GUIDELINES FOR HIGHWAYS ON NATIONAL FOREST LAND

ARIZONA DEPARTMENT OF TRANSPORTATION and USDA FOREST SERVICE

ADOT/USFS GUIDELINES FOR HIGHWAYS ON NATIONAL FOREST LAND

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September, 1994

Produced cooperatively among the Arizona Department of Transportation, the U.S. Forest Service, and the Federal Highway Administration.

Published by the
Arizona Department of Transportation, Highways Division
Roadside Development Section
205 South 17th Avenue, 617 E
Phoenix, Arizona 85007

31-074
$8.00

Acknowledgements

Preliminary content of this manual was prepared by committees with representatives from ADOT, the USFS and FHWA. The following individuals participated in the preparation of material for chapters, as noted:

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Wheat-Gallaher & Associates acknowledges: Joanne Gallaher, Keith Oliver and Joy Garrot—writing, editing and photography; Julie Zapolski—editing, layout and metrication; and Kathy Prefling—graphics.

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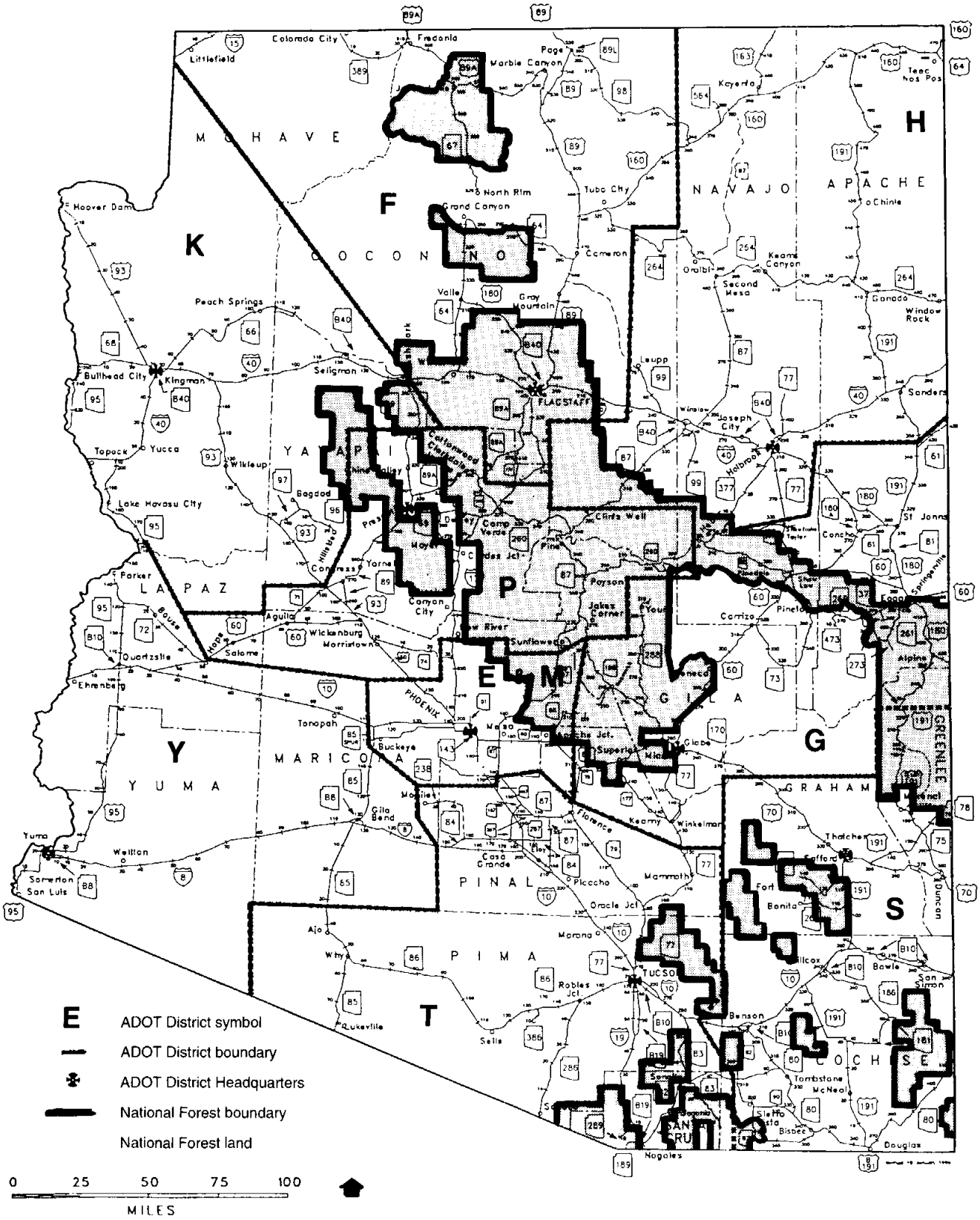


Figure 1 - ADOT Maintenance and Engineering Districts map, with National Forest land, in the State of Arizona.

INTRODUCTION 1

1.1 Purpose and Intent of this Manual

This manual contains information to guide the design, construction and maintenance of Arizona highways on National Forest land (see Figure 1). The manual will be used by the Arizona Department of Transportation (ADOT), its consultants, the Federal Highway Administration (FHWA) and the United States Forest Service (USFS). Personnel involved in administration, roadway design, construction and maintenance will also use the manual.

The purpose of the manual is to articulate the needs of ADOT and USFS regarding the design, construction and maintenance of roadways, and to establish guidelines that will assist each agency in meeting those needs. The FHWA's role in working with ADOT and USFS in the development and implementation of this manual is to provide oversight and assistance, and to assure consistency in laws, regulations, policies and guidelines governing the Federal-Aid Highway Program.

The manual contains ***guidelines,*** not ***standards***. These guidelines should not be construed as rigid requirements that will be applicable to every situation. Rather, the ideas presented in this manual communicate philosophy, approach and examples that have been successful or unsuccessful, from which new ideas and applications can be developed. Deviation from following a guide-line usually does not require formal documentation. However, deviations and inconsistencies should be discussed between the USFS and ADOT, in context with the goals and objectives presented in the manual.

The manual will be updated periodically to reflect new ideas, approaches and examples of successful projects. Various interpretations of the guidelines, in addition to those shown in the manual, should be informally documented for consideration by the agencies for possible inclusion in revisions to the manual content.

The manual builds on the increasingly positive relationship that exists among the agencies; it will act as a bridge to further improve understanding, communication, cooperation, construction and maintenance.

1.2 Applicability: ADOT Highways on National Forest Land in Arizona

This manual applies to roadways designed, constructed and maintained by ADOT, which cross National Forest land. These highways cover the full range of highway classifications from interstate highways to local roads and streets.

1.3 Memorandum of Understanding - ADOT and USFS

ADOT and the USFS have enjoyed a long history of cooperation (see Figure 2). Today, ADOT and the USFS work together under the conditions set forth in the "Memorandum of Understanding on Procedures Related to State Highways over National Forest land." This document, contained in Appendix B, details the administrative requirements, procedures for review, and legal easement requirements for the agencies.

1.4 ADOT, USFS and FHWA Missions and Philosophies

1.4.1 ADOT Mission

The ADOT mission is to "serve the public by providing a quality transportation system, with licensing and related revenue collection." ADOT's Quality Policy is to "consistently provide our customers products and services that meet mutually agreed-upon requirements."

1.4.2 USFS Mission

The phrase, "Caring for the Land and Serving People," captures the USFS mission. As set forth in law, the mission is to achieve quality land management under the sustainable, multiple-use management

NOTE: This manual utilizes the metric system of measurement (See Appendix F)

Figure 2 - Route 66, 4 miles west of Williams, Arizona, circa 1926 (see Reference 22).

concept to meet the diverse needs of people. Included within the mission are:

- advocating a conservation ethic in promoting the health, productivity, diversity, and beauty of forest and associated lands
- listening to people and responding to their diverse needs in making decisions
- protecting and managing the National Forests and Grasslands so they best demonstrate the sustainable, multiple-use concept
- helping states and communities to wisely use the forests to promote rural economic development and a quality rural environment
- developing and providing scientific and technical knowledge aimed at improving our capability to protect, manage, and use forests and rangelands.

Resources managed by the USFS include: timber, wildlife habitat, range, water, soil and recreation. The National Forest Management Act (NFMA) specifically focuses on public participation to determine the management of the various resources. NFMA, along with the National Environmental Policy Act (NEPA) gave the public access to natural resource decisions. The increased role of public involvement in decision-making continues to evolve.

1.4.3 FHWA Vision and Mission

The vision statement of FHWA is: "To meet the need for the safe, efficient and environmentally sound movement of people and goods, and be world renowned in surface transportation expertise and innovation."

The agency's mission is: "To ensure the highest quality surface transportation system which promotes the Nation's economic vitality and quality of

life of its people. Directly, and with our partners, we (FHWA) will:

- preserve, improve and expand the surface transportation system and enhance its operations, efficiency, and intermodal integration
- implement surface transportation programs in a manner that protects and enhances the environment
- provide innovative and effective research and development; market and implement technology
- provide program oversight and accountability for public resources and ensure appropriate uniformity
- improve all aspects of surface transportation safety."

1.4.4 Summary

While each agency has a distinctly different mission, the goals and philosophies are compatible. The USFS responds to a more diverse public constituency, with a wide range of interests, while ADOT and FHWA are primarily focused on transportation related issues. In addition, the USFS administers lands with sensitive environmental resources. This manual highlights examples of how the agencies can work together toward common goals, in ways that are consistent with and in pursuit of their individual missions.

ADOT/USFS ROADWAY DEVELOPMENT PROCESS 2

2.1 Goal

The goal of this Chapter is to help ADOT, USFS and FHWA understand the other agencies' requirements, roles, and timing needs in order to work together effectively. Because ADOT is the lead roadway development agency, the ADOT Roadway Development Process is highlighted as the primary process. USFS and FHWA input and review requirements are integrated with the ADOT process. The USFS planning and development process is also summarized (see Section 2.4).

2.2 NEPA Process

The National Environmental Policy Act of 1969 (NEPA), ensures appropriate levels of environmental analysis, mitigation and public input into the decision making process.

Normally, the USFS is the lead agency with responsibility for environmental documentation and meeting NEPA requirements on National Forest land. However, on Federal-Aid projects, where Federal highway funds are used, the FHWA is the lead agency. On ADOT highway projects, ADOT prepares the environmental document and submits it to the lead agency for approval.

ADOT follows the NEPA process required by the lead agency on highway projects. The NEPA documentation process utilized by the USFS is shown in Figure 3. In this process, the USFS issues decision documents following a "Finding of No Significant Impact" and a "Categorical Exclusion"- category 31.2 (per Forest Service Handbook). The NEPA process followed by FHWA is similar, with the primary difference being that FHWA does not issue these decision documents, which are not required under NEPA. The USFS decision documents provide an opportunity for public appeal. Other legal options are available to challenge the findings, if necessary, under the process utilized by FHWA.

During the NEPA process, environmental and cultural resource issues are identified and assessed. Some resources are covered under specific laws, acts or regulations administered by various agencies. The Endangered Species Act, for example, is administered by the U.S. Fish and Wildlife Service. The USFS assumes the lead role in administering the National Historic Preservation Act. Close coordination is required among the agencies involved to ensure that the pertinent requirements are met and carried out in the construction process.

Because of the environmental sensitivity of National Forest land, the USFS views the NEPA document as the guiding document for highway projects. Substantial public involvement is required in the NEPA process. Commitments regarding environmental mitigation made and documented in the NEPA process are binding to all agencies involved.

2.3 ADOT Project Development Process

A typical design process for ADOT highways crossing National Forest land includes some or all of the following phases: project assessment, environmental analysis/integrated resource management (IRM) process, corridor study, location study, design concept report (with roadway design at approximately 15% level), design and construction documents at 30%, 60%, 95%, and 100% completion levels, construction engineering, project completion and acceptance, and post construction review (see Appendix C). This typical process is sometimes abbreviated under unforeseen conditions, changing public and political priorities, and in emergency situations, when specific projects may be expedited.

Following is a summary of the phases involved in the typical Project Development Process, and the involvement of the USFS in each phase (the Memorandum of Understanding [MOU], Appendix B and C describe the process in greater detail).

The **Project Scoping Phase** initiates the ADOT Project Development Process. All project proposals received by ADOT through the various ADOT Districts, Counties, Cities and Planning Organizations are evaluated and then recommended as candidate projects by ADOT Transportation Planning Division

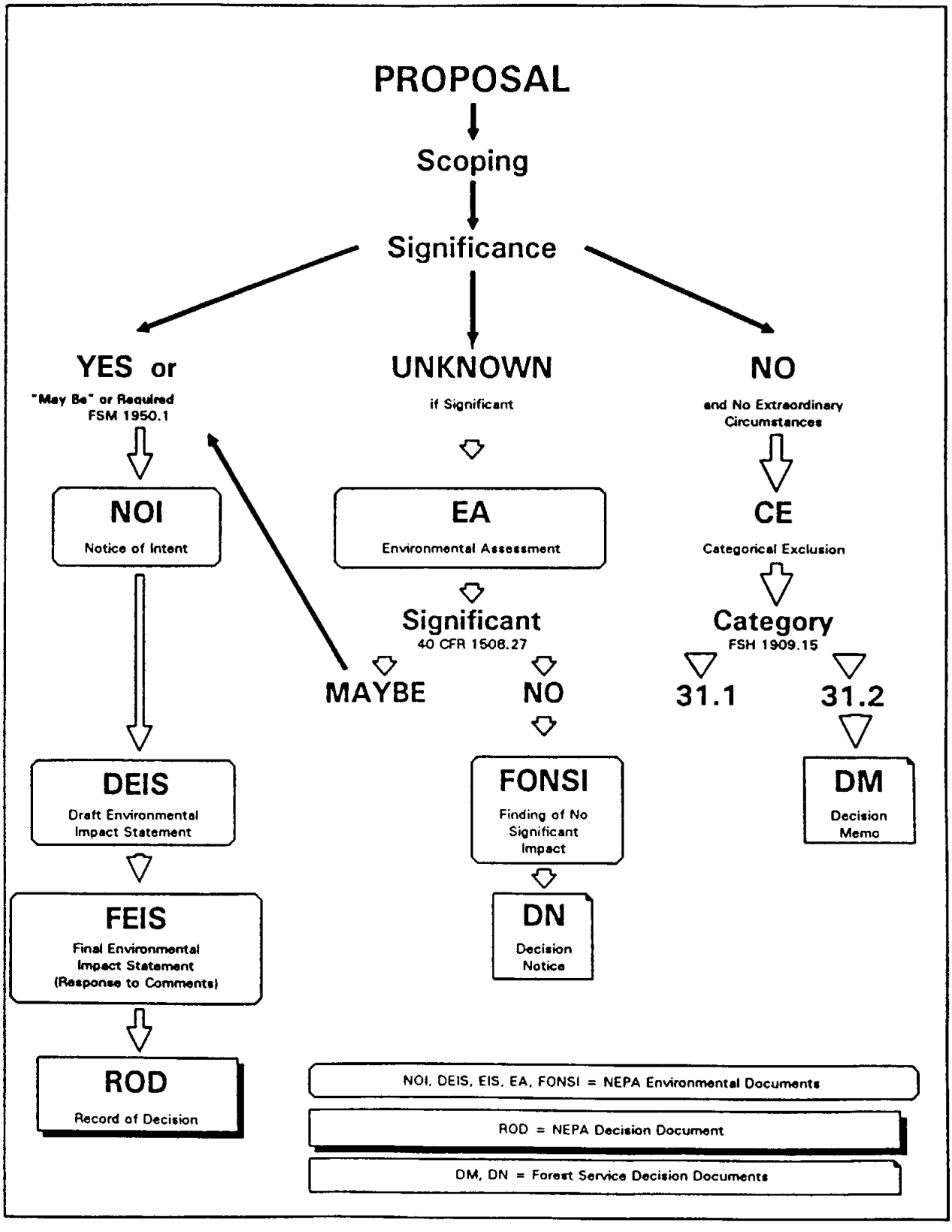


Figure 3 - NEPA Documentation Process used by USFS.

(TPD). These candidate projects are then grouped into Corridor Studies or Individual Projects.

Corridor Studies are completed when there is a need to determine the scope and route for highway construction or reconstruction between two points. The scope of the study is defined by ADOT and the USFS, who must reach a consensus on key engineering and environmental issues during this phase.

The scope of **Individual Projects** are further defined in Project Assessments or Location/Design Concept Reports. These reports are completed to define the specific project scope of work. These reports provide a sufficient level of engineering data to allow the project to proceed to the **Pre-Construction Phase,** which includes the actual design and bid advertisement.

Environmental analysis and NEPA documentation is a key step in the Corridor Study and Individual Project development. It is during these phases that all required environmental analysis is completed. Submission of Final Environmental Documents to the USFS and FHWA for approval is a major milestone during the Project Scoping Phase.

The agencies need to reach consensus on the environmental mitigation at this phase of the project, reflecting the findings of the environmental document. The mitigation requirements should be clearly stated in the Location/Design Concept Report. The roadway design is at approximately 15% completion at the end of this study.

The NEPA document can be reevaluated if new information is obtained or if the final design involves different impacts than those initially considered. In addition, the NEPA document can be reevaluated if significant time passes prior to the initiation of the project (e.g., three years). The document would need to be amended if a different outcome resulted from the reevaluation.

Upon completion of the Project Scoping Phase the candidate projects are prioritized and programmed into the ADOT 5 year Highway Construction Program. Once this program has been approved by the State Transportation Board, the Pre-Construction Phase is initiated.

The Pre-Construction Phase consists of the following activities, which culminate with the advertisement of bids for construction.

The **Initial Design** phase brings the project to the 30% level, and includes the description of specific mitigation measures to respond to commitments made during environmental studies. Normally, plans developed to this level have the roadway centerline staked and identified in the field. Some projects with special requirements may also require the early staking of cut and fill slope limits in selected areas, as well as construction access requirements. This staking can then be reviewed in the field by the agencies.

This phase is where optional decisions are made regarding pullout locations, intersections (see Chapter 9), passing lanes, etc. Consensus should also be reached regarding the amount of rounding, laying back the ends of cut slopes, warping and other special treatments that will be required on the project (see Section 4.3.5 and Section 4.3.7.5).

At the completion of the **Preliminary Design** phase, the plans will be at the 60% level. The mitigation measures should be quantified and specified by location with this submittal. Staking in the field should be adjusted to reflect earlier revisions for review by both agencies. Again, written comments are submitted by the USFS to ADOT for incorporation into the plans.

The **Final Design I** plans, at 95% completion, include a complete set of construction documents. If needed, the USFS submits proposed Construction Stipulations and final comments upon review of this plan set, for inclusion in the construction documents. The Construction Stipulations address certain formal conditions and requirements of the Easement Conveyance.

The **Final Design II** plans, 100% complete, incorporate or respond to all previous comments, and include final Construction Stipulations. ADOT and the USFS resolve any outstanding issues at this time. The USFS provides final written project approval.

After the final plans have been approved, the project is advertised and bid. Additional coordination time (up to six months) may be required between the agencies on projects in timber, where the construction staking must be in place before the timber can be inventoried, appraised and transferred (see Section 10.8.3).

2.4 USFS Roadway Development Process: Access Management

The development process for National Forest land starts with the creation of a Forest Plan and Access Management Objectives for each National Forest.

2.4.1 National Forest Land and Resource Management Plan

Each National Forest is required by law to have a Land and Resource Management Plan or "Forest Plan." The Forest Plan gives Management Area Direction that specifies the activities for implementation, environmental quality requirements, natural and depletable resource requirements, and mitigating measures to achieve the management emphasis or goals for each management area within the Forest.

2.4.2 Access Management Objectives

As a part of the Forest Plan implementation process, each National Forest develops "Access Management Objectives" to provide public access to the Forest. These objectives describe the extent and form of access needed to accomplish management area direction, including how access to and within National Forest land will be provided; whether by foot, horse, motor vehicle or aircraft; over water, roads, or trails; or through the air.

2.4.3 Access Management Process

The USFS's process for Access Management is shown in Figure 4, from the USFS Transportation Planning Handbook (FSH 7709.55). Specific management objectives are developed by USFS District Rangers for each individual road and trail under USFS jurisdiction as well as for off highway travel. Objectives for roads are known as "Road Management Objectives."

USFS engineers and technical specialists use Road Management Objectives and Off–Highway Travel Management Objectives to develop road design standards, maintenance plans, sign plans, use restrictions, Forest visitor maps and all other processes used to manage access to a National Forest.

2.4.4 Relationship to ADOT Activities

Most State highways on National Forest land in Arizona are constructed for State and National transportation purposes as opposed to being constructed to access the National Forest. Most National Forest users in Arizona use State highways to get from their homes to the National Forest. Furthermore, many Forest visitors only see their National Forests while passing through them on a State Highway. Driving for pleasure and viewing the scenery is a popular recreational activity on roadways crossing National Forest land.

For these reasons, the USFS desires to work with ADOT as a partner in National Forest Access Management. Many Access Management Objectives developed to implement Forest Plans can be applied to State Highways without impairing State Highway Transportation Objectives. Deviations from typical practices may be requested by the USFS to make projects comply with Forest Plans (e.g., slope treatments, setbacks, ditch widths, etc.).

Where roads and trails under USFS jurisdiction intersect State Highways, ADOT personnel can take advantage of information developed in the Access Management Process. For example, the Road Management Objectives for a USFS road provide information on number of users, types of users, vehicle characteristics, and season of use. This information is necessary to develop design standards for an intersection between that road and a State Highway.

2.5 ADOT/FHWA Partnership

The Federal-aid Highway Program has established a long-standing and very close relationship between ADOT and the FHWA. ADOT is responsible for planning, location, design, construction, maintenance and operation of all streets and highways on the State Highway System. Most of the streets and highways on Arizona's State Highway System are eligible for Federal-aid highway funding, and ADOT has the prerogative of determining where and when to request available Federal-aid funds for improvements on the State Highway System. When ADOT elects to use Federal-aid funding, they must comply with a wide array of Federal laws, regulations, policies and standards.

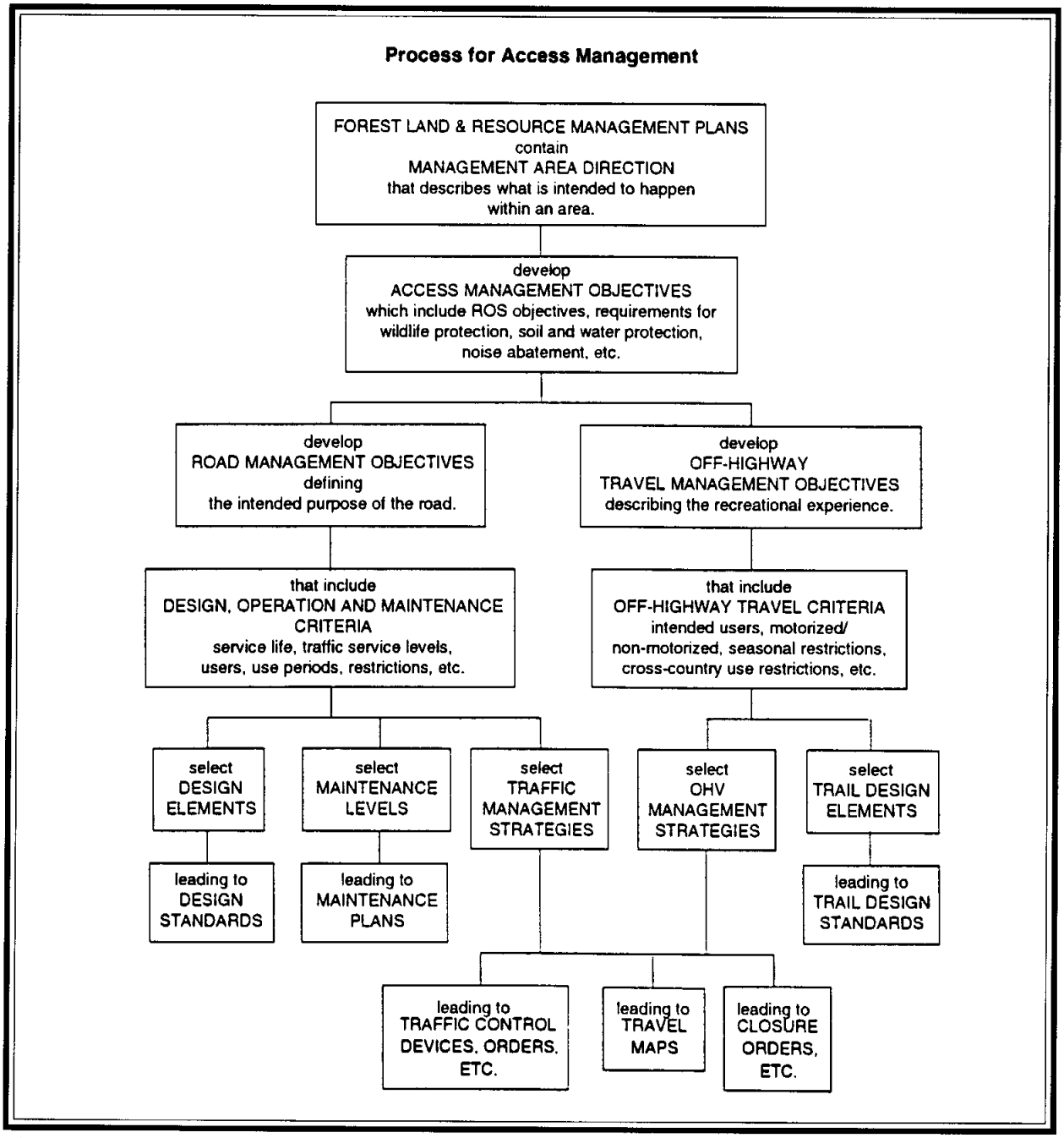


Figure 4 - USFS Process for Access Management.

FHWA's role and responsibility is to assure compliance with these laws, regulations, policies, and standards. FHWA discharges this role through close involvement in and review of ADOT's Project Development Process and ADOT's Construction Process. To a lesser extent, FHWA also has responsibility in the oversight of ADOT's maintenance and operation processes; however, by Federal law, no Federal-aid funds can be used for these purposes. As indicated by FHWA's Vision and Mission Statements, FHWA has assumed an additional role of promoting continual improvement of the highway system and all processes and procedures affecting the highway system.

FHWA also provides environmental analysis, location, design and construction administration services to both ADOT and USFS for roads largely on or serving public lands, including National Forest land. This program is officially titled the "Federal Lands Highway Program," but is often called "Direct Federal."

2.6 Partnering

ADOT, the USFS and FHWA have been cooperating agencies for many years. To strengthen relationships among the agencies, ADOT sponsors "Partnering" during construction, and, on most projects on National Forest land, during the design process. Partnering is the process where stakeholders in the project—including involved agencies, designers, contractors, project engineers and inspectors, adjacent property owners, etc., are included in a meeting, or meetings, where common goals and issues are identified. A process for joint issue resolution is agreed upon by all parties. This process facilitates the continued involvement of the USFS and others throughout the roadway design and construction process. Partnering is discussed in greater detail in Chapter 10.

2.7 Roadway Construction

When road construction is in progress, the representatives of ADOT, the contractor, and the USFS assure that the project is carried out according to the specifications in the contract. Various interdisciplinary team members may be called upon to review proposed design modifications during construction. All USFS input during construction needs to be coordinated through the ADOT Resident Engineer with some exceptions, such as Fire Plan compliance and exercise of USFS law enforcement (see Chapter 10).

ROADWAY DESIGN 3

3.1 Goals

The roadway design goals reflected in this manual are to increase roadway compatibility with forest resources and to minimize disruption of resources on National Forest land (see Figure 5). The philosophy should be to protect the natural and cultural resource base, respect natural land forms and terrain, and visually blend the roadway and related facilities with the natural environment.

This philosophy is based on the protection and enhancement of the natural and cultural resource base while providing a safe, functional and economic roadway system and related facilities.

3.2 Other Design Guidelines and Manuals

The emphasis of this manual is to outline the design and operation conditions unique to State highways crossing National Forest land. Other roadway design goals and applications, pertaining to all roadways, are covered in the ADOT Highway Development Design Guidelines. Guidelines contained in this manual supplement the ADOT Highway Development Design Guidelines Manual and the ADOT Erosion and Pollution Control Manual (see References 4 and 6). These manuals should be used as additional sources of information regarding the design of roadways on National Forest land.

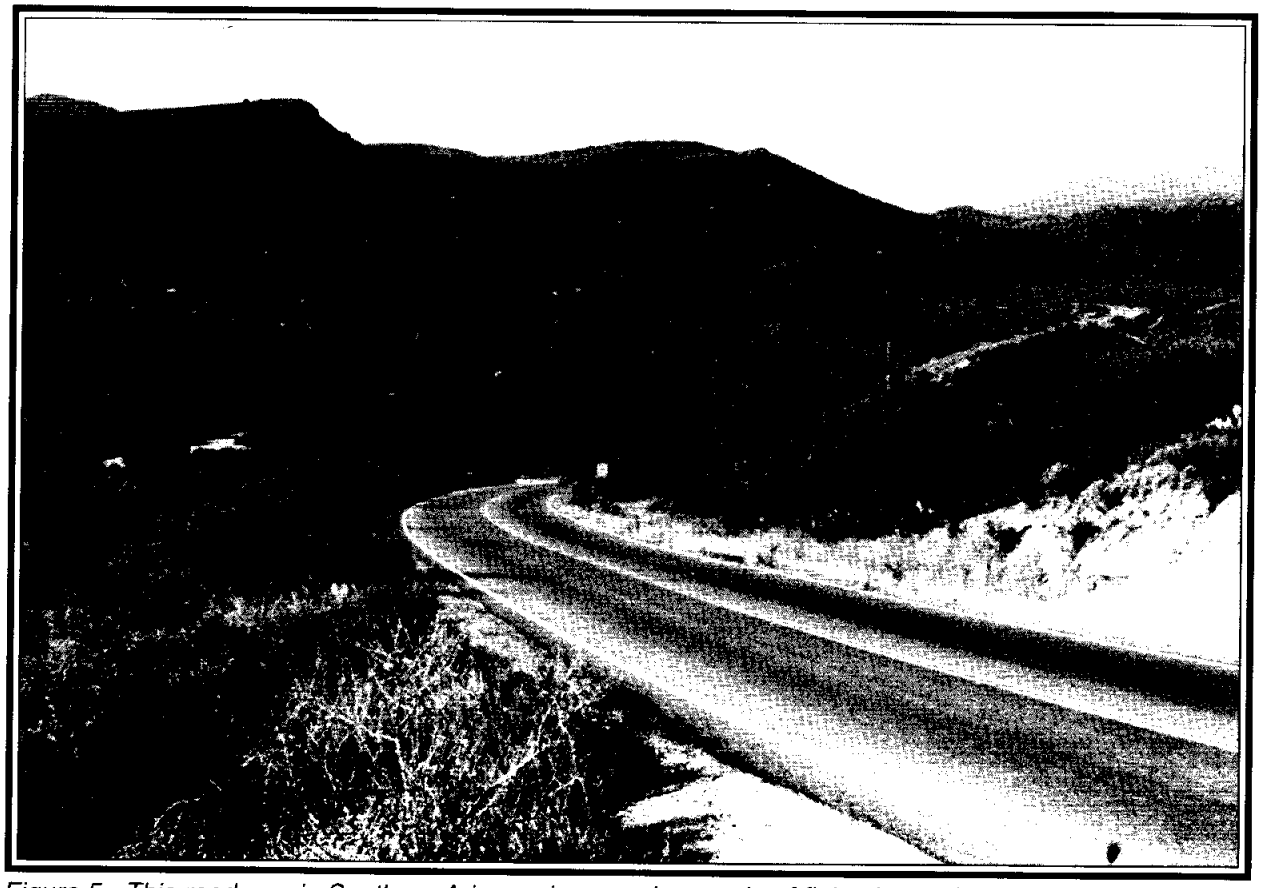


Figure 5 - This roadway, in Southern Arizona, is a good example of fitting into existing terrain.

3.3 State Highways Crossing National Forest Land

Design of roadways crossing National Forest land should address multiple resource considerations (water, range, visual resources, cultural resources, timber, wildlife and soil), and minimize disturbance to existing significant resources.

Unusual aspects of roadways on National Forest land may include possible remoteness of the site, private land and permittee access, separate special use authorizations (such as utilities) within the easement, other agency coordination and public access for recreation.

On most ADOT roadways, ADOT purchases right-of-way for complete ownership of the roadway and affected lands. On ADOT roadways crossing National Forest land, the USFS retains ownership of the land, and ADOT is granted a highway easement deed to construct and maintain the roadway. The easement remains a part of the National Forest land. This arrangement requires that the two agencies come to an agreement on issues relating to the short- and long-term effects of the roadway on the adjacent National Forest land.

Because ADOT normally purchases right-of-way for roadways, the agency generally attempts to minimize the amount of the right-of-way required, which minimizes associated costs and other impacts. On roadways crossing National Forest land, the USFS/FHWA grants the roadway easement at no cost to ADOT. This represents an opportunity for ADOT to consider roadway designs which may involve increased use of lands, without an associated increase in right-of-way costs, to meet design goals, NEPA requirements and Forest Plan objectives.

