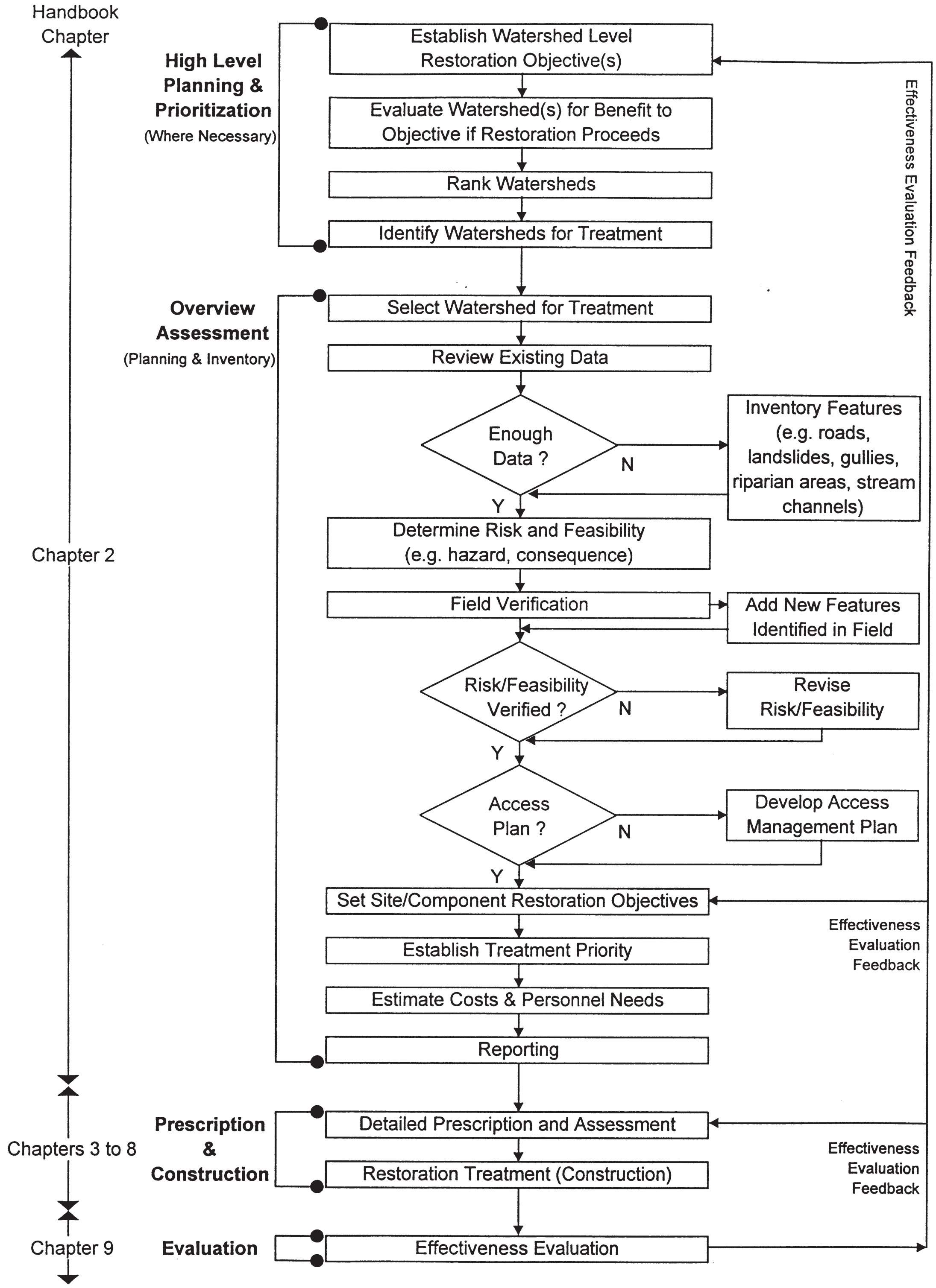

Fig. 2.03 Planning and Inventory Flowchart

2.2 Setting Watershed Priorities

Setting watershed priorities begins once the restoration program objectives are set. Common objectives include, but are not limited to:

- protecting, restoring or enhancing fish habitat;
- protecting target fish species;
- maintaining or improving water quality;
- minimizing the risk to life and property (e.g. logging camps, private property);
- minimizing the risk of disruption along transportation and utility corridors;
- re-establishing productive forest land;
- limiting access for environmental protection;
- maintaining or improving road stability following construction;
- reducing sediment delivery in the watershed;
- decreasing landslide hazard;
- evaluating previously deactivated roads against current deactivation standards and on-site residual risk to decide whether to commit more resources to previously deactivated areas.

Restoration objectives, however, can be influenced by other factors. These may include:

- objectives established under high level plans (e.g., Land and Resource Management Plan (LRMP)) or similar;
- requirements of Forest Development Plans (FDP) or similar operational plans;
- results of the overview assessment (e.g., Restoration Plans (RP) or similar);
- regulations (e.g., regulations concerning minimizing sediment delivery to streams as per the Forest Practices Code (FPC)).

