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Summary of Forest Road Construction and Maintenance Guidelines. Reference, "Influence of Forest and Rangeland Management on Salmonid Fishes and Their Habitats."
Author, William Meehan, U.S.D.A. Forest Service, American Fisheries Society Special Publication 19, Chapter 6, Timber Harvesting, Silviculture and Watershed Processes.

Background: The purpose of this analysis is to identify the important design and maintenance criteria for forest roads and to compare these to the next generation of Forest Practices Road Rules being prepared by the Road Rules task force. A second analysis of these principles will also be performed to compare these principles against the Handbook for Forest and Ranch Roads, Weaver and Hagan's, 1994.

General Principles (Pages 303-324)

1. Know what the erosion process is, how roads can affect these processes. Identify sources of sediment, unstable areas, baseline sedimentation, and high hazard areas to prevent or control changes in erosion patterns.

2. Avoid road construction in unstable, high hazard areas. Minor changes in layout can prevent major problems. This is usually the most important consideration in preventing degradation of fish habitat.

3. Prevention of erosion vs. remediation. It is always less expensive and more effective to build roads so that erosion is prevented or minimized than to control sediment once it is mobilized.

4. Keep roads as far as possible from watercourses and provide buffers of sufficient width to prevent sediment from reaching the watercourse.

5. Planning, reconnaissance, route selection should include the input from soil scientists, geologists, hydrologists and fisheries biologists. Key environmental problems and constraints are easily overlooked when routes are located and roads designed by one person.

Key design Principles

Planning and Reconnaissance

1. Have a long range transportation plan that will ensure that the road network will serve future needs. This will result in lower road density, lower maintenance costs and fewer environmental impacts.

2. Have adaptable standards, fit road to the terrain to avoid unstable areas, avoid "rigid" grade restrictions to allow steeper grades (14-22 %) for short distances to provide flexibility to avoid unstable areas.
3. Avoid mid-slope locations in favor of higher, flatter areas--roads on ridge tops usually have the least effect on watercourses.
4. Avoid tributary sources
5. Avoid Inner-Gorge locations. These areas have the highest incidence of landslides.
6. Avoid slopes that show signs of excessive wetness (springs, water-loving vegetation.)
7. Avoid areas where excessive gullying and slope displacement are occurring
8. Avoid slopes where sidecast material can enter a watercourse or plan to end-haul excess material.
9. Avoid slopes where large cuts and fills would be required. (Maximum depth of fill no greater than 4 ft.)
10. Avoid valley bottom roads. If this is not feasible, have buffers of sufficient width to prevent road runoff from reaching the watercourse.
11. Locate landings and road junctions in naturally flat areas. Good landing locations can reduce the amount of required roads.
12. Minimize the number of stream crossings. Road approach to the watercourse should be at or near 90 degrees. When constructing watercourse crossings minimize the changes to the natural channel.
13. Use the minimum road width for single lane traffic.

<u>Road Design Standards</u>

1. Minimize excavation by balancing cuts and fills.
2. Minimize excavation with balanced earthwork design, bench and terrace construction, drain natural slopes to provide a sound road foundation. Design the cutslope as steep as possible to reduce the size of the cut.
3. Predetermine type, extent of fish habitat before designing culverts and crossings.
4. Bridges and arch culverts are best for fish migration (up and downstream). Culvert slope should be less than 1%, the culvert bottom should be located below the stream bed elevation and the water depth and velocity should conform to DFG design requirements for fish passage.
5. Control scouring at outlets with energy dissipaters such as heavy rock to avoid creating a "perched" outlet that will become a fish migration barrier.
6. Design crossing structures (culverts, bridges) for a peak flow of at least the 50 year flood or preferably the 100 year flood. A culvert designed for a 50 year flood will have a 33% chance of failure during a 20 year design life. Whatever flow rate is used in the design, the crossing structure will have a 100 % chance of failure. Therefore, the design should be designed to "fail soft" i.e. overflow from a plugged culvert should be routed back into the channel downstream of the crossing rather than allowing the overflow to move down the road. Rolling dips can be used for this purpose.
7. Avoid channel width changes when placing culverts, Align the culvert with the

natural direction of the water flow, armor the inlet and outlet with large rock.