Roadways crossing National Forest land normally have a high level of scenic quality, and other associated natural and cultural resources which require protection and management. While other State highways also cross scenic areas and other environmentally sensitive areas, these considerations are always an important factor in roadways crossing National Forest land. Commitments made during the environmental study need to be developed into mitigation measures, integrated into contract documents and implemented during construction.

The USFS also has qualified staff to provide input to ADOT projects and to monitor the project during construction.

3.4 ADOT/USFS Coordination During Roadway Design and Construction Process

3.4.1 Design Criteria and Solutions

To improve communication between the two agencies, both agencies need to reach consensus internally on the issues and needs of the project.

The USFS focuses on resource objectives. The specific goals and/or criteria of resource needs that affect roadway design solutions need to be articulated by the USFS to ADOT early in the design phases. For example, instead of determining the type of structure at a drainage, such as a bridge, solely on roadway and drainage requirements, ADOT should coordinate with the USFS and consider unique needs of the area that have been identified. These could include, for example, specific widths, heights and lengths for wildlife movements. With these criteria, ADOT structural engineers can determine the optimum structure, for a particular situation, that meets the needs of ADOT, USFS and other agencies.

ADOT needs to respond to the unique needs of the project area, and be willing to consider the land management agency's needs in the development of design solutions. Typical solutions, used successfully in the past, may not be the optimum solution on National Forest land.

Knowledge of the background, planning, and concepts that evolved during the design process needs to transfer from design to construction. This transfer of knowledge should occur prior to construction, so the field construction personnel will be fully aware of the agreements made regarding the project during design, including NEPA commitments translated into the construction documents and the specific design intent. One way to maintain consistency in problem-solving is for the agencies to minimize personnel turn-over throughout the life of a project. Participants at the Partnering meetings should include resident engineers, designers, field personnel, USFS and other involved agencies (see Section 10.2). ADOT construction personnel should know all the individuals involved with each project as well as those who could be called upon as problems arise in various disciplines, and each of the assigned personnel from the resource agencies. Both agencies need to be willing to be open to new ideas, and

to take the risk of trying new solutions when appropriate.

3.4.2 Off-setting Considerations

The balance of engineering needs and environmental needs requires the identification and evaluation of trade-offs during design. Both agencies need to be involved in the evaluation of trade-offs and the final decisions regarding roadway design.

Trade-offs involved in roadway design on environmentally sensitive land might include: weighing the costs of aesthetic treatments, long-term maintenance requirements, alternate bids or phasing improvements over time, priorities, time frames, and appropriate levels of mitigation. Other trade-offs may involve exceptions to ADOT standards or other standards, where advantageous and appropriate. These requirements must be integrated into the roadway design and decision-making process to ensure that the final product meets the goals of both agencies.

This manual discusses some of the common needs and typical solutions that have been successfully applied to past projects. Many projects will require unique site specific solutions.

3.5 Roadway Design on Environmentally Sensitive Lands

3.5.1 Alignment

The selection of the roadway corridor and alignment design should respond to the natural and cultural resources of the site. A curvilinear alignment should be considered in roadway design on environmentally sensitive lands which are naturally rolling or mountainous. This often involves a careful balance between providing required engineering constraints versus reducing impacts to the land forms (see Figure 6).

Environmental disturbance during roadway widening, could be minimized by adjusting the alignment to widen on one side of the existing roadway, rather than splitting the widening down the centerline. This approach results in limiting the disturbance to only one side of the roadway, except during transitions, which could leave mature vegetation undisturbed along one side (see Figure 7). It can also help maintain traffic during construction.

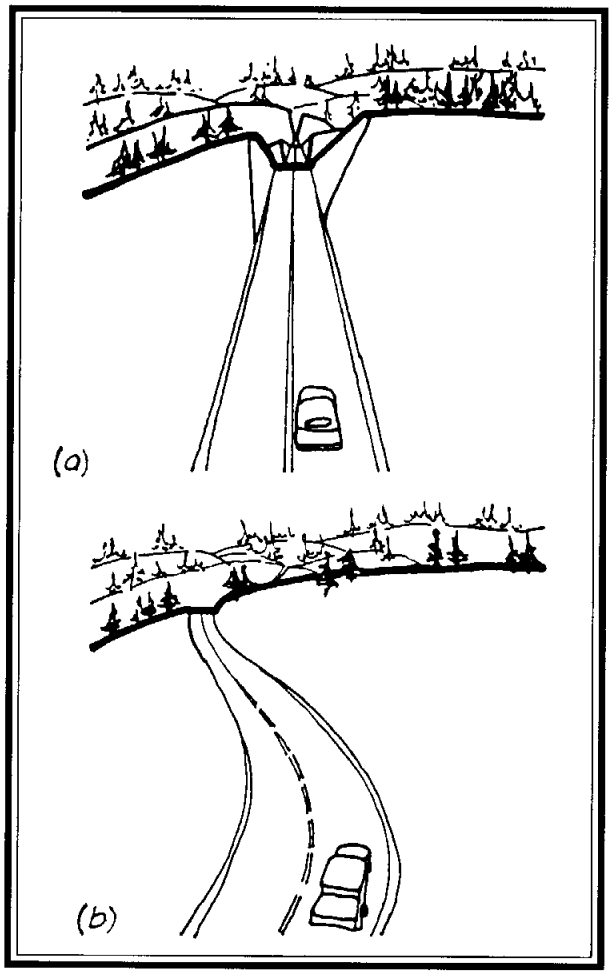


Figure 6 - The roadway in sketch (a) results in greater environmental and visual impacts than the roadway in sketch (b) largely because of the impact of new slopes and drainage patterns.

Divided roadways, with a greater overall width of paving, can create a much larger visual impact than undivided roadways. In the design of a split alignment, retaining existing vegetation in an undisturbed median is one way to reduce impacts. Views between the two alignments should also be taken into account. Ideally, the roadways are treated as two independent alignments (see Figure 8 and 14).

Structures can also be incorporated into early alignment decisions in areas where significant environmental resources need to be protected (see Chapter 5). They may also be desirable to avoid or mitigate environmental and/or aesthetic impacts. Their increased cost, however, must be weighed against the value of the environmental or aesthetic resource impacted (see Figure 9).

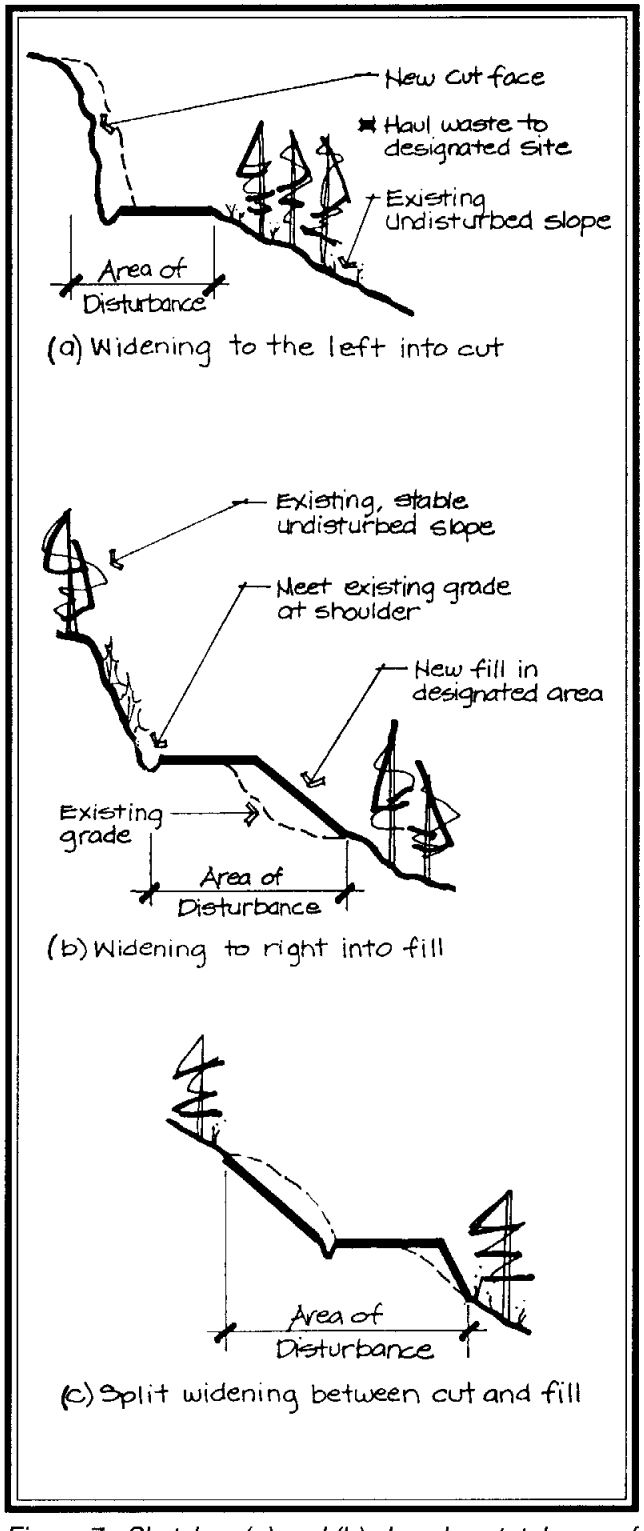


Figure 7 - Sketches (a) and (b) show less total area of disturbance than sketch (c), where the alignment results in new cut and new fill with disturbance on both sides of the roadway.

3.5.2 Slopes

Highway slopes visually demonstrate the integration of highway design, existing terrain, geology, and construction considerations. Slopes are frequently the dominant view of the landscape and can determine its visual quality. Successful cut and fill slopes reflect consideration of materials, geology, topography, climate, vegetative cover and directional aspect in which they are constructed.

The quantities and balance of cut and fill become an important component of project constructibility and cost. Typically, designers strive to limit the amount of borrow or waste material on a project. These attempts to minimize the quantities of earthwork on a roadway project can result in steepened slope angles.

Flatter or irregular cut slopes, requiring greater earthwork quantities, may be more desirable than steeper cut slopes, which can result in a visual scar that never revegetates and a long-term maintenance problem (see Figure 10).

A trade-off may be involved in increasing the earthwork quantities in order to meet visual or other resource requirements. Borrow or waste areas, which are less visible, or areas that can be successfully revegetated to blend with the natural landscape, can be designated. Such sites may require a longer haul distance, but may be preferable to consistent excavations or sidecasting waste materials uniformly along a roadway to minimize hauling costs.

Fills constructed from excess material generated from project excavations should be planned into the project, ideally to be used for improvements to the roadway corridor. The plans for fill areas should include revegetation and other mitigation as required in the environmental documents. Fills can be located in visually unobtrusive areas along the roadway, or in areas where they can provide another future use, such as an overlook or trailhead. Sometimes these areas can be used for staging during the construction project, and rehabilitated upon completion of construction.

Borrow or waste material can also be used to create flatter and safer fill slopes. These fill slopes, with increased revegetation, can be designed to look more natural, blend in with the surrounding land forms, and provide increased stability.

Other possible uses of excess material on a project include plating slopes (if fill meets soil requirements), USFS material site rehabilitation and slight adjustments in road grades.

A recommended hierarchy for the use of excess material on a project is:

(1) balance for roadway improvements within the project limits
(2) balance adjacent projects
(3) slope flattening for safety and environmental benefits
(4) multiple-use opportunities, such as overlooks or parking areas
(5) haul off and away from the project.

Sliver fills (thin fills of up to 1.5 m in width) should be avoided, as they are difficult to construct, they are prone to stability problems, and result in unnecessary environmental disturbance. Sidecasting of waste materials over the side of the road should also be avoided.

3.5.3 Ditch Widths

The typical roadside (cut) ditch width is usually determined as a product of the drainage design, utilizing the ADOT drainage design guide or the Design Concept Report criteria. The cut slope height, ratio, anticipated size of rockfall, natural slopes above cut, recovery area needs, sight distance requirements, blasting options, snow storage requirements, and slope design are additional factors to consider.

Ditch width could be a range for a single project, to accommodate different conditions along the roadway. For example, ditches may need to be widened at rock cuts where rockfall containment is warranted because of geological or slope conditions (see Figure 11). Where this occurs, greater disturbance of the land base may be a trade-off.

3.5.4 Variable Easement Width

Often, easements on National Forest land have been set at a fixed width. This practice has resulted

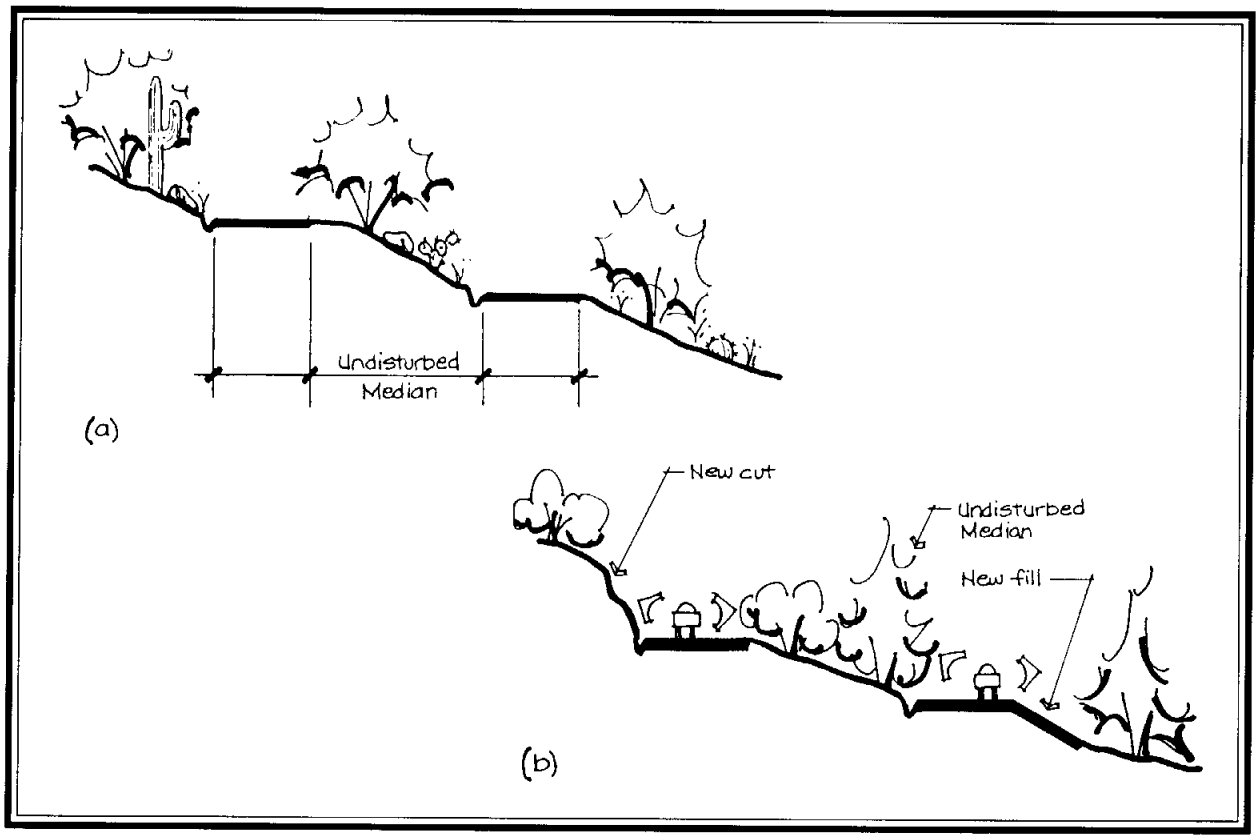


Figure 8 - Sketch (a) shows an existing roadway with an undisturbed median; (b) shows a split alignment widened to the outside to preserve undisturbed median.

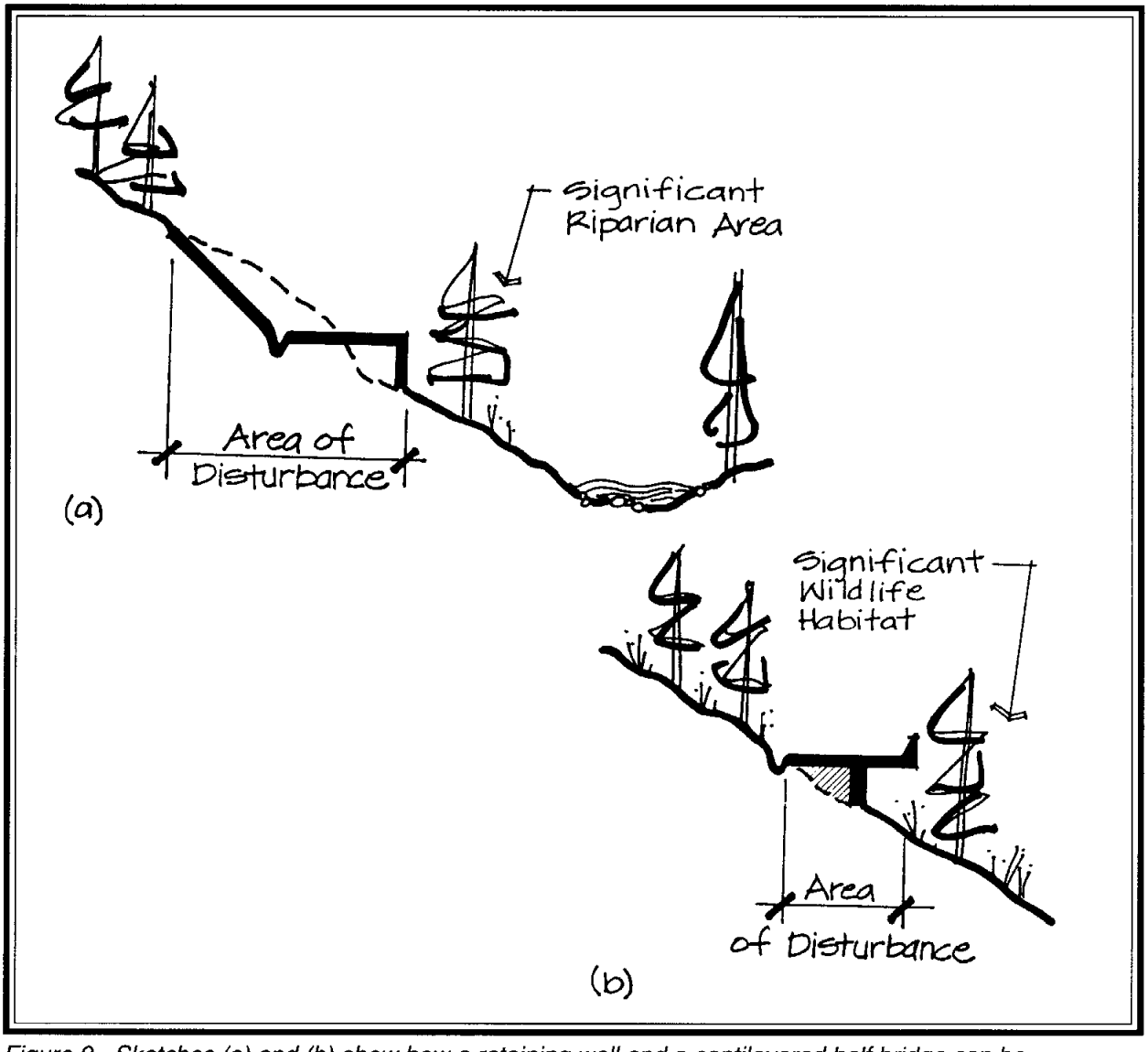


Figure 9 - Sketches (a) and (b) show how a retaining wall and a cantilevered half bridge can be incorporated into the alignment to reduce environmental impacts.

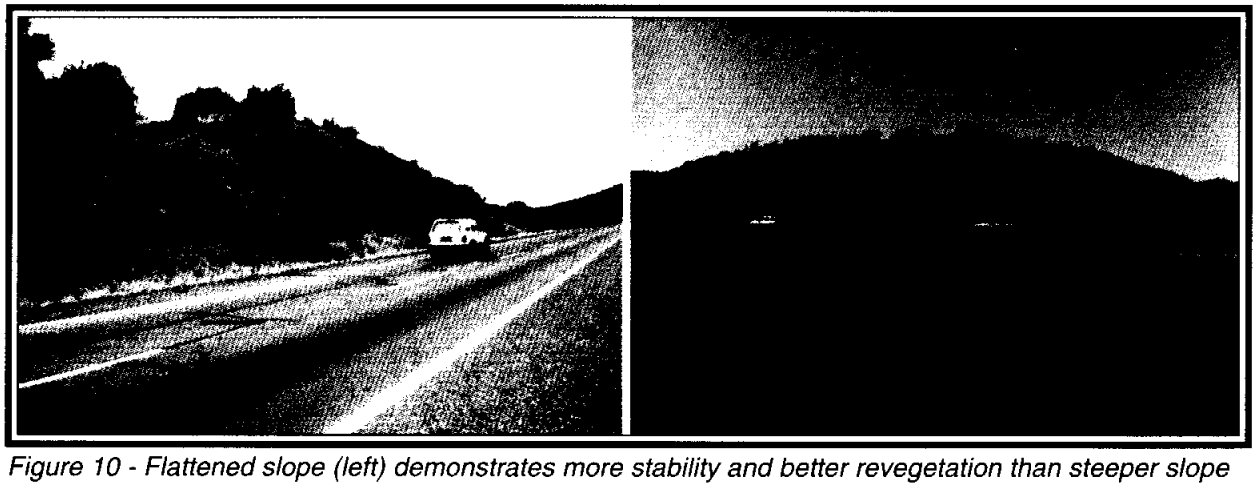


Figure 10 - Flattened slope (left) demonstrates more stability and better revegetation than steeper slope (right), where erosion has occurred.

in restricting roadway design, as features such as slopes and drainageways are forced to fit within the easement. This is evident at some sites where slopes are too steep to revegetate and the easement fence is close to the top of the slope (see Figure 12). Variable easements, which respond to the roadway design, rather than vice versa, allow the roadway features to better fit the topography. The easement designation should be initialized during final design, and finalized after construction.

3.5.5 Daylighting

On projects where the roadway alignment may leave a berm or knob on the outside of a through cut, consideration should be given to whether the berm should be left in place or removed. Removal of this material is commonly known as "daylighting" (see Figure 13).

Advantages of leaving the berm in place include eliminating haul expenses, reducing the disturbed area and revegetation requirements, and possible screening of the roadway or roadway scar from adjacent viewpoints. Advantages of removing the berm may include opening a vista from the roadway, provide a roadside parking area, reducing shading of the pavement, improved drainage, and elimination of an unnatural appearing land form.

Each project should be evaluated for the policy on daylighting, to consider the amount of mature or significant vegetation in place, the character of the land form to remain or be removed, and other advantages/disadvantages.

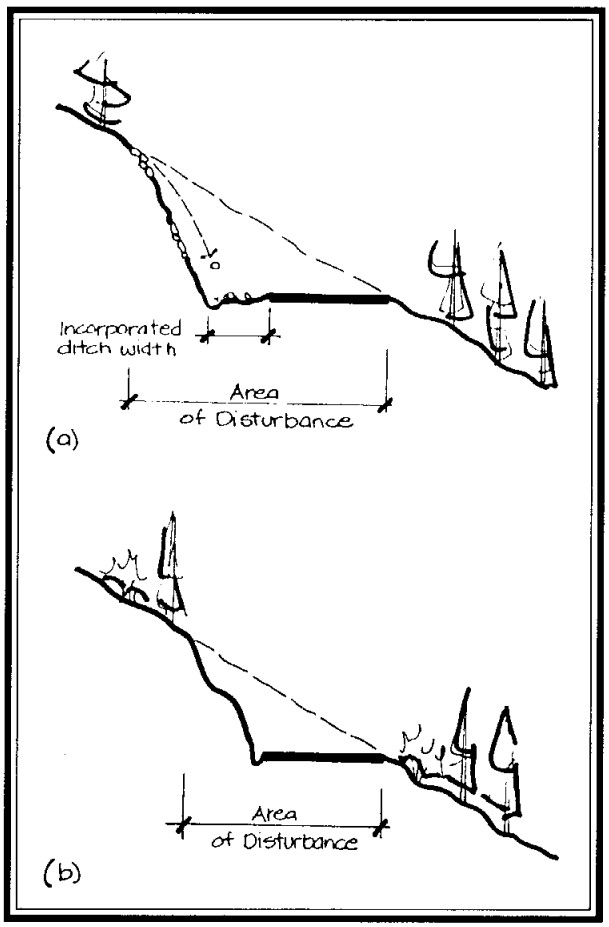


Figure 11 - Sketch (a) shows an increase in ditch width, and overall area of disturbance, over the typical roadway in sketch (b).

Figure 12 - This 9 m high cut (foreground, right) was oversteepened to stay within the R.O.W. fence located at the top of the cut.

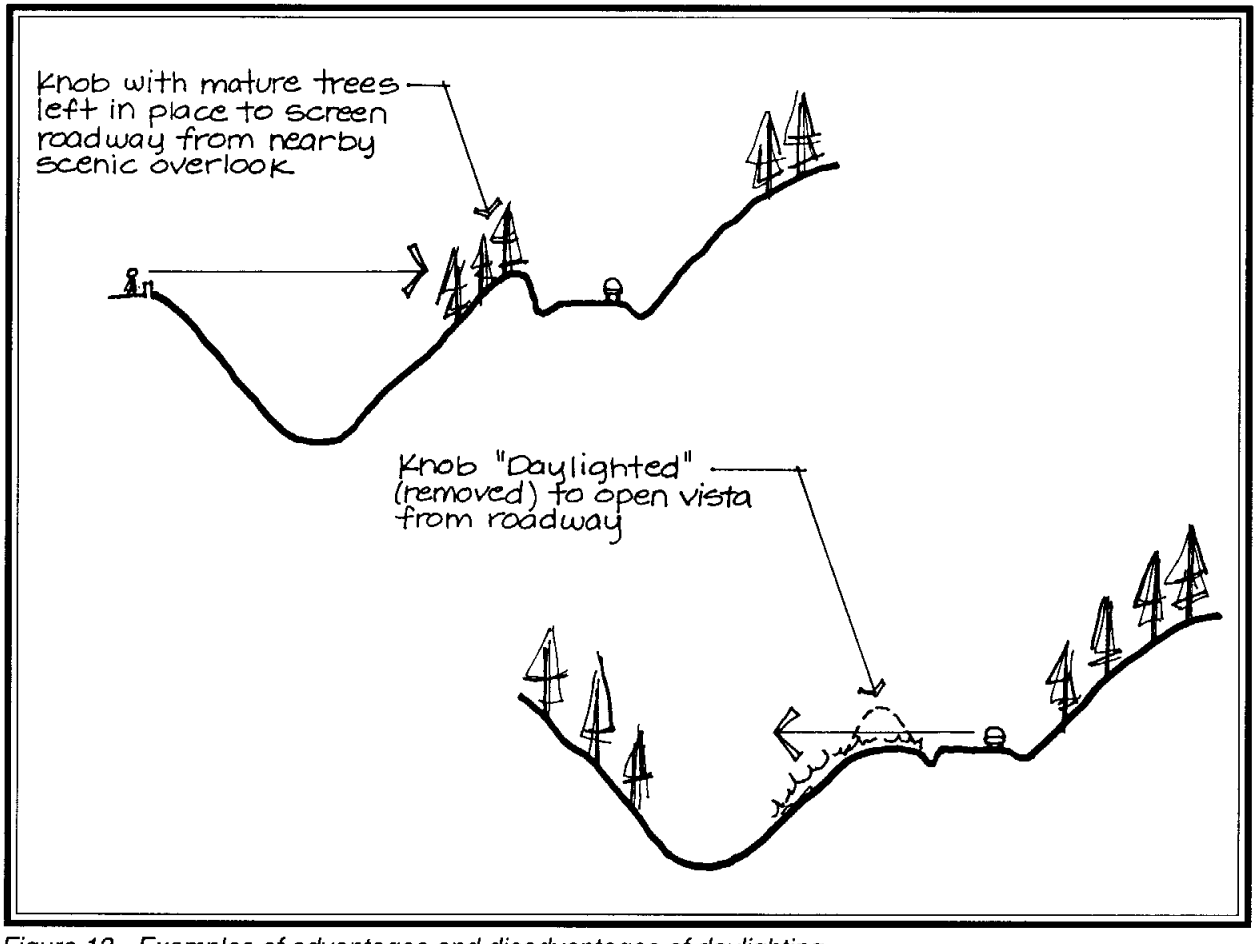


Figure 13 - Examples of advantages and disadvantages of daylighting.

SLOPES AND RETAINING WALLS 4

4.1 Goals

The five primary considerations for slope and retaining wall design are:

- safety
- stability
- cost
- appearance
- environmental mitigation

Slopes and retaining walls should be designed to have long-term stability, a high safety factor, low maintenance, and a pleasing appearance.

4.1.1 Interdisciplinary Approach

The corridor geology and terrain are major factors in the determination of a project's slope angles and the cross sections. Suitable typical sections and slopes need to be developed with participation by an interdisciplinary (ID) team to balance the engineering and environmental requirements for slopes. These decisions need to be made early in the road design process, when preliminary alignments and profiles are determined.

The successful design and construction of highway slopes requires the cooperation of design and resource professionals to solve specific project issues of safety, erosion control, drainage, stability, revegetation and aesthetics. The professionals will usually include civil engineers, geotechnical engineers, landscape architects, horticulturists, agronomists, geologists, and other resource specialists.

To meet visual goals of slope design, the form, line, color, texture and scale of the slopes needs to be considered in the design. With well integrated roadway, slope and wall design, the road will lay lightly upon the surrounding natural terrain and promote revegetation (see Figure 14).

4.1.2 Appearance

Slopes, to the fullest extent practical, should have a natural, rather than artificial, appearance, to blend into the surrounding landscape. All slopes do not warrant the same level of visual mitigation treatment. The agencies need to address the visibility of the proposed cuts, fills and walls, as well as cost factors, and agree upon the appropriate level of visual mitigation.

Cut Slopes

Final cut faces should blend with the form, line, color and texture of the surrounding landscape. On rock cuts with appropriate geology and topographic conditions, it is desirable for the finished slope to have the natural appearance of the surrounding land forms, rock outcroppings and slopes. Detailing, specifying and achieving this final result may require geotechnical investigation and interpretation. Input from engineers and landscape architects regarding the desired appearance is also needed. The geotechnical investigations must address rock type, structural geology and the weathering state of the rock. Generally the jaggedness or natural rock appearance is preferred over pre-split or other unnatural appearances, providing that reasonable safety aspects can be achieved.

On soil and colluvial slopes, natural appearance can be improved by warping the slope, rounding, laying back the ends of cuts, and roughening the face of the cut, where appropriate. These techniques will be discussed in detail in Section 4.3.7.

Fill Slopes

Fill slopes should, ideally, simulate the terrain of the surrounding area. Mitigation treatments may include warping the slopes to leave an irregular, undulating or roughened appearance rather than a uniform grade. This technique is discussed in detail in Sections 4.4.2 and 4.4.4.

Retaining Walls

Walls can introduce a new visual element into the landscape. The wall type, texture, and color selected can help the wall blend with the natural landscape. Alternative wall treatments should be considered during the design phases. The visibility of the wall from the roadway and other significant viewing areas, desired character, and cost factors

Figure 14 - Independent alignments can sometimes reduce the magnitude of slopes and soften the impact of a highway in environmentally sensitive land.

should be determined to develop the appropriate type and level of mitigation (see Section 4.5.2). The need for retaining walls should be considered no later than the 30% submittal.

4.1.3 Constructibility

Slope conditions warrant special attention during the project assessment and design phases prior to construction so that they are properly depicted in the plans and special provisions, and accurately represented to potential contractors. Earthwork should be designed to balance, utilizing the projected shrink and swell factors of the excavated material.

Major elements in slope design which affect construction are:

- site elevation and climatic conditions
- accurate site information, including geology, soil or rock types and extent, orientation of discontinuity in rock, and appropriate samples
- topographic data
- surface drainage and groundwater
- laboratory testing to determine engineering characteristics of the materials comprising the slope
- geotechnical analysis to determine stable slope angles and ditch requirements, and to determine if other measures are needed to stabilize slopes

Some flexibility in the contract is desirable so that specific conditions can be addressed as the slopes are constructed, and the project engineer can take advantage of field conditions (see Figure 15).

4.1.4 Safety

A clear zone, or recovery area, should be maintained free of traffic hazards. This clear zone or recovery area is established as defined in the "AASHTO Roadside Design Guide" (see Reference 9). From a safety standpoint, a 3:1 to 4:1 slope (horizontal:vertical) within the recovery area should be considered to be "traversable" by an errant vehicle, while 4:1 and flatter slopes should be considered "recoverable."