Establishing watershed objectives will also assist in setting watershed priorities. The process of setting priorities will also focus available funds and effort on the critical features within a watershed project. As an example, for projects that focus on water quality and fish habitat, watershed objectives will need to be set with an explicit understanding of the connectivity between sediment source areas and critical stream reaches. If this connectivity is poorly understood, instream works may be at risk from upslope sediment delivery.

The degree and extent to which prioritization occurs will depend on the established watershed level objectives. For example, priorities set in a watershed to minimize landslide hazard will be very different from those set to enhance fish habitat. Some degree of experienced judgment may be needed.

2.3 Overview Assessments

The purpose of an overview assessment is to gauge restoration potential within a watershed. An overview assessment will also identify individual tasks, such as the revegetation of landslides or the location of sediment source areas, that need to be completed to reach the objectives set out for the restoration project.

For the purposes of Section 2, the term “overview assessment” will be considered synonymous with:

- any overviews required for operational watersheds;
- Restoration Plans required for watershed restoration;
- other comparable assessments.

An overview assessment should focus closely on identifying what development-related hazards exist, what risks they present to resources, and whether these risks can reasonably be mitigated by restoration work.

An overview assessment may include:

- identification of the impacts of past development in the context of the geomorphic processes of the watershed (e.g. areas where road construction and land-use activities have occurred);
- identification of “resources of interest” (See Section 2.4 below);
- identification of the natural and man-made sediment sources, and their potential risk to the resources of interest;
- assessment of hillslope-related hazards (primarily terrain stability), and an evaluation of the risk to environmental, social, or economic values, or to human safety;
- identification of areas and priorities for detailed assessment and possible rehabilitation work;
- identification of hazards that can reasonably be mitigated by restoration work and the recommendation of hazard sites for site specific assessment and prescription;
- identification of the need for professional input into detailed assessments and rehabilitation prescriptions
- review of existing access plans or access management strategies relative to identified hazards;
- setting priorities for completing the detailed assessments and restoration work in a logical, orderly and cost-effective manner based on environmental, administrative, and operational risks and the preparation of preliminary time schedules and cost estimates for future assessment work.

Developing an effective overview assessment will depend on the type and extent of existing information, the investigator’s past experience, and the specific characteristics of the watershed. Where necessary, appropriate agency staff (e.g., the local District Manager) may approve comparable methods that achieve the goals of the overview assessment in a cost-effective manner.

2.4 Description of an Overview Assessment

An overview assessment is usually conducted at scales of 1:20,000 (Coastal BC) to 1:50,000 (Interior BC) but may vary depending on the size and specific concerns of the project watershed. The level of effort for each task will also vary depending on the specific concerns within the watershed, and the extent of existing information.

An overview assessment typically involves the following tasks:

- office-based review of existing information and local knowledge;
- inventory of watershed features to fill identified gaps in existing information;
- review of access plan;
- risk assessment of inventoried features and resources relative to identified hazards;
- field reconnaissance of affected areas and sediment sources to verify inventory;
- compilation of information gathered from previous phases, and development of recommendations for site specific assessments.

Identified resources of interest for the purpose of the overview assessment may include:

- fish habitat;
- domestic water supplies;
- human health and safety;
- property and dwellings;
- highways, railways and other transportation corridors;
- utility corridors and associated infrastructure;
- recreational areas (e.g. campsites, caves, trails).

An overview may identify types of restoration activities that should be undertaken within the project area. In some cases, there may be legal obligations to restore particular features. Any restoration plans or activities (e.g. road deactivation) developed or recommended in the overview should be consistent with the governing legal framework (e.g. FPC).

2.5 Background Information Review

The background information review is typically an office-based effort to confirm the resources of interest, identify and inventory past impacts of forest development, and make a preliminary identification of sediment-based hazards and risks within the watershed. Regulatory agencies, forest licensees, and other groups or persons with local knowledge of the watershed can provide valuable information. **Maximum use of existing information will avoid duplication of effort.**

Some typical information sources include:

- 1:20,000 scale Terrain and Resource Inventory Mapping (TRIM) topographic maps;
- 1:20,000 forest cover maps;
- Terrain Mapping, Terrain Stability Mapping (TSM) and/or soil erosion mapping;
- air photos, recent and historic;
- resource data, such as fish stream classifications, water licenses, locations of municipal or community water intakes, and private land locations (including First Nations reserves);
- previous studies completed for the watershed, such as Watershed Assessment Procedure (WAP) reports, terrain attribute studies, road inventory or condition reports, sediment source surveys, landslide investigation reports, and fish habitat assessments;
- access management maps;
- known informal recreational activities (e.g. trails, caves, campsites);

- forest development plans;
- surficial and bedrock geology maps;
- cultural feature inventories;
- current mineral tenures or mining claims;
- biogeoclimatic maps;
- regional climatic data including precipitation.

Not all of this information is readily available or relevant to all watersheds. It may be necessary to:

- update the project base maps (TRIM or forest cover) for recent roads or forest development structures;
- determine the nature and extent of impacts on these resources of interest from past forest development and natural hazards;
- identify probable sources of the impacts, including:
  - unvegetated landslides (natural and from logged gullies or slopes, and from roads);
  - natural unvegetated gullies;
  - eroding escarpments, channel banks, stream reaches and alluvial fans;
  - convex terrain with "flat over steep" profiles;
  - road elements with high chronic sediment delivery to streams;
  - road sections on steep, unstable or potentially unstable terrain;
  - large landings and large debris disposal sites;
  - old rock quarry and borrow pit areas (e.g. in fluvial terraces close to streams);
- estimate the likelihood of slope failure, continued sediment delivery, potential stream diversion (in the case of unstable stream reaches or alluvial fans) and the likelihood of impacts to resources of interest (e.g. via connectivity to streams and gullies, etc).

