Forest Service Handbook
National Headquarters - Washington Office
Washington, DC

Forest Service Handbook 7709.56 – Road Preconstruction Handbook
Chapter 20 - Road Location

Amendment: 7709.56-2011-1

Effective date: July 13, 2011

Duration: This amendment is effective until superseded or removed.

Superseded Directive: 7709.56,2, Amendment No. 1, May 1987

Approved by: James M. Pena, Associate Deputy Chief, NFS

Date approved: July 7, 2011

Responsible Staff:

Explanation of changes: Following is an explanation of the changes throughout the directive by section.

20: Revises entire chapter and makes minor technical and editorial changes throughout chapter. Revises coding from 1-digit to recommended 2-digit coding. Adds references to consider existing trail locations throughout chapter. Adds direction to emphasize the importance of proper road location and states road location procedures may be required in road reconstruction.

20.2: Adds objectives to minimize the environmental impacts and to minimize the life cycle cost of the road.

20.6: Establishes code, caption, and sets forth new direction for "Travel Management Decisions." Adds cross-reference to direction on Travel Management Decisions in FSM 7715.

21: Adds direction to review travel analysis and status of Travel Management Decisions to Road Management Objectives (RMOs) for preparation and signature by line officer, and direction in check list to plan for field crew communications. Adds reference to using data found in Geographic Information Systems (GIS). Revises Forest Service Handbook references related to job hazard analysis and safety requirements.

22: Adds direction to emphasize the importance of a properly located road.

22.2: Adds direction on marking road location on the ground which includes information about alternative alignments considered but not pursued, wetlands, wildlife crossings, special areas, needs for possible slope stability analysis, and Global Positioning System (GPS) coordinates in the location notes.

22.3: Adds direction to consult with appropriate specialists, such as invasive weed specialists and cultural resource specialists when locating construction material sources. Removes direction regarding materials source surveys and recodes direction to chapter 30, section 36.

22.7: Adds direction to consider aquatic passage, riparian, heritage resource, and other sensitive fish and wildlife issues and mitigation needs.

22.8: Adds direction that the field review be completed by an interdisciplinary team.

22.9: Adds direction to assure any information needed to advise environmental analysis and decisionmaking has been collected and transmitted and to assure inventory information in the Transportation Atlas is correct.

23.1: Adds direction on the advantages of using new technology such as GPS, remote sensing, and digital terrain modeling.

23.2: Revises direction in exhibit 01 on changing maximum grade from 4 to 6 percent. Adds direction to discourage locating sharp curves at ends of long tangents and avoid locating "S" curves unless the entire road is winding. Adds direction on locating roads in drainages and riparian areas, and direction to consider future vegetation growth outside the roadway when locating scenic views. Removes obsolete direction in exhibit 01, removes direction on maximum grade of roads with rolling dips and recodes to chapter 40.

23.4: Adds and revises reference materials for road locators.

23.41: Establishes code, caption, and lists references for "Publications."

23.42: Establishes code, caption, and adds electronic hyperlinks to "Internet Sites" for selected references.

Table of Contents

This chapter provides guidance for road location activities. These activities establish the position of a road on the ground, within a predetermined corridor, in a manner that best meets the design criteria.

20.2 - Objective

1. To identify, on the ground, the location of a road that best satisfies the design criteria and Road Management Objectives (RMOs).

2. To accommodate the intended design elements and standards.

3. To provide access for the utilization of the specified forest resources.

4. To minimize environmental and resource impacts.

5. To minimize the life cycle costs of the road, to the extent practical.

20.5 - Definitions

Corridor. A strip of land within which a road can be located. A corridor can vary from several hundred feet in width to a tightly constrained centerline marked on the ground with ribbon flagging. Corridor location is affected by needs and constraints determined in environmental analysis.

20.6 - Travel Management Decisions

Adding a route to the National Forest System (NFS) transportation system, whether by construction of a new road or by incorporating an existing road into the system, is a "travel management decision." Travel management decisions must be advised by appropriate environmental analysis, using NEPA regulations found in 36 CFR 220, FSM 1950, and FSH 1909.15, and decisionmaking. Direction on travel management decisions is found in FSM 7715.

21 - Office Location Studies

The road location process should begin with office location studies. When performing office location studies, review land management plans and other documents that contain management direction affecting prospective road locations. Review travel analyses that address the project. Identify whether travel management decisions have been made to add roads to the system. When decisions have not been made, identify any issues and concerns regarding road location and potential road related resource and environmental impacts that may affect decisions. Assure that Road Management Objectives (RMOs) have been prepared for roads (FSM 7714 and FSH 7709.59, ch. 10). When travel management decisions have been made and applicable environmental analysis has been conducted, assure the RMOs have been approved by the appropriate line officer.

