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Soil and Water Road-Condition Index - Field Guide

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Soil and Water Road-Condition Index - Field Guide

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INTRODUCTION

The San Dimas Technology and Development Center (SDTDC) of the Forest Service, U.S. Department of Agriculture, developed the soil and water road-condition index (SWRCI) to provide a road-condition assessment tool for watershed- and project-scale analysis. SWRCI is intended to be a rapid-assessment tool for soil scientists and hydrologists to identify effects of roads on soil quality and function, as well as impacts to water quality and downstream values.

The road-condition rating uses key indicators to identify potential soil and water problems on a road or road segment (a portion of a road with similar characteristics, such as surface shape, road gradient, hillslope position, or surface condition). This field guide incorporates photographs of road conditions that illustrate both functional and at-risk indicators. Interdisciplinary teams can use the road-condition information collected using SWRCI to identify potential opportunities for soil, water, and road solutions. A companion publication, the soil and water road-condition index- desk reference:

- Provides a description of each road attribute.
- Identifies the questions the attribute addresses for a project- or watershed-scale roads analysis.
- Identifies related indicators, and the usefulness of the attributes, in identifying road impacts to soil and water resources with referenced research findings.

SWRCI and Other Road-Evaluation Tools and Resources

The SWRCI evaluation builds on previous tools and resources, including the *Water/Road Interaction Technology Series* and the *Roads Analysis Process*. SWRCI was developed with input from forest personnel on information needed to evaluate the effects of roads on soil and water resources. The index was developed by synthesizing key road indicators used by many forests.

Some forest staffs currently are collecting more data than is required with SWRCI. Other forest staffs do not have a standard tool to evaluate roads effects to soil and water resources. SWRCI is intended to bridge the gap and provide reliable information quickly to the watershed specialist and interdisciplinary team. Watershed specialists can use SWRCI at any scale to provide input on forest-, watershed-, or project-level roads analysis or access and travel management planning.

SWRCI can be used in conjunction with other tools including the Geomorphic Road Analysis and Inventory Package (GRAIP). GRAIP is a process and a set of tools for analyzing the impacts of roads on forested watersheds. GRAIP combines a road inventory with a powerful geographic information systems (GIS) analysis tool set to predict sediment production and delivery, mass wasting risk from gullies and landslides, and fish passage at stream crossings. SWRCI can help to identify high-value watersheds at risk that may require more intensive analyses, such as GRAIP.

The National Inventory and Assessment Procedure (NIAP) is another resource that is targeted specifically at identifying crossings that impede passage of aquatic organisms in or along streams (Clarkin 2005). SWRCI can be used in conjunction with NIAP but does not provide a substitute for the data collected in NIAP.

Engineers conduct road-condition surveys in accordance with an established national protocol. In 2007, the Forest Service agreed to two new annual performance measures for roads. These new measures are:

- Change in critical health and safety deferred maintenance needs on operational maintenance level 3, 4, and 5 roads.
- Change in critical resource deferred maintenance needs on all operational maintenance level roads.

Surveyors are asked to recognize and document deferred maintenance needs related to regulatory compliance. This includes road drainage no longer functioning as designed, Best Management Practices (BMPs) required by the nonpoint source provisions of the Clean Water Act (CWA), and requirements for aquatic passage. The road-condition information is collected using an electronic road log or data sheets and is inputted into the Infra database (Forest Service database housing information about constructed features on national forests). Information collected for engineering needs can be combined with SWRCI.

The condition-rating tool selected depends on forest objectives, information needs, and onsite and downstream values at risk. SWRCI is a tool for soil scientists and hydrologists to use to evaluate a road’s effect on soil and water resources.

The Forest Service national BMP program is the agency’s nonpoint source pollution control program for achieving water resource conservation and protection. The program consists of direction and guidance to facilitate an adaptive management approach for accomplishing land and water treatments while protecting water resources as required by the CWA. The two main components of the program include:

- Direction (Forest Service handbook) in a consistent set of practices for common Forest Service management activities.
- Guidance (technical guide) of BMP monitoring with a consistent set of protocols for monitoring BMP implementation and effectiveness.

Completed SWRCI forms can provide background information to a BMP road-monitoring project.

Identify Road Maintenance or Reconstruction Needs

SWRCI identifies at-risk or impaired road segments and provides a team with information to determine maintenance or road reconstruction needs. SWRCI assists watershed specialists and engineers in defining the cause-and-effect relationship along a road segment. Equipped with this information, an interdisciplinary team can identify suitable solutions including maintenance, road closure, relocation, reconstruction, or decommissioning. SWRCI clearly identifies why a road segment is at risk or impaired through the use of eight indicators. SWRCI requires journey-level expertise by both watershed specialists and engineers to design appropriate treatments to restore functional components of a road and reduce adverse soil and water effects.

Soil and Water Road-Condition Index Components

The index identifies three condition classes: functional, at-risk, and impaired, using visual indicators as well as quantitative measurements. The indicators selected best identify the potential effects to water and soil quality from roads. The indicators incorporate current guidance in the Forest Service handbook (FSH) and the Forest Service manual (FSM), e.g., FSM 7109.12. Table 1 characterizes the road or road segment being evaluated.

Table 1—Step 1: Characterizing the road segment

Indicator	Measurement (visual or quantitative)	What does it indicate?	Why is it important to soil and water resources?
1. Road-surface shape (template)	Identified road-drainage design (insloped, outsloped, crowned, entrenched, turnpiked, or user created).	Road-prism design influences the delivery of sediment to streams.	The road-template design affects runoff and erosion potential.
2. Hillslope position	Position on slope (upper, middle, lower).	Hillslope position can determine sediment potential and drainage design.	Hillslope position correlates to the amount of water to expect on the slope and effective drainage.
3. Road gradient	Road-gradient identified with the clinometer (0-8%, 9-15%, or >15%).	Road-gradient indicates erosion potential and hydrologic connectivity.	Increased road gradient increases erosional power.
4. Hillslope gradient	Hillslope gradient class identified with the clinometer (0-15%, 16-35%, >35%).	Potential for landslides or fill failures.	Mass failures can adversely affect soil productivity and water quality.
5. Road-surface material	The type of material on the road surface (native, aggregate, paved).	Road-surface material identifies potential erodibility of the segment.	Road-surface material determines the erodibility of the surface tread.

After characterizing the segment, determine the road condition in step 2 (table 2).

Table 2—Step 2: Road-condition evaluation

Indicator	Measurement (visual or quantitative)	What does it indicate?	Why is it important to soil and water resources?
1. Road-surface drainage	The frequency and effectiveness of the surface drainage design or structure (open and functional, blocked or impaired).	If the design is appropriate and maintenance is sufficient to protect soil and water resources.	Roads can increase drainage density. Road surface drainage is often the source of erosion and sediment delivery to streams.
2. Stream-crossing structure condition	The suitability of the structure at crossing location and condition of the structure (open or plugged).	Suitable stream crossing to pass storm flows and debris.	Crossing failure from plugging can result in deterioration of water quality.
3. Road-subsurface drainage	The signs of erosion, ditch scour, or vegetative change.	Sufficient and appropriate drainage features.	Roads can intercept subsurface flows causing landslides, dewatering hillslopes, and modifying drainage patterns.
4. Diversion potential at crossings	The identified diversion potential (road-grade change at stream crossings) determined by reviewing stream crossings.	Its potential to change hillslope hydrology.	Crossings with diversion potential increase the risk to downstream values, including soil and water quality, aquatic habitat, and riparian habitat.

Table 2—Con't.

Indicator	Measurement (visual or quantitative)	What does it indicate?	Why is it important to soil and water resources?
5. Road-stream connectivity	The percentage of the total road segment length that is connected to the channel network (road, ditches, and ditch-relief culverts).	Connectivity is the extent to which the drainage features along the road system are directly linked to the channel network.	Roads increase drainage density, creating new channels for surface runoff. Water, sediment, and chemicals from the road prism enter the stream channel.
6. Road-surface condition	The identified signs of surface runoff (rills, ruts, gullies).	Potential to concentrate water.	Rilling and rutting cause erosion and sediment, which may lead to overwidened road segments.
7. Cutslope condition	The slope stability and vegetative cover (vegetated and unvegetated).	Cutslope stability and vegetation affects sediment production.	Unstable and unvegetated cutslopes contribute sediment and can modify road drainage (e.g., fill inboard ditch with sediment).
8. Fillslope condition	The slope stability and vegetative cover.	Potential for erosion and sediment production.	Unstable and unvegetated fillslopes can increase sedimentation to streams.

Once the road-condition evaluation is completed, the watershed specialist and engineer can evaluate the SWRCI score (functional, at-risk, or impaired) and look at opportunities to reduce risks or potential damage through maintenance or other improvements. Consider the items in table 3.

Table 3—Maintenance or improvement considerations

Consideration	**Measurement**	**What does it indicate?**	**Why is it important to soil and water resources?**
1. Operational maintenance level	Maintenance levels range from 1 to 5. Level 1 is a closed road (physically blocked entrance) and 5 is a road that provides a high degree of user comfort, often a double-lane, paved facility.	The maintenance level currently assigned to a road considers today's needs, road conditions, budget constraints, and environmental concerns.	Environmental and resource protection requirements are important in determining the operational maintenance level of a road.
2. Season of use	Seasonal or year-long use of a road.	This links to the operational maintenance level and ensures that maintenance and design is commensurate with time of use.	Adverse impacts to water and soil quality can occur from road use outside the normal operating period.
3. Traffic level	The vehicle traffic count on road segment (high, low, closed).	Roads with higher traffic and larger vehicles (chip vans, logging trucks) generate more sediment.	The amount of sediment produced can be influenced greatly by the amount and type of traffic.
Design storm	The identified design storm for any crossings at-risk.	Provides designers with information for redesigning road-stream crossing.	At-risk or impaired road segments can be improved with accurate estimates of storm duration and intensity.
Dominant soil texture	Soil texture class (clay, sand, silt).	Erosion and sediment delivery potential.	Soil texture affects erosion rates.