When identifying risk sites, consider including those sites in adjacent terrain where alteration of the natural terrain by past development could trigger potential hazards associated with features such as redirected or 'pirated' drainage, for example. Other features to be considered when identifying risk sites may include skid trails, temporary roads, yarding tracks and backspar trails where relevant.

If an inventory of watershed features is warranted during the preliminary assessment, ensure sufficient data is collected to determine an assessment of risk. An overview assessment inventory would include hillslope features (e.g., roads, landslides and gullies) and stream features (e.g., riparian and channel areas). Common attributes to inventory are discussed in Section 2.6.

2.6 Inventory Assessment

An inventory assessment may be necessary as part of an overview assessment, particularly if no inventory data exists. The level of data collected during the inventory is generally dictated by the overview objectives and by the information requirements of the restoration planning process.

An inventory may contain such components as roads (including road networks, landings and skid trails), landslides, gullies, riparian areas and stream channels. The scope of the inventory will vary depending on the amount of information available for the watershed. The quality of the inventory will depend on available resources and the attention given to detail. For example, inventories can be conducted by a review of historical air photos. This will provide some detail at minimal cost. Inventory quality can be improved by the use of reconnaissance overflights especially by low level, slow speed helicopter. The most detail, but at highest cost, will be obtained by foot traverses. Some degree of experienced judgment may be needed to determine what the inventory will entail.

In general, inventoried features should be numbered using a standard convention. Use of existing names is preferred. Where no such convention exists, a suitable naming convention should be developed. An example naming convention, with roads named in sequence of occurrence from the "0" kilometer marker, is provided below in Figure 2.04.

Mainline Road	Branch Road	Spur Roads	Smaller Secondary Spurs		
Mainline 100	Branch 105	Spur 105A	105A1		
			110A2		
		Spur 105B			
		Spur 105C	105C1	105C1A	
	Branch 110	Spur 110A	110A1	110A1A	
				110A1B	
	Branch 120	Spur 120A			
		Spur 120B			
Mainline 200	Branch 210	Spur 210A	220A1	220A1A	220A1A1
					220A1A2
	Branch 211	Spur 211A			
		Spur 211B			
		Spur 211C			
	Branch 220				
Etc.					

Fig. 2.04 *Example Naming Convention for Roads*

Consider mapping each inventoried feature on a suitable topographic base. Inventoried data may also be incorporated into a Geographic Information System (GIS) platform, if desired. If a GIS platform is being used, time and effort efficiencies may be gained if inventoried data is plotted directly on maps generated by the GIS platform that will be used to store the data. It should be compatible with industry and/or agency platforms.

If the investigator is unfamiliar with the watershed, or if available data is outdated, a brief helicopter reconnaissance of the watershed may be beneficial prior to starting the inventory. Such a reconnaissance may help identify key areas to be addressed and help focus planning activities.

The level of effort established for the inventory will determine the degree to which inventory attributes may be obtained in detail. Examples of inventory attributes are presented in Appendix I. Sufficient information must be provided so appropriate strategies for treatment can be developed. The exact nature of the strategies will depend on the objectives established for the watershed. A qualified professional may be needed to inventory features and determine appropriate treatment strategies so watershed objectives are met.

Watersheds covered by existing plans (e.g. FDP, LRMP) may have established management practices for identified features. Inventory requirements and treatment strategies may depend on any restoration objectives previously established under the existing plan.

2.6.1 Roads

For an overview assessment, each road may be subdivided into sections of similar landslide or surface soil erosion hazard based on a series of recognizable attributes. Possible attributes include:

- hillslope gradient;
- topography;
- terrain;
- geomorphic process;
- risk to resources of interest;
- existing stability conditions;
- assumed construction techniques and age of road.

Possible treatment strategies to consider when conducting a road inventory and estimating restoration priority might include:

- pullback of unstable road fill;
- re-establishment of natural drainage patterns;
- removal of existing culverts;
- construction of water management structures (e.g. waterbars or cross-ditches);
- seeding and planting of exposed ground;
- erosion control and sediment prevention techniques.

Factors to consider when undertaking an overview inventory of roads include:

- high risk roads may be overgrown and require ground assessment to determine existing conditions;
- the behaviour of adjacent, similarly constructed roads on similar terrain may be a good indicator of hazard;
- the risk rating is based on a qualitative assessment of the interaction of hazard and potential downslope consequences;
- if previously deactivated roads are present in the watershed, residual risk on these roads should be considered;
- if water management is the primary issue, evaluation of the areas downslope of water discharge locations may be important with respect to stability as well as erosion;
- a high risk road may be a road that has a high potential to generate or transport sediment to streams even if it has few stability problems.

Some of the inventoried road attributes may be checked during field verification or through review of the background information. See Section 3 for a discussion of treatment methods for road deactivation.