In preparation for field location, resource information, control points, and proposed locations may be projected on aerial photographs, topographic maps, and Geographic Information System

(GIS) displays. Make scales large enough so that they clearly depict the field location information. Special photography or maps may be useful. The use of photos and maps with compatible scales is recommended.

Review the proposed survey and design methods for the project. Select location procedures that are consistent with these methods and are appropriate to the complexity of the project.

1. Resource Coordination Checklist. As a minimum, consider at least the following items when preparing for field location:

a. Control points:

(1) Topographic: Rock outcroppings, stream crossings, saddles, wetlands, landslides, archeological sites and resources, wildlife crossings, or natural barriers.

(2) Management: Non-National Forest System land, National Forest System land dedicated to specific uses, harvest area plans, and proposed logging systems.

(3) Access: Existing landings, termini, overlooks, turnouts, roads, and trails.

b. Resource and access requirements associated with timber, range, wildlife, fire, minerals, heritage sites, wild and scenic areas, watershed, soils, visuals, and recreation.

c. Alternative locations within the planned corridor.

d. Control points must be identifiable on the ground during field location.

2. Final Checklist. Complete the following items before beginning field location activities:

a. A schedule of field activities, including coordination with affected specialists, adjoining landowners, and other interested parties.

b. A job hazard analysis and a review of the safety requirements in FSH 6709.11 and FSH 6709.12, chapter 10. Obtain appropriate safety equipment and be familiar with its use.

c. Arrangements for personnel, equipment, communications, and transportation.

d. Obtain written permission from private landowners or other agencies to work on non-National Forest System lands, when applicable. Written request should be made through the appropriate line or staff officer.

e. Identification of location procedures which are compatible with intended survey and design methods.

f. Review of applicable background files, project objectives, corridor description, and design criteria.

g. Preparation of maps and photos (or photo/map overlays) with corridors delineated and preliminary location(s), control points, and resource features marked.

22 - Field Location

1. Choose the correct location. Choosing the correct location is the most important part of road construction or reconstruction. Proper field location is particularly critical for low standard roads; because the field location often becomes the final horizontal and vertical alignments. The field located alignments also determine drainage patterns that may contribute to long-term maintenance needs, disruption of natural hydrologic processes, and water quality impacts. A properly located road will result in lower costs, fewer maintenance problems, and reduced environmental impacts.

2. Road locators. Road locators should have:

a. A working knowledge of and experience in road survey, design, and road construction techniques and practices.

b. At least a basic knowledge of natural resources issues such as geology, soils, fish, wildlife, hydrology, Threatened and Endangered Species (TES), and cultural resources common to the area.

3. Resource Specialists. Resource specialists should be consulted to identify specific resource issues and concerns in the project area and to assist in road location.

Field location is not just a consideration in new road construction. It is often needed for reconstruction projects. For example, field location may be required when alternatives to the existing road alignment are under consideration to reduce impacts of the existing road.

Often the most effective resource protection measure in road location is to avoid any direct impacts on resources. For example, the best mitigation for aquatic and riparian species is to stay out of riparian areas. However, if there are no feasible alternatives, minimize the length and long-term impacts of the road within the riparian areas using mitigation measures within the design criteria.

Strive to locate roads to minimize future maintenance needs. Consider the effects of the road on the natural drainage patterns of the area and attempt to minimize the disruption of those patterns.

22.1 - Initial Field Examination

Make an on-the-ground examination of the corridor in which the road is to be located.

Verify the control points, critical areas, and resource and management direction identified in the applicable environmental, logging system, travel analysis, and transportation analysis documents

and during the office location studies. Identify and document features within or adjacent to the corridor that would affect previous and subsequent decisions.

If possible, document these features on maps and photos. Consult with appropriate specialists and land managers to resolve conflicts or address specific problems.

22.2 - Location Marking

Using information from the office location studies and the initial field examination, mark road locations on the ground that conform to those identified on the maps and photos that are compatible with the design criteria and other management direction. It may be necessary to mark more than one location of a road or road segment, especially in the vicinity of critical areas such as topographic features affecting logging systems, landing locations, riparian areas, intersections, switchbacks, and private land. If a new NEPA document is being produced, these alternative locations will be analyzed for effects, according to FSH 1909.15, section 15.

Proposed road locations are usually marked on the ground with ribbon flagging. Units should develop standard flagging color schemes. Such schemes help to avoid confusion on the ground between roads and other proposed resource activities. Applying such color schemes across district and forest boundaries enhances consistency. When appropriate, use plastic or metal tags to provide additional information on the located flag line.