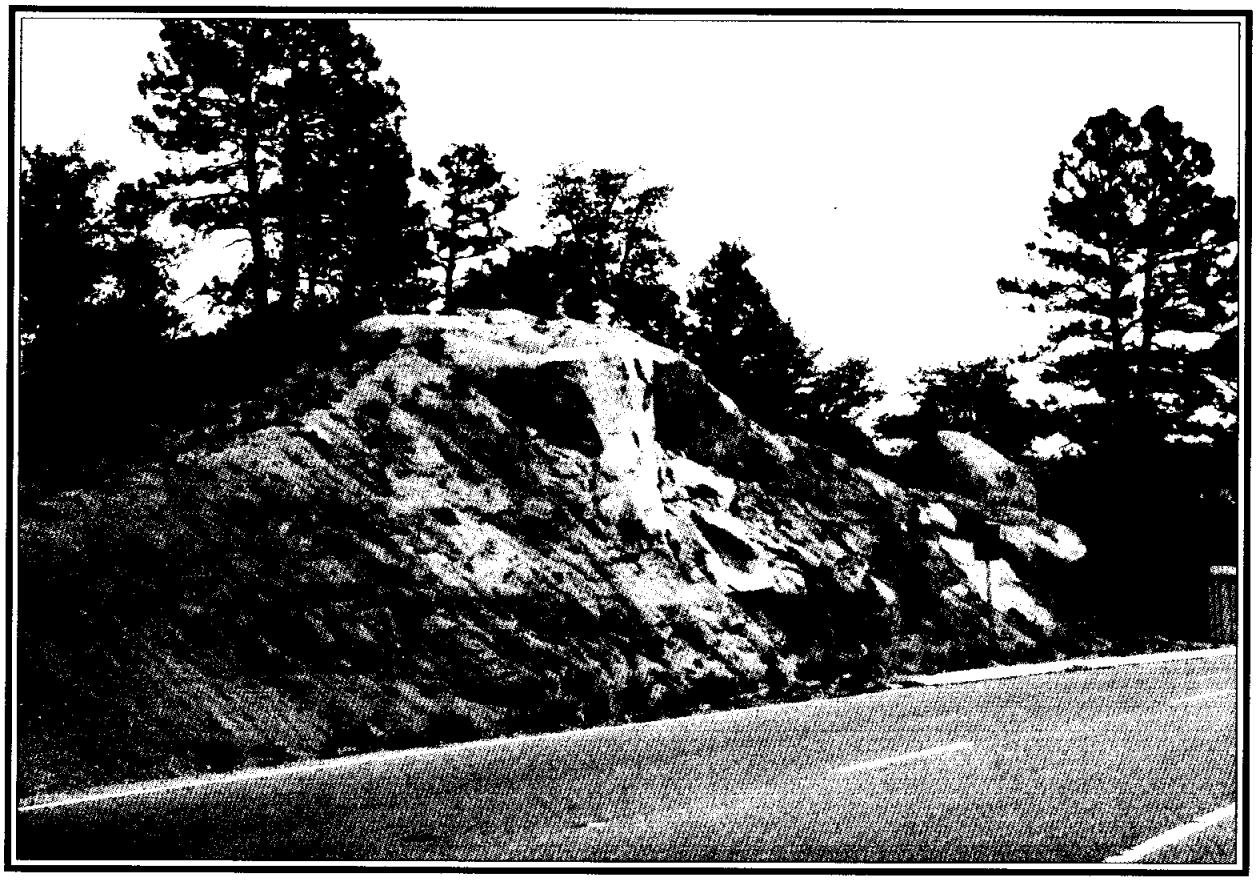


Figure 15 - Existing, stable rock outcroppings in this slope were exposed and left in place during construction as a visual feature.

Traversable slopes within the clear zone do not contribute to the overall recovery area. A consistent recovery area distance may not always be practical. Rather, the slope design should provide the maximum recovery area practical for various site conditions along the roadway (see Section 4.4.1).

4.2 ADOT/USFS Slope Treatment Design and Review Processes

Effective communication is an important aspect in slope design and the construction of slopes that are acceptable to both ADOT and the USFS. Alternatives for slope treatments will be addressed during different stages of the design process. The alignment of the roadway will determine some slope treatment alternatives, such as amount of cut and fill. During the preliminary design phase, alternative slope treatments, including slope ratios, and the use of walls or other structures, will be considered. The project goals and long-term maintenance concerns should be addressed in the evaluation of slope design alternatives.

Prior to the 30% plan review, the slope mitigation treatments should be described for evaluation by the cooperating agencies. For example, if specialized excavation is to be incorporated on the project to achieve visual goals, this technique should be described in the Design Concept Report.

The most effective time for review of slope treatments typically will be during the 30% (Initial) design review. At this level of plan development, a plan-in–hand review should be held for ADOT, USFS and FHWA participation. The centerline of the preliminary alignment should be staked at this time. At the 30% review, selective staking of slope limits should also be considered on projects with extensive earthwork required in sensitive areas. Cross sections should be available for the plan-in-hand review in the field, at both the 30% and 60% levels. Requests for modifications to the slope treatments should be made early in the process, while shifts in the alignment can more easily be incorporated.

4.3 Cut Slopes

4.3.1 Soil and Colluvial Cuts

In general, a flatter slope ratio is desirable for revegetation, safety, slope stability, and visual mitigation.

4.3.1.1 Soil Evaluation

The design of soil and colluvial cut slope ratios will vary on each project. The slopes should be designed for stability, prevention of rockfall, erosion control and revegetation potential.

Some trade-offs are involved: flatter slopes require a greater disturbed area, a wider easement, greater excavation, and possibly increased material hauling costs. However, flatter slopes may be required for increased stability, greater success in revegetation, safety, and more effective erosion control. Soil and slope conditions can change from one cut to the next. The soils and similar slopes in the area should be evaluated to determine the angle that will be stable, resist erosion, and establish and support vegetation.

4.3.1.2 Results of Improper Slope Ratios

Slopes which are constructed too steep do not heal properly and continue to contribute to maintenance and water quality problems because of sparse vegetative cover, sediment transfer, and frequent erosion repair. They also create a visual scar which detracts from the quality of the highway (see Figure 16). These long-term costs can offset the higher initial costs to construct a flatter slope.

If colluvial slopes are not constructed properly, maintenance costs, physical and environmental hazards can result, reducing roadway safety. Rockfall from unconsolidated colluvial slopes can be a constant maintenance problem and also contributes to unsafe situations where rock falls onto the highway. Long-term erosion of the soil that had held the rock in place

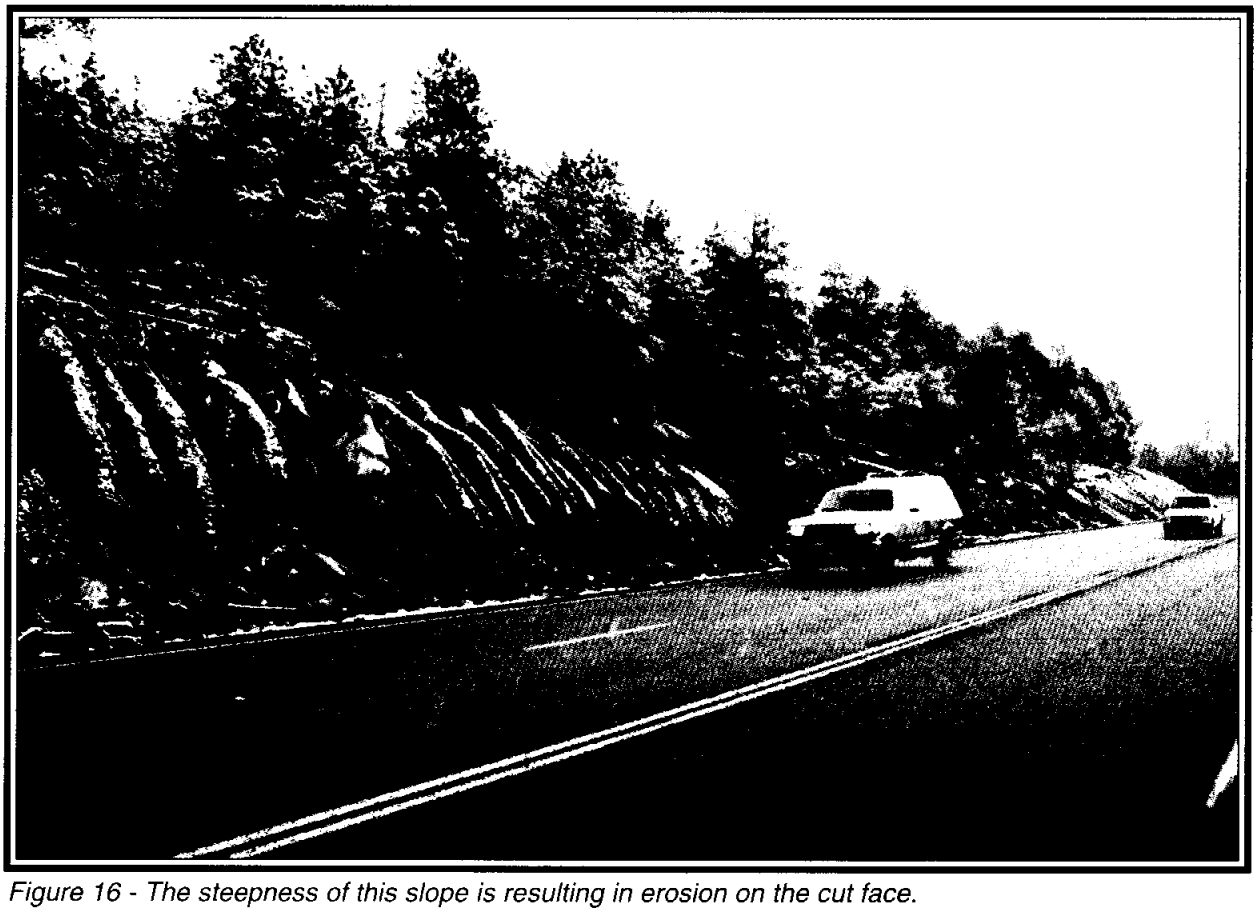


Figure 16 - The steepness of this slope is resulting in erosion on the cut face.

is a major contributor to this problem. Designing to minimize this potential is of primary importance.

4.3.1.3 Typical Slope Ratios

Most soil cut slopes in Arizona need to be a minimum of 2:1 (horizontal:vertical) or flatter. A flatter slope ratio will normally increase stability and reduce erodibility, and improve rainfall infiltration for establishment and maintenance of vegetative cover.

For slopes constructed adjacent to the roadway, 4:1 or flatter slopes should be considered to be recoverable and increase the safety factor.

Cuts generally have greater stability than fills, and, depending on the amount and type of rock present in the slope, can sometimes be constructed at a steeper slope ratio.

In general, the typical, maximum (steepest) recommended slope for cuts in soil or rock/soil (colluvium) mixture is 1.5:1. This slope ratio should be considered where:

- geotechnical studies indicate that a slope at this ratio will be stable
- mature timber, cultural resources, or other significant resources would be disturbed with a flatter slope ratio
- the disturbed surface area would be significantly increased from flattening the slope, such as in very steep terrain
- constraints, such as adjacent private property or wilderness, are adjacent to the slope
- flatter slopes would produce excess material where disposal is a problem.

4.3.1.4 Serrated Slopes and Mini Benches

Some slopes, 2:1 or steeper, and in stable soils, could be constructed with successive steps in the slopes, known as serrations or mini benches. These techniques can be used to increase water infiltration opportunities and soil stability, which can help establish vegetation in poor soils.

Serrated slopes are defined as having regular horizontal and vertical dimensions, each of less than 0.3 m in size. Mini benches also have horizontal and steepened vertical dimensions, but are larger in scale than serrations. The horizontal dimension of a mini bench is greater than 0.3 m with 1 m being the largest optimum size. The vertical dimension is also larger, greater than 0.3 m and often more than 1 m high. Serrated slopes are commonly used on cut slopes in less arid climates, where vegetation establishes more quickly and with greater density than in Arizona. In Arizona, the use of the larger mini benches is more common than serrations.

Both techniques have a long term visual impact and have not been widely endorsed on National Forest land. Serrated slopes and mini benches are most likely to achieve a natural appearance when the plant species selected for revegetation are of a large enough size to visually screen the serrations on the slope. Otherwise, the result can be a long-term unnatural appearance, with visible, regular, horizontal lines across the face of the slope (see Figure 17).

Serrated slopes and mini benches are constructed from the top down, along a nominal fill slope ratio. The horizontal and vertical dimensions are constructed to specified widths and heights depending on the given slope ratio. This technique differs from "ripping" a slope (see Section 4.3.7.3).

Staggered mini benches are the same technique as regular mini benches, except that they are constructed with varying dimensions and located at varying heights on the cut slopes. This technique can result in a less visually obtrusive slope, because of the more natural appearing land form which remains visible over time, while still providing the improved revegetation opportunities. Staggered mini benches are a new concept, and require nontraditional design details, specifications, and additional field supervision during construction.

Serrated slopes and mini benching can be considered in rippable slopes containing soft, weathered rock materials and soil which will slough and fill in gradually, during the process of weathering and revegetating. Soil type and stability are key factors in determining the appropriate technique. Mini benches are more appropriate in soil with less stability, as sloughing will occur regularly and the larger horizontal step is needed. In unstable soil, the smaller steps on a serrated slope could fill too rapidly, before vegetation has a chance to become established, and the soil could be washed to the toe of the cut.

For stability purposes, it is important that the horizontal step is constructed to be flat, rather than following the vertical slope of the road.

The characteristics of serrated slopes, mini benches and staggered mini benches are summarized below for comparison.

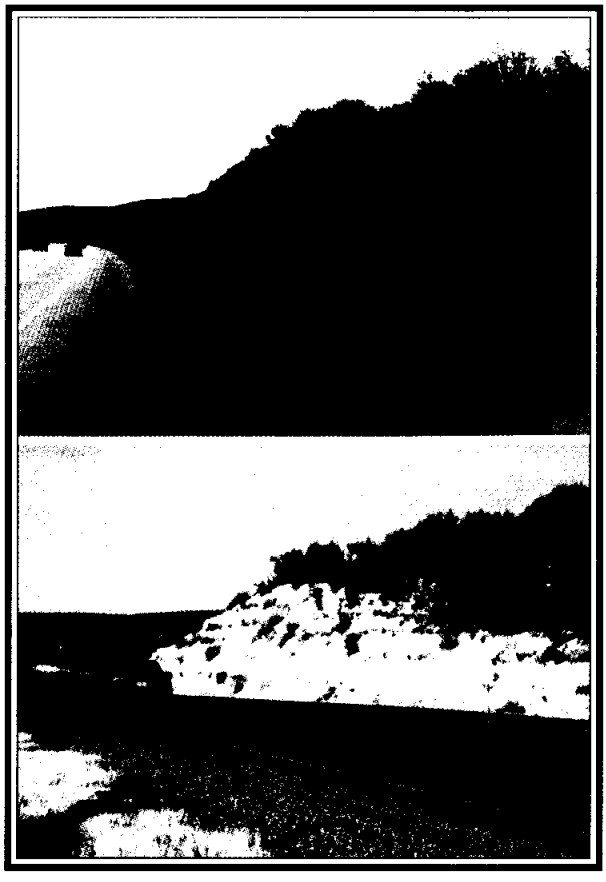


Figure 17 - The mini benches on the top cut have revegetated better than the mini benches on the bottom. The mini benches remain visible in both examples. Staggering the mini benches may achieve better visual results.

Serrated slopes

- horizontal and vertical "steps" up to 0.3 m dimension
- horizontal and vertical dimensions are regular
- steps cross the entire cut face
- serrations diminish over time, as soil sloughs in and fills the step
- steps collect water for increased revegetation
- vegetation will grow in straight lines, following the serrations
- serrations are usually a long-term visual element, unless substantial soil sloughs in and vegetation is tall and dense enough to screen the step effect
- more appropriate for slopes with enough rock and stability to allow gradual sloughing, giving time for revegetation to occur before soil is washed off.

Mini benches

- horizontal and vertical steps exceed 0.3 m, and are up to 1 m or more in width and height
- the steps do not slough in; land form is a permanent visual element
- horizontal and vertical dimensions are normally regular in dimension, but can be constructed with varying dimensions (see staggered mini benches, below)
- steps cross the entire cut face
- vegetation will grow in straight lines
- more appropriate for less stable slopes, where sloughing will occur more rapidly and revegetation will require additional time to stabilize the slope.

Staggered mini benches

- horizontal and vertical steps exceed 0.3 m, and are up to 1 m or more in width and height
- the steps do not slough in; land form is a permanent visual element
- the steps are constructed in varying dimensions
- the steps do not cross the entire cut face
- the steps are located at varying heights on the cut face
- the irregular dimensions of the steps can achieve a more natural appearance in land form
- vegetation will grow in a random pattern, with a more natural appearance
- additional design details, specification and field construction supervision are required.

Also, refer to Slope Roughening and Ripping, Section 4.3.7.3.

4.3.2 Rock Cuts

4.3.2.1 Typical Slope Ratios

Rock cut slopes generally should be steep and natural looking with major consideration given to stability and prevention of falling rock. Slopes with competent rock can sometimes be constructed near vertical and meet stability and visual goals. Other considerations depend on the composition of the slope.

The long term stability of rock slopes for safety is of primary importance. Rock slope ratios must be considered by geotechnical specialists to minimize ravel and rockfall. The design of rock slope ratios must consider constructibility, maintenance and procedures to minimize rockfall to the highway.

Rock slopes can typically be constructed at steeper slope ratios than soil or colluvial slopes. The appropriate slope ratio must, at a minimum, be determined by the rock type, stability and height of the cuts. A slope of 0.25:1 (horizontal:vertical) is a typical maximum slope ratio for competent rock. It may be possible to achieve 0.1:1 in extremely competent rock. Visually, near vertical slopes, 0.25:1 and greater, may appear to be encroaching and can lead a driver of a large vehicle to veer away from the slope. For this reason, near vertical slopes should be moved back from the travel lane to create as much recovery area as practical.

4.3.3 Mechanical Excavation

Rock slopes may be excavated with equipment instead of blasting, usually at the discretion of the contractor. The contract special provisions should address how to achieve desired visual effects on slopes that are ripped. On excavated slopes, hammer, teeth or claw marks from the back hoe or rock hammer can also be unsightly. These marks can be removed or lessened by dragging the side of the bucket or hammer housing over the scars, or with hand labor. These scars are more of a problem in some materials than others. The operator should be made aware of the goal to mitigate scars on the final face before the final excavation. The contractor can then use discretion as to the best techniques for that situation, which will meet the visual goals.

Irregularities and planting pockets can be incorporated into these slopes with a hydraulic rock hammer or backhoe, at the direction of a landscape architect or engineer. Additional construction time may be involved (see Section 4.3.7.3).

4.3.4 Blasting

Because of the expense of constructing roadways through rock area, economic efficiency and budget are major considerations. The degree of a roughened slope, probability of rockfall, and rockfall containment options should be analyzed in relation to budget and the project goals to determine the optimum blasting techniques for the project.

4.3.4.1 Techniques

Different blasting techniques are appropriate for different excavation needs and rock types.

Controlled blasting consists of the controlled use of explosives and blasting accessories in carefully spaced and aligned drill holes, using different explosives and delays to produce specific, free surfaces or shear planes in the rock along the predetermined excavation backslope (see Glossary, Appendix A). Controlled blasting techniques include ***presplitting, cushion*** (trim) blasting, and a special version of controlled blasting using horizontal holes, ***lifters.*** One difference between presplitting and cushion blasting is that, with pre-splitting, drill hole spacing is closer and results in an increase of obvious drill hole scars in the final face.

Uncontrolled, or production blasting consists of the main fragmentation blasting resulting from more widely spaced production holes drilled throughout the main excavation area.

In general, production blasting techniques can be used for the breaking up and removal of large quantities of material. Controlled blasting will be required for finishing final cut faces, to control the quantity of material removed, the final appearance, fragmentation, and flyrock.

Hard, competent rock will produce more favorable, predictable, visible results from controlled blasting. In soft rock, it is difficult to control the outcome of various blasting techniques. Because rock types and structure may differ from cut to cut, geotechnical input is needed to predict blasting results.

The results of presplitting, cushion and production blasting are summarized in Figure 18, and discussed below:

- **Presplitting**—can provide a uniform cut face with minimal damage to the existing rock structure; leaves drill hole scars, which appear unnatural and are sometimes considered to be visually objectionable (see Figure 19). Light scaling may be required on presplit cuts. Often this technique is appropriate in rock with little or no structure where cushion blasting may not be successful.

- **Cushion blasting**—can produce an irregular, but stable, rock face, with a more natural appearance (see Figure 20). Drill hole scars are blasted away, and no follow-up work on scar removal is needed. Irregularities and small ledges can be designed into

the blasting plan by location or achieved by performance specification. Ledges should be located to achieve visual goals, at a safe height on the slope. Ledge width and height, and the irregular face, must not result in a safety problem. Cushion blasting can have a greater potential for ravel and rockfall. Additional scaling will probably be required with cushion blasting.

- **Uncontrolled/production blasting**—can result in highly fragmented rock. Historically, this type of blasting used black powder and was common with early roadway construction. This technique is still used for breaking up large quantities of rock to haul away. It is not suitable for a final cut face because of safety, maintenance and visual concerns (see Figure 21).

4.3.4.2 Blasting Objectives

Objectives for controlled blasting include:

- minimize blast damage behind the trim line
- utilize the natural geologic bedding planes and joint structure in a predicted and controlled manner, to form the final cut
- blast and scale to the trim lines to produce stable faces such that the subsequent rockfall and associated maintenance costs are minimized
- preserve or create sufficient irregularities in the rock faces to allow for pockets and ledges for special revegetation
- minimize obvious drill hole scars (cushion blasting) or machine scaling equipment scars in the final cut faces
- formulate blasting approaches such that the cut faces will blend with surrounding natural features of

BLASTING COMPARISON TABLE

COMPARISON * / BLASTING APPROACH	ADVANTAGES	DISADVANTAGES
PRE/SPLIT	• Most stable cut face • Minimum ditch maintenance	• Drill hole scars remain with visual impact • Straight cut face appears unnatural
CUSHION	• Fairly stable cut face • Irregular face reduces visual impacts • Results in some catch areas for revegetation	• More rock scaling needed • Some ditch maintenance required • Wider ditch catch area required
UNCONTROLLED	• High material production • Highly irregular face reduces visual impacts • Results in most catch areas for revegetation	• Unstable rock face • Most rock scaling required • Widest ditch catch area required • Considerable ditch maintenance required

* Based on similar slope ratio.

Note: Comparisons of advantages and disadvantages are generalized; results can vary widely according to rock type and variations of blasting details among the approaches.

Figure 18 - Blasting Comparison Table.

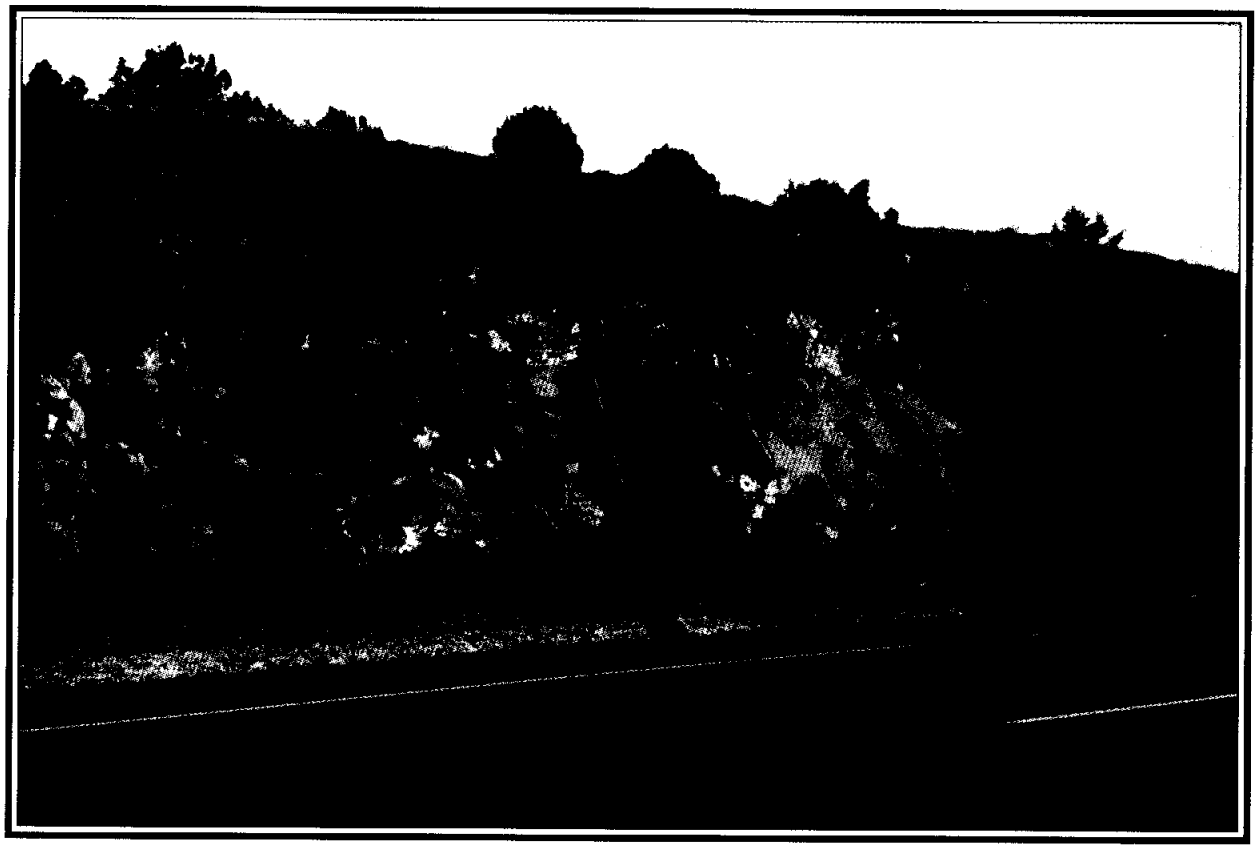


Figure 19 - This presplit cut has visible drill hole scars and has not achieved favorable visual results. (Photo by John Bell).

the landscape, such as rock outcrops, draws and slope of terrain

- prevent damage to the natural or cultural environment outside the clearing limits from fly rock, operation of equipment or other construction related causes
- reduce blasting ground motions and air blast-induced motions in the vicinity of structures
- avoid sliver cuts, and cuts which will leave a highly visible track drill access scar along the top.

The anticipated rockfall from a slope excavated from cushion blasting and/or presplitting should be analyzed in terms of scaling needs and rockfall containment ditch requirements.

4.3.4.3 Blasting Plans

Blasting plans should contain all the information necessary to evaluate the probable effects of controlled and production blasts on the final cut face, including full details of the drilling and blasting patterns and controls the contractor proposes to use. The goal of blasting plans is to provide quality control and accurate record keeping. A General Blasting Plan will be required for all projects including blasting. This plan must be approved by the Resident Engineer prior to the commencement of blasting.

The General Blasting Plan outlines the blasting techniques proposed by the contractor. Most slopes will need additional, site specific, blasting designs, as one blasting plan does not fit every slope on the project. The blasting pattern plan for specific cuts should include the following features: the drill hole grid to define the spacing and burden; an explosive type; sonic velocity matched to seismic velocity of the rock, and an effective delay in timing.

On these projects, the contractor is also required to submit specific blasting plans prior to proceeding with each blast.

Contents of a typical General and Specific Blasting Plan are in Appendix E.

Measures should be specified and enforced to eliminate or minimize overshot rock, and to minimize

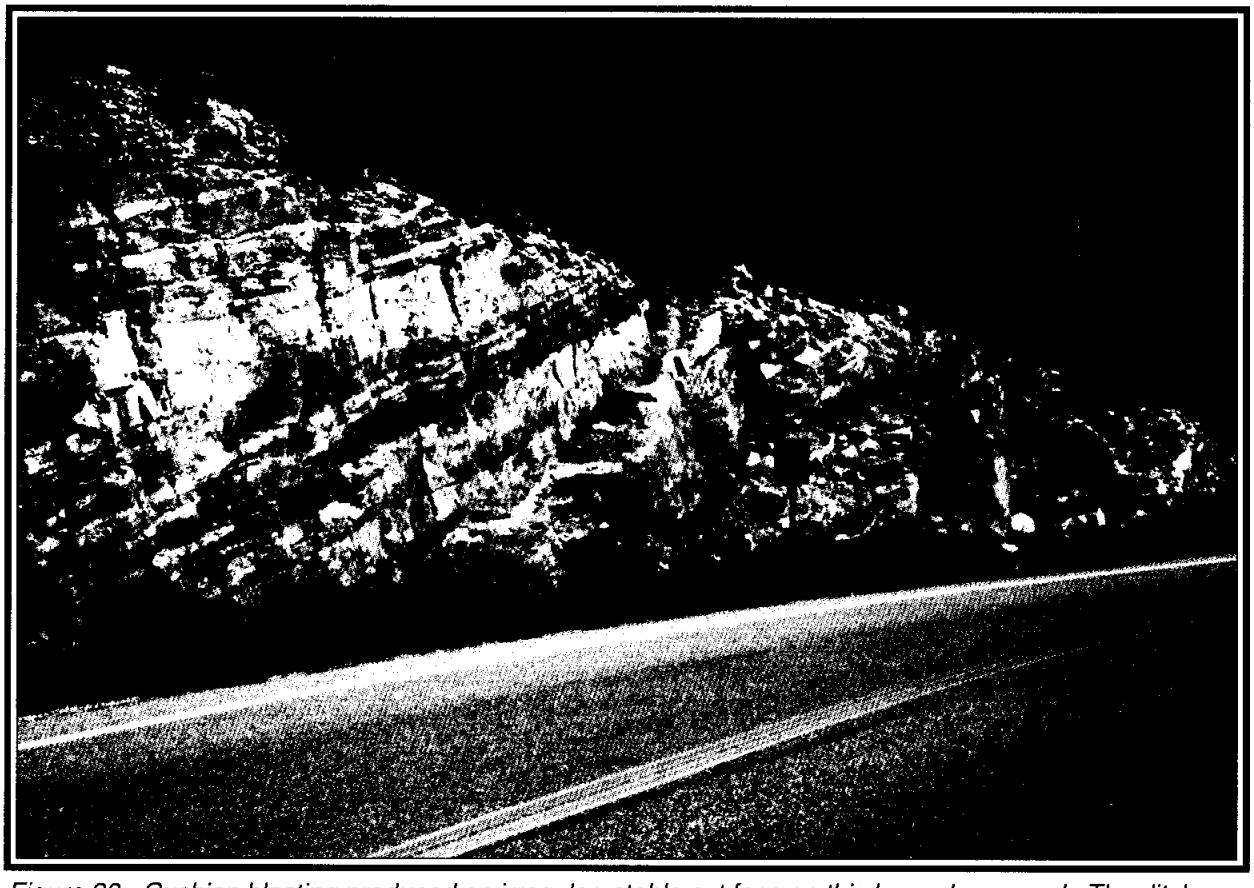


Figure 20 - Cushion blasting produced an irregular, stable cut face on this low volume road. The ditch area is extremely limited.

backbreak behind the trim line. In environmentally sensitive areas, it may be necessary to limit the shot quantities in order to prevent damage to adjacent resources from flyrock, or from clearing rock from the travel way to allow traffic to safely pass through with minimal road closures. Load restrictions and vibration limitations may also be required in areas where structures or unique features, such as rock pinnacles, are present. Other protective measures may be required in blasting areas to protect adjacent vegetation, wildlife or other resources from clearing activities or noise.

The General Blasting Plan will be submitted to ADOT by the contractor. ADOT will review and approve the plan with review input from the USFS. The use of a "Blasting Consultant" for ADOT, or as a requirement of the contractor, should be a consideration as part of such contracts. When the contract requires the use of a blasting consultant, all blasting plan submittals must be approved by the blasting consultant.

Members of the interdisciplinary team need to have a designated "expert," familiar with blasting capabilities, so that reviews are conducted with everyone speaking the same "language."

4.3.4.4 Test Blast

Each project with specialized blasting should have one or more test blasts shot. The requirements need to be addressed in the contract documents.

Test blasts are required before the contractor can proceed with production or controlled blasting. They are used to evaluate the adequacy of the proposed blast plan. Typically, the test blast will be conducted in sections up to 30 m in length, and include drilling, blasting and excavation to determine which combination of method, hole spacing, charge and delay works best. If results of test shots are unsatisfactory, the contractor should adapt such revised methods as are necessary to achieve the desired results. The results of the test blast should be evaluated by the

project engineer, blasting consultant (if used), and a designated representative of the USFS interdisciplinary team. The Resident Engineer has the final authority in directing the contractor (see Chapter 10).

4.3.5 Major Warping

Major warping of a cut slope refers to the design and construction of a cut face which is not parallel to the roadway. This technique can be accomplished on different scales (see Minor Warping, Section 4.3.6.1.). Major warping can be required for visual mitigation to create variety along a corridor, especially where cut slopes are large in scale and where through cuts could create a "tunnel" effect (see Figure 22).