2.6.2 Landslides

The density of regenerating forest canopies may obscure landslide features if office-based inventories are conducted without some field verification. Landslides may be assessed using the Landslide Rehabilitation Assessment Procedure (LRAP) or other suitable method. Planimetric representation of landslide features may be done by:

- hand transfer (least cost, lowest precision);
- Global Positioning System (GPS) references;
- monorestitution;
- stereo plotting (highest cost, highest precision).

Treatment strategies to consider when conducting the landslide inventory and estimating restoration priority could include:

- seeding (dryseeding or hydroseeding on the ground or aerially);
- planting (shrubs, hardwood or conifer);
- fertilizing;
- stabilization of headwall areas;
- stabilization of sediment stored in deposition zone.

Because some landslide scars revegetate fairly rapidly or are obscured by the surrounding canopy, not every landslide, especially smaller events in standing timber, may be identified solely from office-based work. Also, it may not be possible to tell if a landslide scar represents more than one event (i.e., there has been more than one landslide at that location). Some degree of field verification may be needed to identify recent landslide events or determine if landslide scars represent more than one event, especially if the feature has a high risk. Revegetation on landslide scars may indicate that stability of the local surface material has increased since the landslide occurred.

Any landslide runout zones that are determined from air photos and/or overview flights and plotted on the project map base will represent the possible downslope distance traveled by landslide debris. In some cases, landslides (primarily debris flows) may travel short distances under the forest canopy without actually pushing the trees over. In these cases the true extent of the runout zone may be difficult to estimate on the air photos. A more accurate determination of runout length will require ground assessment but will have limited relevance for revegetation assessments. Field verification of runout zones may be costly and some degree of experienced judgment may be necessary to determine if the extent of runout zones needs to be confirmed.

Some of the inventoried landslide attributes may be checked during the field verification of the inventory or through review of the background information. See Section 4 for a discussion of treatment methods for landslide rehabilitation.

2.6.3 Gullies

The density of regenerating forest canopies may also obscure gully features. Since not every gully can be inventoried from air photos, it may be best to initially concentrate on those gullies that represent a significant risk to the watershed. Gullies may be subdivided into relatively homogeneous "reaches" using the guidelines of the Gully Assessment Procedure (GAP) or other suitable methods.

Not all gullies will need to be inventoried and the selection of which ones to inventory will vary greatly from watershed to watershed and from the interior to the coast of British Columbia. Experienced judgment may be needed to establish what features to include in a gully inventory. Factors to consider when selecting inventory features include:

- importance of gullies within the watershed as transport corridors for sediment;
- existing development (e.g. harvesting) adjacent to or across gully reaches;
- noticeable gully impacts to downslope resources;
- age and type of disturbance (e.g. date harvested and methods used) in and around the gully;
- observable density of woody debris in gully, if any;
- stability of woody debris in gully, if any;
- stability of gully sidewalls and headwalls (may be inventoried under landslide inventory if landslide has already occurred);
- coupling between gullies and avalanche chutes (important in the Interior);
- distance traveled by avalanche snow and debris upon reaching gullies, if any (important in the Interior);
- number of road crossings, if any;
- presence of deep road fills at crossings, if any;
- applicable definition for a gully.

Treatment strategies to consider when conducting the gully inventory and establishing treatment priority could include:

- cleaning of woody debris (a less common practice now);
- stabilization or removal of sediment wedges;
- stabilization of gully sidewalls and headwalls.

Some of the inventoried gully attributes may be checked during field verification of the inventory. See Section 5 for a discussion of treatment methods for gully rehabilitation.

2.6.4 Riparian Inventory

For watersheds where improvements to fish habitat and water quality are the defined objectives, riparian treatments that help to stabilize sediments delivered to the channel margins, stabilize channel margins and/or minimize the risk of sediment delivery to the streams from upslope areas are beneficial. Additionally, riparian treatments may be appropriate where there is a high potential for such work to improve overall channel stability.

The inventory should identify riparian areas in the watershed and develop riparian management strategies where no strategies have been developed. Treatment strategies to consider when conducting the riparian inventory and estimating restoration priority might include:

- planting of coniferous and/or broadleaf species to re-establish forest cover;
- silviculture treatments to trees or other competing species to allow space for conifers to emerge;

When determining the appropriate treatment strategies the following information should be considered:

- The historical species (pre-disturbance) and its abundance
- Proposed restoration species
- Provision of shade for stream channels
- Provision of future LWD for stream channels
- Treatment cost / benefit compared to hillslope / road work

2.6.5 Channel Inventory

Where channels appear to have been affected by upslope activities, or where improvements to water quality and fish habitat are the defined objectives, an inventory of stream channel characteristics prior to embarking on restoration prescriptions and treatments may be beneficial. Channel inventory provides a baseline of data that can be used to monitor the effectiveness of the upslope works.

The impact of landslides and sediment delivery from roads on stream channels depends on the connectivity between the stream channel and the sediment sources. An inventory of the channel characteristics may identify whether the channels have been disturbed or not and provide a basis to determine the extent of future potential disturbances. The inventory may show that stream channels are amenable to treatment because the supply of material from the hillslopes is limited.

The inventory should identify affected stream channels and develop in-stream management strategies if no strategies exist. Treatment strategies to consider when conducting the stream channel inventory and estimating restoration priority could include:

- willow staking of in-stream sediment;
- placement of bank stabilization along channel margins;
- placement of woody debris or other habitat enhancing structures;
- establishment of side or back channel habitat.