How To Use the Soil Water Road-Condition Index (SWRCI)

The SWRCI is a rapid-assessment tool to identify road condition relative to soil and water resource concerns. The tool is for soil scientists, hydrologists, engineers, and resource specialists involved in roads analysis, site-specific project assessment, and/or National Environmental Policy Act documentation. The form can be used on a single road or on every road on a forest. SWRCI is a systematic process that first characterizes the road by identifying surface shape, location, road gradient, hillslope gradient, and surface material, and then rates its condition using the following eight indicators.

1. Road-surface drainage.
2. Stream-crossing structure condition.
3. Road-subsurface drainage.
4. Diversion potential at crossings.
5. Road-stream connectivity.
6. Road-surface condition.
7. Cutslope condition.
8. Fillslope condition.

For each of the indicators, the reviewers identify if the road design, structure, or stream crossing is functioning. If the structure and design are operating in the proper or expected manner, the road-condition evaluation for that indicator is “functional.” If the structure or design is not operating as expected and is blocked, eroded, or has the chance of damaging resources (soil and water) in its present condition, the road-condition evaluation is “at-risk.”

To determine the overall condition index for a road or segment, the reviewers evaluate each indicator for functionality and track each score to determine the percentage. Road segments with greater than 25 percent of the surface-drainage structures “at-risk” receive an overall “impaired” condition rating. If less than 25 percent of the segment’s surface drainage is not operating or functioning in the proper or expected manner, the overall rating is “at-risk.” The rule set is located on the form.

Steps to determine the overall condition index for a road or segment.

1. **Drive the entire road or road segment to review the road and identify potential road segments.** Road segments can be delineated from U.S. Department of the Interior, U.S. Geological Survey (USGS) quadrangles or routed linear Arc/Info coverage found in Infra. Refer to appendix A for additional tips on segmenting a road. Without any preidentified segment breaks, look for the following when segmenting a road:

- Surface shape (insloped to outsloped).
- Location (road within stream zone, climbing segment, upper one-third).
- Surface material (gravel, native, paved).
- Surface drainage.

2. **Characterize each segment by examining closely the indicators on the form.** Return to the first road segment and (before driving the segment) identify the road-surface shape, location, gradient, hillslope gradient, and surface material. Together with your coworker identify the following:
    a. What surface drainage is used? Is it functioning?
    b. Are there stream crossings within the segment? Are they open and functional?
    c. Does the road intercept subsurface drainage? Is it a point or linear feature throughout the segment? Is the ditch eroded? What vegetation is growing on both sides of the road?
    d. Is there diversion potential with insloped roads, ditch-relief culverts, or at natural stream crossings? If a structure fails, where will the water flow?
    e. Is the road segment connected to the stream at natural stream crossings or from gullies delivering sediment to the stream?
    f. Are there rills or ruts on the road surface?
    g. Are the cutslopes and fillslopes well vegetated and stable? Or are there rills, sparse vegetation, and indications of mass wasting?

3. **Drive the remainder of the segment** and identify the number of functional drainage structures. Often if one culvert is plugged, many culverts on the road will be plugged too. The recordkeeper tracks the ratings to determine the overall road segment SWRCI.

4. **Complete a form for each segment.** Circle “functional,” “at-risk,” or “N/A” for each of the indicators. Add the circled rating for each category. Determine the percentage of functioning indicators for each indicator. Follow the rule set to obtain an overall SWRCI. Turn the form over and answer the questions on the back related to maintenance or improvement considerations, potential causes of sediment, and site-specific concerns.

5. **Repeat the process and drive to a typical location within the next segment.** Identify the segment (2) of Forest Service road (x) and complete the form. Identify the segment breaks on quadrangle maps or with a global positioning system (GPS) waypoint. Photograph a representative segment of the road.

How To Segment a Road

Roads segments can range from 100 feet to 5 miles or more depending on the overall road design. SWRCI is intended to be a rapid-assessment tool to identify problems on roads that may adversely affect soil or water resources. Segmenting a road can help pinpoint where a problem occurs.

There are several tools to use when getting started. Use a USGS quadrangle or GIS database to:

- Delineate breaks at road intersections.
- Identify changes in road-segment location (ridge or upper one-third, middle one-third, lower one-third, climbing segment, or stream and riparian influence zones).
- Identify hillslope gradient.

Soil-survey and geologic maps identify sensitive or unstable areas within the proposed survey area.

Work with the engineering staff to reference existing road-condition ratings. Locate reports from the Infra database building upon previous surveys. Many forests have information on culverts, surface types, maintenance objectives, and traffic levels. Incorporate available records prior to conducting the field review. Locate any damage-survey reports for the area under review.

To avoid over segmenting a road, look for major changes in the road design. If, as the road gradient changes, there is a corresponding change in surface drainage, diversion potential, and/or road-surface condition, an additional segment should be added. If the road-gradient ranges from 2 to 8 percent, with a short section of 15 percent, and then goes back to 4 percent, consider including the short, steep climb in the original road segment. However, if the road template changes from insloped to outsloped, and the road-surface drainage changes from ditch-relief culverts to drainage dips, identify another segment.

Validate your findings by reviewing the answers on the form. Discuss the overall rating with your coworker; if the overall rating does not represent the segment, go back through each indicator to ensure that it was answered properly. Identify any additional comments on the back of the form.

Table 4—Soil and water road-condition index form used to determine the road condition and its potential effect to soil and water resources.

Soil and Water Road Condition Index

Road #
Segment Length________________ Total road length_______________
Reviewed by:__________________

STEP 1 ***Road Characterization (circle each to characterize segment)***

Road Surface shape	***Hillslope Position***	***Road Gradient***	***Hillslope Gradient***	***Road Surface Material***
Inslope	upper 1/3	0-8%	0-15%	Native
Outslope	middle 1/3	9-15%	16-35%	Aggregate
Crown	lower 1/3	>15%	>35%	Paved
Entrenched	climbing segment			
Turnpiked	within SMZ			
User Created				

STEP 2	**Road Condition Evaluation**			
1. Road Surface Drainage (Identify surface drainage on road segment from list below)	**N/A**	**Functional**	**At-Risk**	**Impaired**
Ditch (linear feature)		No signs of erosion or scour	Eroded ditch with signs of downcutting or scour	>25 percent of segment "at-risk"
Lead-off or winged ditch		Open / no deposition/ no scour	Partially blocked or blocked, scour at outlet	>25 percent of segment "at-risk"
Ditch relief culverts (point)		Open / no deposition/ no scour	Partially blocked or blocked, scour at outlet	>25 percent of segment "at-risk"
Drainage dips / broad-based dips(point)		Open / no deposition/ no scour	Deposition, scour, erosion at outlet	>25 percent of segment "at-risk"
Overside drains (point)		Open / no deposition/ no scour	Blocked or scour at outlet	>25 percent of segment "at-risk"
Diffuse Drainage feature (outslope) linear		Equal distribution of runoff, no signs of erosion or concentrated flows.	Concentrated flowpaths on fill slopes, erosion present	>25 percent of segment "at-risk"
Non-engineered (user-created)		No signs of erosion.	Surface has erosion from concentrated flowpaths	>25 percent of segment "at-risk"
2. Condition of Stream Crossing (point)		Open & Functional	Reduced capacity at inlet, development of terrace at inlet	>25 percent of segment "at-risk"
3. Road Subsurface Drainage (Pt or linear)		Intercepts subsurface flows with no adverse effect to vegetation & no ditch scour	Eroded ditch, evidence of vegetation change	>25 percent of segment "at-risk"
4.Diversion Potential at Crossings (point)		No diversion	Diversion potential present at stream crossing	>25 percent of segment "at-risk"
5. Road-stream Connectivity (point)				
Road connected to stream crossing		No flowpaths from road prism to stream	Direct flowpaths present from road surface or ditch to stream	>25 percent of segment "at-risk"
Road connected thru gully formation to stream		No signs of gully or sediment entering stream	Gullies present	>25 percent of segment "at-risk"
6. Road Surface Condition (linear)		No rilling/rutting	Rills and ruts prevalent	>25 percent of segment "at-risk"
7. Cutslope Condition (linear)		Vegetated/stable	Unvegetated and unstable	>25 percent of segment "at-risk"
8. Fillslope Condition (linear)		Vegetated/stable	Unvegetated and unstable	>25 percent of segment "at-risk"
Add together the numbers for 1-8 at the base of each column				
Select SWRCI for segment from criteria on back of sheet		Functional	At- Risk	Impaired

Comments:

STEP 3				
Maintenance or Improvement Considerations				
Operational Maintenance Level (Level 1-5)				
Season of Use for road		Seasonal	Year long	
Traffic Level		High	Low	Closed
Design Storm (Circle dominant storm type for which road and structures are designed)	Snow	Short duration/high intensity	Rain	Rain on Snow
Dominant Soil Texture		Sandy loam	Silt Loam	Clay loam

If sediment transport is occurring what is the cause?

Inappropriate time of use of road with respect to soil and weather conditions.		
Inappropriate location/design of road.		
No maintenance of structures or road prism		
Inadequate drainage features		
Natural events (large storm event)		
Unknown		
Will sedimentation continue?	Yes	No
Are downstream beneficial uses at risk?	Yes	No

Site specific concern on road requiring immediate attention?

GPS location:
Photo numbers:
Describe problem:

Additional comments

Definitions:
Functional: To operate in the proper or expected manner.
At-risk: The chance of damage to resources (water or soil quality) are present in the current condition.
Impaired: Not functioning as designed or maintained.

Rule set for determining an **overall at- risk condition rating** for the segment any of the following must be true:

1. Any road surface drainage is evaluated as at-risk.
2. Diversion potetial is identified at road stream crossings.
3. If road stream connectivity is present.
4. The combination of road stream connectivity and unvegetated or unstable cutslopes.
5. A road segment with ONLY an-at risk surface condition rating and no other indicators even if >25% is still at-risk.

Rule set for determining an **overall impaired condition rating** for the segment any of the following must be true:

1. A road segment with greater than 25% of the surface drainage structures at risk.
2. A road segment with greater than 25% of the stream crossing structures at risk.
3. A road segment with greater than 25% with at subsurface drainage at risk.
4. A road segment with greater than 25% of the crossings with diversion potential
5. A road segment with greater than 25% road stream connectivity.
6. A road segment with a combination of at-risk ratings for road surface drainage, diversion potential, road-stream connectivity, road surface conditon, and cutslope or fillslope condition.