Major warping can be specified by adjusting the trim (cut) line back from the roadway 6 m - 12 m in distance. This technique would generally be considered only in areas where large drainages occur or cuts of high visual sensitivity. If this approach is used, the large scale warping concept should be designed into the cross sections, excavation quantities and fill area plans, as additional material will be generated.

4.3.6 Rock Slope Surface Treatment

Rock slope surface treatment includes the roughening of the cut face to incorporate short, staggered ledges, minor warping, planting pockets, and other irregularities in the rock that have a natural appearance. Rock slope surface treatment also may include removal of drill hole scars (half rounds) following presplitting.

Rock slope surface treatment can normally be achieved through cushion blasting, mechanical excavation, or a combined approach. When blasting or excavating a rock slope results in too much uniformity, the face can be roughened and shaped with a hydraulic rock hammer or backhoe. Teeth or hammer scars can also create a visual problem, so an experienced operator is needed (see Section 4.3.3).

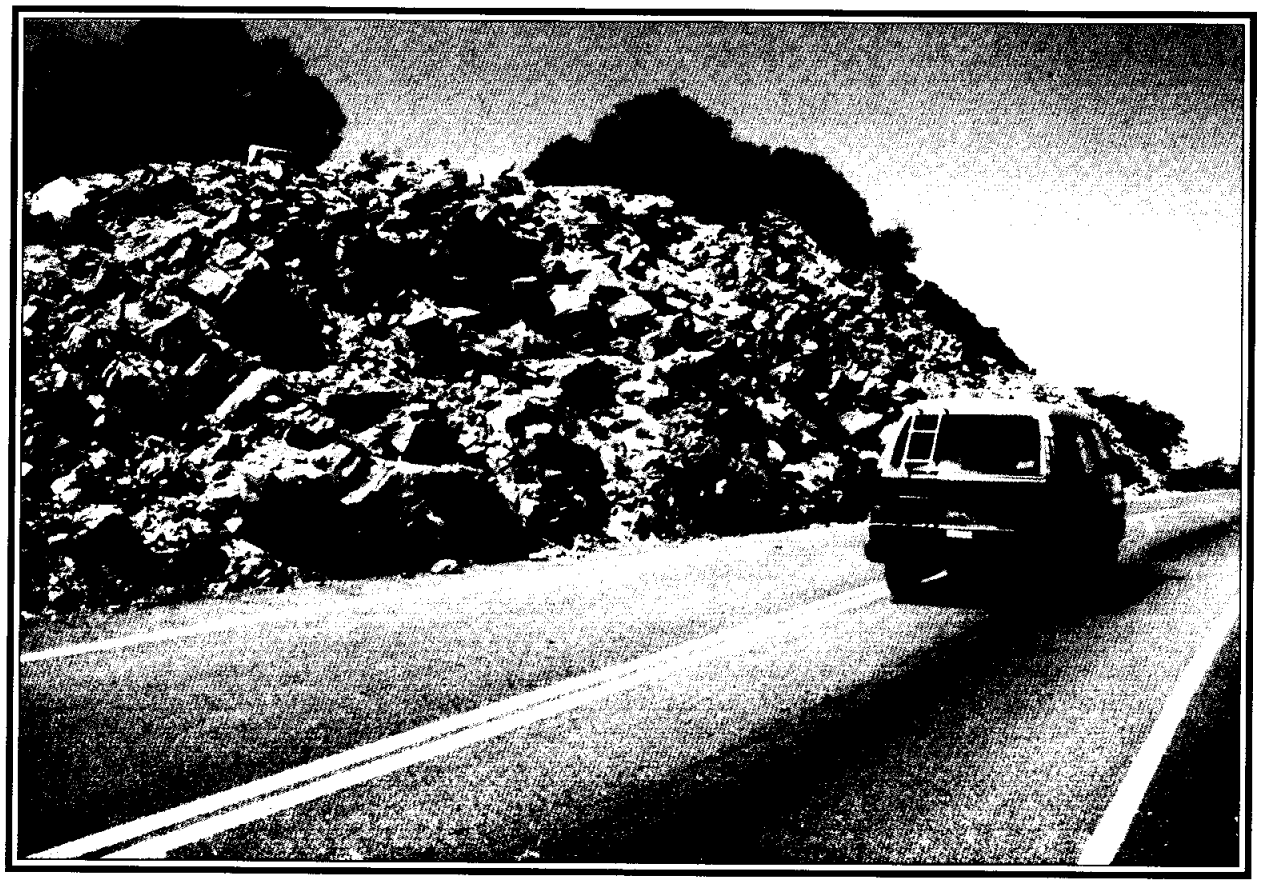


Figure 21 - Uncontrolled blasting resulted in a highly fractured face which created a visual scar, safety problem and increased maintenance costs.

4.3.6.1 Minor Warping

Minor warping is a technique used to increase variety, texture and shading on a cut face, which can result in a more natural appearance. Minor warping refers to a non-parallel cut face, which steps in and out from the roadway. Depending on the rock type and joint patterns, warping can be achieved on a small scale with cushion blasting (see Figure 23). If not achieved during the blasting, minor warping would be possible with mechanical excavation (see Section 4.3.3).

4.3.6.2 Staggered Ledges

Ledges constructed for visual mitigation need to be designed to be small enough so that they will not serve as rock storage or launching areas. Care must be exercised that, if the ledges collect material, they do not become rock launching features. This is critical where cuts are near the roadway (see Figure 24). Larger ledges can also have an unnatural, undesirable appearance (see Figure 25).

The acceptable range of ledge sizes will depend on the height of the cut, slope ratio and distance from the travelway. Input will be required from a geotechnical engineer to determine size limitations for each project.

4.3.6.3 Planting Pockets

Planting pockets can be achieved by placing soil on irregularities on the cut face. Pockets can be achieved during cushion blasting or, through follow-up slope work, with a rock hammer or backhoe. Soil can sometimes be caught on planting pockets during the rounding process. Planting pockets and ledges must be designed in such a way that maintenance on the cut face is not required (see Figure 26).

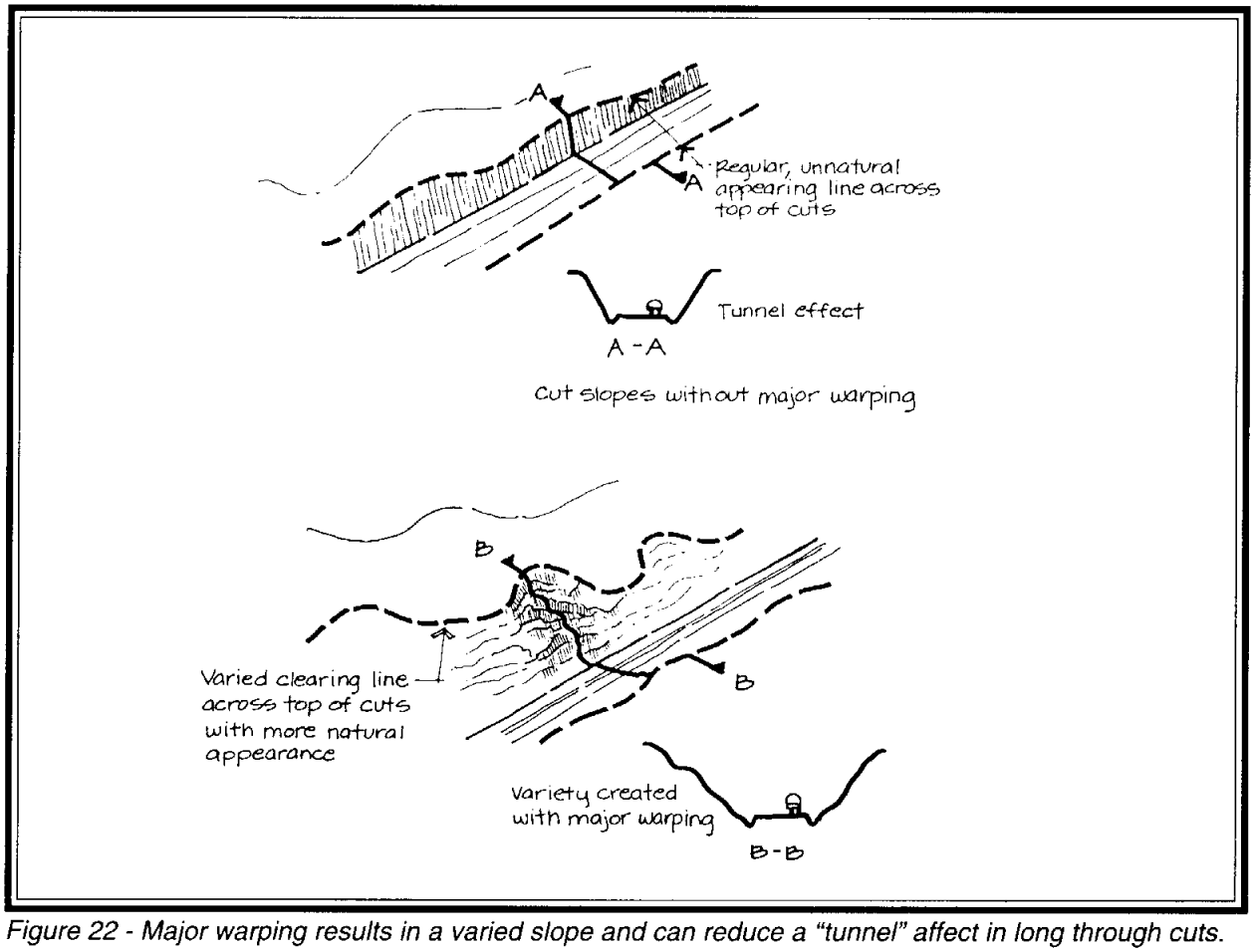


Figure 22 - Major warping results in a varied slope and can reduce a "tunnel" affect in long through cuts.

Figure 23 - Minor warping was achieved by blasting on this cut, which revealed the natural joint patterns of the rock (see also, Figure 20).

4.3.6.4 Drill Hole Scar Obliteration

On cuts where presplitting is used, it is possible to remove half rounds of presplit holes with a hydraulic rock hammer or other equipment, to meet visual requirements. This is a "manual" process and can slow production depending on the number of presplit holes and rock quality. This process is extremely slow in hard rock. This work should be limited to areas with significant visual impacts, such as the lower 9 m - 12 m of a cut face in highly visible areas. If areas are not deemed essential for visual goals, the cost and time for this work can be reduced or eliminated (see Figure 27).

4.3.7 Finishing Rock, Soil and Colluvial Cut Slopes

4.3.7.1 Scaling

Scaling of rock cut faces is a necessity, because blasting operations, regardless of control methods used, will result in local occurrences of loose or overhanging rock. Any condition which creates a potentially hazardous situation should be removed or stabilized to the Resident Engineer's satisfaction, during or upon completion of each lift.

4.3.7.2 Stain

Where the cut rock varies in color from the surrounding rock areas, a penetrating oxide coloration product can be applied to the rock to provide a darker, weathered rock appearance. All staining materials must be environmentally safe and approved by the Engineer. Final decisions on locations of staining are normally made by the Engineer with consultation from the USFS representatives.

4.3.7.3 Slope Roughening and Ripping

In general, many of the soil and colluvial cut slopes are constructed too smooth and need to be roughened or ripped with sheepsfoot rollers, cat tracks or

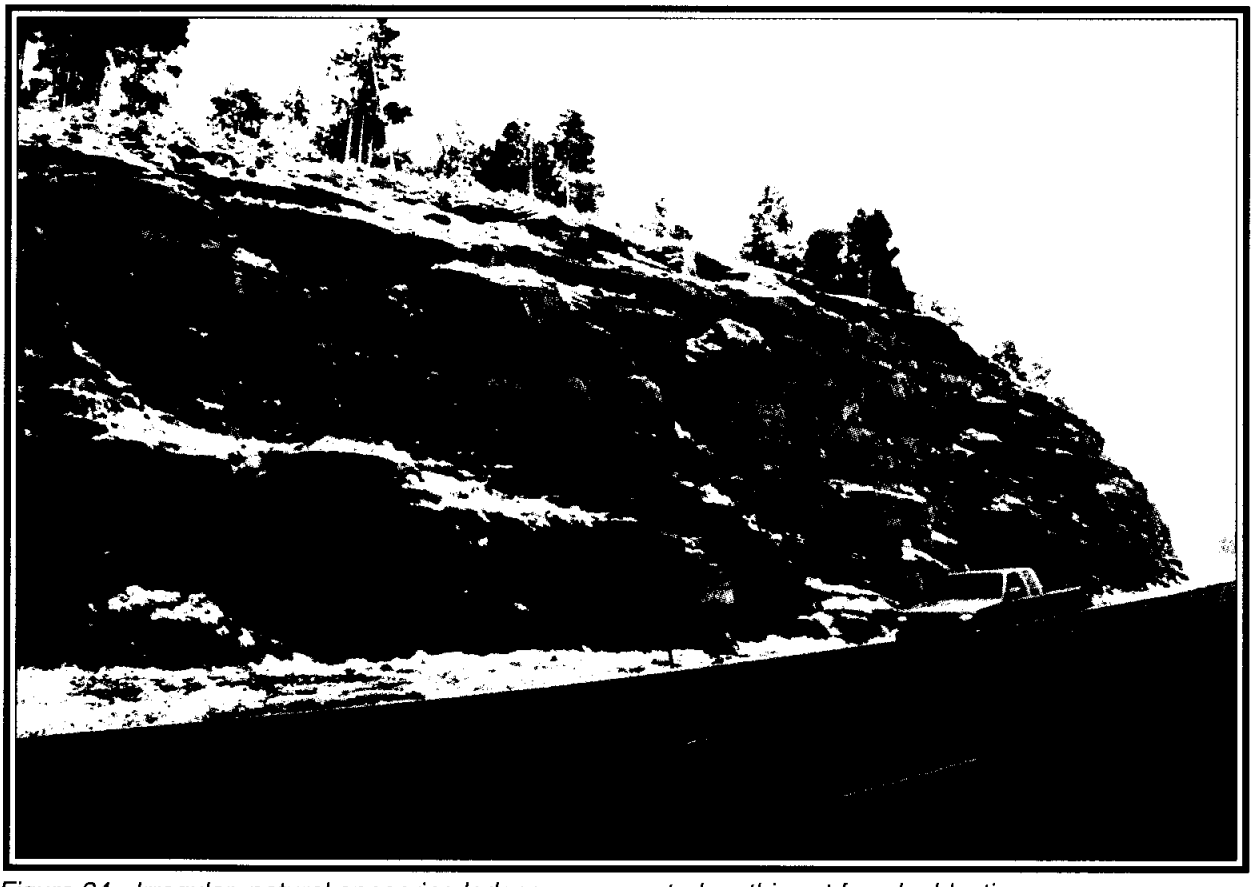


Figure 24 - Irregular, natural appearing ledges were created on this cut face by blasting.

blade attachments to enhance the infiltration of water for the establishment of vegetation. Generally 2:1 and 3:1 slopes should be roughened or ripped; 4:1 and flatter can be left with a smoother finish.

On more stable colluvial slopes, short ledges or planting pockets may be worked into the slope at points of the soil/rock interface (see Figure 28).

4.3.7.4 Highlighting Rock Outcroppings

Exposed rock, if solidly embedded in a cut face (so that it does not present a safety problem), can be left in place as a natural-appearing outcropping, where possible (see Figure 15). This technique can add variety and texture to a cut face.

4.3.7.5 Rounding and Laying Back Ends of Cut Slopes

The land forms of the surrounding terrain should be matched to the extent possible through slope rounding and laying back the ends of cut slopes.

Rounding refers to the additional excavation at the top of the cut slope in a "rounded" shape, in order to blend the slope into the natural terrain above the cut. Rounding typically involves an area from 3 m - 7 m, but may be exceeded in areas of extreme topography (see Figure 29).

Laying back the ends of cut slopes refers to the flattening of the slope ratio at the ends of cut slopes in order to provide a smooth transition to the adjacent cut, fill or drainage area (draw) (see Figure 29). Laying back the ends of cut slopes to the degree of providing a transition to adjacent terrain should be a standard treatment for all cut slopes. The degree of flattening the ends of slopes depends on the design, adjacent topography, cost factors and visual effect desired. This treatment, similar in scale to rounding the tops of cuts, should be a typical detail to be applied throughout the project.

A trade-off may be involved with rounding and laying back cut slopes, as additional grading will be required in order to blend the new slope into the

surrounding natural terrain. Where the typical approach is to minimize earthwork, clearing and ground disturbance, rounding and laying back the ends of cut slopes increases the disturbed area, and can also increases project costs. These short-term impacts must be weighed against the long-term benefits achieved with the blending, such as better revegetation and a more natural appearance (see Figure 30).

Rounding and laying back ends of cut slopes, while done mostly for visual improvement, can also be used to reduce the surface velocity of runoff and control water within the easement. Rounding the tops of cut slopes is often needed to avoid a future eyebrow and overhanging vegetation at the top of a slope (see Figure 31). By rounding a slope at the time of construction, slope stability and safety can be increased, and future maintenance needs are reduced.

It is apparent from project to project that the appropriate degree of rounding and laying back the ends of cut slopes is a subject of broad interpretation. In general, these techniques need to be extended out proportionally for large cuts and fills. Minimal rounding may be incorporated on rock cuts to remove topsoil and vegetation at the edge and/or to avoid an existing or future overhang. If topsoil is conserved at the tops of rock cuts, behind the clearing limit, this material can be spread over the cut during the rounding process, onto the irregularities in the cut face.

The material generated from rounding of slopes can sometimes add considerably to earthwork quantities. This material should be considered when project designers are determining these quantities. Rounding should not ideally be used as a way to add or generate material for projects, but should be used primarily to blend slopes into adjacent areas.

The clearing limits should be designed and adjusted, if necessary, to account for the protection or removal of vegetation at the tops and ends of cuts. Staking accuracy is critical to the USFS, as additional clearing is usually required during rounding and laying back the ends of cut slopes. The clearing limit staking should provide for these techniques where required on the project, and should be reviewed by the agencies during the design process (see Section 2.3).

Rounding around existing vegetation needs to be determined on a case-by-case situation. In some

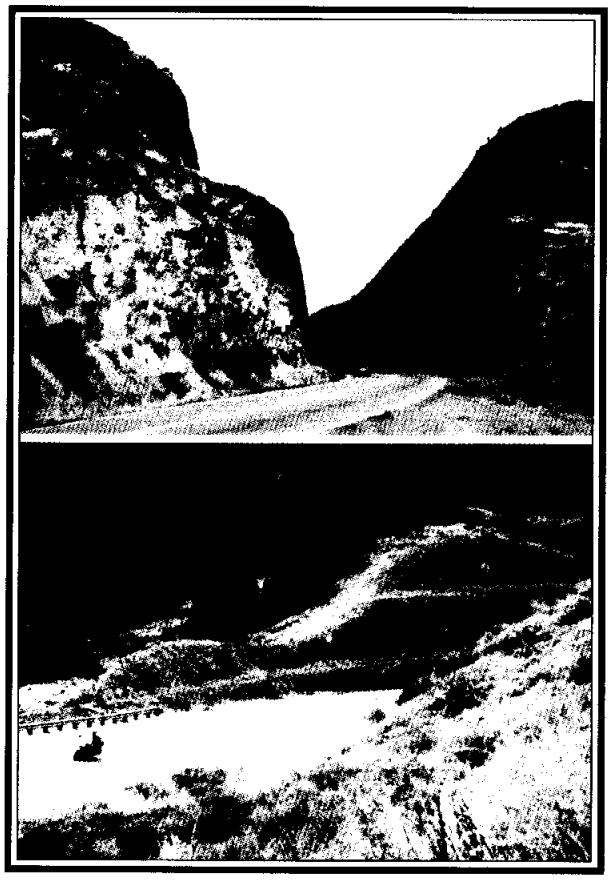


Figure 25 - These larger, uniform ledges are visually obtrusive, as they do not relate to surrounding land forms.

Figure 26 - Example of planting pockets and ledges on irregular rock face.

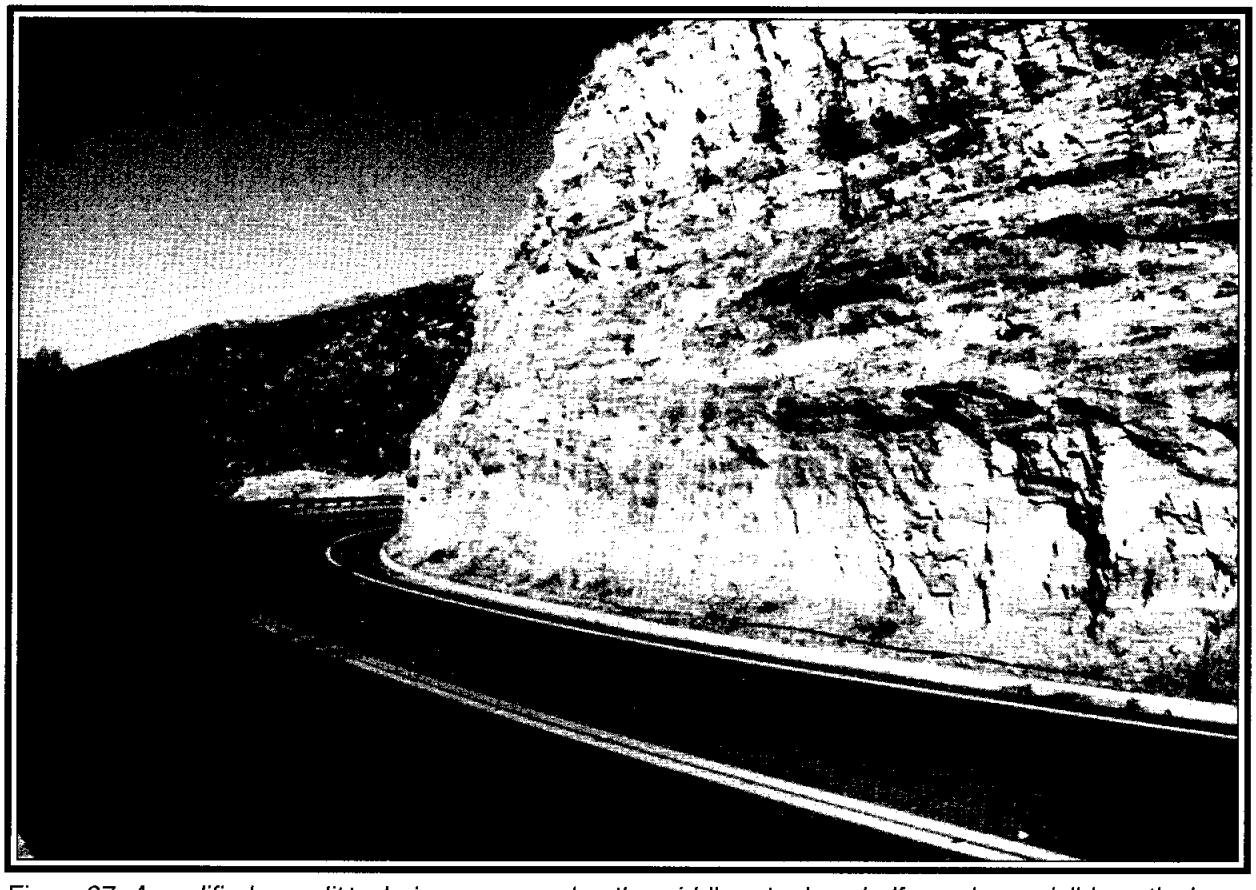


Figure 27 - A modified presplit technique was used on the middle cut, where half rounds are visible on the lower left portion of the cut. This was acceptable on the inside of a curve, not visible from other locations.

cases, mature vegetation is important for the stability of the slope, and removal may induce increased rockfall or erosion, with resulting future rockfall. In other cases, leaving vegetation at the top of a cut slope could result in a hazardous situation (see Figure 32).

Rounding is best accomplished during initial excavation of the slope. After the slope is completed it is often impossible for equipment to access the top of the cut. Daily or weekly inspections during the rounding operation are recommended (see Chapter 10).

Rounding can also be incorporated into a cut slope to vary the top line of the cut and vary the clearing limit line for a more natural appearance (see Figure 33). Care must be exercised not to create a new drainage area over the face, leading to maintenance problems.

4.3.8 Rockfall Containment

Rockfall containment measures may be needed on any type of rock slope. On blasted slopes where uncontrolled blasting was used, the likelihood is greater that rockfall containment will be needed. In addition, if scaling does not meet the desired safety requirements, further slope stabilization or rockfall containment will be required. These measures will generally consist of in-place treatments, such as additional scaling, rock bolting or anchoring, soil nailing or other engineer-approved techniques. Alternatives may be submitted by the contractor, blasting consultant or geotechnical engineer. The visual impacts of the preferred stabilization technique, if not evaluated previously during the environmental study, should be considered for input to the techniques considered.

Figure 28 - Rock hammer is used to create irregularities on colluvial slope.

Rock bolting and soil nailing

Geotechnical slope protection measures provide erosion control and increased slope stability. They are generally used on slopes that are marginally stable and need an integral reinforcement system in order to assure long-term stability. In both cases, a grid of long reinforcing bars are drilled and grouted into place in the rock or soil faces. Wire mesh, coated or colored mesh, or a shotcrete facing could be used over the grid.

Wire mesh

Wire mesh or chain link is often pinned and draped over slopes as a measure to control rockfall. While it does not prevent rockfall, it prevents falling rocks from bouncing out into the travelway. Catchment ditches or benches are usually incorporated to collect the fallen rock. Depending upon the gage of the mesh, the location and the anchoring system, the visual impacts of wire mesh can vary widely. On soil slopes, wire mesh can also be used as an erosion control blanket, although it is a very expensive alternative.

Fence /Barrier

A barrier and/or fence can be placed at the edge of the ditch area to stop rockfall from entering the travelway (see Figure 34).

These treatments can be used in place of retaining structures under limited geological conditions, and can be competitive in price with other structures. Aesthetic treatments, such as artificial rock can be added as a veneer to some rockfall containment treatments.

4.4 Embankments

Fill slopes should be constructed at a suitable ratio for stability and reducing erosion, thus improving rainfall infiltration for establishment and maintenance of vegetative cover.

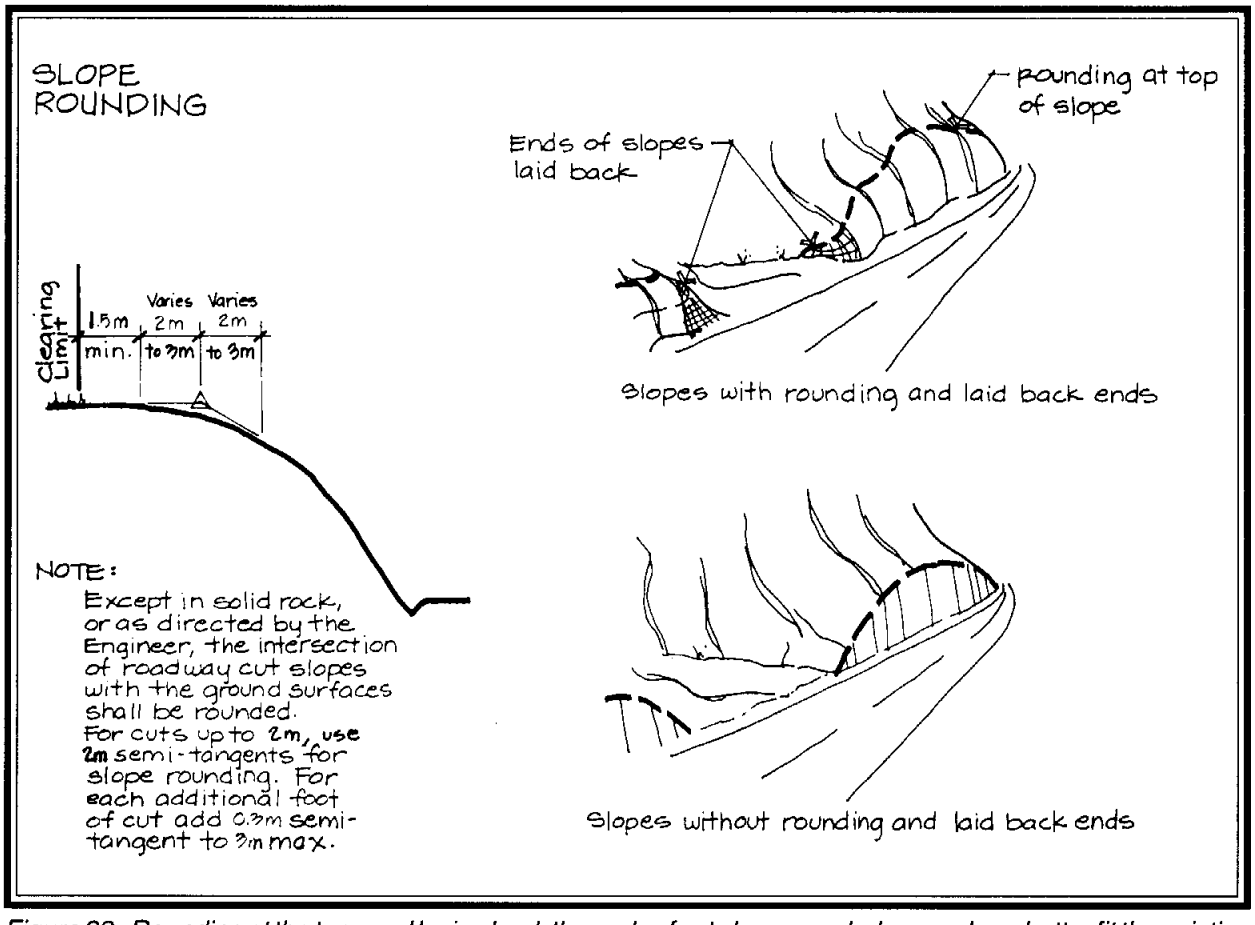


Figure 29 - Rounding at the tops and laying back the ends of cut slopes can help a roadway better fit the existing terrain.

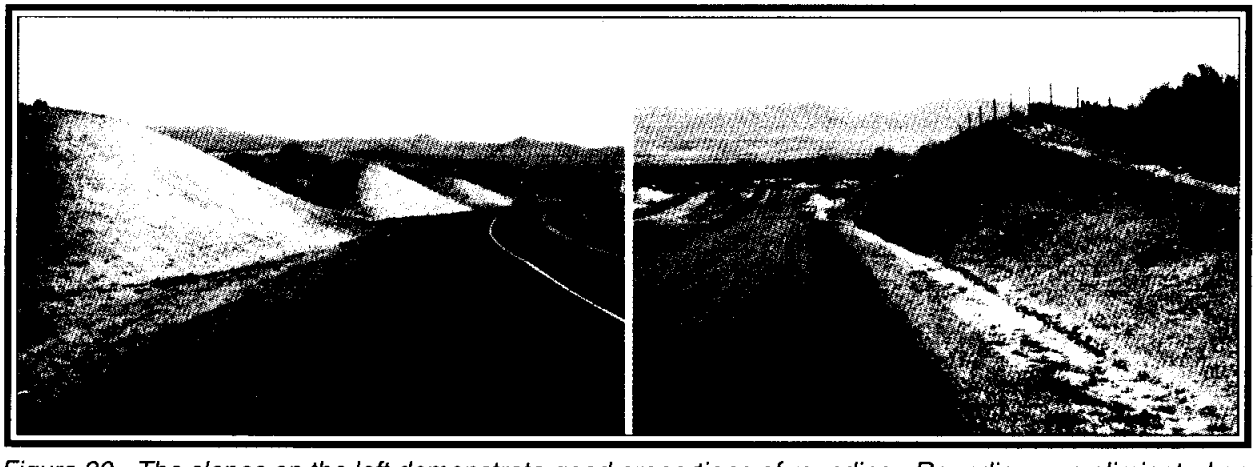


Figure 30 - The slopes on the left demonstrate good proportions of rounding. Rounding was eliminated on the slope on the right to stay within the right-of-way fence, and an unnatural form results. The photos were taken immediately after completion of slope work.