The density of established forest canopies and their proximity to stream channels may obscure channel features if office-based inventories are conducted without some field verification. Since not every stream can be inventoried from air photos, it is best to concentrate on those streams with potential fisheries habitat that are classified/stratified using the S1-S4, Forest Practices Code designations. Additionally, S5 and S6 streams with direct connectivity to S1-S4 streams may also be considered. These streams can be subdivided into relatively homogeneous “reaches” using the guidelines of the Channel Assessment Procedure (CAP) or other suitable procedure.

High embankment fills immediately adjacent to stream crossings can be a cause for specific concern. Where these fills occur on shallowly sloped terrain they may not be identified in the hillslope inventory. Identification of these areas of potential sediment delivery to creeks can be critical to the successful restoration of water quality and fish habitat.

Fish habitat restoration and channel stabilization success will depend largely on reducing the volume and frequency of sediment supplied to the stream channels. Where sediment supply is already limited, channel restoration may be considered. Suggested strategies for channel and riparian rehabilitation may be developed during the overview but these strategies may change as watershed restoration progresses.

2.7 Risk Assessment

The risk assessment develops risk ratings for the potential impacts on resources of interest identified in the preliminary assessment. Example risk assessment procedure outlined in the Forest Road Engineering Guidebook or any other comparable method that clearly describes the hazard (or likelihood of occurrence) of events and the risk to resources of interest may be used. For the purpose of the overview assessment, estimates of hazard and risk are usually qualitative.

For each source of impacts identified in the preliminary assessment, the following may be undertaken:

- estimate the hazard (probability or likelihood) of failure, continued sediment production, or in the case of unstable stream reaches or alluvial fans, potential stream diversion;
- estimate the likelihood of impact to the resources of interest (directly or via connectivity to streams and gullies, etc.);
- estimate the potential consequence on the resources of interest;
- if the hazard is moderate or high, indicate whether the hazard is short term or long term. A short-term hazard is one that is considered imminent. Long term hazard is typically associated with latent instability that may occur;
- for each source, identify whether the hazard or consequence could reasonably be mitigated by restoration work;
- determine the residual risk of previously treated sites and evaluate the cost of mitigating this risk versus the benefit to the project area;
- identify whether the site may be easily accessed or if reactivation/rebuilding of a road is necessary to reach a site and develop an estimate of costs;
- identify problem sites that are not eligible for funding under current regulations;
- identify the state of vegetation cover on risk rated sites. Vegetation may affect access on the site and may have implications for site stability and erosion.

The determination of hazard may be made from a combination of the following factors:

- air photo interpretation;
- terrain contours (e.g. slope ranges);
- environmentally sensitive area mapping (e.g. Es1 and Es2 polygons);
- reconnaissance Terrain Stability Mapping (TSM, e.g. P and U polygons);
- detailed TSM (e.g. Class IV and V polygons);

- experienced judgment (by a qualified registered professional where appropriate).

The determination of consequence may be derived from the available consequence (impacts) information collected during the preliminary assessment. Where appropriate, experienced judgment may also be used to determine consequences in consultation with stakeholders.

Treatment feasibility may also be considered part of the risk assessment depending on the type and scope of the overview required. Any restoration treatment can reach a desired objective given sufficient funding. However, limited funding is typical and treatment options may be constrained to the point that feasible options will not produce a benefit. Considerations when evaluating treatment feasibility may include:

- site accessibility;
- technical aspects of proposed treatments (e.g. will reasonable type of treatment provide benefit);
- cost/benefit with limited available budget (e.g. will allotted budget provide benefit).

Examples of hazard and consequence criteria and risk determination matrices for use in office-based overview assesements and for identifying project priorities are presented in Appendix II. The criteria and matrices presented are illustrative examples only and should not be considered as a procedural standard. Criteria will likely be specific for each watershed and should be developed using professional and/or technical experience and judgment and in consultation with stakeholders.

2.8 Field Verification

The level of effort involved in field verification must be consistent with the established watershed objectives. For an overview assessment, the objective is to assign priority to risk sites and identify what sites should be investigated in detail for site-specific remedial work. It is not necessary to field check every potential risk site at this stage. If certain roads are clearly unstable from airphotos and known information, it is not necessary to visit each one to determine that these roads should be targeted for deactivation assessments.

Air photo interpretation, review of topographic maps and helicopter overviews may be more cost-effective techniques to assess the potential for impacts to a particular site than on-the-ground field investigation. It is expected that a field reconnaissance will be undertaken to confirm or adjust the preliminary information on impacts and hazard sites in the inventory. Project personnel must exercise judgment as to the best methodology and appropriate level of effort for this task.

The level of effort invested in the field reconnaissance will depend on the extent of existing information, and on the investigator's personal knowledge of the watershed (whether from previous field work or other means). It will also depend on existing access into the watershed. The watershed may have limited road access, for example, because major drainage structures have been removed, or the area is ground accessible only by barge or winter road, etc.

Although a helicopter overview flight is generally recommended, if good road access is available field reconnaissance can be carried out mainly by vehicle. If road access is limited, the field reconnaissance may be limited to a helicopter overview with stops at critical sites where it is possible to land, and traversing of questionable areas that are overgrown.