Locators should establish markings that are readily inter-visible from both directions along the flagged line. A guideline in brushy terrain is to flag no further apart than 20 feet and use 18- to 24-inch streamers on each flag. Use colors and material that meet the unit's flagging color scheme and that will last for more than one season. Mark the final location so it cannot be confused with other alternate locations, removing any markings from dropped alternative locations.

Use special marking for proposed structures or other features that require collection of additional survey information, special surveys, changes in survey procedures, special consideration during design, or involve engineering specialties such as structural or geotechnical engineers.

1. Location Techniques. Depending on topography and site conditions, special location techniques may be required for the following:

    a. Intersections.

    b. Ridges.

    c. Draws.

    d. Switchbacks.

    e. Grades.

    f. Drainages.

g. Landings.

h. Road closure and/or decommissioning.

i. Visual considerations.

2. Location Notes. Road locators should complete location notes during on the ground field location activities to document essential information and incidental observations. Deviations from the intended survey and design methods should be clearly noted. Typical location notes may include the following:

a. Sections requiring unusually large cuts and fills.

b. Extent and type of clearing.

c. Potential disposal sites for unsuitable construction material and clearing debris.

d. Potential landing locations and key topographic breaks essential to setting of logging equipment, particularly cable machines.

e. Cross slope.

f. Classification of soils and construction materials.

g. Cultural and historical sites.

h. Constructed features.

i. Opportunities for scenic overlooks and viewing openings.

j. Survey monuments or established survey control points.

k. Type, estimated volume, and recommended extraction methods of rock materials that may be incorporated in the final design.

l. Relationship to private lands and lands managed by other agencies.

m. Areas needing additional investigation.

n. Maximum and minimum grades.

o. Proximity to riparian areas, drainage features, aquatic species, and recommended drainage structures.

p. Potential construction and maintenance problems.

q. Other control points identified during initial field examination.

r. Comments on adequacy of intended survey and design methods.

s. Alternative alignments considered and reason why they were or were not pursued.

t. Proximity to wetlands, wildlife crossings, or other sensitive or special areas.

u. Areas that may require slope stability analysis.

v. Satellite based global positioning system (GPS) coordinates for all of the above as appropriate.

22.3 - Construction Material Sources and Materials Investigation

In conjunction with road location, identify and mark potential sources of materials within or adjacent to the road corridor that could be used for construction. Consult with land managers, resource and engineering specialists, and private landowners regarding the use of the sources. Document specific management direction that is applicable to each site. Locate and mark needed access roads and site boundaries of approved sources. Consult with appropriate specialists, such as invasive weed specialists, cultural resource specialists, and materials engineers to determine the type and extent of subsequent investigations required. Selected locations for source material may be considered a connected action or indirect effect, according to 40 CFR 1508.8, and must be considered in the applicable environmental analysis.

22.4 - Related Facilities and Features

While marking road locations, identify, mark, and document the locations of related facilities and features needed for the immediate project and be aware of how future needs and projects may affect or be affected by the location and design of roads, according to 40 CFR 1508.8.

Examples of related facilities and features are log landings, critical logging corridors, road intersections, water sources, cattleguards, fences, gates, pipelines, power lines, other utilities, turnarounds, trails, parking areas, scenic overlooks, and future recreation sites.

22.5 - Preliminary Costs

When required, prepare preliminary cost estimates for each feasible location. Project the costs used for out-year programming to the anticipated time of construction (ch. 70). Compare preliminary cost estimates with other planning documents to validate the economic assumptions made during initial planning and document significant differences.

22.6 - Comparison of Proposed Routes with Management Direction and Design Criteria

Evaluate road locations to ensure that they meet the design criteria and management direction. Resolve conflicts between road locations and the design criteria and other management direction and justify the solution in terms of social, economic, and environmental effects. If an environmental document is being produced, proposed routes must be compared, according to 36 CFR 220 and FSH 1909.15.15, alternatives. Changes in design criteria or management direction require line approval.

22.7 - Field Location Report

Prepare a written Field Location Report (FLR) immediately upon finishing field work. The FLR documents information obtained in the field and serves as a reference for the project design criteria and preconstruction package. The FLR conveys information from the location phase to the field review and project design. The FLR should include the transportation information needed to make informed management decisions about proposed resource projects. Concisely present the findings and provide qualified recommendations for the succeeding survey, design, construction, and system management phases. One FLR may incorporate information for several roads.