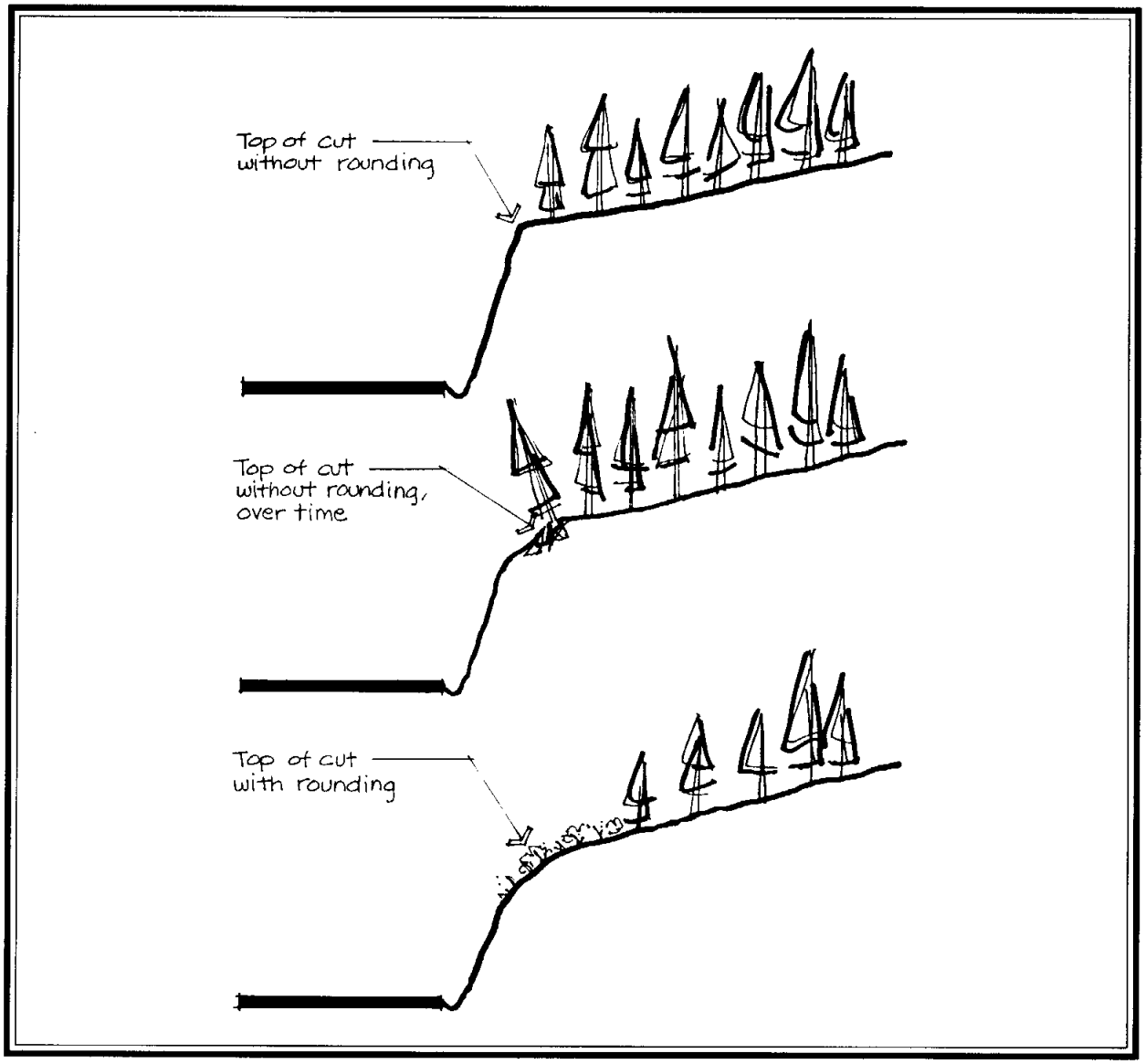


Figure 31 - A rounded but slope (bottom) results in a natural appearing slope with better revegetation and stabilization over time.

4.4.1 Typical Slope Ratios of Embankments

Cost, appearance, stability and safety are the considerations for fill slope ratio determination. The steepness of fill slope ratio is the determination of geotechnical design. Fill slopes steeper than 2:1 (horizontal:vertical) may exhibit stability and erosion control problems.

From a safety standpoint, a 3:1 to 4:1 slope should be considered to be "traversable" by an errant vehicle, but vehicles are not under control and not able to recover. A 4:1 and flatter slope should be considered "recoverable." Technically, a traffic barrier, such as guard rail, is not required in front of a 3:1 or flatter slope adjacent to the roadway. A barrier may be warranted if hazardous conditions exist at the toe of 3:1 slopes (see Figure 35).

4.4.2 Varied Slope Ratios

Fill slopes are traditionally constructed with a uniform slope ratio. In order to better blend into the natural terrain in some parts of Arizona, fill slopes can be constructed to provide an irregular, or undulating

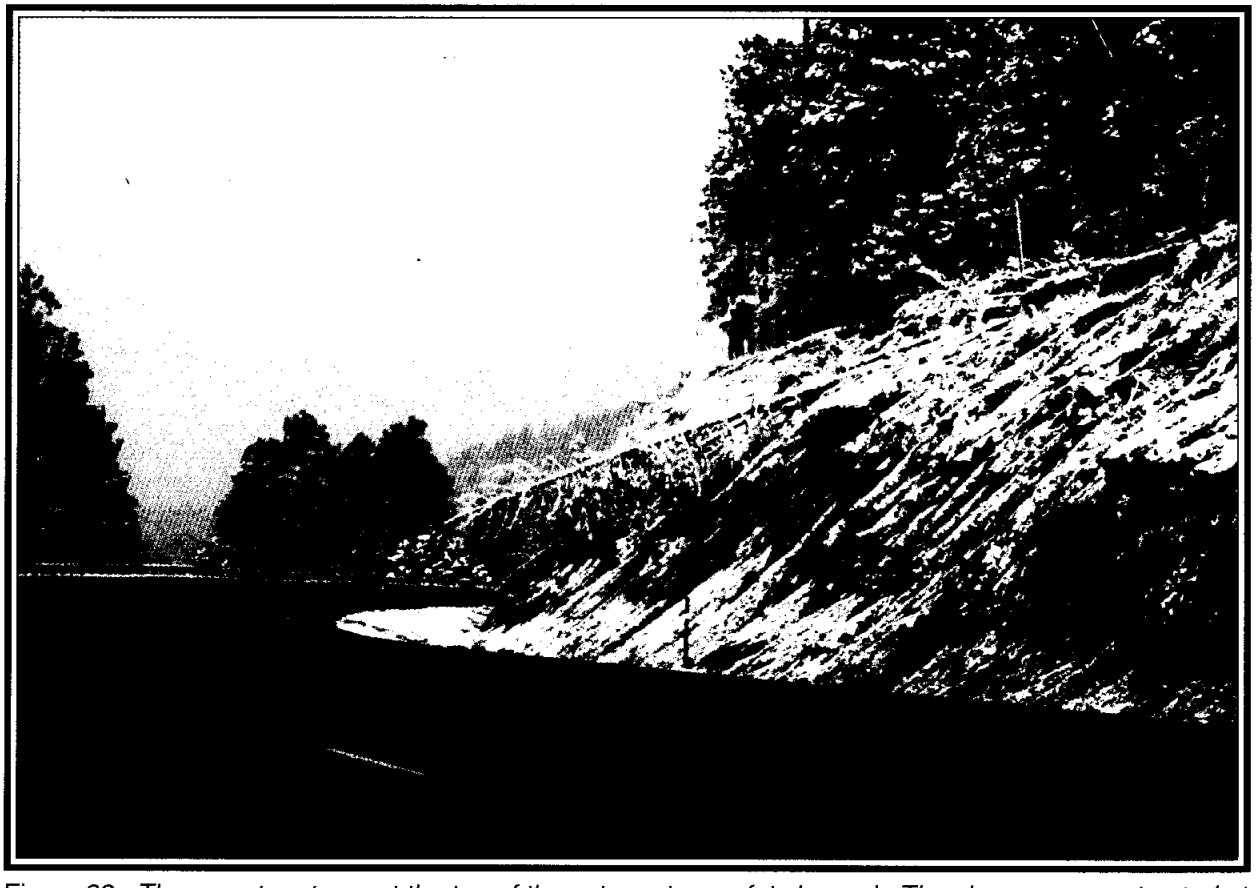


Figure 32 - These mature trees at the top of the cut create a safety hazard. The slope was constructed at too steep an angle and was not rounded adequately.

surface. This technique will require additional design and construction time and should be used only where significant visual or environmental benefits can be achieved.

Varied fill slope ratios can be accomplished by incorporating staggered ridges, steeper than the nominal slope ratio, and staggered ledges, or mini benches, flatter than the nominal slope ratio. Planting areas can be incorporated into the ledges or rocky portions of the slope, (see Section 4.4.4).

Fill slopes constructed with varied slope ratios, to incorporate staggered ledges, should be staked at 7.5 m intervals to more closely control the location of the ledges. These complex slope ratios and ledges should be shown in the plan cross sections. Treatments to the fill slopes must be incorporated as the slope is constructed (see Figure 36).

4.4.3 Boulder Placement

Natural appearing groupings of large boulders, placed behind guard rail or well outside of the recovery area, can be exposed above the nominal fill slope to help blend the slope in visually with the surrounding area. The boulders should be buried to the proper depth (50% to 65% boulder diameter) and arranged randomly (see Figure 37).

4.4.4 Warping Fill Slopes

Warping can be used as a design tool to overcome shallow slope stability problems, or to transition the fill to natural terrain. Warping a fill slope refers to the steepening or flattening of the slope ratio in specified areas, usually at the edge or toe of the fill.

Fill slopes can be warped to reflect the surrounding land forms and topography. The degree to which this

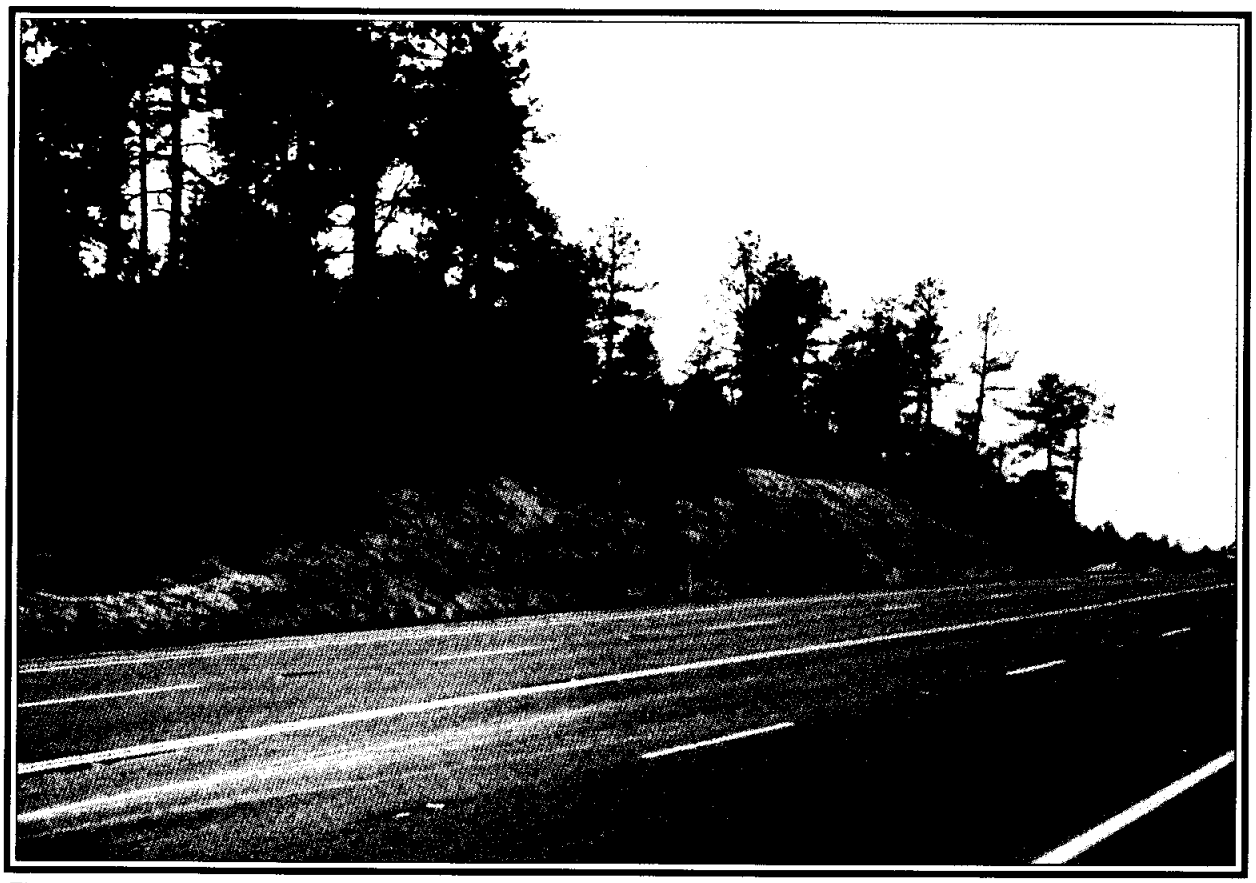


Figure 33 - This slope has been rounded and laid back with good proportions.

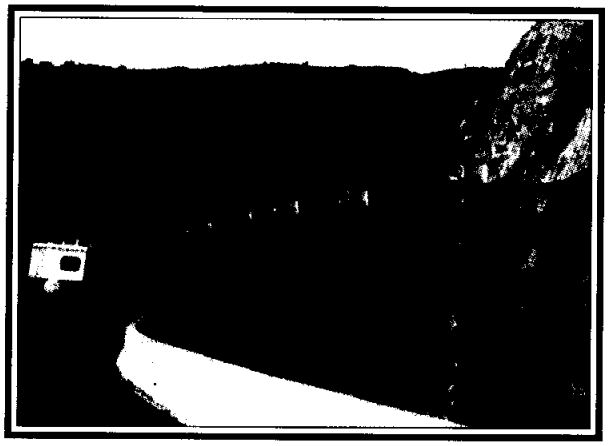


Figure 34 - A barrier with a fence was placed at the bottom of the slope as a safety measure, without requiring additional slope disturbance.

is done must be balanced with the need to minimize the area disturbed. A site by site evaluation is often needed to determine the appropriate degree of warping. In some situations, the toes of fill slopes can be warped, or steepened slightly, to avoid significant vegetation, a drainage or other significant resources near the toe of the fill slope.

If fills are constructed on existing slopes of 3:1 or steeper, they need to be keyed in at the toe, for stability. In these situations, it may not be possible to warp the toe of the slope around vegetation.

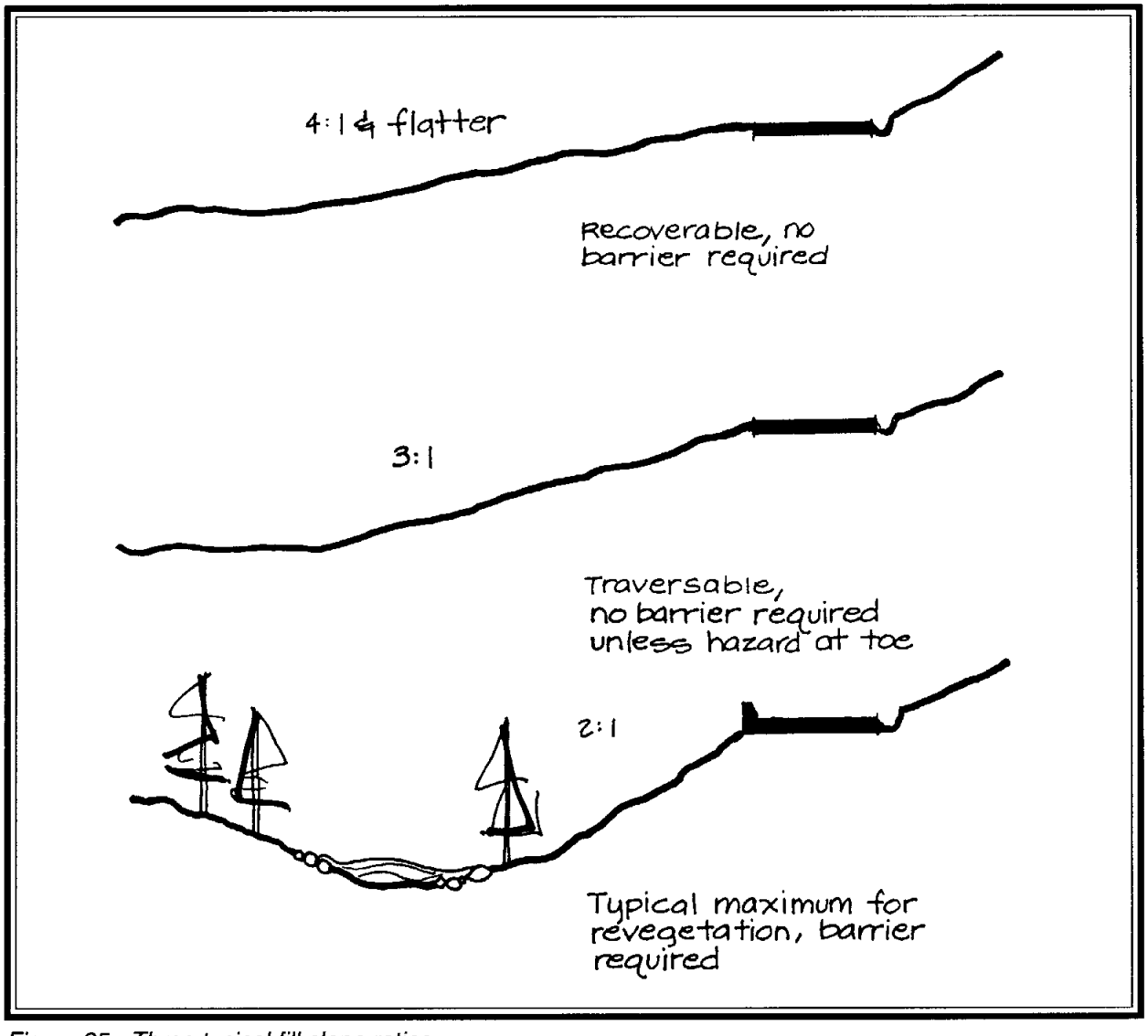


Figure 35 - Three typical fill slope ratios.

Figure 36 (a)

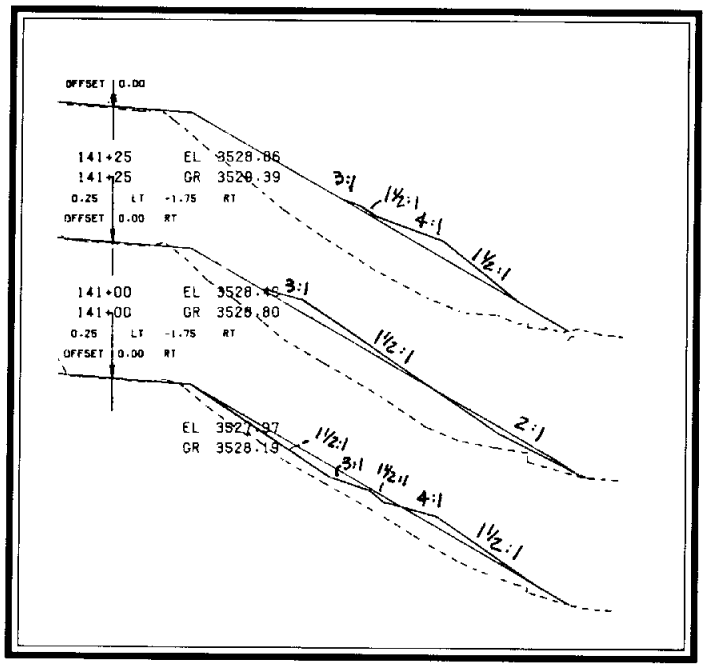


Figure 36 (b)

Figure 36 (a) and (b) - Varied slope ratios (see cross sections, right) were used to construct this fill slope (above), which results in undulating, staggered ledges, and a slope with a natural appearance.

Figure 37 - Boulders in the top example appear more natural to the site than boulders in the bottom example.

4.5 Retaining Walls

4.5.1 Wall Requirements

Walls are generally used in roadway projects when the natural terrain is too steep for a fill to catch, or a wall is less expensive than clearing and/or additional excavation. Walls may also be used to reduce visual impacts, to limit disturbance and add stability, or to solve erosion problems in a particular area on a project. In environmentally sensitive areas, such as streams, riparian areas, and mature forests, walls may be an economical solution, as they can avoid a fill slope encroaching on the area, or reduce impacts on the cut side (see Figure 38).

A wall can minimize the need for additional easement. Walls can also be used to affect the amount of borrow and waste to the advantage of a project. Depending on its location, a wall could be a hazard and require appropriate roadside barriers.

4.5.2 Wall Alternatives

Wall types vary widely in cost, constructibility, character and appearance. Some wall types or facing treatments, such as concrete or masonry, may be more suitable for areas where they will be viewed at close range. Other, more rustic treatments may be suitable for long distance viewing. Common wall types include: gabion, reinforced concrete, metal bins, mechanically stabilized (soil reinforced), and crib. Following are examples, with pros and cons, of several walls which are commonly used in Arizona:

<u>Mechanically stabilized (soil reinforced) walls</u>

Mechanically stabilized retaining walls can be constructed quickly and easily. The need for some specialized equipment can be reduced by using mechanically stabilized walls. These walls are composed of layers of soil reinforcement (welded wire mesh, metal strips, polymer geogrids or geotextiles), compacted backfill, and facing material.

There are several variations on the mechanically stabilized retaining wall. They are all gravity structures which cause the retained soil to act as a single mass. They have only a level pad at the base instead of footings and can be used on fill slopes. Problems associated with some mechanically stabilized retaining walls include: settlement and deformation,

which create an uneven wall face, difficulty of attaining the specified compaction behind the wall without movement of facing elements, and aesthetic treatments.

The appearance of some wall types can be mitigated by applying stain, paint or a penetrating oxide coloration product (see Figure 39). Depending on the aesthetic treatment of the wall, these types of walls can be less expensive than standard cast-in-place concrete retaining walls. However, some specific aesthetic treatments, such as attached facing, may increase the cost to be comparable with other walls.

Crib walls and Metal bin walls

Crib walls offer design flexibility in that some types, with open fence elements, can be vegetated. Crib walls are a gravity wall with a series of interlocking open or closed faced modules, usually concrete, constructed with a 0.15:1 to 0.25:1 batter. Timber crib or metal bin walls are available. These modules are manufactured off site and installed with standard equipment. Construction is quick and uncomplicated. Seeding or specimen plants can be planted in the face openings to visually mitigate the structure and assist with soil stabilization.

Metal bin walls require frequent monitoring for erosion, especially after large precipitation events, and can be susceptible to corrosion.

Crib walls have proven to be economical for heights of 2 m to 12 m.

Gabions

Gabions are typically composed of welded or twisted wire fabric cages filled with rock. These cages extend back into the slope and are usually stacked in terraces. The final appearance is angular but there is some flexibility in design and the rock can blend with surrounding terrain.

Gabions are often used along drainageways because they are also excellent for bank stabilization (see Section 6.4.1.3). Gabions are comparable in price to the Crib wall.

Reinforced Concrete

Concrete walls are typically cast-in-place construction using forms. This type of wall allows flexibility in wall aesthetics. Custom or standard formliners can be used to simulate a number of materials and surfaces. These walls easily accept concrete stain, or integral color, which helps blend the wall with surrounding terrain.

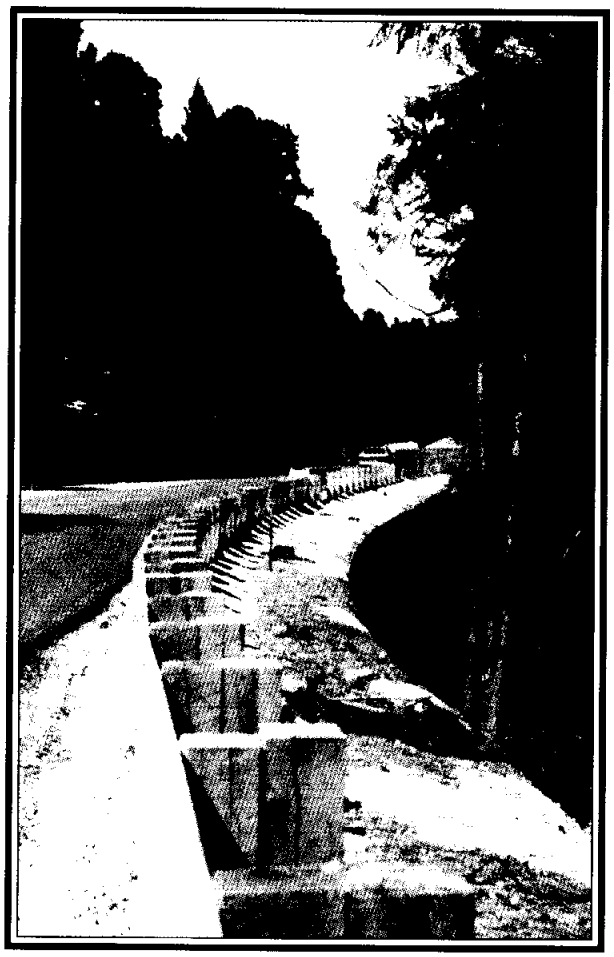


Figure 38 - A retaining wall was installed to reduce impacts to significant vegetation and to maintain the enclosed view along the corridor.

Masonry faced

Mechanically stabilized and concrete walls can be faced with masonry or rock to blend with the surrounding terrain, or to achieve the desired aesthetic result. Several techniques and variations are available. Field rock can be salvaged from the project, for example, and used to form the facade of a battered mechanically stabilized or concrete wall.

Treated timber walls

Treated timber walls are slabs of wood, typically 130 mm to 150 mm wide, 150 mm high and 2.5 m long. Various types of wood are used, with various preservatives that retard decay and insects. Timbers are easy to handle and can be aesthetically consistent with timbered areas. The life span of these walls is less than others, but the cost may also be less.

Anchored walls

Soil or rock anchors are used to tie back facing elements. Anchors are either mechanically tied to the underlying soil or rock, or may be grouted in place and post-tensioned. Anchored walls can be faced with patterned or colored concrete panels, or masonry to improve aesthetics.

4.6 Permanent Erosion Control Features

Special erosion control features are typically needed at the downstream end of cut ditches, sag points of fills, at the low point between cuts, and where cuts intercept cross drainages. Permanent erosion control features should be designed into the roadway project.

Constructed erosion control measures may introduce a visual impact and will require maintenance. Ideally the slopes will be designed and revegetated so that sheet drainage over the face of the slope will not cause erosion.

The finishing, stabilization and erosion control of slopes may include the handling of drainage from above and around the slopes.

Figure 39 - Clockwise from upper left: mechanically stabilized wall sprayed with a penetrating oxide coloration product to darken galvanized face; stone faced wall; metal bin wall close up; and metal bin wall from a distance, screened by vegetation.

4.6.1 Erosion Control On Slopes

4.6.1.1 Mechanical or Hardscape Measures

Mechanical or hardscape items should be used in limited areas where severe conditions exist. Following are examples of several common hardscape measures:

Slope Paving

Slope paving, including concrete and shotcrete, is typically used under structures to protect adjacent banks from scour or erosion. Due to the additional costs, maintenance requirements and aesthetic challenges, these measures generally are not considered for widespread applications. They should only be considered where there are no other means to adequately handle the problem. Although aesthetic treatments can make small stretches of paved slopes more interesting, large expanses without adequate mitigation can look out of place in the landscape (see Figure 40).

Shotcrete

Shotcrete paving is fiber reinforced concrete that is blown onto the surface of slopes to prevent erosion and sometimes, with additional reinforcement, provide stability. Shotcrete is easier to apply to slopes than regular concrete, and can be applied to irregular surfaces. Aesthetic treatments can be added at additional cost (see Figure 41).

Artificial Rock/Soil

Where aesthetics are a critical factor, shotcrete and other structural slope treatments can include a finish coat of concrete that is articulated to resemble natural rock outcroppings or soil banks. These treatments can be very expensive, requiring hand labor, as well as additional attention to design and construction administration (see Figure 42).

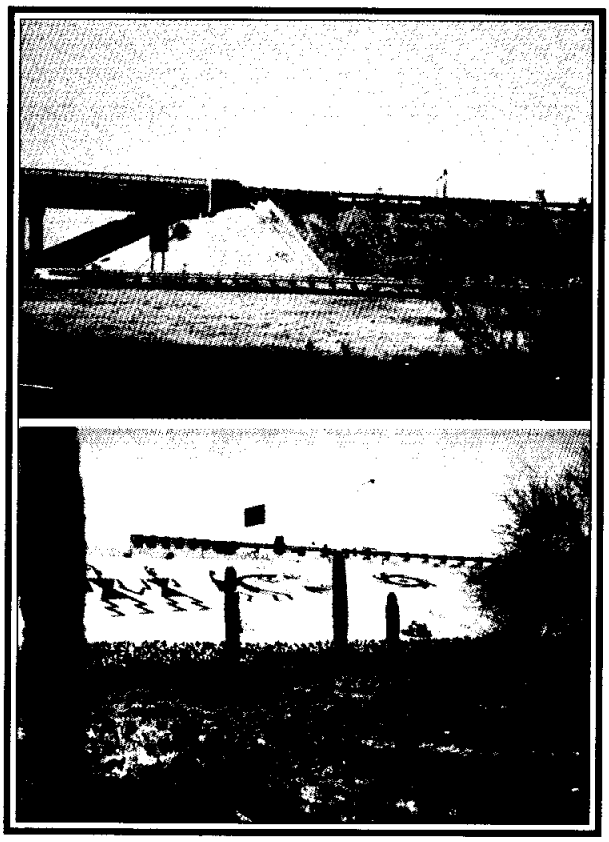


Figure 40 - Slope paving without mitigation (top) has a stark appearance; bottom mitigation includes concrete stain, artwork, boulder placement and vegetation.

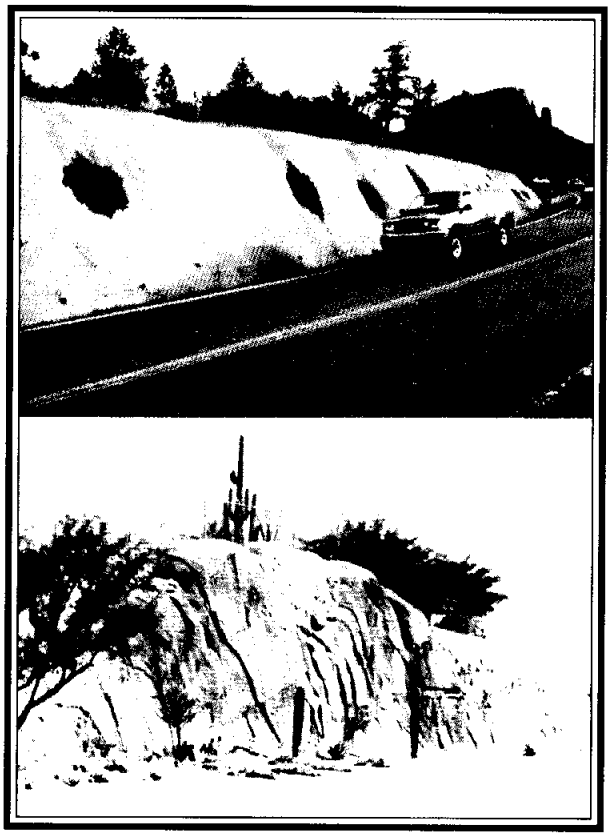


Figure 41 - Top: shotcrete with unnatural appearance. Bottom: shotcrete sculpted and stained after application to improve aesthetics.

Rip Rap

Rip rap slopes are paved with a veneer of rocks, with or without mortar. In fully mortared rip rap, the rock is completely covered with mortar, and resembles irregular shotcrete. Rip rap with mortared joints provides a moderate level of structural strength, with the exposed rock faces providing added visual interest. Hand set rip rap, without mortar, provides limited strength but maximum visual interest, especially if plants grow between the rock cells (see Figure 43). Refer also to Section 6.4.5.1.

Exposed Aggregate Concrete

Exposed aggregate concrete is a common concrete finish, where the aggregate in the concrete is exposed for a more textured surface.

Concrete Stain

Concrete stain is available in numerous colors to blend the concrete in with surrounding soil or vegetation. Concrete stain can be combined with exposed aggregate concrete.

4.6.1.2 Other Geotechnical and Biotechnical Measures

Wattling (or live facines)

Wattling is a technique that involves placing live branch cuttings in moist slopes, and weaving branches or other materials through to create a series of terraces or silt fences. Under proper conditions, the branch cuttings will root into the slopes, and the woven bands trap sediment, encouraging plant pockets (see 4.7.6).

Erosion Mats

Erosion control mats are natural or synthetic blankets applied over steep slopes, drainage channels, or prepared seed beds. They are used to reduce rainfall impact, hold moisture near the surface, and hold soil in place. They may be used alone or in combination with a vegetative cover. Varieties include jute, straw, wood excelsior, glass fiber, paper and cloth. Mats vary widely in cost, water permeability, life span, appearance, and ability to support or inhibit vegetation (see Section 10.14).

Figure 42 - A concrete retaining wall is used to stabilize this slope, which is faced with artificial rock.

Figure 43 - This rip rapped section of cut slope has good visual results and provides slope stabilization.

Slope revetment blankets

Slope revetment blankets are similar to erosion control mats in that they are laid over slopes and held in place with pins or anchors. They are engineered, though, to hold an additional layer of material, such as rock or soil, in a system of pockets over the existing slope. This layer can be revegetated.

4.6.1.3 Drainage Features

Drainage features reduce erosion and help stabilize slopes by directing flows away from sensitive slopes or unstable areas, and by lowering water tables. Following are several examples of drainage features:

Down Drain/Overside Drain

These drains are installed down the face of a cut or fill, and usually do not achieve a natural appearance (see Figure 44 and Figure 45).