The coverage of the field reconnaissance should be sufficient for the investigator to confirm his/her understanding of terrain conditions, stability and erosion events, natural sediment sources and stream characteristics, and the nature of impacts that have occurred to the resources of interest. The actual time spent in the field will vary depending on the size and characteristics of the watershed, the specific restoration objectives of the project and access conditions.

No fieldwork should be conducted with snow on the ground, or under weather conditions that hamper visibility or represent a significant safety issue. A brief discussion of safety issues is presented in Section 8.4 of this handbook, but practitioners should be familiar with the relevant safety regulations.

If at any time, a high or very high risk to dwellings, rural or industrial development, highway, public utility or water supply is identified, the Ministry responsible for the assessment should be immediately notified in writing.

Some means of recording information in the field include:

- field forms or other tabular means of data capture;
- video record of any overview flights;
- photographic record of any foot traverses;
- GPS locations of specific features if GPS coordinates can be obtained;
- time and/or date stamps on video and photo records if available.

Field recording techniques may vary widely between projects. Field forms, if used, should be developed for each specific watershed or project. General factors for consideration may include:

- terrain attributes including, bedrock, slope morphology, soil types;
- slope geometry;
- road prism geometry (e.g. fillslope length, cutslope height);
- presence or absence of residual fill on roads or past restoration efforts;
- restoration status of road segments (e.g. level of deactivation);
- recommended restoration prescription;
- gully geometries, including gradient, gully wall angle and gully depth;
- presence of unstable fills at gully crossings;
- presence or absence of armouring at outlets of water management structures;
- number of fish stream crossings;
- condition of bridge crossings;
- condition of roads;
- proximity to lakes or streams;
- number of large culverted embankments;
- current road use;
- sediment sources;
- condition of drainage networks.

Fig. 2.04 Example field card for field verification of road conditions

Deactivation review field notes: Road:_____________________Page________of______.

Attribute	1	2	3	4	5
Station #'s					
Deactivation proposed					
Actual Deactivation					
Deactivation date					
Terrain					
Bedrock					
Slope morphology					
Soils					
Seepage present?					
Slope Range (%)					
Gully gradient					
Gully wall angle					
Gully depth (m)					
Stability conditions					
Surface erosion					
Residual fill present?					
Residual fill instability?					
Pullback complete in gullies?					
Gully gradients re-established?					
Stream gradients re-established?					
Cross-ditch water directed to steep slopes below?					
Residual fill at cross-ditch outlets could fail?					
Excessively armored cross-ditch					
Seepage sites/cross-ditch adequately armored?					
Cross-ditch/slopes>50% excav to natural gradient?					
Outsloping?					
Unnecessary deactivation?					
Will residual fill erode into streams?					
Revegetation	**1**	**2**	**3**	**4**	**5**
Seeded?					
Date?					
Germination?					
% cover					
Conifers?					
Shrubs?					

Station #s	Photo #	Comments:

Fig. 2.05 (below) *Example field card for field verification of road conditions observed from helicopter.*

Road/Slide/ Gully	GPS Location	Terrain	RP#	Slope gradient (%)	Cut height (m)	Stability/ erosion indicators	Rehab status	Rehab prescript	On-site staff P/T/PT
Comments/photos:									
Comments/photos:									
Comments/photos:									
Comments/photos:									
Comments/photos:									
Comments/photos:									

Notes: Stability/erosion indicators: TC=tension cracks, VD=vertical displacement, RTF=road fill failure, XE=x-ditch erosion, SRS=severe road surface erosion , Staff; P=professional, T=technical.

Area:______________________________**Watershed:**______________________________

Date:______________________________Recorded by:______________________________

Factors to consider when planning and undertaking ground investigations include:

- proportion of features to be field verified;
- proportion of sites to be ground checked;
- proportion of sites to be checked from the air;
- extent of High and Very High risk sites;
- requirements, where appropriate, for assessment by qualified professionals;
- purposefully conservative approach of office-based inventories.

The field verification also allows for limited updating of landslide activity, which has occurred subsequent to the date of the air photos used for the overview. Any additional landslides that have occurred since the most recent set of air photos reviewed should be considered for inclusion in the inventory.

Factors to look for during field verification include:

- tension cracks and slumps in road fills;
- eroding road surfaces and deeply scoured ditchlines connected to streams;
- high, culverted embankments with signs of instability (e.g. ravelling);
- fresh ravelling or terrain disturbance within landslides;
- seepage indicators;
- disturbed soils in gullies;
- eroding channel margins;
- connectivity of sediment sources to stream channels.

In some watersheds where previous road deactivation has occurred, field verification may be necessary to identify whether any residual risk remains along the previously deactivated road and whether this residual risk is acceptable.

2.9 Access Management Planning

Access management planning identifies current and future access needs within the watershed so that roads which may be needed for access are not deactivated without due consideration. Access requirements vary widely from watershed to watershed. Watersheds under current Forest Development Plans (FDPs) will commonly have an access plan already in place. Also, access plans may be in place if higher level planning (e.g. LRMP) exists for the watershed. If additional access management planning is required, the existing plans should be used as a base for further work as they will have commonly undergone some form of public review. Experienced judgment may be needed to establish how much and what form of access management is still required in the watershed under study. Where an access management strategy is not available, an appropriate strategy should be developed for review and consultation with the suitable agency representative (e.g. District Manager).