Soil and Water Road Condition Index

Road # FS9999 4/23/2008

Segment Length______1___________ Total road length___4_____________

Reviewed by: CNapper_______________

STEP 1	Road Characterization (circle each to characterize segment)			
Road Surface shape	Hillslope Position	Road Gradient	Hillslope Gradient	Road Surface Material
Inslope	upper 1/3	0-8%	0-15%	Native
Outslope	middle 1/3	9-15%	16-35%	Aggregate
Crown	lower 1/3	>15%	>35%	Paved
Entrenched	climbing segment			
Turnpiked	within SMZ			
User Created				

STEP 2	Road Condition Evaluation			
1. Road Surface Drainage (Identify surface drainage on road segment from list below)	N/A	Functional	At-Risk	Impaired
Ditch (linear feature)		No signs of erosion or scour	Eroded ditch with signs of downcutting or scour	>25 percent of segment "at-risk"
Lead-off or winged ditch	X	Open / no deposition/ no scour	Partially blocked or blocked, scour at outlet	>25 percent of segment "at-risk"
Ditch relief culverts (point)		Open / no deposition/ no scour	Partially blocked or blocked, scour at outlet	>25 percent of segment "at-risk"
Drainage dips / broad-based dips(point)	X	Open / no deposition/ no scour	Deposition, scour, erosion at outlet	>25 percent of segment "at-risk"
Overside drains (point)	X	Open / no deposition/ no scour	Blocked or scour at outlet	>25 percent of segment "at-risk"
Diffuse Drainage feature (outslope) linear	X	Equal distribution of runoff, no signs of erosion or concentrated flows.	Concentrated flowpaths on fill slopes, erosion present	>25 percent of segment "at-risk"
Non-engineered (user-created)	X	No signs of erosion.	Surface has erosion from concentrated flowpaths	>25 percent of segment "at-risk"
2. Condition of Stream Crossing (point)		Open & Functional	Reduced capacity at inlet, development of terrace at inlet	>25 percent of segment "at-risk"
3. Road Subsurface Drainage (Pt or linear)	X	Intercepts subsurface flows with no adverse effect to vegetation & no ditch scour	Eroded ditch, evidence of vegetation change	>25 percent of segment "at-risk"
4.Diversion Potential at Crossings (point)		No diversion	Diversion potential present at stream crossing	>25 percent of segment "at-risk"
5. Road-stream Connectivity (point)				
Road connected to stream crossing		No flowpaths from road prism to stream	Direct flowpaths present from road surface or ditch to stream	>25 percent of segment "at-risk"
Road connected thru gully formation to stream		No signs of gully or sediment entering stream	Gullies present	>25 percent of segment "at-risk"
6. Road Surface Condition (linear)		No rilling/rutting	Rills and ruts prevalent	>25 percent of segment "at-risk"
7. Cutslope Condition (linear)		Vegetated/stable	Unvegetated and unstable	>25 percent of segment "at-risk"
8. Fillslope Condition (linear)		Vegetated/stable	Unvegetated and unstable	>25 percent of segment "at-risk"
Add together the numbers for 1-8 at the base of each column		3	6	
Select SWRCI for segment from criteria on back of sheet		Functional	At- Risk	Impaired

Comments:

STEP 3				
Maintenance or Improvement Considerations				
Operational Maintenance Level (Level 1-5)			Level 2	
Season of Use for road		Seasonal	Year long	
Traffic Level		High	Low	Closed
Design Storm (Circle dominant storm type for which road and structures are designed)	Snow	Short duration/high intensity	Rain	Rain on Snow
Dominant Soil Texture		Sandy loam	Silt Loam	Clay loam

If sediment transport is occurring what is the cause?

Inappropriate time of use of road with respect to soil and weather conditions.			
Inappropriate location/design of road.			
No maintenance of structures or road prism	x		
Inadequate drainage features		x	
Natural events (large storm event)			
Unknown			
Will sedimentation continue?		Yes	No
Are downstream beneficial uses at risk?		Yes	No

Site specific concern on road requiring immediate attention?

GPS location:
Photo numbers:
Describe problem:

Additional comments

Definitions:
Functional: To operate in the proper or expected manner.
At-risk: The chance of damage to resources (water or soil quality) are present in the current condition.
Impaired: Not functioning as designed or maintained.

Rule set for determining an **overall at- risk condition** rating for the segment any of the following must be true:
1. Any road surface drainage is evaluated as at-risk.
2. Diversion potetial is identified at road stream crossings.
3. If road stream connectivity is present.
4. The combination of road stream connectivity and unvegetated or unstable cutslopes.
5. A road segment with ONLY an at-risk surface condition rating and no other indicators even if >25% is still at-risk.

Rule set for determining an **overall impaired condition rating** for the segment any of the following must be true:
1. A road segment with greater than 25% of the surface drainage structures at risk.
2. A road segment with greater than 25% of the stream crossing structures at risk.
3. A road segment with greater than 25% with at subsurface drainage at risk.
4. A road segment with greater than 25% of the crossings with diversion potential
5. A road segment with greater than 25% road stream connectivity.
6. A road segment with a combination of at-risk ratings for road surface drainage, diversion potential, road-stream connectivity, road surface conditon, and cutslope or fillslope condition.

Chapter II—Characterizing the Road Segment (Step 1)

Start SWRCI by characterizing the road segment using these five descriptors:

1. Road-surface shape.
2. Hillslope position.
3. Road gradient.
4. Hillslope gradient.
5. Road-surface material.

Road-surface shape may be insloped, outsloped, crowned, entrenched, turnpiked, or user-created. A road's design elements include the traveled-way width, shoulder, road gradient, curve widening, and pavement structure (FSH 7709.56 Chapter 4-Design).

Road-surface Shape

Insloped roads are shaped to drain all water toward the backslope (uphill or cutbank side) away from the road-fill material. Water collects, and then flows along the backslope or in the roadside ditch, until a cross-drain or relief-culvert directs the flow to the other side and away from the road (Moll 1997).

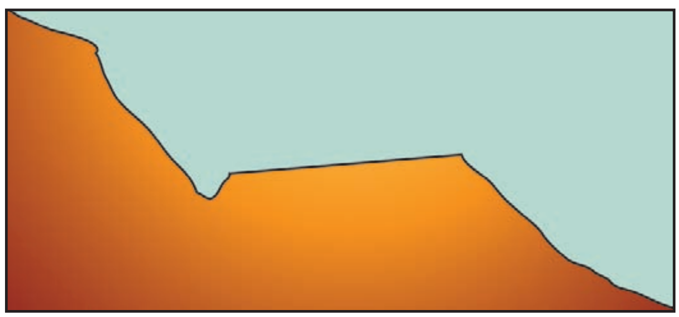

Figure 1—An insloped road surface shape concentrates runoff against the backslope or inside ditch.

Figure 2—An insloped road directs road runoff towards the inside ditch, San Bernardino National Forest.

Outsloped roads are shaped to drain all surface water to the downhill or fill-shoulder side where it flows away from the road and is dispersed over or absorbed into the slope below the road (Moll 1997). Outsloping disperses surface runoff.

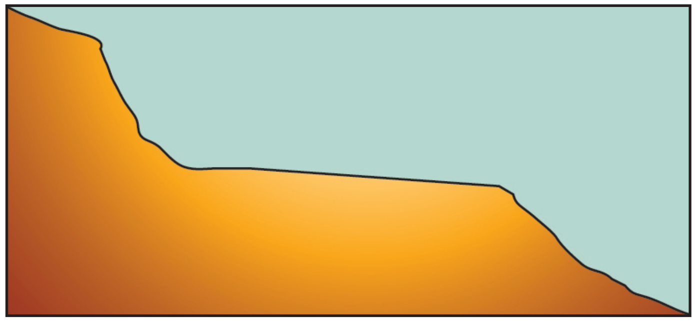

Figure 3—The outsloped road-surface shape directs and disperses runoff toward and over the fillslope.

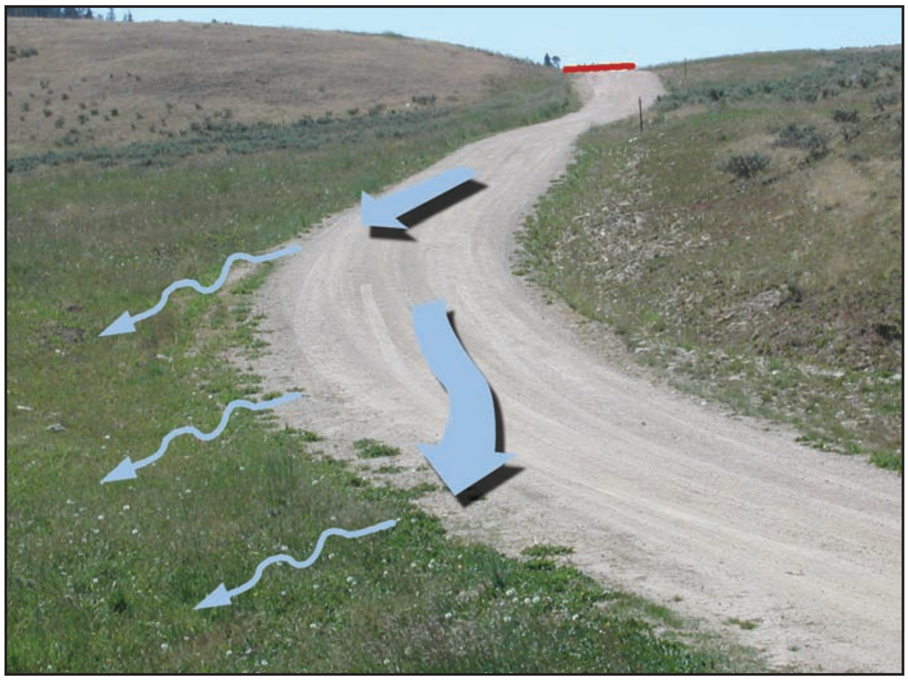

Figure 4—The outslope road surface disperses runoff, and any sediment generated is trapped in the vegetation below the road, Bighorn National Forest.

Crowned roads are a combination of an outsloped and insloped surface with the high point in the center of the traveled way. The crowned surface is combined with a ditch on the uphill or backslope side to transport runoff to a surface cross drain, relief culvert, or leadout ditch (Moll 1997).