If the Office Location Study and Field Location Report are completed prior to the applicable environmental analysis, use the findings from both reports to inform the NEPA document. If the FLR is conducted in tangent with the environmental analysis for the project, integrate information to avoid redundancies and ensure accuracy of data. Include all reports and documentation in the project record.
The FLR should include the following:

1. Title Sheet. The title sheet identifies the project area and lists the administrative unit; project name; date location was finalized; the proposed date of construction; the road name(s) and number(s); an index of contents, names, and working titles of location team members; and name(s) of the lead locator and report author(s).

2. Geospatial information. Geographic Information System (GIS), photography, photo overlays, vicinity maps, resource maps, and other information delineate the project area. Topographic maps show the recommended location(s), as well as other considered locations.

3. Special Problem Summary. The FLR may include a brief description highlighting areas of management, technical, or environmental concern for rapid identification of critical elements in the location. Note in particular cultural resource issues, aquatic passage issues, riparian areas, and other sensitive fish and wildlife areas.

4. Discussions and Recommendation. The FLR should summarize the results of the field location with the following:

   a. A brief summary of the RMOs, the effectiveness of the route in meeting the desired objectives, the nature of the area to be traversed, and a description of the coordination that has been accomplished.

   b. A summary statement discussing the preferred location. Be specific about the controlling factors, such as saddles, rock, drainage crossings, intended access needs for resource management, and how the preferred location addressed them. State how the preferred alternative satisfies the design criteria and management direction.

   c. A brief statement of alternate routes investigated, and why they are not the preferred location.

d. A comparison of estimated costs of the various alternatives, with specific justification when the lowest cost alternative is not recommended.

e. A brief description of how existing facilities are incorporated into the road location.

f. Right-of-way necessary or granted, cost-share area inclusions, permissions granted to enter private land, and existing mining claims that may affect the road.

g. Marking devices and colors schemes used on the ground.

h. Recommended deviations from planned corridors and associated justification for the deviations.

i. Recommendations regarding survey, design, and construction that include:

(1) Survey:

(a) Verification of, or changes to, the previously selected survey methods.

(b) Property boundaries, land survey corners, and other survey monuments to be tied to the project survey.

(c) Special survey requirements.

(d) Access instructions.

(e) Identification of known survey control points.

(2) Design:

(a) Verification of, or changes to, the previously selected design methods.

(b) Road geometry guidelines/standards incorporated.

(c) Landslide and avalanche potential.

(d) Logging system and landing requirements.

(e) Scenery management objectives

(f) Stream crossings: geomorphic and hydrologic characteristics, including potential debris load of the drainages. Describe why crossings were selected, where they are, and applicable influences on the road location.

(g) Riparian, wetlands, and meadow ecosystems: Describe special location and design considerations to preserve or enhance these features.

(h) Aquatic species: Describe aquatic species present and identify the need for special passage considerations.

(i) Wildlife protection measures: Describe sensitive wildlife areas, potential limited operating periods (LOP), and location of wildlife corridors and possible conflicts.

(j) Soils and geology observed and needs for slope stabilization, erosion control, and surfacing.

(k) Heritage resource mitigation.

(l) Other mitigation measures.

(3) Construction: Information such as material sources, water sources, weight restriction of bridges on access routes, and alternate access routes.

5. Reference Appendix. Include the following, where applicable,:

a. Specialist reports such as fish and wildlife, soil scientist, geotechnical, archeological, and visual.

b. Consultation with other entities, such as Federal, State, and local agencies or adjacent landowners.

c. Listing of reports and references not included elsewhere.

d. Changes in direction or criteria.

e. Justification for deviations and related approvals.

f. Requirement for additional permits.

22.8 - Field Location Review and Approval

An interdisciplinary field review of the proposed locations should be conducted when warranted by project complexity and risks. Locators and those responsible for determining the design criteria, or their designated representatives, should participate in the field review. Make the Field Location Report (FLR) available with adequate lead-time to allow participants to become familiar with the report.

Upon completion of the interdisciplinary field review:

1. Document all additions or changes resulting from the review and add them to the FLR.

2. Check the final results against design criteria and management direction.

3. Obtain necessary approval for changes to criteria or direction. The signature of the responsible engineer and the land manager, or their designated representatives, in the FLR or by letter indicates technical and management approval for the road location.

4. Obtain the concurrence of cooperators when appropriate.

22.9 - Field Location Checklist

Upon completion of the field reviews and FLR, check to see that:

1. The final road location has been marked for survey.

2. The final FLR has been signed and placed in the appropriate project file.

3. For purposes of environmental analysis and decisionmaking:

   a. When a Travel Management Decision is on file, assure that deviations from the transportation plan and applicable environmental documents have been properly documented (narrative and maps) and approved in accordance with applicable guidance, regulations, and policy. Significant changes may trigger additional environmental analysis for the current Travel Management Plan, prior to implementation.

   b. When the Travel Management Decision is yet to be made, because information developed during road location has been identified as necessary to advise environmental analysis and decisionmaking, assure that the information has been obtained, documented in the required format, and transmitted to the decision maker.