The goal of an appropriate access management strategy is to integrate the watershed restoration plan with the needs of the various users of the watersheds. An access strategy should be developed for each specific road within the watershed. It is recommended that some degree of distinction be made during access planning between people who have a tenured right to access within the watershed (e.g. forestry companies, utilities, mining claims holders, grazing leaseholders) and those who desire public access (e.g. hikers, bikers, spelunkers, hunters, fishers).

Where no access plans are in place, public access issues need to be included in the overview assessment. The relevant agencies may require that the plan be put through a public consultation process. The typical product of an access management strategy conducted for a restoration plan is an Access Management Map (AMM). The exact requirements for the access management strategies and the resulting AMM will need to be assessed on a district by district basis through consultation with the relevant stakeholders.

Some of the stakeholders (users) who may need to be considered during access management planning may include:

- the public (e.g. informal or organized groups such as recreation groups);
- licensees;
- companies (e.g. ecotourism firms);
- First Nations;
- trappers;
- agency staff;
- mineral exploration claims holders.

It is possible that access conflicts may be encountered for which resolution lies beyond the scope of the watershed restoration project. If such conflicts are encountered in areas of high risk, it is recommended that these be identified as sites for discussion with the relevant stakeholders. Such discussions may commonly lie beyond the scope of the overview project.

Various access levels may be considered when planning or managing access within a watershed. Typical access levels include but are not limited to:

- 2 wheel-drive vehicles;
- 4 wheel-drive vehicles;
- All-terrain vehicles;
- Bicycles;
- Foot access.

Appendix 3 includes typical drawings of road deactivation techniques that may be used to address these access levels.

Example issues for access consideration during an overview may include:

- seasonal and informal recreational access (e.g. fishing, hunting, hiking);
- commercial recreation access (e.g. ecotourism, rafting, snowmobile and mountain bike tours, guides and outfitters);
- operational access (e.g. hauling or salvage);
- caving access (in areas with limestone or other cave-forming environments);
- mining claims access;
- traditional lands access;
- traplines access;

- access to communications facilities (e.g. radio beacons, cellular telephone towers, microwave relay sites);
- access to transportation or utilities infrastructure (e.g. railways, pipelines);
- access to remote sites (e.g. Coast Guard access to lighthouses in coastal areas);
- access for other road deactivation;
- fire suppression access (important in the Interior);
- rangeland access;
- silvicultural access;
- construction timing windows (e.g. noxious weed control, fish windows).

When conducting access management planning, proposed plans should consider existing road conditions, slope processes and downslope resources. For example, planning may include future road use considerations with recommendations for:

- permitting of roads required for regular industrial use. Such roads should be maintained where appropriate and as required by the FPC;
- where the road is required for non-industrial use, the road should be deactivated to standards appropriate for user needs, and select sections may require structural upgrades or relocation;
- where the road is not required for either industrial or non-industrial use, or the road presents a significant risk to the watershed, the road should be deactivated to standards that minimize the risk to the watershed to an acceptable level;
- where the road is overgrown and/or access to the area is extremely difficult such that disturbances and damage caused by carrying out rehabilitation works may have a net negative effect on the watershed, the road should be left alone.

The access management plan should seek to match the listed road strategies with the identified access needs while recognizing the need to minimize the risk to the watershed from the road network.

2.10 Development of Restoration Objectives

Restoration activities should coincide with the overall watershed restoration objectives. Established restoration objectives should be amenable to monitoring (e.g. effectiveness evaluation or comparable process) so that the effectiveness of the restoration activities can be assessed. Restoration objectives may be set at several levels including watershed level objectives, component level objectives and site level objectives.

Feedback from the monitoring of restoration activities will enhance planning, strategy selection, treatment design and cost-effectiveness. However, the feedback benefit will only be achieved if measurable, obtainable objectives, goals and/or targets are clearly set at the beginning. Evaluation of restoration activities should be carried out so that the effectiveness of the applied restoration treatments may be discerned.

For example, the following watershed restoration objective has been set for a project area:

- Watershed restoration objective: maintain or improve water quality at current levels.

To meet this objective, then the component level objectives could be developed as:

- hillslope component: reduce sediment supply to streams from roads and landslides to natural levels;
- channel component: stabilize sediment stored within channels and enhance channel bank stability.

These watershed objectives and component goals are used to fine tune the treatment priority of sites and suggest applicable restoration strategies. Restoration strategies that may be considered when setting site level objectives may include but are not limited to:

- pullback of oversteepened fills;
- seeding of exposed landslide scars;
- removal of culverts at stream crossings;
- stabilization of channel margins and sediment stored within the channel.

Site-level treatment targets may be set for each of these restoration objectives. Examples of corresponding treatment targets could be:

- pullback of all high and very high risk rated oversteepened fills;
- establishment of 65 % vegetation cover within three years of treatment on all seeded landslides;
- removal of all high and very high risk rated culverts;
- stabilization of 65 % of exposed gravel bar surfaces and all harvested channel margins within 3 years of treatment.