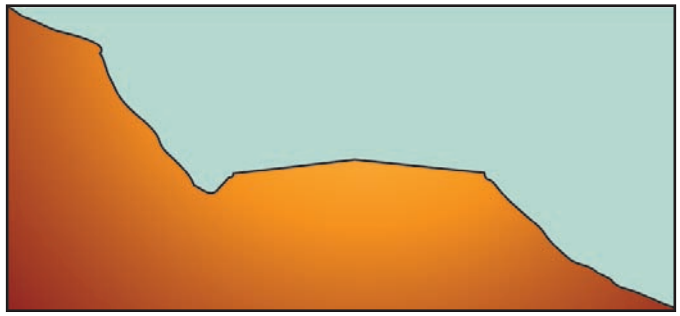

Figure 5—The crowned road-surface shape has a high point in the center and divides runoff between the backslope or ditch and the fillslope.

Figure 6. A crowned road requires maintenance of the ditches, ditch-relief structures, fillslopes, and surfaces to ensure that drainage is maintained over time, Okanogan National Forest.

Entrenched roads have a constructed berm or a throughcut on both sides of the road prism preventing runoff from leaving the road prism except at designated locations.

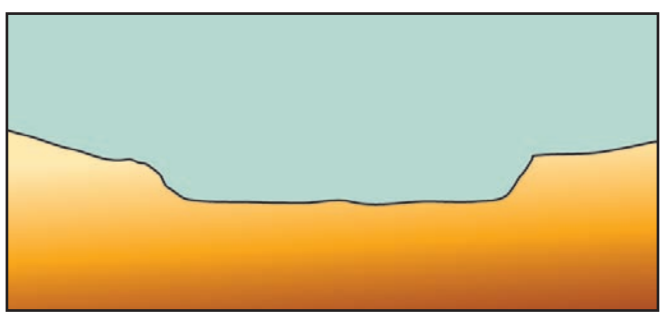

Figure 7—Entrenched road segments are prevalent on Forest Service roads.

Figure 8—Entrenched road segments vary in length and are easily identified on steeper road gradients, Ozark-St. Francis National Forest.

Figure 9—Entrenched road segments trap runoff, causing erosion along the entire segment length, Ozark-St. Francis National Forest.

Figure 10—Berms on the outside of the road often cause the entrenched road segment. Regardless of the cause, the effect on road drainage is the same, San Bernardino National Forest.

Turnpiked roads are constructed above the natural topography of the adjacent landscape. Turnpiked-road gradients are generally slight. Turnpiked roads are used where soil strength is low and where surface ponding may occur for significant portions of the year.

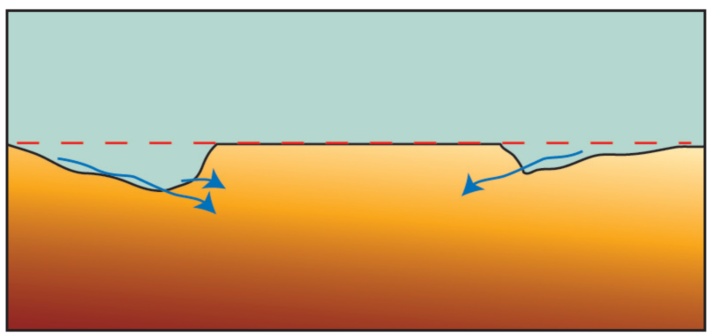

Figure 11—Turnpiked-road segments are used commonly when a road crosses a meadow.

Figure 12—A turnpiked-road segment crossing a bog in Alaska, Tongass National Forest.

Figure 13—A turnpiked-road segment using a permeable fill allows for subsurface flows. No deleterious effects to meadow vegetation is evident, Tongass National Forest.

User-created roads are roads developed from use of an area. These roads lack any design elements and may be limited to wheel tracks only.

Figure 14—User-created roads proliferate on National Forest System lands, Lassen National Forest.

Each road-surface shape has an associated set of road-drainage features. For example, an insloped road should have cross-drained culverts and a ditch that allows control of drainage-release points. An insloped-road design is commonly used for steep road gradients to ensure driver safety. Insloping also is used in highly erodible or unstable soils to direct water away from the fillslope to avoid accelerated erosion or fill failures (Moll, 1997).

Figure 15—An insloped-road directs road runoff to a well-maintained inside ditch, Los Padres National Forest.

Conversely, outsloped roads are generally located where road hazards to drivers are low, and road gradients range from flat to moderate (less than 8 percent). Outsloping on flat-road grades disperses surface runoff.

Figure 16—Outsloped roads may incorporate drainage dips (broad-based dips) to break up the contributing road-drainage area, Klamath National Forest.

The crowned-road shape is used on many double-lane roads because the wider surface area generates more surface runoff. Crowned roads can be used effectively on grades steeper than 7 percent without adverse impacts to soil and water resources.

Figure 17—Less cumulative surface erosion may occur if the drainage is split between an inslope and outslope section, Ozark-St. Francis National Forest.

Try to identify the road segment's surface shape. An undefined road-surface shape can indicate lack of maintenance, or a user-created road. Segment the road as the surface shape changes. The surface shape is the first step in determining how the road prism affects runoff and its potential impact to soil and water resources.

Figure 18—A road segment with an insloped surface shape that incorporates ditch-relief culverts, Tongass National Forest.

Figure 19—An entrenched road segment with a gentle road gradient, Lake Tahoe Basin Management Unit.

Figure 20—An insloped road without a clearly constructed ditch. The outside berm also traps water creating an entrenched road-surface shape, San Bernardino National Forest.

Hillslope Position

Identify the road-segment location within the watershed. The hillslope position of a road segment can determine sediment potential and drainage design.

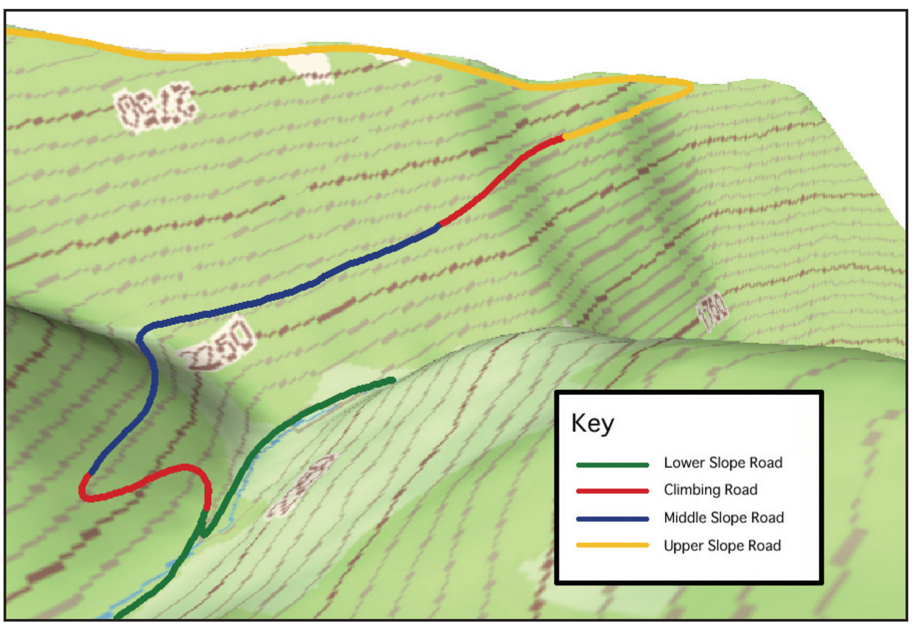

Figure 21—Hillslope-position classes include ridge (upper one-third), midslope (middle one-third), and bottom (lower one-third), or within a streamside management zone or riparian area designation, and a climbing segment from the bottom to the ridge.

Figure 22—Road located on the ridge has less contributing drainage area above it; this may affect the type of road-surface shape and drainage used, San Bernardino National Forest.

Figure 23—This midslope road is full-bench construction with an insloped road-surface shape and ditch-relief culverts, Los Padres National Forest.

Figure 24—Road located within the bottom one-third of the slope and within the streamside management zone, Lolo National Forest.

Figure 25—A climbing road segment traverses the slope from the bottom one-third to the top one-third, Bighorn National Forest.

Circle the hillslope position of the road segment being evaluated. Hillslope position is another criterion that is used to segment a road.

Road Gradient

Road gradient is the road's slope along its longitudinal axis. Road gradient is a design element used in planning for both construction and reconstruction of a road facility. Road gradient affects soil and water resources by erosion potential, runoff, and sediment delivery. Studies show that sediment generation is a function of traffic intensity, road gradient, and the road's contributing length.

Figure 26—Road gradient affects the type of road-drainage structure, road-surface shape, and surface requirements, Klamath National Forest.

Forest Service guidance on road grades is identified in FSM 7700 and FSH 7700. Steep road-gradient segments are common throughout National Forest System roads and require review to ensure that adverse impacts to soil and water resources do not occur.

Figure 27—The road gradient in a segment may change slightly. Break road segments more frequently if there are signs of accelerated erosion (rills or gullies) or extended slope length, Arapaho-Roosevelt National Forest.

Use a clinometer to determine the road gradient for the segment being traversed. Road gradients range from 0 to 8 percent, 9 to 15 percent, and over 15 percent.

Figure 28—The road gradient for this segment is less than 8 percent. Provide survey crews with clinometers to ensure accurate readings, Tongass National Forest.

Figure 29—A midsloped road with steep sideslopes uses a rolling grade with broad-based dips to provide proper road-surface drainage. Note the discontinuous outside berm, which may be a safety feature given the steep sideslopes, Klamath National Forest.

Figure 30—Steep road gradient with aggregate helps to reduce erosion, Tongass National Forest.

Figure 31—Steep road gradient with a native-surface road shows signs of accelerated erosion, San Bernardino National Forest.

Figure 32—A road gradient of less than 2 percent can cause surface ponding on roads. Fine-textured soils on the native-surface road cause large puddles to form. Road widening or braided routes can adversely affect soil productivity, Lassen National Forest.

