

**APPENDIX E:
FOREST ROAD SEDIMENT ASSESSMENT METHODOLOGY**

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SEDIMENT ASSESSMENT METHODOLOGY

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1.0 INTRODUCTION

This document describes a method of analysis for calculation of sedimentation rates from both natural background and forest roads (including road tread as well as cut and fill slopes).

This process is repeatable, rigorous, and defensible, but it does rely on a substantial amount of professional judgement. An integral part of this assessment methodology is concise and careful notation in the field of rationale behind judgement calls as they are made. These should be included in the final assessment report and can serve as valuable documentation during scrutiny of the process and the values derived.

2.0 NATURAL RATES OF SEDIMENTATION

There are numerous ways to calculate a natural background erosion rate. Two are presented here as examples. Depending on available data, more reliable methods may be derived.

2.1 Soil Creep Estimate

The soil creep calculations described here are from the *Washington Forest Practices Board* (WFPB) manual (1995). Annual erosion rates are calculated using the following equation:

$$\text{Annual Erosion Volume (m}^3\text{/yr)} = (L*2) * D * C$$

where:

- L = length of stream channel in meters (this is doubled to account for both sides of stream).
- D = soil depth in meters.
- C = creep rate in meters per year.

Based on information provided in WFPB (1995) the creep rate was assigned as 0.001 m/yr for basins with average slope of <35% and 0.002 m/yr for basins with average slope of >35%. Stream length may be determined by planimeter or GIS, if available. The hydrography layers should be checked for accuracy by direct observations.

Soil depth information is often available from a local USDA office or other government office depending on the location. In many cases, soils inventories provide erosion rates for a combination of both coarse and fine sediment. If this is the case, one must apply a factor for the percent fines in the soil types in the study area.

2.2 Landtype Estimate

A second common method for estimating natural erosion rates is with Forest Service landtype estimates of base surface erosion rates. A watershed erosion rate may be calculated as a weighted average by area of landtype. This may be done manually with a planimeter or with GIS.

The values of natural background sedimentation are then compared to road sedimentation to determine the percentage of total sediment load that is coming from forest roads.

3.0 RATE OF SEDIMENTATION FROM ROAD SURFACES

3.1 Collecting Data and Applying Mitigation Factors

The assessment of erosion and fine sediment delivery from roads is essentially an accounting procedure that involves actual field observations of erosion and delivery of sediment to streams. Streams are defined as “any drainage depression containing a defined bed and banks extending continuously below the drainage site. Flow regime can be ephemeral, intermittent, or perennial”. Therefore, erosion that was delivered to a drainage feature known to be discontinuous below (i.e. no connection to downstream waterbodies) should not be counted in the sediment budget presented below.

The contributing area associated with stream crossings is considered to be all areas of road tread, cut slope, and fill slope, from which water could flow to the stream. In other words, if the road tread and cut slope were relieved by a drain dip 100 feet from the culvert, then only that 100 feet between the dip and the culvert would be considered in the sediment budget. In some cases, road drainage features such as drain dips are not 100% effective. That is, they do not capture all runoff from the uphill sections of road. In these instances, the observer must take this into account when characterizing the ultimate delivery ratio for any given site.

Several mitigating factors were applied to this measurement of actual eroding surface area. These were applied as average factors over each individual eroding area.

The factors are shown in **Table 1**.

Table 1. Factors Applied in Road Surface Sedimentation Assessment

Factor	Definition
Cover	Percent of non-soil cover
Gravel	A categorical factor accounting for mitigating resulting in gravel road surfacing
Traffic	Factor accounting for higher erosion from higher traffic roads
Snow	Percent of the year when snow or ice mitigates surface erosion (applied directly to traffic factor)
Delivery	Percent of displaced fine sediment which is delivered into a waterbody

Cover Factor

The cover factor is the percent of non-erodible cover on each of the three road features (tread, cutslope, and fillslope). Cover percent translates into the following factors applied in the sediment calculations:

Table 2. Factor for Percent Cover Values

Cover Percent	Factor
>80%	0.18
50%	0.37
30%	0.53
20%	0.63
10%	0.77
0%	1.00

Gravel Factor

The gravel factor accounts for reduced erosion from roads with gravel applications. With a gravel lift of 2” to 6” depth the factor is 0.50. With a gravel lift of >6” the factor is 0.20.

Traffic and Snow Factors

The traffic multiplier accounts for the fact that roads which receive heavy truck traffic have higher erosion rates. This factor ranges from 1 to 50 as shown in **Table 3**. The value assigned depends on the use that the road experiences. Greater traffic results in a greater multiplier. The actual factor one uses should be a judgment call.

Table 3. Traffic Factors

Traffic use / Road Category	Annual Precipitation	
	<1200 mm	1200 mm-3000 mm
Heavy Traffic / Active Mainline	20	50
Moderate Traffic / Active Secondary	2	4
Light Traffic / Not Active	1	1

The snow factor is the estimated percent of the year that the road feature being assessed is under snow and/or ice. The factor works counter to the traffic multiplier. It accounts for the fact that when a road is covered with snow or ice, the traffic is not dislodging soil particles.