Treatment targets are set so that the restoration activities may be evaluated for effectiveness. Some of the restoration activities should be evaluated at the end of construction (e.g. if treatment target is to build a cross-ditch to manage flow, then target has been attained if cross-ditch is built and flow managed). The cumulative effect of completed site level treatments may then be evaluated against the component level goals to determine if these goals have been met. The net effect of addressing the component goals may then be evaluated against the established restoration objectives to determine if the restoration activities have met the watershed objectives.

Section 9 of this handbook expands on the concept of effectiveness evaluation for watershed restoration.

2.11 Assessment of Restoration Treatment Priority

Where the hazards can reasonably be mitigated by restoration work, it is usually beneficial to assign priority to sites based on their potential consequences to the resources of interest. Generally, the treatment priority ratings are derived directly from the inventoried risk ratings. However, treatment priority ratings may differ from inventoried risk ratings as a result of field verification data and experienced judgment. Adjustment of the priority rating relative to the risk rating depends on the circumstances in each watershed.

2.12 Cost Estimates & Personnel Requirements for Detailed Assessments

Any estimate of the cost and personnel requirements for detailed assessment and prescription work will depend on the specific characteristics of the watershed. Cost estimates for detailed assessment and prescription development should be completed as part of the overview report. Cost estimates will depend greatly on a range of factors. Typical factors to consider may include:

- type and condition of access into watershed or along road network (including accessibility by all-terrain vehicle or four-wheel drive vehicle);
- degree and type of vegetation covering road network;
- degree and type of vegetation covering landslides;
- size and accessibility of landslides;
- presence of unstable material on landslides;
- density of road network;
- distance from stream channels to road network;
- density of debris and vegetation in gullies;
- seasonal factors such as weather, seasonal access and time of year (e.g. snow cover);
- need for helicopter access and availability of helicopter drop sites or landings in remote areas;
- estimated risk rating from overview (high hazard/risk areas often require more effort);
- interpreted hazard rating from overview (high hazard areas may require crews of two people working together for safety reasons);
- proximity to other crews and radio contact with these crews;
- size of crew required.

Additional cost factors associated with detailed assessments and prescriptions may be included in the cost estimates that accompany the overview report. Typical factors to keep in mind include:

- equipment costs (e.g. any necessary specialized field gear);
- requirements, if any, for helicopter time on overview flights;
- use, where appropriate, of qualified registered professionals;
- accommodation and meal costs;
- travel costs.

Cost estimates will need to reflect the time requirements for both office work and field work.

2.13 Overview Reporting

Specific details that should be included in an overview report or similar planning document, will vary depending on the characteristics of the watershed involved. Typically an overview report might include the following:

- a brief description of the project watershed including access constraints, seasonal constraints, possible fisheries window constraints, and other information pertinent to restoration work;

- a brief description of the physiography of the watershed including area, landform history, present-day natural processes, distribution of slope types and the range in elevations within the watershed;
- a brief description of the geology of the area including identifiable major fault traces, type of bedrock, nature of surficial material (e.g. colluvial blankets) and known mineral occurrences in the watershed;
- a brief description of the climatology of the watershed, commonly derived from an established series of climate normal stations run by Environment Canada including relevant data such as annual precipitation, daily rainfall totals, occurrence of snow and the duration of the wet season (although the closest station to the project watershed or with similar elevation and aspect characteristics may be used, considerable extrapolation and experienced judgement may be required);
- hydrologic behaviour of streams (e.g. response time of streams in coastal areas, implications of hydrology for work timing and sediment management requirements);
- a summary of the field reconnaissance indicating time spent, sites visited, and factors which may have limited the extent of the field reconnaissance;
- recommendations for restoration actions or works, and site-specific assessments needed;
- a discussion of the expected effectiveness of the remedial works at reducing risks to the resources of interest;
- the risk assessment described in Section 2.7 with site priorities assigned for restoration (presentation in a summary table is preferred; the table should include the type of remedial work needed and the type of site-specific assessment to be done, i.e. road deactivation prescription needed);
- where possible or appropriate, a proposed work plan with time frames for the detailed site assessments and remedial work to be carried out in a logical, orderly and cost-effective manner;
- depending on how the project is to be delivered, preliminary cost estimates for detailed assessments and site work are likely to be required either in the report or as an appendix submitted separately.

It is useful to include a summary of land uses and resource values in the overview report if summaries of this information are not already available. Example uses and values for consideration include:

- forestry activities including date and extent of harvesting;
- mining activities including date and extent of mining and current mineral claims;
- existing and potential recreation opportunities;
- extent of target fish streams, type of fish present, escapement numbers, barriers to fish, and suitability of fish habitat;
- number and location of water licences;
- known cultural sites and First Nations traditional use of the land within the sub-basin;
- extent of private lands, public lands and rights of way (e.g. transport or pipeline corridors, hydro transmission lines, railway lines).

Where appropriate, the professional taking responsibility for the work must have expertise in assessing geomorphic and fluvial processes and slope stability, and have basic knowledge of forest harvest systems and forest road engineering. A qualified registered professional should sign all overview reports. The Forest Practices Code defines a qualified registered professional as a person who:

(a) has appropriate education and experience to carry out the activity, and

(b) is a member of, or licensed by, a regulatory body in British Columbia that has the legislated authority to regulate its members or licensees performing the activity.