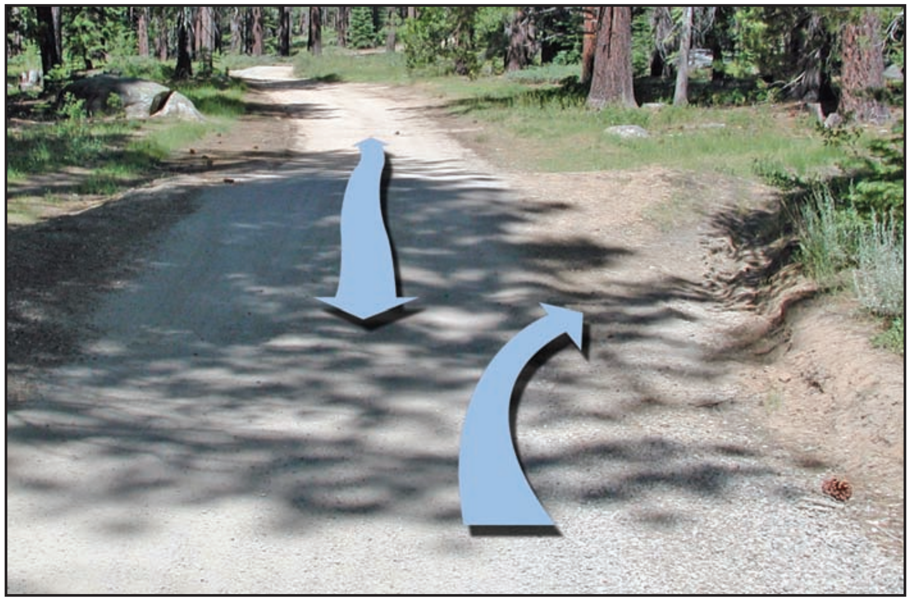

Figure 33. A broad-based dip and lead-out ditch provide surface drainage on low-gradient roads, Lake Tahoe Basin Management Unit.

Hillslope Gradient

Hillslope gradient is both the uphill and downhill slope where the road is located. The hillslope gradient is important because any hillslope runoff onto the road needs to be designed for in a road-drainage structure. Steep hillslope gradients often have steep cutslopes that are hard to vegetate and can intercept subsurface flow. With more gentle hillslopes, there are more opportunities to disperse runoff and avoid concentrating flows.

To field-verify hillslope gradient, use a clinometer to identify both uphill- and downhill-slope gradient. Take the reading away from the cut-and-fill of the road to ensure accuracy.

Figure 34—Hillslope gradients vary, posing unique design considerations, San Bernardino National Forest.

Figure 35—Above the road the hillslope gradient falls into the 0 to 15 percent category, San Bernardino National Forest.

Figure 36—Steep, rocky outcrops above the road reflect a hillslope gradient over 35-percent slope. Take readings both above and below the road, San Bernardino National Forest.

Road Surface Material

SWRCI is intended for use on low-standard, native-surfaced roads (maintenance level 1 and 2), but is used to inventory all roads in a watershed rapidly. Higher maintenance level roads (level 3 through 5) may have aggregate or paved road segments.

Figure 37—Typical aggregate-surface road, White Mountain National Forest.

Figure 38—Native-surface road, Bighorn National Forest.

Figure 39—Aggregate-surface road, Bighorn National Forest.

Figure 40—Low-volume native-surface road, White River National Forest.

Figure 41—Paved road segment on a turnpiked permeable fill. Pavement is used to reduce sediment potential in this stream and meadow crossing, Lassen National Forest.

Figure 42—Paved road provides access to forest recreational opportunities, White River National Forest.

Circle the road surface material: native, aggregate (gravel), or paved, for the road segment evaluated.

Chapter III—Road Condition Evaluation (Step 2)

Evaluate the road condition using the information, descriptors, and photographs from the following pages to categorize each road segment.

Answer each item in step 2 as “not applicable,” “functional,” “at-risk,” or “impaired.” Once the indicators are answered, add up the score and use the rule set to determine the overall adjective rating.

Definitions

- *Functional*: Operating in the proper or expected manner.
- *At-risk*: Operating with the chance of damage to resources (water or soil quality).
- *Impaired*: Not functioning as designed or maintained.

Rule set for determining condition rating

To determine an **overall “at-risk” condition rating** for the segment, *any* of the following must be true:

1. Any road-surface drainage is evaluated as at-risk.
2. Diversion potential is identified at road-stream crossings.
3. Road-stream connectivity is present.
4. The combination of road-stream connectivity and unvegetated or unstable cutslopes is present.

Rule set for determining an **overall "impaired" condition rating** for the segment: *any* of the following must exist:

1. A road segment with greater than 25 percent of the surface-drainage structures at risk.
2. A road segment with greater than 25 percent of the stream-crossing structures at risk.
3. A road segment with greater than 25 percent of the subsurface drainage at risk.
4. A road segment with greater than 25 percent of the crossings with diversion potential.
5. A road segment with greater than 25 percent road-stream connectivity.
6. A road segment with less than 25 percent of any indicator but with a combination of at-risk ratings for road-surface drainage, diversion potential, road-stream connectivity, road-surface condition, and cutslope or fillslope condition.

Road-Surface Drainage

Ditches

Ditches provide surface drainage for the interception, collection, and removal of water from slope areas and road surfaces. Design considerations for ditches include resource objectives for soil, water, visual quality, and maintenance capabilities. Ditch grades should be no less than 0.5 percent to provide positive drainage and to avoid siltation.

	Functional	At Risk	Impaired
Ditches	Ditch accommodates runoff without indications of erosion or scour.	Erosion, scour, or downcutting is visible. Road width is reduced in areas.	More than 25 percent of the ditch length is eroded, downcut, or scoured.

The ditch transports water leaving the road surface or cutslope to the nearest ditch-relief culvert, lead-out ditch, or natural channel. The ditch is constructed between the traveled way and the adjacent terrain. Drainage ditches are found on insloped and crowned roads. On some outsloped roads there also may be a ditch, although this is not the design standard. The effectiveness of drainage ditches varies with length, slope, and armor.

Figure 43—Example of a side ditch, yet portions of the road-surface shape are insloped, White River National Forest.

Figure 44—Ditch shows signs of erosion and scour placing it in the "at risk" category, Arapaho-Roosevelt National Forest.

Figure 45—Insloped road with ditch. No signs of erosion or scour within the ditch, Bighorn National Forest.

Figure 46—During condition surveys, examine the length of the ditch line and frequency of cross-drain culverts. Ditches with large contributing areas may show signs of erosion and scour, White Mountain National Forest.

Figure 47—Ditches can become overwidened from inadequate capacity. Eroded ditches can reduce the traveled-way width, which affects driver safety. Eroded ditches that exceed 25 percent of the segment are rated as "impaired," Tongass National Forest.

Figure 48—Fine sediment deposited in the ditch indicates a flat road and ditch gradient, which also may have plugged culverts. Ditches with accumulated sediments also are rated as "at risk," and if over 25 percent of the segment has deposited sediment the rating is "impaired," Ouachita National Forest.

Figure 49—Carefully inspect ditches on roads with continuous grades, Tongass National Forest.

Figure 50—Roadside vegetation can obscure road-drainage features from view and render many useless during rain events, Ozark-St. Francis National Forest.

Ditch Types

Trap Ditch. A trap ditch is designed to catch and hold slough from the cutslope and/or snow. The trap ditch is a form of drainage ditch and performs all the same functions as a drainage ditch.

Lead-Off or Winged Ditch. Lead-off (winged) ditches carry surface runoff away from the road prism. Commonly used on flat or gentle topography, lead-off ditches are used with a crowned or outsloped road-surface shape. For crowned roads the lead-off ditch may alternate from side to side or be on both sides of a road depending on the contributing area.

Figure 51—Lead-off ditch is located outside of a streamside-management zone to allow an adequate buffer for road sediment. "Functional" rating, Bighorn National Forest.

Figure 52—Ensure that lead-off ditches are adequately spaced for the amount of contributing runoff and sediment. "Functional" rating, Ouachita National Forest.

	Functional	At Risk	Impaired
Lead-Off or Winged Ditch	The lead-off ditch spacing is adequate for the contributing road area. No signs of sediment delivery to channels.	Lead-off ditch is plugged, not functioning, gullied, or contributing sediment to stream.	More than 25 percent of the ditch is plugged, not functioning, gullied, or contributing sediment to stream.

Outlet Ditch. The outlet ditch carries water away from the road to prevent the road subgrade from being saturated or eroded. It is typically implemented on flat ground where water may not flow away from the road. Locate the ditch at the lower end of a culvert or drain dip.

Ditch-Relief Culverts. Ditch-relief culverts periodically relieve the ditchline flow by piping water to the opposite side of the road, where flow can disperse away from the roadway without creating erosion. Spacing depends on road gradient, road surface and ditch soil types, runoff characteristics, and the effect of water concentrations on slopes and streams below the road (FSH 7709.56 Road Preconstruction Handbook).

	Functional	At Risk	Impaired
Ditch-Relief Culverts	The cross drains are free of sediment and debris, no indications of scour or plugging at inlet. No erosion is visible at the outlet.	The cross drains are partially blocked or blocked by vegetation, rocks, or debris. There is scour or erosion at outlet.	More than 25 percent of the cross-drain culverts are partially or fully blocked. There is scour and erosion at outlet.

Figure 53—Ensure that ditch-relief culverts are open and free of debris, Tongass National Forest.

Figure 54—Observe the length of the contributing ditchline to determine if spacing is adequate, Tongass National Forest.

Figure 55—Inspect the inlet condition; signs of sediment deposition place this cross-drain in the “at risk” category, White Mountain National Forest.

Figure 56—Inspect the outlet of the cross-drain for erosion and or deposition. This cross-drain culvert is "at risk" due to the amount of sediment deposited, White Mountain National Forest.

Figure 57—Rust or mechanical damage to culvert inlets can reduce their capacity and result in plugging, White Mountain National Forest.

Figure 58—Ditch-relief culverts are commonly used on roads that intercept subsurface drainage. The ditch and culvert provides for a dry roadbed and ensures adequate load-bearing capacity, Okanogan National Forest.

Figure 59—Consult with engineering staff on maintenance contracts needs. All ditch-relief culverts on this road had been maintained recently, Ozark-St. Francis National Forest.