Crown Ditch

Crown ditches are ditches that are placed near the top (crown) of slopes to intercept sheet flow and keep drainage from going over the face of a slope. The water is generally diverted parallel to the face of the slope, to another drainageway. A lead off ditch functions in a similar manner, however it is not necessarily at the top of a slope. If properly designed and constructed, crown ditches can effectively protect features without adverse impacts. Improperly constructed, too steep, too long without checks, under capacity, or too close to features, they can create erosion and cutting, slope failure, and eyesores. Most ditches also need routine maintenance and cleaning to function properly (see Figure 46). Crown ditches should generally be avoided if possible (see Section 6.4.3).

Lead Off Ditch

A flat V ditch used to drain water away from the roadway ditch or culvert, onto natural grade; usually on flat terrain.

French Drain

French drains are sometimes called recharge trenches, and are linear ditches filled with granular material. Water collects in the voids and seeps through the walls of the trench. The free draining backfill may be surrounding a perforated pipe to carry off flows, as well. These types of drains can be covered with topsoil and revegetated. They are subject to clogging with sediment, a problem which is solved by separating the soil with geotextile.

Underdrain

Underdrains function in a similar manner to French drains to collect water on one side of a road and pipe it on the other side. Water is collected in a trench filled with granular material, sometimes with a filter fabric covered central core, which feeds pipes that carry the water away from the roadway structural section. These are often used to drain ephemeral springs in cut slopes. Geotextile is normally used in conjunction with an underdrain to prevent the migration of fines.

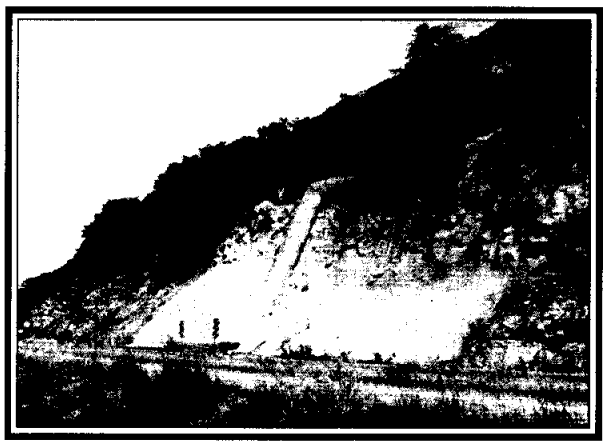


Figure 44 - This overside drain with slope paving does not blend with the surrounding terrain.

Figure 45 - This down drain is also visually obtrusive. The slope has eroded away from the drain.

Horizontal Drain

A horizontal drain consists of a well drilled into a cut slope or slide, at an upward angle, with a pipe inserted to intercept and lower the water table behind the cut or slide (see Figure 47). A horizontal drain is used to stabilize the cut slope or slide area.

4.7 Revegetation

4.7.1 Function of Revegetation

The primary purpose of revegetation is erosion control, however, revegetation also helps accomplish visual, and other ecosystem management goals. Revegetation on cut and fill slopes is of primary importance for improving the appearance of these disturbed areas. Slopes that are continually eroding into a ditch or drainageway are not acceptable from a maintenance nor an environmental standpoint. A successful establishment of vegetation could satisfy the requirement for visual mitigation and minimize scarring.

Saving mature vegetation in place can be very cost effective in some cases. By adjusting the clearing limits, or constructing tree wells or tree walls, mature specimens can be left in place (see Figure 48). Care must be taken not to damage trees and roots during construction.

Vegetation can also be designed to screen new retaining walls, and help the walls to blend into the surrounding landscape. Access at structures and drainages should be kept clear for future maintenance operations. A minimum of 1.5 m at the face of the wall is needed for a person to check for structural integrity of the wall over time.

Revegetation in rock cuts is desirable, under certain circumstances. This can be achieved by creating planting pockets and crevices where plants can exist. Plants can seed in naturally, or revegetation can be accelerated by direct seeding cut faces. This practice should take into consideration that revegetation can encourage rockfall and could become a maintenance problem under some rock and rock-soil conditions. In particular, vegetation that creates extensive root systems that could promote rock fall should be avoided. The existence of vegetation on surrounding, undisturbed slopes, is a good indication of whether or not revegetation on new rock cuts will be successful, and is appropriate. On projects with major fills, seeding should be progressive during construction, with ADOT accepting the work as it is completed (see Section 10.14).

Figure 46 - The crown ditch (top) is designed to blend with the surrounding terrain. The crown ditch (bottom) has caused erosion and is visually obtrusive.

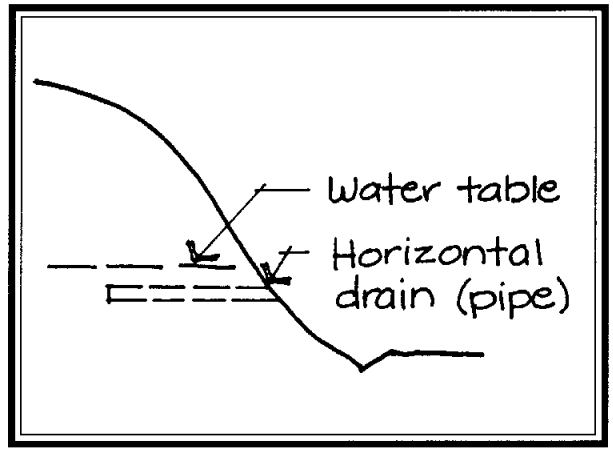


Figure 47 - Properly installed, a horizontal drain will lower the water table in an unstable cut or slide.

The edge treatment along roadways should provide for adequate clear zones and sight distance, with a meadow like transition to heavier shrubs and trees. Unpalatable or moderately palatable species should be selected to avoid attracting wildlife and game onto the roadway.

Safety of the motorists must be considered by planting trees outside the recovery area and limiting planting in this area to shrubs, grasses and forbs. The use of trees, shrubs and grasses near the roadway should be checked for sight visibility at intersections and curves.

4.7.2 Soil

On certain projects, where feasible and cost effective, topsoil (see glossary) from the site should be salvaged, stockpiled and reinstalled prior to seeding or planting.

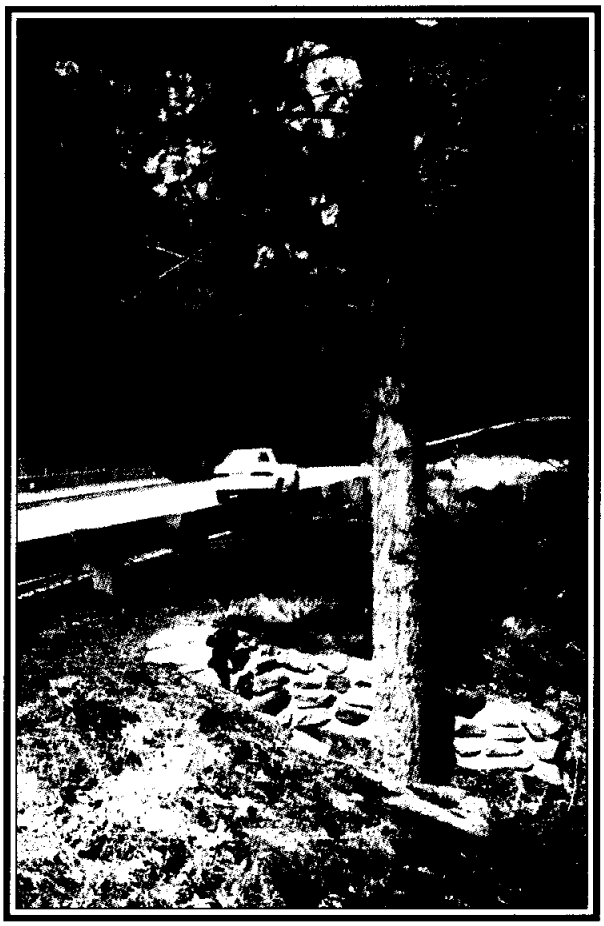


Figure 48 - This tree well protected the roots of the mature tree which was saved in place during construction.

In these situations, topsoil required for the project, and other suitable soil, organic duff, and material capable of supporting vegetation encountered in the excavation can be stockpiled. Vegetation less than 1 m in height and limbs less than 50 mm in diameter may be incorporated as topsoil in the stockpiles.

The key to stockpiling healthy topsoil is to maintain the mycorrhizal fungi. This is done by:

- keeping the soil pile as shallow as possible (e.g., a series of small stockpiles or windrows)
- keeping the soil stored for a short amount of time (i.e., less than one year)
- allowing vegetation to grow on top to maintain fungi
- protecting soil stockpiles from erosion.

The stockpiles for the conserved material should be located to avoid disturbance of designated vegetation or environmental or cultural features.

4.7.3 Seeding and Mulching

Non-irrigated seeding is the most common revegetation technique on cut and fill slopes. Seeding can be effective for slope stabilization, erosion control and revegetation, including biological mitigation of habitat replacement. Irrigation may be considered in some areas, however, maintenance is required.

The vegetation seeded into slopes must be ecologically responsive, primarily using native trees, shrubs and forbs that have the ability to establish in disturbed soils, and have root systems that help to stabilize the slope. Native seed is preferable on National Forest land and may be mandated in some areas. Native seed germination may be slower, reducing the erosion control benefits. If non-native species are used, annuals are preferred, which provide a quick cover and a nurse crop for the native species in the mix. The USFS should provide input to seed selection.

On projects with major cuts and fills, seeding should be progressive with construction, with ADOT accepting the revegetation work as it is completed (see Section 6.3.4).

A mix of seed types, native to the area, that will result in a natural appearance and meet biological requirements is recommended. Five to ten species is generally recommended. The seed mix designer

should have an inventory of existing plant cover throughout the project area. In addition, horticultural soils information should be provided to the designer for different soil types anticipated throughout the project, including subsurface soils and materials anticipated for fill slopes. Seed collection of native species may be needed (see Section 4.7.7).

Different seed mixes can be specified for areas within the recovery area, at intersections, and on cut and fill slopes outside the recovery area.

Because of changing rainfall patterns it generally takes two to three years before the success or failure of the project seeding can be determined. An evaluation should be made after two years to determine those areas where vegetation is probably not going to establish at a satisfactory level. These areas should then be seeded either by a construction project set up for the purpose or by maintenance staff. Contingency funds for this purpose could be set aside at the beginning of a project.

To mitigate the visual contrast of a new seed mixture or straw mulch applied to slopes, charcoal can be added to the hydraulically applied seed, mulch and tackifier slurry. This procedure also appears to darken the soil or rock, but may fade over time (see Figure 49).

Since National Pollution Discharge Elimination Systems (NPDES) permit requirements specify that erosion control measures must be installed as soon as possible after disturbance, it is not practical to wait until an ideal season to reseed (see Section 6.3.4). In general, the summer and winter seasons provide more reliable precipitation throughout most of the State. If slope preparation and seeding can be coordinated to fall close to typical summer or winter rains, there is a slightly higher chance for successful germination, however, no guarantee.

Seeds should be drilled into disturbed areas, where slopes allow. If drilling is not possible due to steep slopes or rocky conditions, broadcast seeding is acceptable. Broadcast seeding may be accomplished with hydroseeding or other methods. All seed applications will require straw mulching, either crimped into the soil or tacked on with an organic binder. Refer to ADOT standard seeding specifications for more information regarding construction techniques.

All newly constructed soil and soil/rock slopes will require mulching. Slopes 2:1 or steeper, in particularly sensitive areas or in erosive soils, may require erosion control matting for increased stability and greater effectiveness in establishing vegetation (see Chapter 10 for correct installation techniques).

4.7.4 Seedlings

The use of non-irrigated seedlings may be appropriate for revegetation of soil cut slopes in forested areas.

The planting site should be plowed, disked, or in some way broken up prior to planting. If cultivation is impractical, a 1 meter diameter area should be cleared around each seedling location, to reduce soil moisture competition. This greatly improves root growth and increases survival during the first year. Seedlings can be grown and delivered either bareroot or in containers. Bareroot seedlings may outperform containerized seedlings on sites with high insolation rates or where animal damage is a problem. Most container grown stock lack sufficient caliper and bark thickness at the ground line to withstand severe heating. Container plugs may also be more susceptible to frost heaving than bareroot seedlings (see Reference 7).

Seedling stock for some species is available as 1- 2- and 3-year-old seedlings. A minimum of 2-year-old stock is recommended for most species in Arizona.

Following is a chart of recommended bareroot seedling planting dates by elevation for Arizona:

0 - 600 meters:	late January - early February
600 - 1200 meters:	early February - early March
1200 - 1500 meters:	early March - late March
1500 - 1800 meters:	late March - mid April
1800 - 2000 meters:	early April - early May
over 2000 meters:	mid April - mid May

Containerized seedlings can be planted at later dates (see Reference 12). In the southern part of the State, the planting of containerized seedlings can be timed with summer monsoons to increase survival of non-irrigated stock.

Tree shelters can be used to increase the survival of containerized seedlings. Tree shelters protect seedlings from wildlife, increase humidity, and provide shade. Different levels of ultraviolet protection are available.

Figure 49 - This hydroseed mixture contains charcoal to reduce the visual contrast between mulch and the existing landscape.

4.7.5 Salvaged plants

Cacti can be salvaged from a construction area and replanted on the project without supplemental irrigation. A landscape architect or landscape contractor with experience in native plant salvage should designate the plants to be salvaged based on size, survival rate, and length of time to be stored. Plants salvaged and replanted on the site better guarantees the adaptability of the plant to the project area.

If the salvage plans include trees, these transplants should be done either before construction, as a separate project, or prior to clearing in the main contract. Trees need to be boxed and stabilized during different seasons for different species. If tree salvage is included with the main roadway contract, the timing of the operation should be brought to the contractor's attention at the preconstruction meeting (see Chapter 10).

Salvage of native trees and shrubs should always be done based on species survivability rates, uniqueness of the specimen, a cost/size analysis and life expectancy of the species. Some specimens or species possess high landscape or horticultural value, which should also be taken into account. These include unique or uncommon specimens or otherwise protected species.

Depending on the time of year salvaged, some species tolerate the salvage process better than others. Survival rate is due to many factors including root structure, susceptibility to insect and disease infestation, and growth habit. The project Landscape Architect should, based on their expertise and consultations with arborists or salvage specialists, determine those species that have proven to be most tolerant of salvage, and this information should be used to guide the selection of salvage species. The appropriate seasons for salvage of each species should be identified in the specifications. Species that can be salvaged in a time frame consistent with construction scheduling should be specified.

The size of the salvage specimens should be weighed against the cost to the project. Smaller specimens

are less expensive and survivability decreases as the size increases. Trees with a caliper greater than 330 mm can be poorer salvage candidates. Trees larger than this generally require quite large equipment to move and are more difficult to move without damage. This can be disruptive to the root systems, cause trunk scarring and be detrimental to survival. However, large specimens should be considered for salvage if they posses other valuable characteristics and the budget is adequate to cover the costs.

Some species are short lived and may not have long term revegetation value for a project. These species represent poor salvage candidates. Conversely, slow growing species represent valuable salvage candidates. Mature, slow growing species such as saguaro, oak and ironwood could not easily be replaced through seeding or juvenile nursery stock plantings. Often these species are not even available from nurseries in mature form.

Salvaging has been done successfully on public projects using boxing or spading. Boxing is the more accepted method and involves canopy trimming, side boxing, bottom boxing and transporting to a holding facility where the tree is held until transplanting to its permanent location. It is not recommended to hold trees in boxes for more than two years. Spading can be done on most species if soil conditions are acceptable (without a lot of rock or caliche). Spading involves canopy trimming, digging a specimen with a truck-driven spade, transporting it in the spade to a holding facility, transplanting it into the ground for holding, and then spading it again when it is time to put it in its permanent location. With spading, it is also possible to move the tree directly to its new location, if the space if available. Spading is a less expensive operation than boxing, but it should not be specified unless conditions are acceptable.

4.7.6 Cuttings

Revegetation of riparian areas is most successful when the causes of site impact or degradation are addressed first. Studies indicate that riparian areas naturally regenerate fairly successfully if the channel and riparian area are otherwise in good condition. This includes the uplands and stability of the stream channel, year round water availability in the root zone, lack of direct competition from aggressive introduced vegetation, availability of a natural seed source, and protection from disturbances to the riparian ecosystem. Of these, the biggest reason for revegetation failure is availability of water.

Rooted cuttings are a feasible method of propagation for some species such as cottonwood. It needs to be remembered that cuttings are genetic clones and care should be taken not to create a monoculture. Using cuttings from a variety of parent stock should provide the desired genetic diversity.

Revegetation with cuttings can provide soil stabilization while natural regeneration occurs or if stream channel degradation mitigation is included within the scope of the project.

Cuttings should be at least 75 mm in diameter and 2 m long, and cut from trees that must be removed from the site, if available. Poles can be cut from any part of the tree as long as it is at least three-year-old wood. Evidence indicates that larger cuttings have a better chance for success. Poles should be cut and planted when trees are dormant. Specifications for preparing and planting cuttings should be included in the contract documents, including timing of harvesting and planting (during dormancy).

4.7.7 Seed Collection

Native seed from a project site can be collected for seeding, or for growing seedlings or containerized plants for revegetation. This is the best technique for revegetation with plants which are genetically correct for the site. Seed utilized in Arizona must be in compliance with State and Federal seed laws. Seed testing is regulated by State statute, administered by the Arizona Department of Agriculture. Current seed laws require that range seed be tested for germination and pure live seed, no more than 9 months prior to the time of seeding. Ornamental seed does not have these requirements. If native seed is collected for seeding purposes, the seasonal time of availability must be considered for testing and application timing, to meet the requirements of the State statute.

4.7.8 Contract Growing

Plants can be grown under contract for a specific project, to ensure that the species and sizes will be available at the time of planting. This arrangement is ideal for projects where native plants needed for revegetation are in short supply commercially. Because of the lead time involved in contract growing,

this practice would be most appropriate on projects with a 2 - 3 year design and construction schedule.

4.8 Slope and Retaining Wall Construction Access

Temporary construction access should be identified early in the design process, so that the impacts of disturbance can be evaluated. Separate mitigation plans may be required, which should be included in the contract documents.

The designer needs to evaluate what access the contractor will likely need for the slope treatments. Access for a track drill, for example, and mitigation of a scar left at the top of a cut, should be addressed in the contract documents. If such access is not allowed, restrictions on access should be specific in the construction documents.

For retaining wall construction, the area of construction access varies with retaining wall types. A minimum of 3.5 m past the face of the wall will normally be needed. The actual amount should be accounted for in clearing limits and mitigation plans.

If significant resources are located close to the construction limits, a special notation in the plans or a physical barrier installed prior to construction may be required for protection (see Chapter 10).

4.9 Construction Documents

Affecting the contractors' willingness to provide specialized slope treatments, such as rounding and varying slope ratios, is the fact that this work is often included in other bid items and not charged as a separate bid item. Following are options for incorporating specialized slope treatments into the contract documents:

- set up separate pay items for slope treatments. Rounding, for example, can be measured by the linear meter
- pay for the work under a Force Account, which usually results in a higher unit cost
- utilize the Construction Partnering process to improve communications and understanding of concepts (see Section 10.2).

Detailed drawings of slope treatments should be included in the project plans, as part of grading plans or special details. Supplemental plans, details and the present standards, which contain a note describing rounding, should be brought to the attention of the bidders and field personnel.

Non-traditional requirements, such as working around fencing, significant resources, or tight clearing limits, should also be brought to the attention of prospective bidders.

MAJOR STRUCTURES 5

5.1 Goals of Structure Design

The goals for structure design are to fit the structure to the site, to have the least impact on the natural resources, and to provide a safe, aesthetically pleasing, cost effective facility. Major structures include bridges and box culverts.

5.2 ADOT/USFS Structure Design and Review Process

The development of major structure plans, including design criteria, consideration of alternatives, and final design of structures for a project occur throughout the ADOT project development process (see Section 2.3). At the 30% review, a field review of structure type, location and extent of resource impact is ideal for USFS review and input, at the same time of the slope and alignment review. After the 30% review, final subsurface investigation at the structure site should be completed, with final structures design completed after the 60% review.

5.2.1 Identification of Structure Needs and Evaluation

The Corridor Study phase will include the identification of major structure needs and an evaluation of existing major structures within the corridor. The information is to be compiled in a report, and will include information from the following sections.

5.2.1.1 Major Structure Site Identification

The structure site identification should include a topographic map, typical roadway section, possible structure size, existing hydrologic data, existing geotechnical data, and square meter structure cost.

5.2.1.2 Coordination Requirements for Each Site

The site requirements should consider Forest Plan Requirements, environmental data, Executive Orders 11988 and 11990 (dealing with wetlands and floodplains), input from USFS resource specialists, Cooperative Agreements, hydraulic and structural design and site surveying needs. See Section 6.3.5 for 404 permit coordination requirements.

5.2.1.3 Discussion on the Feasibility of Alternatives

Alternatives evaluation should include various structure types (bridge verses culvert verses multi-plate), abandonment or removal considerations, alternate access routes, use of natural or engineered fords, use of temporary or detour structures, additional easement needs, and construction access requirements.

Decisions about bridges consider length of span and value of the bridge. On bridges over $10 million in cost, alternate bids are required by FHWA. ADOT may determine that alternate designs are desirable on bridges of a lesser cost. All alternatives carried forward must meet the NEPA requirements. In this case, the low bid determines the type of bridge built. If NEPA studies determine that no alternatives are acceptable, then a special exception to alternatives can be specified.

Possible NEPA concerns, which should be considered in the alternatives evaluation process, are pedestrian access, wildlife habitat, cultural or historic resources and riparian areas (see Figure 50). Other concerns include drainage and economics.

Evaluation of alternatives should be based on thorough input from all stakeholders. The evaluation of alternatives and selection of the best alternative represents a major decision point in the design process.

5.2.1.4 Documentation of the Condition of Existing Major Structures

Evaluation of existing major structures should include current National Bridge Inspection Standards (NBIS) inspection report, photos, existing structure plans, existing hydraulic reports, and existing geotechnical reports.

5.2.2 Structure Planning Report

The Location Study includes a final Structure Planning Report for major structures within the limits of the selected corridor on the preferred alignment. The Structure Planning Report should include elements from the following sections.

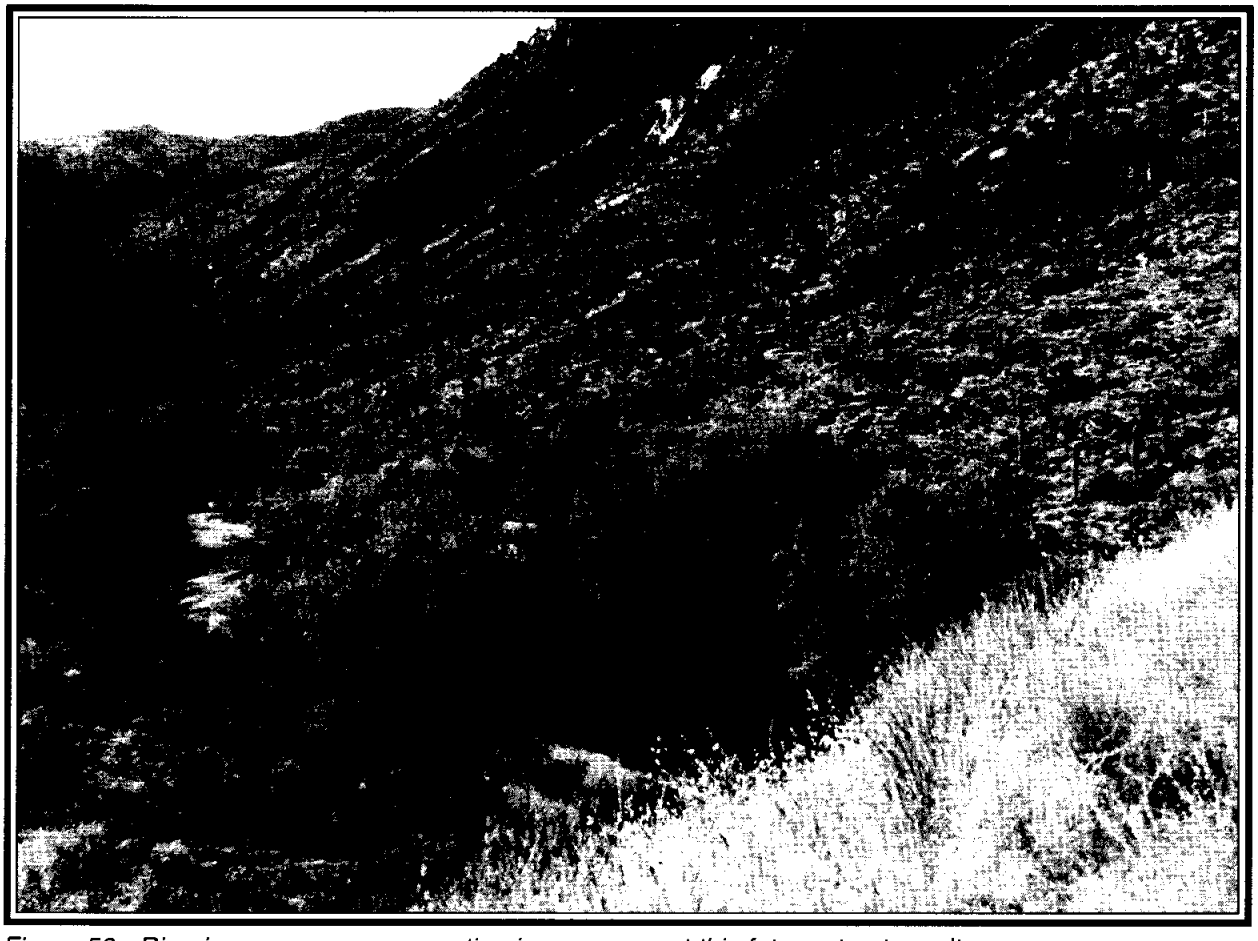


Figure 50 - Riparian resource conservation is a concern at this future structure site.

5.2.2.1 Site Identification and Reconnaissance

This section constitutes the site analysis and should include current site photos, existing hydraulic and geotechnical data, information of existing structure, site visit information, traffic considerations, safety considerations, and environmental considerations.

5.2.2.2 Site Requirements and Considerations

These requirements include Forest Plan requirements, environmental considerations, resource specialist requirements, construction and traffic bypass limitations, utility requirements, and easement needs.

Evaluation of alternatives to a major structure should address abandonment or removal, alternate access routes, and use of temporary or detour structures.

5.2.2.3 Design Requirements

Design requirements include roadway design information, roadway typical section, and applicable AASHTO and ADOT design standards.

5.2.2.4 Structure Alternatives and Costs

Structure alternatives should address new structure, replacement structure, rehabilitation, and alternative structure types.

USFS typical concerns include the number and exact placement of piers, access for drilling, construction access and temporary detours. These issues should be taken into account as early as possible during the structure selection process.

5.2.2.5 Site Selection

The Site Selection process should be performed by conducting more detailed studies of the more promising sites, considering the following:

- placing the crossing on a straight reach of stream or at a stable point
- avoiding skewed crossing where possible
- avoiding curves and steep grades particularly in snow and ice country
- selecting sites with stable soils and slopes
- selecting sites where rock is near surface
- avoiding locations requiring channel change
- avoiding stream crossings where channels are subject to channel degradation, shifting, aggradation, or excessive scour
- responding to the character of the area
- protecting the historic resources of the area
- analyzing the visual resources, visibility of structure and visual mitigation guidelines
- evaluating the construction access.

Sketches of each site being considered should be prepared. The various road alignments, gradients, possible locations for abutments and piers, height of bridge decks, clearances, the possible outline of the toe of approach fills, environmental and visual impacts and any other factors pertinent to the specific design should be considered. A rough cost estimate for each alternative site should be prepared to assist in making the final selection. An appropriate balance between the bridge cost and road cost, including life-cycle costs, should be considered.

5.2.2.6 Site Surveys

A Site Survey should be conducted for all major structures. The Site Survey should be commensurate with the complexity of the site and the proposed structure. Sufficient environmental analysis should be completed at this point to allow access for geotechnical investigation, if required. This analysis could be part of the final environmental document or could be addressed separately as a preliminary environmental study.

Preliminary Foundation Investigation

The preliminary foundation investigation should include the following steps:

(1) Review known or recorded information, including biological evaluation, archeological data, and visual information.
(2) Conduct site visit to classify soil and rock type, evaluate their stability, and obtain information on topographic features, natural flora and fauna, and any built features.
(3) Conduct preliminary foundation investigation based on proposed layout for structure.
(4) Prepare preliminary bridge foundation report.

Topographic Map

The site topographic map should be prepared using conventional or photogrammetric methods. The area covered must be sufficient to design and detail the drainage structure and related improvements such as dikes, channel improvements, bank protection measures, detour structures and overflow channels.

Initial Drainage Report

The initial drainage report should include the following steps:

(1) Conduct stream channel surveys.
(2) Assess existing and future conditions affecting drainage areas, flow patterns and flood areas.
(3) Prepare drainage map showing topographic features and drainage features.
(4) Calculate hydrology for project area including peak runoff rates from each drainage area.
(5) Describe the stream channel, including high and low water elevations, previous floods and other events, and the streambed material.
(6) Propose concepts for disposal of storm water during and after construction.
(7) Design criteria, procedures, methodology and assumptions for analysis and design.
(8) Specify initial size and location of major drainage structures and channels that affect the roadway location.

5.2.3 Structure Selection Report

After completion of the project Structure Planning Report, a Structure Selection Report will be prepared for each major structure within the project limits. The USFS should have an opportunity to review the preliminary Structure Selection Reports at the 60% level. Input from the USFS should be submitted to ADOT with the 60% plan review comments. The purpose of the report is to document the evaluation used in determining the recommended structure type and to present criteria for proceeding with final design.

Development of the Structure Selection Report should proceed with the following design process:

(1) Select structure types for analysis from the Structure Planning Report.
(2) Analyze the alternatives (see Figure 51).
(3) Develop cost comparisons of alternatives.
(4) Select an alternative for final design.

The Structure Selection Report should include the following information as required:

- bridge geometrics including roadway and bridge cross sections, alignment and grade, location, minimum vertical and horizontal clearances, and provisions for future expansion
- drainage considerations, including hydrology and hydraulics for channel, stream, or river, and identification of bank protection needs
- bridge superstructure alternatives, including cast-in-place concrete, precast concrete, or steel girders
- bridge substructure alternatives including piers, abutments, foundations and scour vulnerability
- resource protection, including flora, fauna and fisheries
- utility considerations
- visual impacts and architectural treatments, including rustication, railing details, and coloring of surfaces (see Figure 52)
- the availability of structural components
- construction procedures including construction phasing, traffic detours, falsework and disruption to the site (see Section 5.2.5.)
- construction cost comparisons
- recommended alternative based on above comparisons
- supporting data, including calculations and plans for various alternatives, with structure analysis and

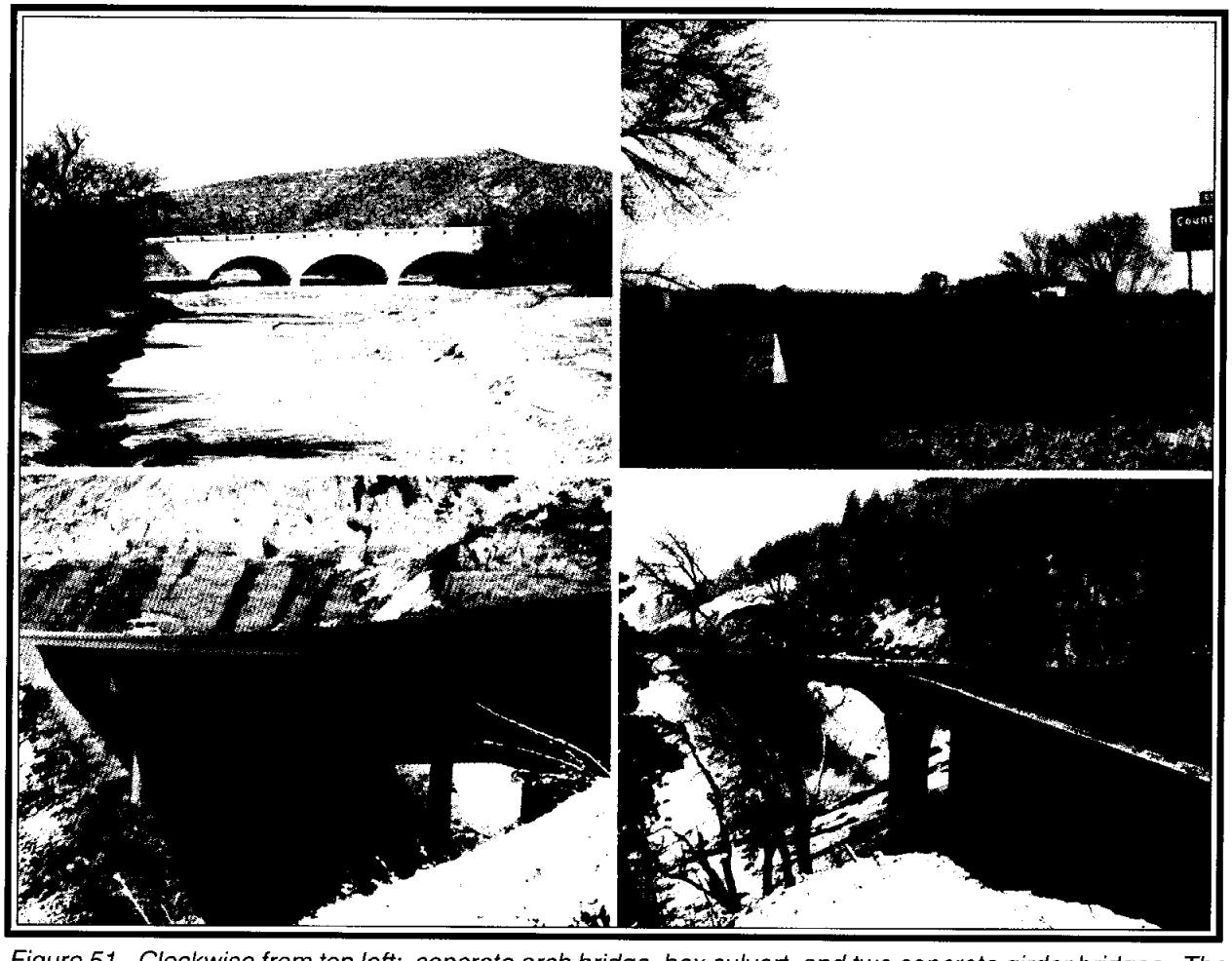


Figure 51 - Clockwise from top left: concrete arch bridge, box culvert, and two concrete girder bridges. The bridge, lower left, was constructed on a soffit fill, which resulted in the loss of riparian resources below. (Top, left photo courtesy of Concrete Arch; top, right photo by John Bell.)

design calculations completed only to the extent necessary to evaluate variables for each alternative for the purpose of cost comparison.