Percent Delivery

The determination of the percent of eroded fine sediment which is delivered to a stream is perhaps the most challenging part of this assessment methodology. This factor must take into account the observer’s sense of sediment delivery over time and, without an accurate way to characterize historical or potential future sedimentation, it becomes a judgment call.

It is also easy to “double mitigate” with the percent delivery. In other words, one could reduce the calculated amount of sediment being generated at a given location by using the gravel factor and on top of that, claim that the *delivery* was very low due to the lack of sediment *generation*.

This is double mitigation for the gravel. The amount of fine sediment generated and the amount of fine sediment delivered are two different factors. To avoid this pitfall, one should be careful to consider “delivery” as the *potential* for sediment to be carried to a stream once it is eroded. If there is no sediment being eroded, take that into account with the cover factor, gravel factor, etc.

Table 4 shows the descriptions for delivery categories. These can be adjusted based on the experience and judgment of the observer.

Table 4. Categories of Sediment Delivery to Streams

Percent Category	Description
100%	Chronic direct delivery under most erosional scenarios.
75%	Direct delivery evident but not chronic, effective buffer (provided by distance, gentle topography, or vegetation) during low intensity erosional events.
50%	Direct sediment delivery but minor amounts or older events.
25%	Direct delivery unlikely except in moderate to major erosional events.
5%	Effective buffer, but proximity of road to stream makes 5% necessary.

3.2 Sedimentation Calculation

To calculate the volume of sediment contribution from each road location take the following steps:

1. Assign a base (natural) erosion rate from roads in tons/acre/year. This commonly comes from a combination of published values and professional knowledge of the soils in the watershed.
2. Calculate the area of erosion (length times width) for the tread, cut and fill slopes, and convert it to acres.
3. Apply each multiplier (cover, gravel, traffic, snow (applied to traffic factor directly), and percent delivery).
4. Multiply all of these together for the road tread, cut slope, and fill slope individually to derive the sediment volume from each of these features.
5. Sum these three values for the total delivery for that location, in tons of sediment per year.

Location totals thus derived are then summed for the entire watershed to arrive at a total fine sediment contribution from roads.

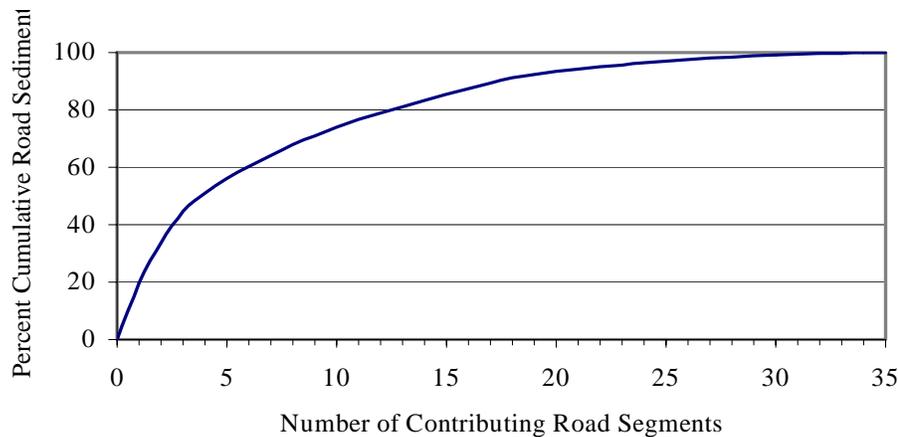
4.0 APPLICATION OF DATA TO WATERSHED RESTORATION PROCESS

The tabulated data for sedimentation from road surfaces can be used to plan and account for sediment reductions in a watershed. For most watersheds, a small number of road segments will be responsible for a large portion of the total sedimentation load. **Figure 1** shows a typical distribution of watershed-scale sedimentation volumes for road segments. The road sediment data can be used for the following purposes, depending on the ultimate objectives of the assessment project:

- Comparison to natural background rates to determine a quantitative impact.

- By ranking road segments in terms of total fine sediment delivered, one can determine where restoration or mitigation activities would most efficiently reduce sediment delivery to streams. By addressing the erosion from these segments, a quantitative reduction in sediment delivery may be achieved.
- Proposed restoration activities can be “modeled” in the spreadsheet to show projected sediment reduction volumes.
- As improvements are made to specific road segments (e.g., better drainage, improved sediment buffers, etc.) the total volume of sediment coming from roads in the basin is reduced and this can be used in a TMDL.

Figure 1. Typical Cumulative Frequency Distribution of Road Segments Contributing Fine Sediment



Applying the data from the culvert failure assessment is a qualitative exercise. As improvements are made to specific stream crossings (e.g., larger pipes installed, better rock armoring, better alignment, replacement of pipes with a bridge, etc.) the total volume of sediment at risk of failure in the watershed is reduced and this, although qualitative, can be used in a TMDL.

Using this assessment methodology, managers can more efficiently focus their restoration dollars and can document improvements. This planning process and the subsequent mitigation activities are likely going to be a strong foundation in the development of a TMDL for waterbodies impaired by fine sediment resulting from forest management.