Figure 60—Roads with ditch-relief culverts require routine inspection and maintenance. "At risk" or "impaired" ratings should be discussed with the forest road manager to ensure necessary maintenance is performed in a timely manner, Ozark-St. Francis National Forest.

Figure 61—"At risk" rating from partially blocked inlet, Tongass National Forest.

Figure 62—To reduce erosion and protect the fillslope, rock armor is placed at the outlet of the ditch-relief culvert, Ozark-St. Francis National Forest.

Figure 63—"Shotgun" culvert is "at risk" even though some rock armor has been placed. The large gully extends downslope and contributes sediment to the stream channel, Los Padres National Forest.

Drainage Dips

Drainage dips (broad-based dips, rolling dips) intercept and remove surface water from the traveled way and shoulders. Properly constructed dips provide an uninterrupted flow of traffic and a maintenance-free drainage structure. Drainage dips are not recommended on road gradients over 10 percent.

	Functional	At Risk	Impaired
Drainage Dips	Dips are placed frequently to disperse runoff and sediment. No scour or sediment deposition is visible.	Dips are widely spaced with signs of sediment deposition, scour at outlet, or wheel tracks through the crest of dip that compromises its function.	More than 25 percent of dips in segment are at risk.

"At risk" evaluations are common where sediment is deposited within a dip. This compromises the dip's function and may indicate a long contributing road length and/or an inadequate depth, gradient, and skew of dip. Dips should be self-cleaning and sediment deposition may indicate inappropriate design or location. An "impaired" rating is assigned if over 25 percent of the dips within the segment demonstrate deposition and scour at outlet.

Figure 64—Broad-based dips are located along this road segment and are frequently spaced to disperse runoff, Klamath National Forest.

Figure 65—Sediment has started to deposit within this broad-based dip making it "at risk" to soil and water resources. Dips should have an adequate skew so to be self-cleaning. Follow engineering specifications for construction of dips to avoid long-term maintenance, San Bernardino National Forest.

Figure 66—The Klamath National Forest uses road-condition inventories to identify road reconstruction opportunities and to reduce maintenance costs. Changing the road template (surface shape) from insloped to outsloped with broad-based dips can help reduce maintenance costs and sediment delivery to streams, Klamath National Forest.

Figure 67—Road reconstruction to improve drainage should adhere to road management objectives, which include information on the design vehicle. This forest road provides the recreational user access to a trailhead. Broad-based dips intercept and remove surface water from the traveled way, Lake Tahoe Basin Management Unit.

Overside Drains

Overside drains protect the fillslope from increased erosion. Overside drains are commonly used in conjunction with drainage dips or entrenched (berms) road prisms. To be effective, all structures must be properly located, installed, and maintained.

	Functional	At Risk	Impaired
Overside Drains	Overside drains are frequently spaced and accommodate the runoff and sediment from the road surface. No signs of erosion or scouring at outlet, and inlets are free of deposition.	There is long spacing between overside drains with sediment deposited at inlet. There is scouring and erosion at the outlet.	More than 25 percent of the structure's inlet may be blocked, or gullies exist at outlet. Large amounts of sediment are deposited at inlet.

Figure 68—The metal overside drain is used for concentrated flows where fillslope stability is a concern, San Bernardino National Forest.

Figure 69—Any overside drain has the potential for road-stream connectivity since erosion often occurs at the outlet of these structures. In this case, the surrounding soil has eroded leaving only the metal overside drain, Los Padres National Forest.

Stream-Crossing Condition

Proper road drainage prevents adverse impacts to water and soil resources. Road-drainage structures are designed with consideration of topographic, climatic, and other environmental conditions (sensitive soils, springs, unstable geology). Evaluate the physical condition of the structure and its ability to pass debris and water.

	Functional	At Risk	Impaired
Stream-Crossing Condition	Structure is free of debris; structure-opening width is equal or greater than streambed width.	Stream crossing has an opening width less than the streambed width; debris blocks portion of streambed-channel cross section. There are signs of rust or piping around structure. Terraces are developing at inlet.	More than 25 percent of the stream crossing is at risk.

Figure 70—Multiple culverts can trap debris and sediment more easily. This structure, on the paved road to the left, plugged and catastrophically failed in 2005, San Dimas, CA

Figure 71—The vented-ford structure on the right was designed for stream bedload and debris, Plumas National Forest.

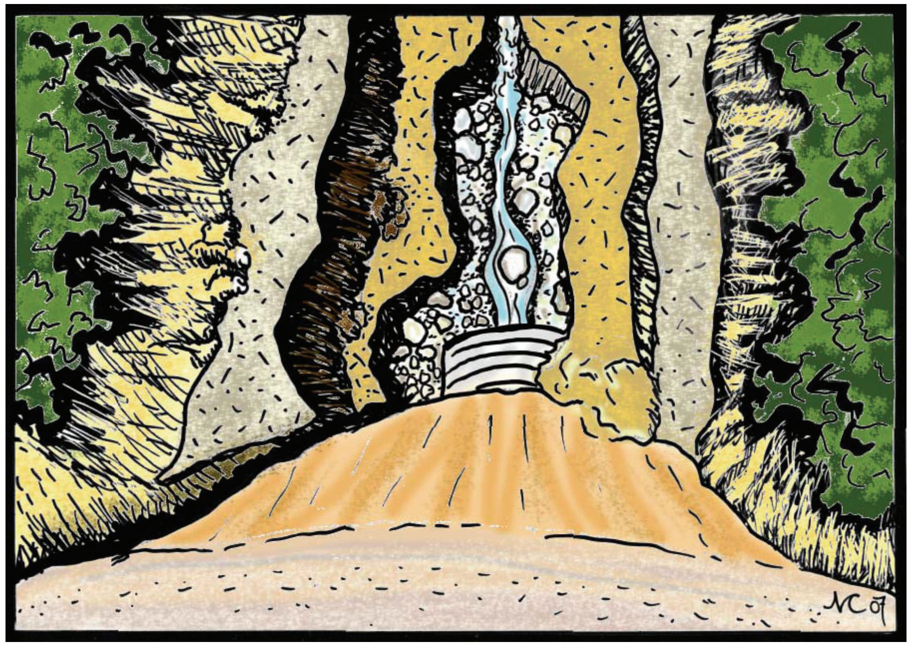

Figure 72—Signs of deposition above a culvert are often reflected by development of terraces. Stream crossings with deposition are "at risk."

Figure 73—Terraces have developed in the front of this culvert on a seasonal or intermittent channel, Los Padres National Forest.

Figure 74—Deposition at the entrance to the culvert with a concrete headwall reduces the capacity of the culvert; the crossing is “at risk,” San Bernardino National Forest.

Figure 75—Inspect the inside of culverts at stream crossings to ensure the structure is debris-free, San Bernardino National Forest.

Figure 76—Healthy vegetation also can obscure inlet conditions. Take the time to inspect culverts and crossings and see if they are functioning as designed, White Mountain National Forest.

Figure 77—Rust on culverts can signal the need for replacement, White Mountain National Forest.

Figure 78—Inspect low-water stream crossings to ensure there is no scouring or erosion of the channel, Stanislaus National Forest.

Figure 79—Unarmored low-water stream crossing is overwidened from changes to the stream gradient through the road's traveled way, San Bernardino National Forest.

Road-Subsurface Drainage

Subsurface drainage is designed to intercept, collect, and redirect ground water that may otherwise flow into the road subgrade. Subsurface-drainage systems vary by design depending on the resource objectives. A common method uses ditch and ditch-relief culverts that intercept and redirect ground water into a stream. Permeable fills are constructed to allow ground water to percolate through the subgrade of the road. French drains (or an engineered drainage system) may be designed for isolated water pockets to keep water away from the road surface while maintaining soil strength and improving the road's load-bearing capacity.

Evaluate subsurface-drainage features by looking at ditch erosion; vegetation composition above and below the road; and/or adverse impacts from intercepting subsurface flows, such as vegetation community changes.

	Functional	At Risk	Impaired
Subsurface Drainage	Intercepts subsurface flows with no adverse effects to vegetation and shows no signs of ditch scour.	The visual indicators show the ditch is eroded. There is evidence of vegetation community change, or the ditch does not adequately accommodate subsurface flow.	More than 25 percent of the road segment is at risk.

Figure 80—Inside ditch is used to capture subsurface flows. Drainage is functional with no adverse effects to vegetation or signs of ditch scour, Tongass National Forest.

Figure 81—Subsurface drainage is not accommodated adequately in ditch; segment is “at risk,” Tongass National Forest.

Figure 82—Roads intercepting springs may show signs of rutting. French drains often are installed to serve as a conduit for springs and help maintain the road’s load bearing capacity, White River National Forest.

Figure 83—Constructing and maintaining roads in areas with high ground water tables is prevalent in regions 9 and 10. Other regions also experience high water tables associated with riparian or meadow ecosystems. Turnpiked-road segments with culverts or a permeable fill allow for subsurface water movement. Inspect these areas for signs of vegetation changes or stress, Tongass National Forest.

Figure 84—Permeable fills can provide the load-bearing capacity needed for many roads while maintaining healthy meadow environments, Tongass National Forest.

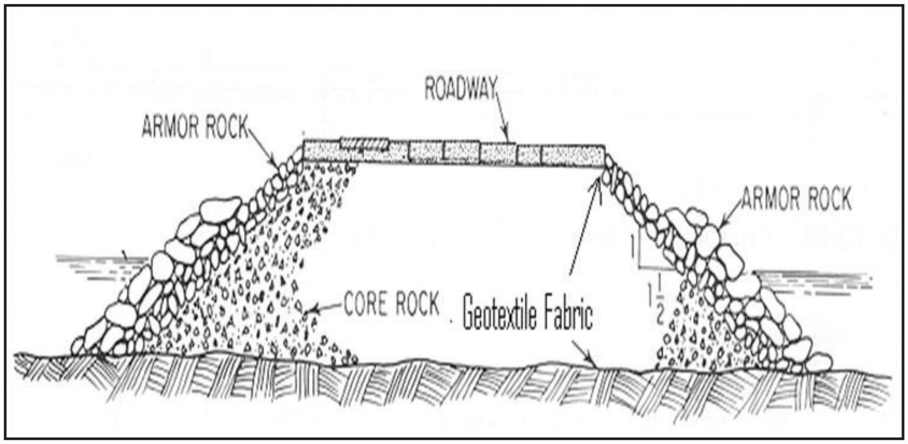

Figure 85—A permeable fill uses different rock sizes to complete a matrix that has both load-bearing capacity and permeability. Subsurface flows move through the structure, and in the event of surface runoff, the permeable structure has water moving through—and in some cases—over the road.