8. Design the road surface to maintain a stable operating surface during the wet season. Hard surface or rock where practicable. Control access on roads intended for dry season use.
9. Use outslope drainage wherever feasible to disperse runoff. Generally outslope drainage works well when side slopes are greater than 20%. Insloping with frequent cross drainage is appropriate on steeper roads. On roads with insloped drainage, install cross drains at frequent intervals being careful to avoid discharging onto areas prone to gullying, slumping or landsliding. Ditches along steep grades should be lined with rock to control ditchline erosion.
10. When discharging onto a long erodible fill, use a discharge pipe to convey the drainage to the bottom of the fill. Use energy dissipaters at the outlet.
11. Provide for vegetative or mechanical stabilization in areas where cut and fill erosion will cause sediment delivery to watercourses.
12. Keep approaches to streams as close to right angles as possible to minimize streamside disturbance.
13. Develop a specific plan for stream crossing construction that addresses potential diversion, disturbance limits, equipment limitations, erosion control and operational time period when disturbances caused by construction can be minimized.
14. Design and construct watercourse crossings so that they will not divert stream flow out of the channel and down the road if the culvert should plug or fail. (See rolling dip comment # 6 above)
15. Field check the designs before plan drawings are prepared to make sure that the design fits the terrain, drainage needs have been met, that critical slope conditions and unstable areas are indentified.

<u>Construction Practices</u>

1. Schedule construction to avoid critical spawning, rearing and migration periods.
2. Complete erosion control structures prior to the beginning of the wet season even if construction is not complete.
3. Remove loose earthen material and debris from stream banks at the crossing
4. Avoid having woody debris buried in fills.
5. Locate camps and fuel storage areas well away from watercourses. Construct spill protection dikes to retain spills
6. Locate water removal points to minimize stream bank degradation and erosion.

<u>Maintenance Procedures</u>

1. Don’t leave berms on the outside edge of the road after grading. Berms channel drainage down the road.
2. Regularly inspect ditches, cross drains and culverts. Avoid excessive cleaning as it increases likelihood of increased sedimentation.
3. Grade and shape roads to conserve surface material.
4. Don’t side cast material when grading unsurfaced roads during the wet season.

5. Close/reclaim unneeded roads, remove crossings, culverts etc.

Fish Passage Considerations (Ref. California Salmonid Stream Habitat Restoration Manual, Department of Fish and Game, Third Edition, 2/2003, Fish Passage Evaluation)

State and Federal Guidelines for new crossing installations aim to provide for unimpeded passage for both adult and juvenile salmonids. However, many crossings are barriers to anadromous adults, more so to resident and juvenile salmonids whose smaller size limits their swimming and leaping abilities.

Characteristics of fish-friendly crossings include:

1. Crossing width should be at least as wide as the active channel. This reduces the constriction of flows at the inlet and reduces the chances of debris blocking the culvert inlet.
2. The culvert should pass a 100 year storm flow at a depth of less than 100% of the culvert height.
3. The crossing (culvert) bottom is buried below the stream bed grade.
4. Natural bed material is accumulated on the crossing (culvert) bottom.
5. The water surface within the crossing blends smoothly with upstream and downstream water surfaces without excessive drops.
6. Obvious turbulent conditions are not present
7. No obvious signs of excessive scour of the tail water pool
8. Stable stream banks upstream and downstream of crossing

Other considerations

1. Consider low-water depth crossings instead of culverts. Low water crossings can be used where transportation requirements are seasonal and the slope and stream channel configurations are suitable. Use of concrete sills and grade control structures can be barriers at low flow however. These crossings are preferable to culverts because at high flow conditions the crossings do not become barriers and at low flow the barrier conditions can be mitigated.

2. Consideration of fish passage during the planning and design of a road system can greatly reduce the risk of creating barriers to fish migration. Where culverts are deemed necessary, close coordination between fisheries biologists and engineers is critical. The first consideration is whether the stream is used by fish to migrate during their life cycles. The designer must know what species are present and what their swimming and jumping capabilities are. Facilities for fish passage should be based on the least capable fish in the stream, not the champion swimmers. The following conditions are necessary:

   A resting-jumping pool must be immediately below the obstacle. This allows the fish to rest and conserve energy and build up swimming speed to overcome the

obstacle.

Individual jumps should not be too high (Salmon and steelhead can jump .6-.9 meters or a series of .3 meter jumps)

Water depth through the culvert must be adequate for swimming. A minimum depth for salmon is .3 meters.

Water velocity in the culvert must not exceed the maximum sustained swimming ability of the migrating species for which the passage is designed. (6 m/sec for Adult Coho)

Resting areas should be provided en route whenever the swimming distance through a difficult obstacle exceeds 15-30 meters.

A resting pool at the upstream end of a difficult obstacle is necessary so that exhausted fish are not swept down stream.

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