4. All significant construction, operation, and maintenance problems identified during or before location have been resolved so the located road can be built and utilized consistent with the design criteria and standards as initially intended or as revised. If appropriate, identify needed monitoring.

5. Work to assure that information on the proposed project is accurately reflected in the forest transportation atlas (FSM 7711.2). This includes both the required tabular data as well as spatial data, as appropriate.

23 - Location Techniques

Following are techniques that may be used both in the office and in the field to help efficiently locate roads while meeting management objectives.

23.1 - Office Location Techniques

To use field time most efficiently make a thorough office study before going to the field. The corridors identified in transportation area analysis can be refined and alternative road locations studied by use of Geographic Information System (GIS), maps, stereoscopic resource

photography, and digital terrain modeling. Consider the use of appropriate remote sensing techniques. Digital terrain modeling has the advantage of not only identifying alternative locations but also providing preliminary design quantities for use in calculating preliminary cost estimates.

Preliminary grade lines can be run in the office on GIS, contour maps, orthophoto maps, and similar documents.

23.2 - Field Location Techniques

Exhibit 01, Field Location Technique Guidelines, outlines information and techniques that are useful in identification and marking of road locations on the ground. Other procedures may be used that also provide acceptable results. Note that the techniques generally apply to the location of very low volume roads with design speeds under 25 mph. Location of higher standard roads may require the application of other techniques that incorporate higher design standards. Check equipment frequently and prior to field work to assure it is working properly. Appropriate accuracy during field location can generally be accomplished using hand held compasses, clinometers, and cloth tapes. Hand held Global Positioning System (GPS) equipment may be useful.

Field Location Technique Guidelines

1. Overall location	Locate road using gradeline control when cross slopes are greater than 15 percent. Locate road using horizontal control when cross slopes are less than or equal to 15 percent or in rolling hummocky ground with no specific side slope. Fit road to the topography, minimizing landform modifications. Start trial lines at specific control points and go from those to more general points. Tie into previously selected control points using an altimeter, and/or a Global Positioning System (GPS). Check against air photos, profiles, and maps. Exhaust other feasible alignment options before locating roads on exposed slopes that will adversely impact scenery viewed from afar.
2. Running grade line	The final design will often be steeper than the located line. The shorter the "shots" and the more broken the terrain, the greater the deviation from the field location. This deviation is the least evident where the located line is essentially the final design line. Located Grade — Design Grade 2-4 percent — Approx. ½ percent steeper 5-10 percent — Approx. 1 percent steeper 10-18 percent — Approx. 2 percent steeper Grades should be slackened in broken terrain to allow sufficient design flexibility.

	State logging safety codes may impose requirements for maximum grades. Often the maximum grade is stated as a percentage (that is 20 percent) with no indication over what length it should be measured. Check appropriate guidance to assure that requirements for the maximum lengths of steep grade sections are met. For example, 20 percent over a 100 foot slope distance. When "pushing" maximum allowable grades, be sure to allow for breaks in grade to accommodate roadside features, such as log landings, as well as to assure that maximum grades are not exceeded. Where the difference in grades between segments exceeds 5 percent, transition grade changes in increments of 5 percent or less. Separate incremental transitions by 25 to 50 feet.
3. Log landings	When a road will provide access for cable logging, to the extent possible, locate roads on topographic breaks to fit logging system needs. Coordinate landing locations with turnout opportunities. Reduce or minimize visual impacts by avoiding locating landings on ends of ridges, if possible.
4. Switchbacks	Locations should be limited to areas with side slopes of 35 percent or less. Locate switchbacks to minimize visual impacts using vegetation or topography to screen impacts. Mark approach grades and grades within switchbacks in accordance with design standards. Design grades will be steeper than located grades on switchbacks. Lay out short radius switchbacks as circular curves using radius point or by deflection angle.

5. Intersections	Locations should be limited to areas with side slopes of 25 percent or less. Angles formed by intersecting roads should not be less than 60 degrees. Grades of through and approach roads should be the same, until adequate horizontal separation is achieved, and should not exceed 6 percent.
6. Horizontal curves	Approximate curve locations by establishing a series of points on the curve (POCs). Incremental deflection angles should be less than 30 degrees. Lay out short radius curves as circular curves using a radius point or by using deflection angles. Low standard roads may not require circular curves. The locator should consider the flagline to be the approximate centerline of the road. Avoid laying out curves that coincide with sharp crest vertical curves. When a road is located with a curve on a crest or ridge, a potentially unsafe condition is created. It may be difficult or impossible to provide for adequate sight distance. Lay out alignment along natural curvature of terrain to minimize cuts and fills and to provide self-balanced sections. Check curves to see that they are smooth and without sharp breaks. Check topography to be sure necessary curve widening and turnouts can be accommodated. Avoid sharp curves at the end of long tangents. Avoid "S" curves, except when located in continuously winding road locations.