Figure 86—Signs of ditch scour may indicate increased subsurface flow and inadequate ditch capacity. Use the "at risk" rating for subsurface flows, Tongass National Forest.

Diversion Potential at Crossings

Diversion potential is the potential for natural flowpaths, such as streams, creeks, and channels, to be intercepted by the road crossing. Diversion-potential predicts how a stream responds if the capacity of the stream-crossing structure is exceeded, or if the culvert plugs with debris. If the stream would overtop the crossing and remain in its natural channel, there is no diversion potential. If the stream overtops the crossing and flows down the ditch or road, diversion potential exists (Furniss 1997).

Diversion potential is often found on roads with a continuous climbing grade intersecting streams, or where the road slopes downward away from a stream crossing in at least one direction. Insloped roads are more likely to have diversion potential because the inboard ditch and road-bed orientation keeps flows moving down the road versus across the road. Diversion potential is eliminated by changing the road grade with a drainage dip below the crossing or cross-drain culvert.

Evaluate diversion potential by locating the low point of the road over the crossing structure compared to the surroundings. Reviewers identify the water flowpath if the culvert plugs or in an exceedance event. Track the number of crossings with diversion potential within a road segment; not recognizing one location with diversion potential can adversely affect soil and water resources.

	Functional	At Risk	Impaired
Diversion Potential at Crossings	No diversion potential exists at natural drainage crossings.	Natural drainage crossings have diversion potential.	More than 25 percent of the natural drainage crossings have diversion potential.

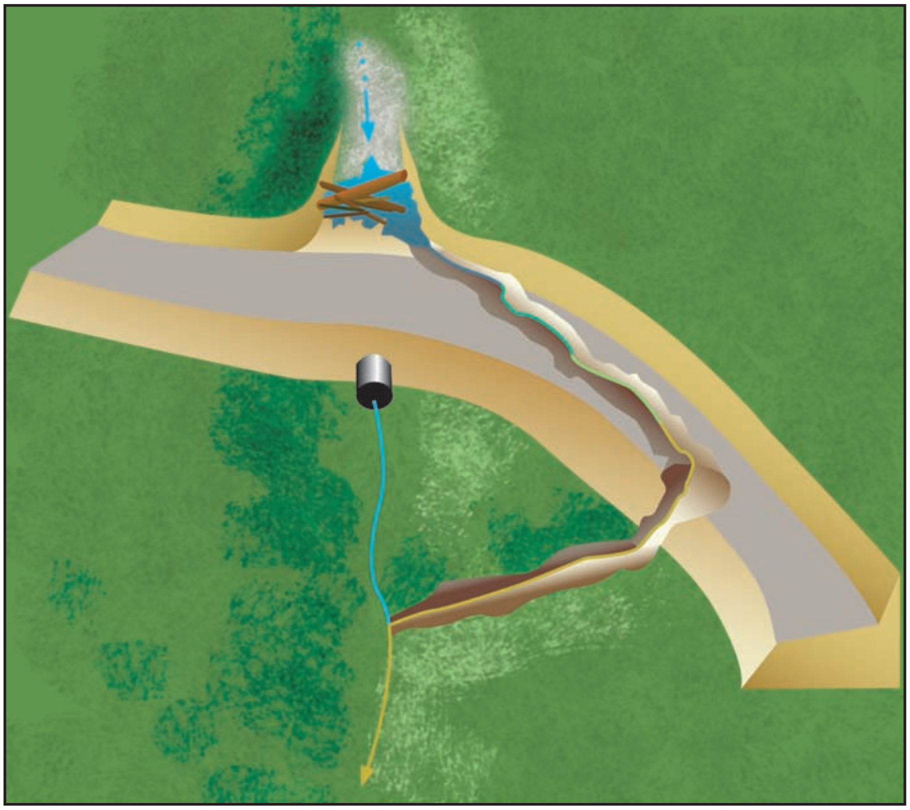

Figure 87—Diversion potential occurs when there is an exceedance or plugging of a natural stream crossing causing the stream to divert out of the channel.

Figure 88—Diversion potential can often be exacerbated by insloped roads with a ditch. Once diversion potential is identified, determine where the water is most likely to go prior to returning to the stream channel, Tongass National Forest.

Figure 89—The effects of diversion potential often render a road undriveable, cause accelerated erosion and loss of soil productivity as large gullies are created, and may result in tons of sediment being delivered to streams, San Bernardino National Forest.

Road-Stream Connectivity

Connectivity is the connection of road-drainage features to the stream. Research indicates that roads are connected to the channel network through ditches, ditch-relief culverts, gully incision, and natural stream crossings. Connectivity is generally expressed as the percentage of the total road length that is connected to the channel network rather than the percentage of a given road segment.

Road-stream or hydrologic connectivity of a road is broken into two categories. Category 1 is the road-segment length (surface or ditch) that discharges directly into a stream channel. Category 2 is the length of a road segment draining into a ditch-relief culvert with gully incision at the outlet providing a continuous flowpath to a stream.

	Functional	At Risk	Impaired
Road-Stream Connectivity	The road is disconnected from channel network. Surface water from road prism reinfiltrates into soil. There are no established flowpaths.	Gullies are evident from cross-drain culverts or there are continuous flowpaths from road surface to stream channel.	More than 25 percent of the road segment is connected to the channel network from drainage ditches or cross-drain outlets.

Note: Rating is for each segment. Combine all road segments for the entire road length connectivity.

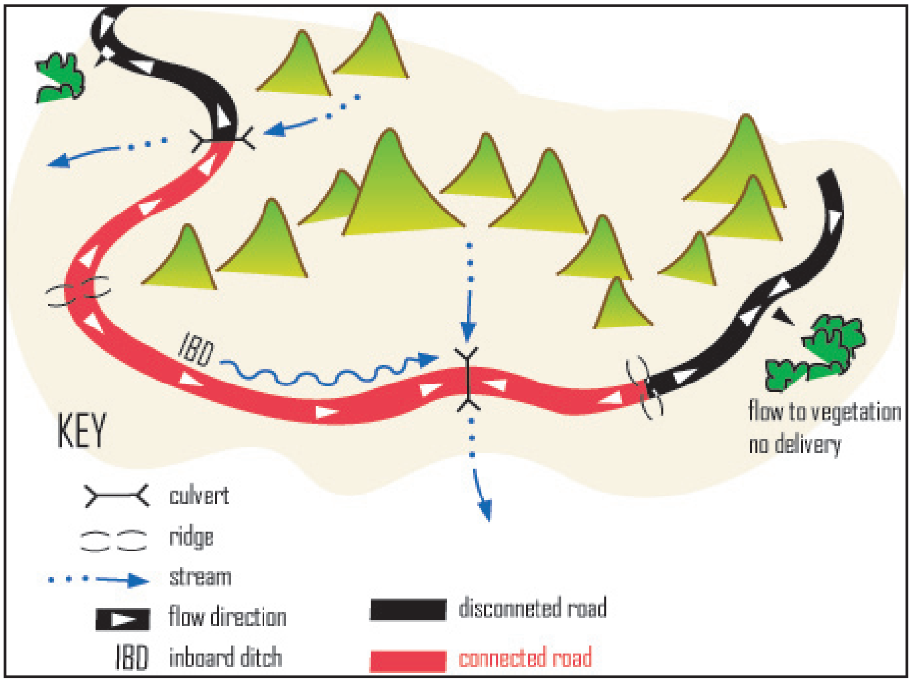

Figure 90—The red segment shows how a road segment is directly connected to a stream channel from an inboard ditch and also the slope of a road. Black road segments are disconnected and reinfiltrate into the soil.

Figure 91—Road segment is directly connected to the low-water crossings. All sediment that comes from the road will enter the stream. Rate this segment as "at-risk," Los Padres National Forest.

Figure 92—Road-stream connectivity as material moves on to the bridge and then enters the stream channel. Bridge approaches are commonly paved to "disconnect" roads from streams at crossings, Maine State Forest Service.

Figure 93—Road-stream connectivity is illustrated by the sediment in the ditch and the sediment on the road surface both entering the stream channel, Bighorn National Forest.

Figure 94—Road-stream connectivity is present as water and sediment move in the inboard ditch to ditch-relief culverts that release road runoff and sediment into the adjacent stream channel. Inspect outlets of ditch-relief culverts for signs of erosion and connectivity to streams, Los Padres National Forest.

Figure 95—Category 1 road-stream connectivity: road sediment directly entering the stream, Bighorn National Forest.

Figure 96—Options to eliminate road-stream connectivity at this crossing are being analyzed by the Bighorn National Forest.

Figure 97—Category 2 road-stream connectivity: ditch and ditch-relief culvert are connected to the stream below this gully. Inspect the ditch-relief-culvert outlet for gullies and determine if the road is connected to the stream via the gully, Los Padres National Forest.

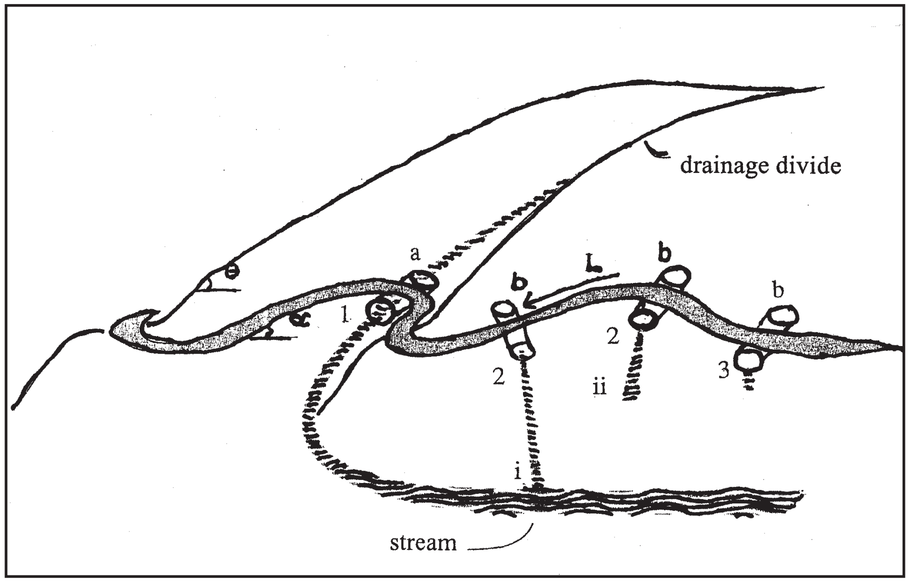

Figure 98—Stream-crossing culverts, which route a stream below a road. Ditch-relief culverts were classified according to whether they discharged (1) directly to a stream channel, (2) onto hillslopes below roads where gully incision occurs, or (3) where water reinfiltrates into the hillslope soil. Gully incision may provide a continuous flowpath to stream or may function as a discontinuous channel segment. Adapted from Wemple.