5.2.4 Visual Appearance Considerations

Structures should be selected and designed to be compatible with the natural surroundings. Massiveness should be avoided by proportioning the bridge superstructure and substructure units. Large expanses of concrete, such as long retaining walls, should be interspersed with architectural details in the surface, such as those obtained by using vertical form boards of varying thickness or appropriate artwork. Materials which are compatible with the surrounding environment should be selected. The desired character, such as historic, urban or rural, should be considered in the selection of styles, types, colors and materials.

5.2.5 Riparian Protection and Wildlife Considerations

Following are considerations for protecting riparian resources:

- evaluate using a longer span structure with spill-through abutments in lieu of a shorter structure that uses high retaining wall abutments
- locate the substructure out of the stream channel, where possible, to lower costs and reduce potential for scour and damage from debris to the bridge abutment and surrounding vegetation
- do not constrict the waterway with approach fills, abutments and piers.

Some bridge construction methods, such as soffit fill require obliteration of vegetation under the future bridge site during construction (see Figure 51). The site resources should be considered in evaluating constructibility in the structure selection process.

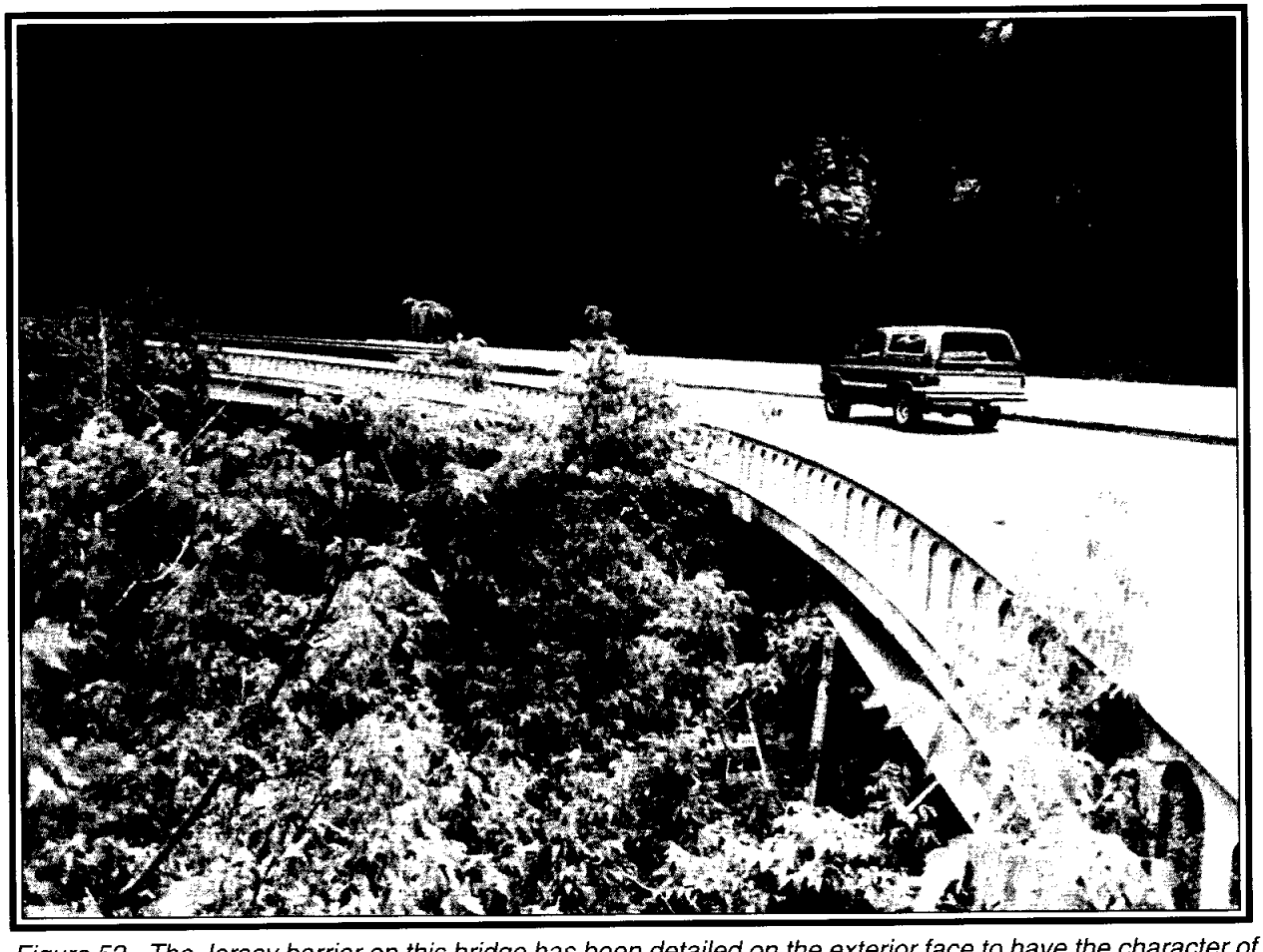


Figure 52 - The Jersey barrier on this bridge has been detailed on the exterior face to have the character of the older structure, after renovation.

Waterway crossings should maintain natural stream conditions. Ensure that streambed and fish habitat are protected when selecting the structure type. If fish use streams for habitat, spawning or migration, this habitat should be maintained in optimum condition and designers should consider using arches or bridges. These means help protect fish habitat and fish passage by minimizing streambed disturbance and limiting changes in water velocity and depth.

Impacts to drainage areas may be reduced by including low impact access ways at major structures which are anticipated to require routine maintenance.

Where drainage structures are required they should be designed to facilitate wildlife movement. These structures should provide a minimum of 3 m in height for wildlife movement and use a ratio of 1:10 (height: length) for proportion (see Figure 53).

5.3 Construction and Access Requirements

The construction access requirements for the structures designed for the project should be clearly identified to the USFS for input early in the review process. Clearing limits, which take access requirements into account, should be identified in the field at the 30% level for all sensitive riparian areas. ADOT bridge engineers should provide this information prior to the 30% review so that access requirements for different structure alternatives are considered (see Figure 54).

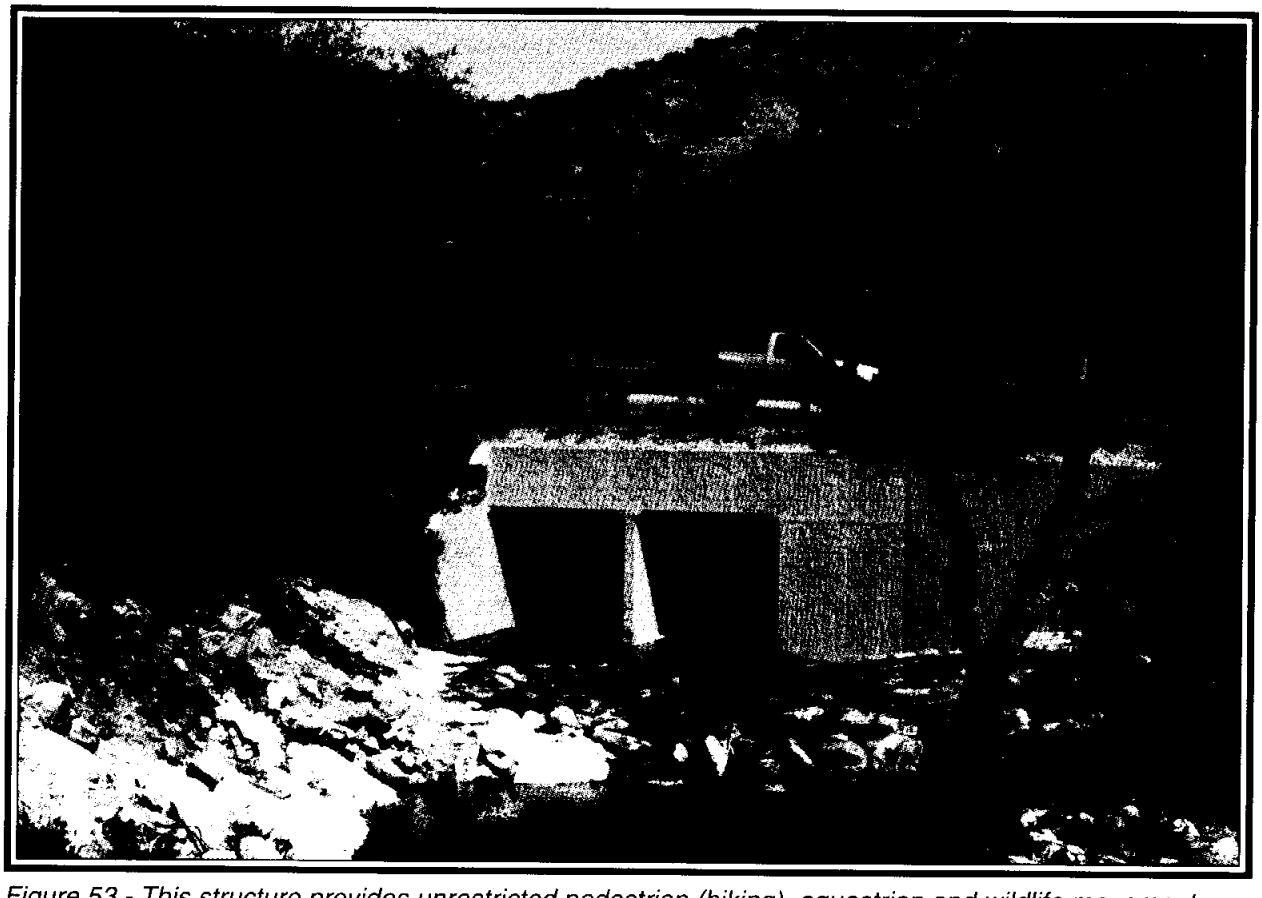


Figure 53 - This structure provides unrestricted pedestrian (hiking), equestrian and wildlife movement.

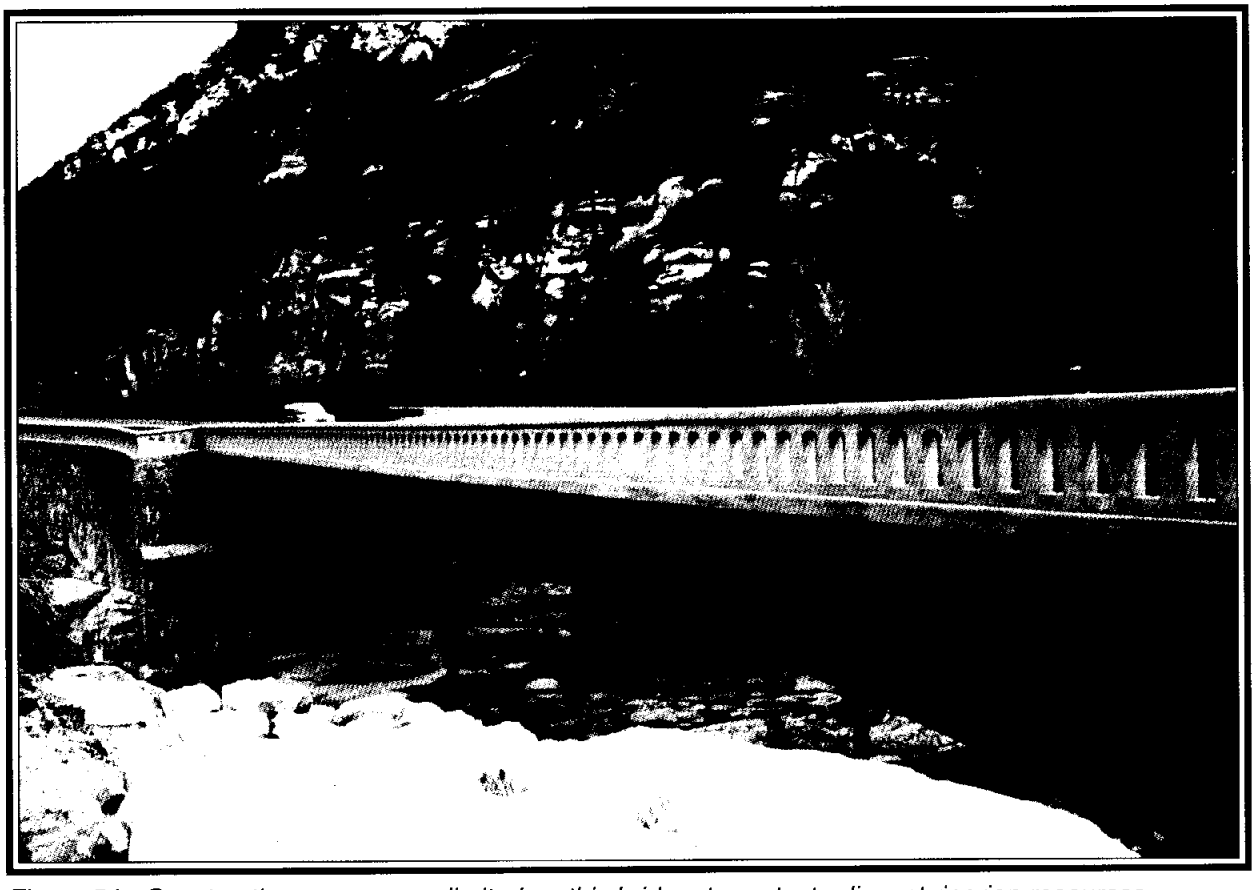


Figure 54 - Construction access was limited on this bridge, to protect adjacent riparian resources.

DRAINAGE 6

6.1 Goals of Drainage Design

Drainage design goals for existing and proposed State Highways on National Forest land are primarily to keep water off of the roadway and to protect the adjacent resources. These goals can be accomplished by transporting water originating on or near the roadway, away from the roadway prism, with minimum impacts on road and traffic, and with minimum impacts to the adjacent resources.

During the drainage design process, special consideration should be given to the following:

- recognize that the protection and restoration of riparian areas are of critical importance to the National Forests and to the State
- balance any loss or degradation of riparian areas caused by the roadway design with restoration or enhancement of other riparian areas of equal values and functions
- minimize adverse drainage impacts both within and outside the easement, including temporary stream disturbance
- accelerate revegetation of native species
- follow natural drainage patterns to the extent practical
- integrate drainage plans with roadway plans and environmental documents to improve coordination and to insure that all mitigation issues are being addressed
- consider future management practices that will result in maintenance of existing riparian areas and restoration of degraded riparian areas.

ADOT, the USFS and FHWA can work together to help promote public awareness of the benefits and values of riparian areas and the need for their protection and careful management.

6.2 ADOT/USFS Drainage Design and Review Process

6.2.1 Riparian Inventory

An inventory of existing and degraded or lost riparian areas should be made for both highway project development and for highway maintenance purposes. This information should be prepared by ADOT and submitted to the USFS for review no later than the 30% plan level, for new projects, and to the ADOT Maintenance Division, for completed projects (see Figure 55).

6.2.2 Field Review

Highway designers should utilize a formalized field review process at the Initial Design (30%) stage to help incorporate drainage design into the roadway plans. Field reviews should involve ADOT engineers, designers and USFS field liaison personnel (see Section 2.3).

6.2.3 Best Management Practice (BMP)

The following requirements apply to the Initial (30%) through Final (100%) roadway design process:

(1) Projects should be designed to meet BMPs (see Reference 6).

(2) Detailed mitigative measures, including operation scheduling, should be developed and incorporated into the National Environmental Policy Act (NEPA) documentation and contract documents.

6.2.4 Easement (Right-of-way) Limits

The best solutions to meet BMPs and revegetate the project should be designed regardless of easement limits. When it is necessary to flatten slopes and extend lead-off ditches beyond easement limits, USFS personnel should work with ADOT designers to enable the optimum design, and adjust the easement accordingly (see Section 3.5.4).

6.2.5 Post Project Evaluation

Project drainage design can be improved with knowledge of the effectiveness of standards and practices utilized on prior projects. Therefore, a percentage of completed projects should be reviewed 3 to 5 years after completion to determine effectiveness of standards utilized for drainage, revegetation, and riparian protection. Written review reports should be prepared by ADOT, with input by

the USFS, and made available for planning of future projects.

6.3 Drainage Design Criteria

6.3.1 Riparian Areas

6.3.1.1 Riparian Awareness

Personnel involved in design of highways should be properly trained in the identification, importance and protection of riparian areas and values.

6.3.1.2 Riparian Enhancement

Riparian areas should be protected, enhanced and restored where practical. Roadway improvements should not cause any of the following adverse impacts:

- attract wildlife onto highways
- saturate highway structural sections
- disrupt stream channel dynamics
- lose function of highway drainage structures.

Where practical, agencies are encouraged to work with local citizens groups to enlist support and participation in the protection, maintenance and restoration of riparian areas.

6.3.1.3 Revegetation of Riparian Areas

Only native riparian vegetation should be established and maintained in identified riparian areas.

Riparian areas generally revegetate better naturally than when they are planted, as long as the area is not degraded by lowered water table, increased velocities, siltation, and erosion. Planting with native species, however, can accelerate the revegetation process. The nature of a riparian area is not static; the natural cycle of change should be provided for in the design. Larger species should be located on the "high" flow area of the channel. Riparian grasses, aspen pads, or wattling should be considered in channel bottoms (see Section 4.7).

Revegetation measures for erosion control include seeding herbaceous species (grass, legumes, or

Figure 55 - The riparian vegetation at this drainage is a significant resource both visually and biologically.

browse species), and planting cuttings, shrubs, cacti or trees. Additional measures may include fertilization and mulching to improve results (see Section 4.7).

When designers identify a significant amount of revegetation work on a project, the budget and contract should provide for a plant establishment period of up to two years. A separate maintenance contract may be easier to administer than keeping the prime contractor involved.

6.3.2 Erosion Control Plan

Erosion and sedimentation should be minimized through effective planning prior to initiation of construction activities and through effective contract administration during construction (see Chapter 10). Land disturbing activities including pioneer roads (routes cleared of vegetation before road construction is started) usually result in some erosion. By effectively planning for erosion control, water quality impacts can be reduced. Practices, locations of practices, and specifications for practices will be used to minimize erosion and sedimentation. Erosion control objectives usually require a combination of practices that promote the reestablishment of vegetation on exposed slopes, provide physical protection to exposed soil, prevent the downslope movement of soil, or control drainage. Such practices need to be compatible with requirements under NPDES (see Section 6.3.4).

6.3.2.1 Temporary Erosion Control Preventative Measures

Preventative, temporary erosion control measures may include:

- the removal of water controlling devices that will not carry anticipated seasonal water runoffs, such as temporary culverts, culvert plugs, diversion dams, or elevated stream-crossing causeways
- the installation of temporary devices that will carry anticipated seasonal water runoffs, such as culverts, side drains, flumes, cross drains, diversion ditches, energy dissipaters, dips, sediment basins, berms, debris racks, or other facilities needed to control erosion
- the removal of debris, obstructions and spoil material from channels and floodplains
- grass seeding, planting deep-rooted vegetation, and/or mulching
- placement and maintenance/cleaning of straw bales and silt fences to catch sediment (see Figure 56).

6.3.3 Visual Appearance

The appearance of riparian areas often contributes to the visual quality and variety of a roadway corridor, particularly in arid areas. Visual quality of riparian areas should also be considered during roadway design (see Figure 49).

6.3.4 NPDES Requirements

After October 1, 1992, all construction activities which grade or disturb 20235 m^2 or more when completed must be covered by a permit from the Environmental Protection Agency, prior to construction. The (402) permit coverage is derived from the National Pollution Discharge Elimination Systems

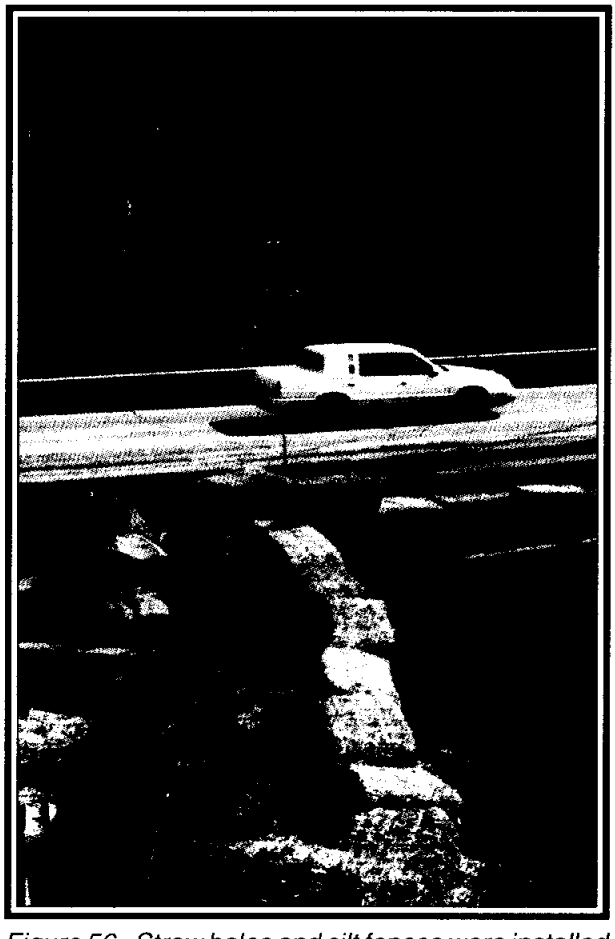


Figure 56 - Straw bales and silt fences were installed during construction in this riparian area.

(NPDES) General Permit, in compliance with the Clean Water Act, for the control of pollution from stormwater discharge. Goals of the program include reducing erosion, minimizing sedimentation, and eliminating non-stormwater discharges from construction sites. ADOT, in conjunction with the contractor, will be responsible for obtaining the 402 permit as required.

6.3.5 404 Permit Requirements

Section 404 of the Clean Water Act regulates discharge of fill or dredged materials into "navigable waters of the United States," including watercourses throughout Arizona which are dry much of the year. The U.S. Army Corps of Engineers is the lead coordination agency which administers this program. The Corps may also solicit involvement from other federal, state and local agencies to assure compliance with the Clean Water Act.

Project activities are regulated based upon the type of construction activity and amount of disturbance or fill material proposed to be placed within waters that are under the U.S. Army Corps of Engineers' jurisdictional limits or ordinary high water mark. Section 404 also allows several categories of project activities to be administered under a 'Nationwide Permit,' with general requirements. If project activities do not meet the categories of actions allowed under a Nationwide Permit, an application for an individual permit must be submitted to the Corps of Engineers.

In Arizona, water quality certification through a 401 permit is also required when project activities disturb 1350 m^2 or more. ADOT is responsible for obtaining the required 401 certification and necessary 404 permits.

6.4 Drainage Alternatives and Design

6.4.1 Stream Channels

Highway drainage should be designed to minimize disruption of natural drainage systems, including stream channel hydraulics.

6.4.1.1 Stream Crossings on Temporary Roads

Temporary roads should not degrade water quality, damage streams, disturb channels or impede fish passage. Requirements of State and Federal water quality standards must be met.

Culverts, coarse rock fills, hardened fords, low water crossings, and temporary bridges should be evaluated in the design process for each stream crossing. Such facilities should be designed to provide for unobstructed flows and the passage of fish, and to minimize damage to streamcourses. The number of crossings should be kept to the minimum needed for access. Channel crossings should be as perpendicular to streamcourses as possible. Streambank excavation should be kept to the minimum needed for use of the crossings, and entry and exit ramps may need to be rocked. Fords or turnpike crossings hardened with washed rock or landing mats are sometimes an acceptable alternative, depending on fishery and hydrological considerations.

Crossing facilities must be removed, obliterated and rehabilitated when the facility is no longer needed.

6.4.1.2 Controlling In-Channel Excavation

Sedimentation and turbidity, resulting from excavation for in-channel structures should be minimized to comply with State and Federal water quality standards. Soil material developed in the construction of bridges, culverts and minor streamside structures should neither obstruct the streamcourse (including natural floodplains) nor the efficiency of the associated structures. If spoil or imported material is needed within the wetland as defined by Corps of Engineers, then a 404 permit will need to be secured from the Corps (see 6.3.5). Preventative measures include:

- keeping excavated materials out of streamcourses (including ephemeral and intermittent)
- removing any materials stacked or stockpiled on floodplains prior to high water
- diverting flowing water around work sites to minimize erosion and downstream sedimentation
- suitably locating detours, and other temporary roads with plans made for their subsequent obliteration and stabilization when needed
- importing fill material for better soil compaction. Original fill may have to be exported to a designated disposal site.

For streams designated as important fisheries by Arizona Game and Fish and the USFS wildlife specialists, culverts should be installed only during specified flow periods. Normally, this work would occur during minimum flow periods when water could be more easily diverted. Work will not be

allowed during spawning periods. Downstream sediment basins may be necessary to mitigate impacts during low flows. Downstream water flow must not be reduced to a level that may be detrimental to aquatic resources, fish passage or other established uses. The minimum levels should be defined and addressed, if applicable, in the contract documents (see, also, Section 10.9.3).

6.4.1.3 Bank Protection

As with slope paving, bank protection is an alternative that generally has adverse impacts upon the quality of the riparian area (see Section 4.6.1). Alteration of a natural watercourse, even at one point, can have hydrological and water quality impacts upstream and downstream. Impacts are often gradual and incremental. Bank protection is installed primarily to control erosion of drainage banks in the vicinity of structures, especially bridges. Alternatives to bank protection should be carefully evaluated prior to developing bank protection concepts and alternatives. Alternatives to bank protection, as related to road use, may include: dip sections, changes in alignment, and structures that span and completely avoid the floodplain and erosion buffers of watercourses.

There are many forms of bank protection including rock rip rap, gabion baskets, rail bank, revetment systems, concrete, shotcrete, soil cement and metal sheet piling (see Figure 57). Each type can be designed in several different ways, with varying costs, structural characteristics, construction implications, and appearance. The selection of the appropriate alternatives should involve consideration of ultimate strength, construction requirements, visual considerations and cost. Some options, such as gabions, may be installed with relatively minor construction and visual impacts. Others, such as soil cement, can have major impacts as they require large staging and batch plant areas, haul roads and

Figure 57 - Gabions were selected on this drainage to minimize visual impacts. Bank protection, clockwise from left: shotcrete over rock, rock and rail, gabions and rock rip rap, and gabions with revegetation.

significant clearing. A combination of alternatives can sometimes achieve the best results (see Figure 58).

6.4.2 Dispersion of Subsurface Drainage from Cut and Fill Slopes

The possibilities of cut or fill slope failure due to subsurface drainage problems and the subsequent production of sediment should be minimized.

Roadways may change the subsurface drainage characteristics of a slope. Since the angle and height of cut and fill slopes affect slope stabilization on steep and/or high slopes, it may be necessary to provide subsurface drainage to avoid moisture saturation and subsequent slope failure. Where it is necessary because of slopes, soil, aspect, precipitation amounts, inherent instability or other related characteristics, methods such as the following should be used:

- pipe under-drains
- horizontal drains (see Section 4.6.1.3)
- stabilization trenches.

Dispersal of collected water should be accomplished in an area capable of withstanding increased flows. Energy dissipaters may need to be placed below pipes carrying large volumes of water (see Section 4.6.1.3).

6.4.3 Water Concentrations

Highway drainage design should avoid concentrating water when practical. When water must be concentrated, design should include energy dissipation and other mitigating measures to prevent erosion.

Crown ditches are used to intercept water before it cascades down the face of a cut slope (see Section 4.6.1.3). Designers should not use crown ditches unless they are absolutely necessary as they can also result in water concentration with potential to cause serious erosion if not properly designed and constructed. They can also result in visual impacts to a site. Crown ditches are typically used where there is a large drainage area above a cut. When crown ditches are necessary, the ditches must be designed in a manner to prevent erosion by appropriate use of alternative ditch locations, energy dissipaters, and ditch linings.

Storm drains are often designed with extremely long or steep runs. This can result in increased water velocity, which can blow out outlets. Likewise, ditches are often designed with long runs, resulting in ditch erosion, sediment build-up and clogged inlets. Designers can reduce maintenance costs by taking these factors into account.

Surfaced ditches, with hardened sides and/or bottoms, are often used where velocities are anticipated to be high, or where soils are very erosive. Surfacing can be concrete, asphalt, rock rip rap or porous pavers. Surfacing can look out of place in a natural setting, and transitions from paved to unpaved drainages can be erosive and problematic (see Figure 59). Surfaces can be damaged during cleaning with large equipment.

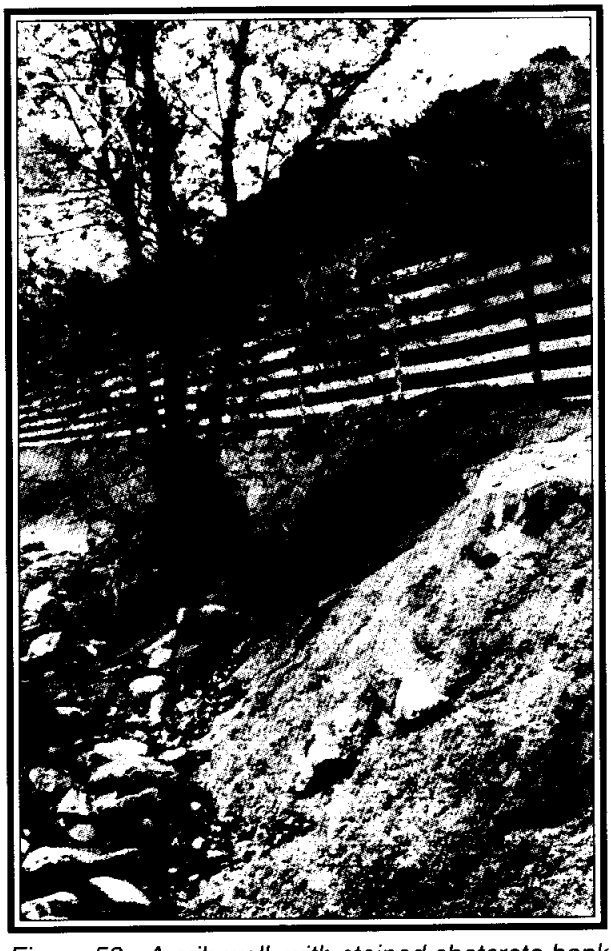


Figure 58 - A crib wall, with stained shotcrete bank protection at the bottom, was used to protect both the road embankment and riparian vegetation.

6.4.4 Surface Erosion Control at Developed Sites

On lands developed for facilities, such as rest areas, parking lots, maintenance yards and other facility sites, some ground is usually cleared of vegetation. Erosion control methods should be implemented to minimize erosion and sedimentation. Some examples of erosion control methods that could be applied at a site are:

- applying grass seed, jute mesh, tackifiers, and hydromulch
- paving
- placing rock on roads, water bars, and cross drains
- constructing retaining walls.

Potential negative effects to the balance of the natural drainage pattern should be mitigated. Sediment basins and sediment filters should be established to filter surface runoff where such runoff may enter streams. Diversion ditches or berms should be built to divert surface runoff around bare areas.

6.4.5 Visual Mitigation of Drainageways and Structures

Formliners, concrete stain, exposed aggregate, paint or integral color can be specified for highly visible concrete headwalls and endwalls.

Pipe inlets and outlets with visibility concerns can be mitigated by treating galvanized surfaces with a penetrating oxide coloration product to dull the finish and reduce glare. Other alternatives are asphalt coated culvert, mitered culvert end sections and masonry faced concrete (see Figure 60).