7. Ridges (sharp and narrow)	Avoid abrupt vertical curves on ridges. Lay out short radius curves as circular curves using a radius point and cloth tape or by deflection angles. Reduce grade to provide sufficient design flexibility.
8. Riparian Areas and Drainages	Avoid roads in riparian areas if possible. Avoid wetlands. Avoid paralleling riparian areas for prolonged lengths. Avoid locations that will result in filling of natural stream channels. Cross drainages directly, preferably at a right angle. To allow for aquatic species passage, cross where the stream is stable, gradient is low, and stream width is narrow. Avoid crossing at braided stream channels, oxbows, and meanders. Attempt to maintain natural flow patterns. Understand when dredge and fill permits are required as well as when the nationwide general permit conditions are applicable. Understand other permit requirements such as Clean Water Act and State and local requirements, and consider those requirements in the location. Locate vertical points of intersection (VPIs) in vicinity of transition between cuts and fills (ch. 40), and provide grade relief for designer to adjust location of vertical curve to control water. Where possible, either reduce the location grade to 0-1 percent approximately 100 to 200 feet before crossing draws and extend 100 to 200 feet beyond draws or reduce favorable grades by 5 percent, adverse grades by 2 percent (reduces the need for shifting or braking on curves).

	Minimize potential for stream diversion should culverts plug. The risk is eliminated entirely when roads have adverse grades in both directions from stream crossings.
9. Surface drainage	If surface drainage is to be controlled by rolling grades and surface cross drains, incorporate grade breaks in the road location. Avoid locating cross drainage at turnouts and intersections.
10. Full bench	The marked grade line will be above the anticipated design grade line and it will be shifted into the side hill ½ road width compared to self-balanced areas. Provide for transitions into and out of full bench sections.
11. Bridge sites	Locate in naturally confined and stable locations where the flow characteristics of the stream can be maintained. <u>Guidelines</u>: *Avoid grade changes or curves on bridges. *Look for solid abutment foundations. *Cross where stream courses are straight. *Cross perpendicular to the stream. *Location of economical crossings may control location of approaches. *See FSH 7709.56b, Drainage Structures Handbook.
12. Road closures	Locate intersections to facilitate effective road closures. Locate closure points where turnarounds can be provided for critical vehicles. Locate closure points that tie into natural barriers.

13. Scenic vistas	Consult with landscape architects or visual specialists regarding scenery management objectives. When specified in design criteria and RMOs, identify parking areas in the vicinity of scenic features. Provide safe sight distance for vehicles entering or leaving parking areas. Consider the effect of long-term vegetation growth outside the roadway on desired vistas.

23.3 - Field Location Techniques for Special Situations

In some areas, it is necessary to mark the field location of sharp radius curves through switchbacks, draws, and ridges as a circular curve regardless of the actual design method that will be used.

1. Marking Curves by Deflection Angle. Vegetation, topography, or other factors may preclude locating a curve by using a tape held at the radius point and marking the arc of the curve. In these cases, marking the curve by deflection angle and chord can be effective, as shown in exhibit 01.

Deflection Angle (d) for Various Radii for Establishing Horizontal Curves for Road Location[(1)]

Radius (ft)	15 foot Chords		30 foot Chords		50 foot Chords	
	½ d	d	½ d	d	½ d	d
40	11°	22°	22°	44°	-	-
80	5°	11°	11°	22°	19°	38°
120	4°	8°	8°	16°	12°	24°
160	3°	6°	6°	12°	9°	18°
200	2°	5°	4°	9°	7°	14°
240	2°	4°	4°	8°	6°	12°
280	2°	4°	3°	7°	5°	10°
320	1°	3°	3°	6°	5°	9°
360	1°	2°	2°	5°	4°	8°
400	1°	2°	2°	4°	4°	7°

[(1)]Turn ½ (d) at P.C. for first P.O.C., turn full (d) for remaining P.O.C.'s, and turn ½ (d) at P.T. for first P.O.T.

2. Marking Switchbacks. Switchbacks can be located in the following manner (and as illustrated in ex. 02) unless the radius is relatively large. For switchbacks with a radius greater than 100 feet, consider using the deflection angle method.

a. Step 1. Extend the upper and lower gradelines of the approaching alignment until they intersect.