Figure 99—Gully from a ditch-relief culvert extends 1,000 feet, White River National Forest.

Figure 100—Road-surface condition ratings also will help to determine road-stream connectivity as rill patterns are identified. Although this road is only slightly entrenched, it captures road runoff and creates a gully across the meadow before entering the stream channel, White River National Forest.

Figure 101—An entrenched road delivers all road sediment directly to the stream, San Bernardino National Forest.

Figure 102—Sediment deposition in channel below crossing, San Bernardino National Forest.

Figure 103—Road with overside drains, located within streamside management zone, efficiently conveys sediment directly to seasonal channel, San Bernardino National Forest.

Figure 104—Determine the flowpaths and length of contributing road where road-stream connectivity is present. Treatments that reduce the length of contributing area are often implemented and include modifying the road shape with broad-based dips, paving approaches, redirecting runoff to buffers, and relocating roads outside of streamside management zones where possible, Ouachita National Forest.

Road-Surface Condition

Road-surface condition may reflect season-of-use or maintenance needs to restore surface-drainage features. In wet conditions surface runoff can be observed through rills or gullies on the road surface. Rutted roads alter road drainage, which may affect soil and water quality. Dry-road conditions can result in soft powdery material (surface fines) that is susceptible to erosion with the first storm event.

Identify the presence of rills, ruts, or gullies on the road surface. Fluffy, uncohesive soils also indicate an at-risk road segment.

	Functional	At Risk	Impaired
Road-Surface Condition	The road surface has no concentrated flowpaths, rills, or gullies.	Rills and gullies are evident on road surface.	More than 25 percent of road segment has rill network or rutting that alters road-surface drainage.

Figure 105—Road-surface rating for this road segment is "functional," Panhandle National Forest.

Figure 106—Entire road is "impaired" due to its use during wet season under saturated conditions, Maine State Forest Service.

Figure 107—Road-surface rutting alters runoff flowpaths. Determine access requirements for roads and include them in the road-management objectives, White River National Forest.

Figure 108—Steep road with rutting along its entire length would rate as "impaired," Los Padres National Forest.

Figure 109—Road-surface rilling can result from infrequent maintenance of the road-surface shape. Declining road-maintenance budgets combined with a large number of miles to maintain results in only critical resource items being addressed during maintenance, Ouachita National Forest.

Figure 110—Rill pattern on the road is highlighted, White Mountain National Forest.

Figure 111—As road surfaces dry out they can become fluffy and unconsolidated with use. With rain the loose road-bed material generated is vulnerable to erosion. Document road segments with loose, unconsolidated material during field inventories, Lake Tahoe Basin Management Unit.

Cutslope Condition

To measure cutslope conditions, evaluate the segment from the top of the cutslope to the roadbed. Identify any signs of erosion or mass wasting and the amount of vegetation.

	Functional	At Risk	Impaired
Cutslope Condition	Cutslope is vegetated and stable with minimal signs of erosion.	Slope is unvegetated and unstable with signs of erosion.	More than 25 percent of segment is unvegetated or unstable.

Figure 112—Observe the vegetation pattern while driving the road segment. Often, a pattern develops as shown in this picture. Determine if the vegetation is sufficient to reduce erosion, White River National Forest.

Figure 113—A rocky and unstable cutslope. Examine the effects of the cutslope and determine if road drainage is affected, Tongass National Forest.

Figure 114—This unvegetated and unstable segment rates as "impaired" since the vegetation pattern persists for entire segment length, San Bernardino National Forest.

Figure 115—A well-vegetated cutslope, Los Padres National Forest.

Figure 116—This unstable cutslope shows signs of erosion and sediment delivery to road. Unstable cutslopes can fill in ditch segments and divert water from the ditch, San Bernardino National Forest.

Figure 117—Rilling on short cutslope, White River National Forest.

Figure 118—This cutslope has sloughed into inside ditch and will divert flows out of ditch, Klamath National Forest.

Fillslope Condition

To measure fillslope conditions evaluate the segment from the outside edge of the road to the toe of the fillslope. Identify any signs of erosion or mass wasting and the amount of vegetation.

	Functional	At Risk	Impaired
Fillslope Condition	Fillslope is vegetated and stable with minimal signs of erosion.	Fillslope is unvegetated and unstable with signs of erosion.	More than 25 percent of the fillslope is unvegetated; signs of mass wasting or slumping; partial loss of road width.

Figure 119—In this picture erosion of the fillslope can be seen from across the canyon. Additionally, a large unvegetated cutslope is clearly visible. Aerial photos and photographs can be useful in locating unstable cutslopes and fillslopes, San Bernardino National Forest.

Figure 120—Unstable fillslope shows where runoff exited the road leaving this hole and unconsolidated fill. Place warning signs and flagging to increase driver awareness of hazards, San Bernardino National Forest.

Figure 121—Rill erosion on unvegetated fillslope. Erosion and sediment is delivered effectively to the water body below, White River National Forest.

Chapter IV—Maintenance or Road Improvement Considerations (Step 3)

Once step 2—the road condition evaluation—is completed, collect the following information to identify maintenance or improvement considerations.

Operational Maintenance Level

The operational maintenance level is the maintenance level currently assigned to a road considering today's needs, road condition, budget constraints, and environmental concerns. The engineer can provide information on the operational maintenance level. Use this information to ensure environmental concerns are being met.

Maintenance levels are defined by the FSH 7709 as the level of service provided by, and maintenance required for, a specific road. Maintenance levels must be consistent with road management objectives (RMOs), and maintenance criteria. (FSH 7709.58, Chapter 10, 12.3)

Maintenance prescription guidelines include the traveled way, shoulder, drainage, roadway (vegetation), structures, and traffic service. Maintenance levels range from level 5 (highest) to level 1 (lowest). A level 5 road is normally double-lane, paved, and meets the requirements of the Highway Safety Act and Manual of Uniform Traffic Control Devices. A level 1 road is assigned to intermittent-service roads and is closed to vehicular traffic. The closure period must exceed 1 year. Basic custodial maintenance is performed to keep damage to adjacent resources to an acceptable level and to perpetuate the road to facilitate future management activities. (USDA Forest Service 2005)

Season of Use

Many Forest Service roads are closed seasonally by snow. However, lower-elevation roads are often designed to receive traffic year long. Adverse impacts frequently occur to roads designed for seasonal use. Early or late season use may result in ruts modifying surface runoff and adversely affecting soil and water quality.

Identify the road's intended season of use to determine cause-and-effect relationships with the road-condition evaluation rating. Soil scientists and engineers can determine if RMOs are being achieved and if subsequent actions are necessary, such as a seasonal road closure.

Traffic Level

The traffic a road receives may change yearly depending on management activities. Some roads receive constant use and others may have increased traffic due to recreational activities. Roads leading to trail heads, campgrounds, fishing areas, or woodcutting sites are revisited yearly. Roads to forest health and thinning projects may have increased use during the project. Traffic levels become important when trying to interpolate sediment production from a road segment. The Forest Service road erosion model, Water Erosion Prediction Project (WEPP), includes traffic level to predict sediment.

Increased traffic volume may result in a change in the road's operational maintenance level for the duration of a project. Work with the engineer to determine what constitutes high- and low-traffic levels for the forest or district.

Identify traffic level as high, low, or closed on the SWRCI form.

Design Storm

The design storm is used to determine the proper sizing of stream-crossing structures to prevent damage to the road infrastructure and soil and water quality. Many factors are taken into consideration, including the rainfall duration and intensity (i.e., 24-hour, 6-inch storm). Manning's equation or the continuity equation can be used to calculate flow in channels. Plus there are other regional regression equations for estimating magnitude and frequency of floods to determine culvert and bridge sizing.

Since SWRCI is a rapid assessment tool, reviewers should identify the dominant storm type for the structures on the road segment (e.g., snow, rain, or rain on snow). Reviewers should look for evidence that a stream-crossing structure is not sized adequately. Indicators may include the following:

- Rock and soil piles adjacent to crossings from frequent maintenance removal.
- Fillslope erosion from exceedance or overtopping events.
- Sediment wedge or terrace development at the culvert inlet.
- Erosion and scour at the culvert outlet.

Soil Texture

Soil erosion from the road surface, cutslope, or fillslope can adversely impact water quality. Stream diversion creates tremendous soil loss, and few restoration actions are performed to restore the eroded hillslope. Soil on cutslopes is often low in organic matter and soil nutrients. Identify the soil texture to select suitable vegetative mixes that are resilient in subsurface horizons.

Identify the soil texture as clay loam, sandy loam, silt loam, or loam, and use WEPP roads to model the amount of road-prism erosion and sediment leaving the buffer.

Causes of Sediment Transport

Field crews can identify potential or known causes of sediment transport during field observations. Capturing observations on the time of use of the road, location or design elements, lack of maintenance, or inadequate drainage features provides the reviewer with valuable information.

Site-Specific Concerns During the course of survey work a crew may identify an area requiring immediate attention. Using a GPS or a USGS map, clearly identify the location and provide this information to the crew leader immediately. In situations with an unstable travelway or washed-out culverts, place barricades or use flagging to warn other motorists.

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Forest Service and U.S. Department of the Interior, Bureau of Land Management employees also can view videos, CDs, and SDTDC's individual project pages on their internal computer network at: http://fsweb.sdtdc.wo.fs.fed.us/

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