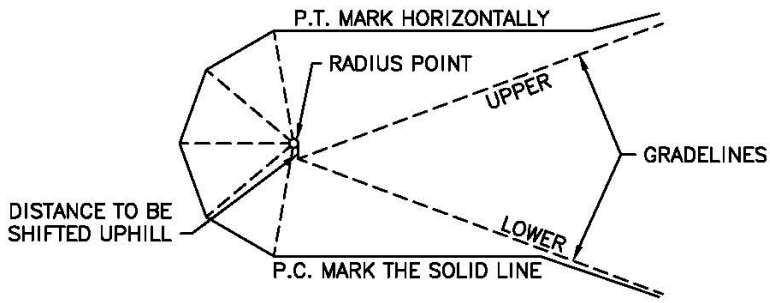
b. Step 2. Shift the intersecting point uphill. The steeper the side slope, the greater the shift. This becomes the radius point of the curve. The shift results in better balance of earthwork.

c. Step 3. Mark the curve by measuring radially from the radius point.

d. Step 4. Connect the point of curvature (PC) and point of tangent (PT) of the curve to the upper and lower gradelines with a horizontal line that follows the natural ground contour.

23.3 - Exhibit 02

Procedure for Locating Switchbacks



SHIFT GRADELINE INTERSECTING POINT UPHILL TO ESTABLISH THE CURVE RADIUS POINT ACCORDING TO THE FOLLOWING TABLE.

SLIDE SLOPE %	SHIFT (ft)
5	3
10	4
15	6
20	7
25	10
30	13
35	16

(SEE ALSO EM 7100–10, ENGINEERING FIELD TABLES, P. 171, FOR AN ALTERNATE METHOD OF SWITCHBACK LAYOUT.)

3. Locating and Carrying a Grade Through a Narrow Ridge. A road can be located to cross through a narrow ridge by using the procedures described below and illustrated in exhibit 03.

Step 1. Select a location for crossing the ridge. Extend the approaching gradeline to the beginning of the curve (Point A).

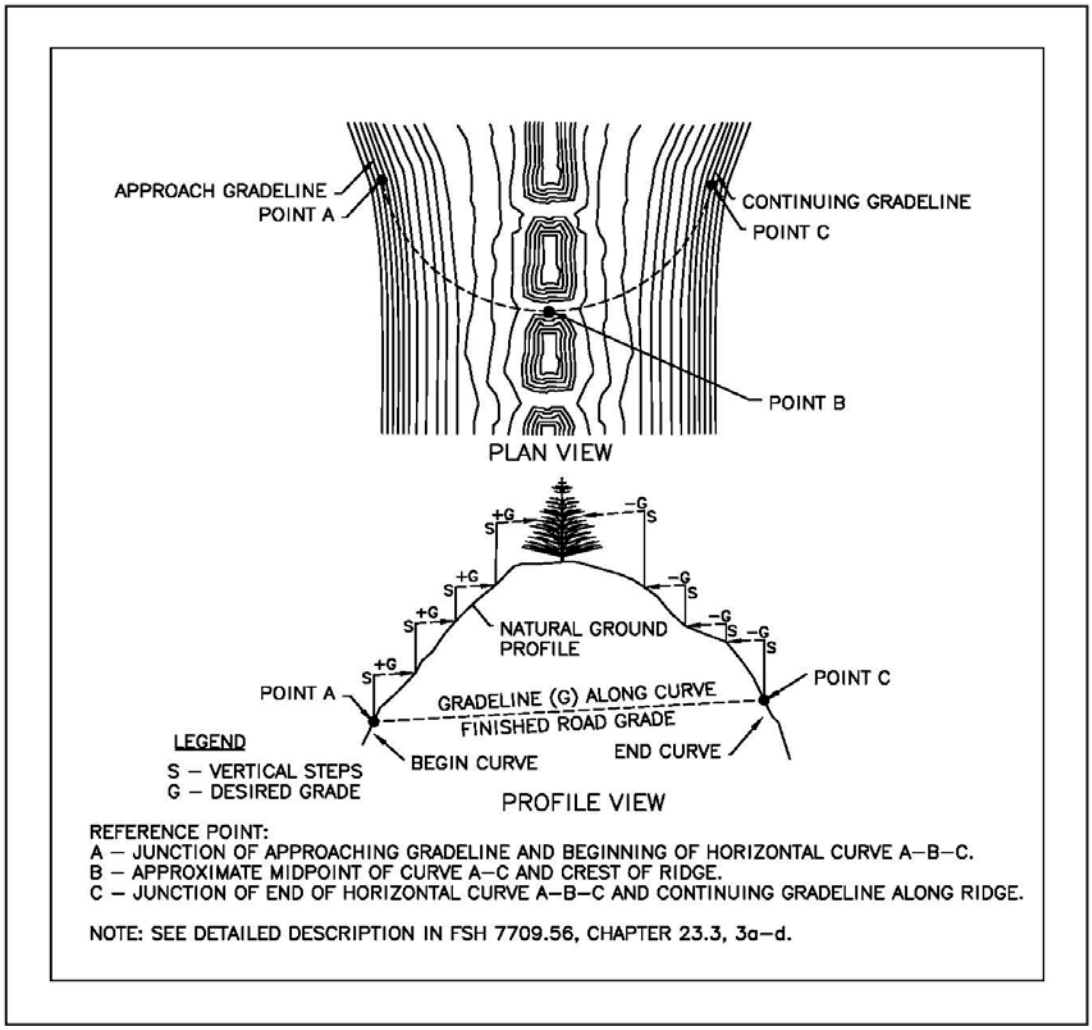
Step 2. Using the radius point or deflection angle methods, establish the horizontal alignment through the selected ridge point. The midpoint on the curve (Point B) will lie approximately at the crest of the ridge.

Step 3. From Point A, use a clinometer to mark equal vertical step(s) up the ridge on the approach side, and down the ridge on the other side at the desired grade (G), while following the horizontal alignment. The number of steps up must equal the number of steps down. The grade setting on the survey instrument must be reversed before stepping down.

Step 4. Where the topography will permit proceeding on grade with a smaller deflection angle than is required by following the horizontal curve (Point C), continue running a grade-line along the ridge.

23.3 - Exhibit 03

Locating and Carrying Grade through a Narrow Ridge



24 - Reference Material for Road Locators

24.1 - Publications

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5. British Columbia Ministry of Forests, 1994. A Guide for Management of Landslide-Prone Terrain in the Pacific Northwest Second Edition, ISSN 0229-1622.

6. Federal Highway Administration. Federal Lands Highway Project Development and Design Manual, current edition. FHWA-DF-88-003; available in electronic format from Federal Lands Highway's Internet sites.

7. Federal Highway Administration. Flexibility in Highway Design. Pub. No. FHWA-PD-97-062.

8. Federal Highway Administration. Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, current edition.

9. Garber, Nichols J. and Hoel, Lester A. Traffic and Highway Engineering, Second Edition, Revised. 1996 PWS Publishing Co., 1126 pp. Available from the Institute of Transportation Engineers.

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13. Rosgen, Dave, 1996. Applied River Morphology. Wildlife Hydology, Pagosa Springs, CO.

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15. The Asphalt Institute Reprinted 1997 Soils Manual (Fifth Edition,) MS-10. Fully illustrated, 260 pages, 150 x 225 mm (6 x 9 in.).

16. The Asphalt Institute. Asphalt Surface Treatments. MS-13

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18. U.S. Forest Service. 1976. Engineering Field Tables EM 7100-10 or equivalent.

19. U.S. Forest Service March 1977. National Forest Landscape Management, Volume 2, Chapter 4, Roads., USDA Handbook No. 483.

20. U.S. Forest Service, Alaska Region. April 1978 Logging Systems Guide, Series R-10-21.

21. U.S. Forest Service, Pacific Northwest Region. 1974. Cable Logging Systems,, printed by Oregon State University.

22. U.S. Forest Service, Pacific Northwest Region. 1990. Forest Engineering Handbook, Edition #1.

23. U.S. Forest Service, Technology & Development Program, 1998. Water/Road Interaction Technology Series,

24. Wenger. Forestry Handbook, 2nd Edition, Wiley and Sons Publisher. ISBN:0-471-06227-8.

24.2 - Internet Sites

1. American Association of State Highway and Transportation Officials (AASHTO) Home Page: http://www.transportation.org

2. American Society of Civil Engineers (ASCE) Home Page: http://www.asce.org

3. Federal Highway Administration, Context sensitive Design Home Page: http://www.fhwa.dot.gov/context/index.cfm

4. Federal Highway Administration, Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD): http://mutcd.fhwa.dot.gov

5. Federal Highway Administration, Western Federal Lands Highway Division Home Page : http://www.wfl.fha.dot.gov

6. Institute of Transportation Engineers: http://www.ite.org

7. Local Technical Assistance Program (LTAP): http://www.ltapt2.org

8. National Association of County Engineers Home Page: http://www.countyengineers.org

9. U.S. Department of Transportation, National Transportation Library: http://ntl.bts.gov

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