6.4.5.1 Rip Rap

Rip rap should be laid in a natural appearing, curvilinear configuration, with undulations, rather than in straight lines. Rip rap should be designed to withstand expected maximum storm flows. Size, gradation, and angularity should be in accordance with the design. Rip rap should be keyed into native materials. A geotextile is useful to separate rip rap from these native materials. Rip rap should be natural appearing in color when installed in high visibility areas (see Figure 61 and 62).

Figure 59 - The rip rap in the median (top) is less visually obtrusive than the concrete median pavement (bottom). The rip rap would appear more natural if it had been placed in an undulating pattern.

Figure 60 - Masonry facing helps blend this pipe endwall with its surroundings.

Figure 61 - This rip rap blends with the surrounding area.

Figure 62 - This rip rap is placed in straight line and appears unnatural. Erosion is also minimizing its effectiveness.

MATERIALS (AGGREGATE AND MATERIAL SOURCES) 7

7.1 Goal of Materials Use

Through interagency cooperation and communication, existing and potential material source sites throughout the state can be utilized efficiently and meet environmental standards.

The following section will set the standard for both ADOT and the USFS for establishing materials sources and attaining permits for geotechnical investigations. Policies, procedures, best management practices (BMP's), vocabulary and expectations will be clarified. These include current agency policies, common use of terminology and areas of concern or misunderstanding.

7.2 ADOT/USFS Materials Standards and Special Use Permit Application and Review Process

7.2.1 Standards

This section outlines a coordinated process, and establishes a common understanding using guidelines to implement and ensure uniform application of the process.

These procedures establish an outline to follow when temporary or annual Special Use Authorizations are required for occupancy of National Forest land for highway related uses outside the public road or highway easement. The procedure addresses BMP's as they relate to materials and geotechnical investigations (see Section VI B. of the MOU, Appendix B).

7.2.2 Special Use Permits Applications

All new permits should follow the following process:

Application Process

This process is the same for potential materials sources, existing ADOT sources, geotechnical investigations, corridor studies, TCE's and drainage easements.

(1) ADOT makes the initial contact to the Forest Supervisor concerning the proposed Special Use, well in advance of the need. Initial contact can be by letter or by phone. If the proposal occurs on more than one District, the Forest Supervisor will designate a lead District.

(2) A Special Use Application and Report (USFS 2700-3) will be completed if the District Ranger decides that the proposal appears to be viable. All pertinent information will be recorded on this form. If the Ranger decides that the proposal is impractical or contrary to law, regulations or USFS policy, the Ranger will notify ADOT within thirty days, stating the reason(s) for denial.

(3) The USFS and ADOT will jointly develop a time frame for completing the permitting process. Frequent and open communications between District and ADOT personnel is necessary to make this process work smoothly. ADOT and the USFS will agree on a liaison for each project.

(4) The District Ranger will review the application for sufficiency and then will start the National Environmental Policy Act (NEPA)/Integrated Resource Management (IRM) process. The USFS, as land management agency, is responsible for ensuring that the NEPA documents are prepared. Depending on time, budget, and personnel availability, the Ranger will decide whether the USFS or ADOT will prepare the NEPA documents. The extent of environmental analysis will be dependent upon the significance of surface disturbance or environmental impact (see Figure 63). If the environmental analysis and decision document is prepared by the USFS, a copy will be sent to ADOT.

NEPA documentation will determine long-term development of the site (desired future condition), as well as USFS and other agency needs. The materials source development plan or operating plan is initiated during this phase (see Section 7.4).

For existing ADOT materials sources, refer to the existing development plan and/or previous NEPA documentation.

(5) The District Ranger will then complete page 4 of Form 2700-3. At this point, the Ranger determines a recommendation of approval or disapproval and will proceed as follows:

(a) When the District Ranger has the delegated authority for the use (e.g., temporary permit, over 12 months):

APPROVAL: District Ranger will prepare and issue a permit.

DISAPPROVAL: The District Ranger will prepare a written notice to ADOT that the application is disapproved and stating the reason(s). This decision is appealable under 36 CFR 215, and must be well-founded and defensible.

(b) Where the authority for the use rests with the Forest Supervisor:

APPROVAL: The District Ranger will prepare the permit and submit it and all supporting documents to the Forest Supervisor. If the Forest Supervisor concurs, the authorized officer will sign the permit.

DISAPPROVAL: The District Ranger will submit completed form 2700-3 with the recommendation of disapproval, and any supporting documents. If the Forest Supervisor concurs with the Ranger's recommendation, ADOT will be notified of the disapproval with the reason(s) stated. This is also an appealable decision.

(6) The plan of operation and development plan will be finalized and approved by the District Ranger after permit approval.

(7) The BMP's to be implemented will be attached to each permit, along with a monitoring plan and the designated USFS representative.

7.3 Materials

7.3.1 Material Sources

ADOT desires to establish a statewide network of about 250 materials sources, some of which will need to be located on National Forest land. Each source may require a geotechnical investigation and an analysis of its usefulness in relation to long or short-term needs, other potential users, accessibility and haul distance in addition to environmental documentation and a master plan.

The USFS will attempt to meet the needs for ADOT materials sources where environmentally feasible, while ADOT operates all sources in accordance with approved plans. Where ADOT will not designate a materials source for its contractors, the USFS will consider using only those sources where ADOT is currently permitted to operate or where all development plans and the NEPA process are complete. After coordinating with the USFS, ADOT will inform its contractors which materials sources are available for use.

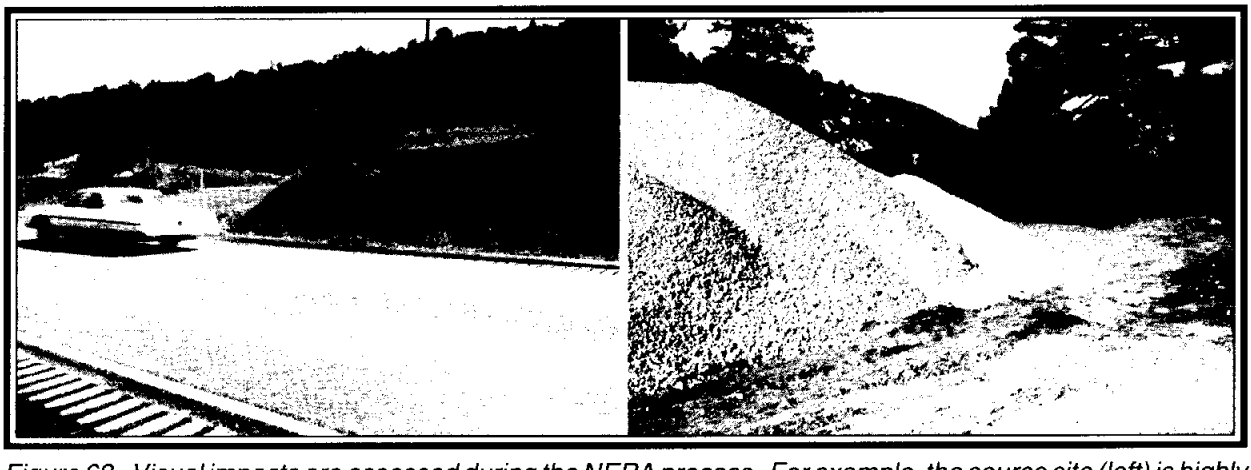


Figure 63 - Visual impacts are assessed during the NEPA process. For example, the source site (left) is highly visible from the roadway and creates a visual impact. The staging area (right) is screened from the traveling public, and has little visual impact.

Each materials source will have an approved development plan and a plan of operations as part of the permit. It is possible that the development plan could require an amendment if large quantities (i.e., 76500 cubic meters) are removed.

7.3.2 Geotechnical Investigations

Geotechnical investigations are needed to evaluate the extent, type and engineering properties of materials encountered. They are conducted on roadway alignments and material sources, and will usually consist of excavations, backhoe test pits or borings by drill rigs.

Geotechnical investigations and access requirements are accomplished through the permit process. All projects require NEPA compliance, including archeology clearance, biological evaluation and mining claim clearance prior to permit issuance. ADOT will contact the USFS well in advance of need to alert them of upcoming projects so that future work impacts can be assessed. The USFS may request the results of geotechnical investigations.

The following types of information should be discussed between the two agencies:

a. equipment proposed for use (e.g., backhoe, drill rigs, water trucks, etc.)

b. type of investigation proposed (e.g., test pits, boreholes, seismic work, etc.)

c. access requirements -

- use of existing roads
- new road construction (amount of cut/fill required, width, length)
- need to remove trees or cut brush
- equipment needed (e.g., dozer, grader, backhoe)
- length of time access is needed
- streams or drainage that must be traversed (see Chapter 6)
- need to conduct investigations in phases (over time)
- need to construct drill pads, disturbance required and area required for pads (approximately 10 m x 6 m is average)
- need for maintenance access after construction.

d. rehabilitation needs -

- revegetation requirements and maintenance needs (e.g., seeding, watering and plant establishment periods)
- type of obliteration
- need to make some areas inaccessible (e.g., block with soil or rock)
- drainage measures needed (e.g., water bars)

7.3.3 Joint Use Material Sources

A materials source can be an exclusive use source or it can have joint uses, in which case it would be referred to as a nonexclusive use source. For example, material may be used for aggregate if the contractor takes the responsibility for testing and getting approvals. Joint use refers to use by more than one agency or party (e.g., USFS, ADOT, county etc.). At a known or potential joint use area, site development plans must take all uses/needs into consideration. Typically, within a joint use source, each user has a designated area. It is recommended to avoid situations where one agency is allowed to remove material immediately adjacent to another agency's designated removal area, unless there is a special need. Each user provides their own plan of operations in accordance with the development plan. The USFS may designate which portion of the source is assigned for use by a specific agency or other user. Site development plans or plans of operation are usually developed jointly by ADOT and the USFS, but ADOT may be required to provide a plan for the entire joint use material source. Each user will be responsible for maintenance or rehabilitation within their own area of use.

7.3.4 Environmental Documentation

NEPA work required by the USFS should be completed in a timely manner to meet the project schedule, to include testing and use of the site during the project. For joint use sites, the NEPA documentation may need to address the entire site, including cumulative effects.

7.4 Materials Source and Waste Site Development Plans

7.4.1 Source Development Plan

A development plan will be required for a materials source or waste site for long-term use (i.e., greater

than five years) and/or large quantities (i.e., greater than 19000 cubic meters). A development plan usually consists of a series of descriptive paragraphs, drawings, calculations, test data, and geological information.

The purpose of the Source Development Plan is to plan, direct and document the proper management of the source; it addresses location, excavation, construction and protection activities and the rehabilitation of the land to its desired future condition. It contains management objectives, BMP's and guidelines to direct a plan of operation.

The Development Plan will be a joint effort between ADOT and the USFS and may be amended as needed. A new Development Plan will be required if significant changes in volume, location, etc., are required.

The Development Plan will be finalized and approved by the District Ranger after permit approval, which will be referenced in a Plan of Operation.

7.4.1.1 Materials Source Development Plan Requirements

Following are requirements of Materials Source Development Plans:

- estimated lifespan, estimate of volume available, horizontal and vertical extent of differing materials, basis of estimate and unusable material
- proposed excavation methods and location where the source will be excavated
- end use of the site (e.g. campground, wildlife/ stock pond, day use area, helicopter pad, waste area, etc.). Site excavation and grading should fit with end design needs (see Figure 64). Each subsequent Plan of Operation would be designed for closure
- mitigation factors and design features (e.g., visual concerns, safety, pollution control, blasting concerns etc.)
- long-term site access and road standards
- estimated type and magnitude of activity area needed (e.g., batch plants, crusher, waste areas, stockpiles etc.)
- Reclamation or rehabilitation objectives and plan
- Legal location, reference points (e.g., bench marks, fences, gates, etc.) and their protection, site contour map with pertinent annotated features, and end use contour map addressing desired future conditions.

7.4.2 Plan of Operations

A Plan of Operations for an individual project will be developed for geotechnical investigations, access road construction, materials sources and waste sites.

The purpose of the Plan of Operations is to implement the Development Plan as it relates to the excavation, removal, stockpiling and rehabilitation of the materials source. For small scale or single entry sources, a Development Plan may also be considered as the Plan of Operations.

A Plan of Operations covers the area intended to be used within a source. It may be used for material extraction for a specific construction project, a borrow source for long-term maintenance, a single waste site, or a geotechnical investigation that requires significant surface disturbance.

A Plan of Operations may not be required for geotechnical investigations that will involve only minimal surface disturbance in areas of minimal environmental concern.

A Plan of Operations will be provided by ADOT and approved by the District Ranger. In order to facilitate a more timely review, ADOT should advise the District when a Plan of Operations is being prepared. The USFS should work only with an ADOT representative, not its contractor.

Figure 64 - A larger fill to the right of this existing roadway could be designed for a scenic overlook.

7.4.2.1 Plan of Operations Requirements

Following are the minimum requirements of a Plan of Operations:

- name and address of the permit holder and names of ADOT field contacts
- name/number of the materials source and location map, probable start/end dates
- area of excavation, work area limit, benches, faces, clearing limits, elevations, etc. on each plan and section view (see Section 4.3 and 4.4)
- type and magnitude of operations (e.g., batch plant, equipment area, stockpiles) including haul routes
- type(s) and volume(s) of material excavated, location and method of excavation, volume and usage of oversize material produced; blasting notification (see Section 4.3.4.)
- vegetation removal and disposal needs, including clearing limits (see Section 10.8)
- material source reclamation/rehabilitation plan (see Section 4.7)
- site monitoring, storage and cleanup for fuels, oils and explosives
- project access, drainage design and environmental mitigation (see Section 4.6)
- end-of-project contour; stockpiles, if not utilized, may need to be designed for maintenance or incorporated by the end of the permit time. A site survey will be needed for the final plan.

Prior to the contractor's release from an ADOT materials source, the USFS and ADOT will determine compliance with the Plan of Operations.

7.4.3 Restoration of Borrow Pits and Quarries

Sediment production from borrow pits and quarry sites should be minimized.

Borrow pits and quarries are often susceptible to erosion due to steep sideslopes, lack of vegetation, and/or their proximity to water courses. Prior to excavation of the site, topsoil should be removed and stockpiled for surface dressing in the post-operation period (see Section 4.7.2). Once excavation has been completed, final treatment and erosion control for the site will be guided by the future land use. Site slope grading, seeding and mulching will be required. Sediment basins should be considered. Access roads to the site should be ripped, drained, blocked to traffic and seeded unless other treatment is required by the design.

7.5 Inspection

Timely inspection is critical for the effectiveness of material source land uses in the land management process. Designated representatives from both the USFS and ADOT must periodically inspect material source sites, waste sites or geotechnical investigation work as it is in progress. Inspections are needed early in the process of site development so that adjustments can be made before work that is inconsistent with the approved plan has progressed too far. The entire sites and adjacent, affected areas should be inspected on a regular basis to evaluate adherence to the line and grade, volumes, etc., in the Plan of Operations, contract and development plan.

The District Ranger approves the final compliance to the ADOT contract, Plan of Operations, and Development Plan.

SIGNING 8

8.1 Goal of Signing

Through cooperation among agencies, informational and directional signing along State highways crossing National Forest land can be consistent and effective for the traveling public.

The purpose of this section is to establish a uniform practice of signing USFS destinations, features and activities on State highways traversing or parallel to National Forest land in Arizona.

8.2 ADOT/FS Sign Design and Review Process

Forest related signing should be requested in writing by the USFS Forest Coordinator and submitted to the ADOT District Engineer for approval. The District Engineer and Forest Coordinator will jointly review the request before a final determination is made. Requests for signing on freeways should be submitted to the State Traffic Engineer, Traffic Engineering Section, for review.

8.3 Traffic Control Criteria

Following are the references guiding traffic control:

- manual on Uniform Traffic Control Devices for Streets and Highways, U.S. Department of Transportation Administration, 1988 (MUTCD)
- highway Functional Classification Concepts, Criteria and Procedures, Transmittal 155, Volume 20, Appendix 12, U.S. Department of Transportation, FHWA, July 1974
- specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, American Association of State Highway and Transportation Officials, 1985, and 1986, 1987, 1988 Interim Revisions
- roadside Design Guide, American Association of State Highway and Transportation Officials, 1989
- standards for Forest Service Signs and Posters, U.S. Department of Agriculture, Forest Service, Engineering Staff, January 1992, EM-7100-15.

8.4 Signing Practice

This section addresses the most frequently occurring signing issues and is not intended to provide explicit guidance on all possible signing matters that may arise. Signing issues beyond this scope are intended to be resolved jointly by the USFS Coordinator and ADOT District Engineer and/or State Traffic Engineer through "Partnering" concepts.

National Forests generate volumes of traffic sufficient to justify informational and guide signing to facilitate the safe and orderly movement of traffic on and off of highways to recreational destinations. In addition to signing for recreational facilities and scenic attractions, the USFS has a need for certain Forest-specific signing to advise of and safeguard Forest resources, temporary operations and fire suppression activities.

All signing should be installed and located in accordance with the MUTCD and Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, American Association of State Highway and Transportation Officials, 1985, and the 1986, 1987 and 1988 interim revisions. Signs should typically be of breakaway design. Any non-breakaway signs should be located outside the recovery area (see Figure 65). Where not possible, signs should be shielded from out of control vehicles in conformance with Roadside Design Guide, American Association of State Highway and Transportation Officials, 1989.

8.4.1 Signing Needs

Forest-specific signing as well as other Forest related informational, guide and miscellaneous signing may be considered for installation when:

- the signing will not interfere with warning and regulatory signs and is consistent with other guide signs
- the signing will not present a significant obstacle to errant vehicles
- the Forest facility or attraction is located immediately adjacent to the State highway or on a Type 2 Road that is traversable during normal weather conditions by prudent drivers in passenger cars.

Figure 65 - The National Forest boundary sign is ideally located, outside the recovery area. (Photo by John Bell.)

8.4.2 USFS Operational and Emergency Fire Suppression Signing

USFS should furnish, install and maintain all temporary warning, regulatory and guide signs; other traffic control devices (such as delineators, barricades, temporary pavement markings and temporary barriers); and all other appropriate devices which are necessary to warn and control traffic because of construction and maintenance activities, or other temporary operations sponsored by USFS or its contractors. All such traffic control devices and their applications should be in conformance with the MUTCD.

When USFS wildfire suppression activities occur along or adjacent to a highway, the same principles apply. Fire suppression is a response to an emergency. USFS fire suppression and ADOT maintenance personnel must coordinate to identify the need for and accomplish the installation of signs and devices as soon as possible. Often this means using signs and devices from the nearest ADOT maintenance yard. When ADOT incurs significant costs in making the signs and devices available, the ADOT maintenance supervisor should work with the logistics chief and finance chief assigned to the fire to obtain reimbursement. The signs and devices are chargeable to the fire suppression activity. All signs and traffic control devices necessary to warn highway traffic of smoke and fire suppression activity should be in conformance with MUTCD.

NOTE - THE GREATEST HAZARD USUALLY OCCURS ON THE FIRST NIGHT OF A FIRE. Virtually all major wildfires in Arizona have escaped the USFS' initial fire suppression attack and then made a major "run" during extreme burning conditions the first afternoon. Thousands of hectares have become involved in a few hours. It takes the USFS 12 to 24 hours to mobilize a "team" to manage suppression of such a fire, and the team is usually not in place until the second day. In the chaotic first afternoon, with fire activity overwhelming local resources, the consequences of approaching darkness often go

overlooked. Activities that are plainly visible to motorists in daylight become invisible after dark. It is important for ADOT to work with the USFS to identify such hazards and have the necessary signs, barricades, and flashers in place before darkness to both protect motorists from fire suppression activities and to protect fire fighters from motorists.

8.4.3 Informational Signing

Guide and informational signing furnished by ADOT for Forest facilities and attractions should be rectangular in shape and normally have a white legend and border on a brown background. However, when a Forest related destination is displayed on the same sign with a non-Forest related destination, the sign should have a green background.

Signing should not be installed on a State highway until the USFS or local agency, if applicable, installs the appropriate follow-up signing for the direction of traffic to the facility or attraction.

Where a Forest facility or attraction that justifies signing is the only destination along a Type 2 Road or immediately adjacent to the State highway, two signs should normally be installed for each direction of travel: one in advance of the intersection and the other at the intersection. The installation at the intersection should have an arrow pointing the direction to the facility or attraction and, where applicable, should show the distance in kilometers.

Forest related recreational symbols (recreational and cultural interest signs) may be installed and should conform with Section 2H, Recreational and Cultural Interest Area Signs, of the MUTCD. No more than four federal recreational symbols (recreational and cultural interest area symbol signs) may normally be used in a single sign assembly or on a single sign face.

8.4.4 Boundary Signs

The National Forest logo should be used on Forest boundary signs, except on "Entering Private Land" signs, and may be approved for use on Forest recreation area boundary signs and Forest related site specific guide signs (see Figure 66).

8.4.4.1 Boundary Signing Criteria

(1) Signing on freeways should be provided at or near major National Forest boundaries and should be furnished, installed and maintained by ADOT. These signs should display the Forest name and the National Forest logo. The sign at the entering location should display "ENTERING." The sign at the leaving location should display "LEAVING."

(2) Signing on conventional State highways should be provided at the first acceptable site, consistent with highway safety considerations at or inside the National Forest Boundary. These signs should be furnished, installed and maintained by USFS, and conform with EM 7100-15 requirements. ADOT concurrence is required for these installations. The signs may display messages on both sides, where one side displays the National Forest entrance message and the opposite side displays the leaving

Figure 66 - National Forest Boundary Signs - (a) Interstate Highway Signs, and (b) Interior Private Land Signs.

message. The single sign arrangement is preferable to two separate signs, as roadside obstacles are reduced.

(3) "Entering Private Land" signs may be provided on conventional State highways at interior private land boundaries where there is a significant tract of private land surrounded by National Forest. These signs are furnished, installed, and maintained by the USFS with ADOT concurrence required. If the signs cannot be located within 15 m of the actual boundary, they should not be installed. The signs should not normally be spaced closer than 0.4 km apart.

8.4.5 Facility and Attraction Signs

On other than major Forest boundary signing, it is intended that the National Forest logo be used only on signs installed for significant Forest facilities and attractions, generally characterized by meeting the following criteria for quality of access and services:

- primary access is provided over roads designed and maintained for prudent drivers in passenger cars with traffic controls present and obvious
- the facility/attraction should be used by at least 50 persons per day during the recreation season
- the facility/attraction should be located within 24 km of the highway turnoff or exit ramp terminal.
- the facility/attraction should be maintained daily during the recreation season
- forest facilities and attractions that generate 200,000 visitors per year may also have the National Forest logo incorporated into the sign message display (see Figure 67).

8.4.6 Recreation Area Signing

Forest recreation area boundaries may be identified on conventional State highways at or near the location where the recreation area boundary intersects the highway. When used, the signs should be installed with ADOT concurrence, and should be furnished, installed and maintained by USFS. The signs typically

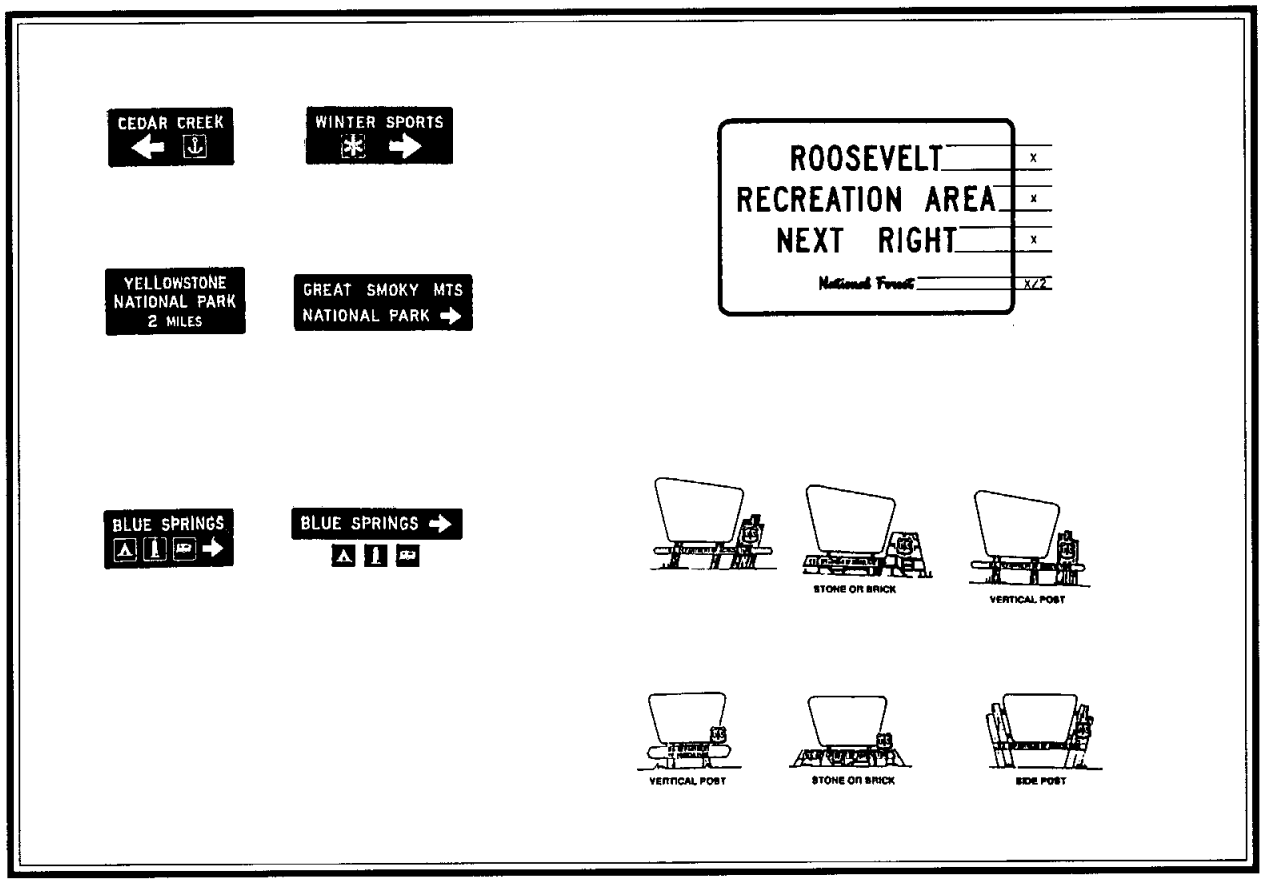


Figure 67 - National Forest Facility and Attraction signs.

display the Forest name, National Forest logo, USFS shield and USDA plaque. These signs should conform with the family of shapes identified in the USFS Standards for USFS Signs and Posters.

Where a Forest recreation area is located on or is near an intersecting conventional State highway, the Forest recreation area may be signed on the intersected highway. The signs on the intersected highway should be furnished, installed and maintained by ADOT, and will display the Forest name, Forest recreation area name, and directional information. The National Forest logo may be used when the Forest recreation area is a significant traffic generator.

8.4.7 Site Signing

Site signing is normal recreational and supplemental guide signing, which directs travelers to specific Forest sites such as camping facilities, trailheads, etc. Only those sites where primary access is provided over roads designed and maintained for prudent drivers in passenger cars should be signed. Principal destinations along a local route should be signed twice: one at the intersection, and one from 150 m to 1.5 km in advance of the intersection.

Where the Forest facility is one of two or more destinations along a local access road, the signing for the Forest facility may be provided as an independent white on brown supplemental guide sign or the Forest destination may be incorporated into the legend display of the white on green guide signs provided for the non-Forest destinations.

Federal recreation symbols (recreational and cultural interest area symbol signs) describing up to four pertinent activities in the Forest facility may be incorporated into the face of Forest-specific guide and supplemental guide signs or installed underneath these types of signs. Where appropriate, the symbols may be provided in an independent installation. Where the symbols are considered for a Forest destination and displayed on a white on green guide sign, the symbols should be installed underneath the guide sign. When two advance signs are used, either white on brown or white on green, the symbols should be installed on the face of or underneath the sign located at the intersection.

Where non-Forest related motorist services signing (Gas, Food, Lodging, Camping, Telephone, Tourist Information and Hospital) is incorporated into guide signing containing Forest destinations, the non-Forest related motorist services signing should be white on blue and should be installed beneath the guide sign located at the intersection.

Site signing should be furnished, installed and maintained by ADOT.

8.4.8 USFS Approaches to State Highways

Signing and traffic control device installations should be commensurate with highway safety requirements and USFS road management objectives (see Section 2.4). Where Forest roads are intended for use by prudent drivers in passenger cars, warning, regulatory, and guide signs consistent with MUTCD requirements should be installed. Where passenger car use is discouraged on intersecting Forest roads, only warning signs necessary for highway safety should be installed.

Signs located within the State highway easement should be furnished, installed, and maintained by ADOT. Signs outside the easement should be furnished, installed, and maintained by the USFS.

The highway edge stripe should be broken at approaches for those roads intended for use by prudent drivers in passenger cars. The stripe should be continued through approaches for other Forest roads.

8.4.9 Administrative Office (Ranger Station) Signing

Signs directing travelers to National Forest administrative offices may be installed on conventional State highways when the facility is located within 8 km of the highway intersection (see Figure 68). Two signs will normally be provided for each direction of travel, one at the intersection and one 150 m in advance of the intersection. These signs should be white on brown and should display the administrative office name, the name of the National Forest, the National Forest logo and appropriate directional information.

Where Forest administrative offices are located on a local access road, follow-up signs to the facility should normally be installed on the local access road by the agency having jurisdiction of the road, before the guide signs are installed on the highway. Where normal white on green guide signs are in place on the highway for other destinations along a local access

road, signing for Forest administrative offices should normally be provided by a single white on brown supplemental guide sign for each direction of travel.

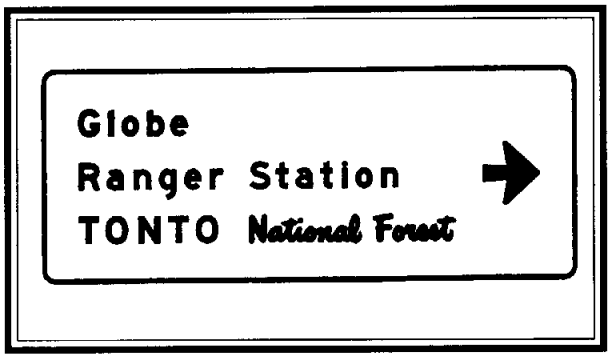


Figure 68 - Administrative office sign.

8.4.10 Interpretive Signing

Interpretive signing is a form of USFS information signing that provides information to Forest visitors on natural and cultural interests, historical features and management practices on National Forest land. These signs may be considered for use in rest areas, scenic vistas, pullouts and other non–highway locations. When used, they should be oriented in such a way that the faces of the signs are not visible from the highway. These signs are furnished, installed and maintained by USFS. The National Forest logo and the Forest name may be incorporated into the sign message display. These signs should conform with the Standards for Forest Service Signs and Posters (see Figure 69).

Figure 69 - Interpretive signs.

8.4.10.1 Wildlife Viewing Area Signing

Wildlife viewing areas may be signed if they are identified in the Arizona Wildlife Viewing Guide, meet MUTCD Section 2H-2 requirements, and meet the following criteria (see Figure 70):

(1) The wildlife viewing area or trailhead to the area is located:

- in a pullout immediately adjacent to the highway
- on a local access road designed and maintained for prudent drivers in passenger cars
- within one 1.5 km of the highway intersection

(2) Where the wildlife viewing area is the only identified attraction at a highway intersection or is the only destination along a local access road, two signs should be provided for each direction of highway travel: one at the intersection, and one from 0.4 km to 0.8 km in advance. Appropriate arrows/distance slats should be provided with these signs.

(3) Where the local access road or highway intersection has other destinations or attractions, the Wildlife Viewing Area signs may be installed:

- at one location as an independent supplemental guide sign
- at the locations of and underneath the existing destination signs
- incorporated into the display of other existing recreational symbol signs.

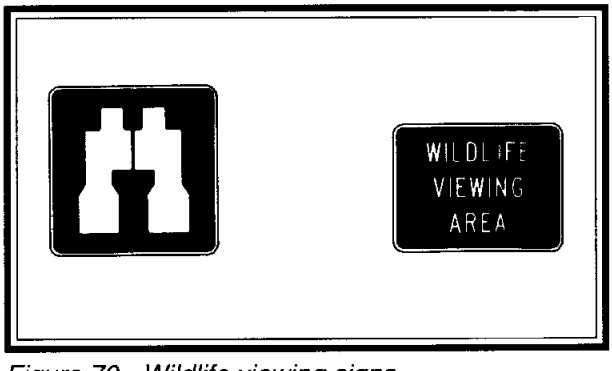


Figure 70 - Wildlife viewing signs.

Where follow-up signs are needed along a local access road, the follow-up signs should normally be installed by the agency with jurisdiction on the local road prior to installing the signs on the highway.

8.4.11 Adopt-a-Highway Program Signing

Adopt-a-Highway signing is an ADOT program whereby the public assists the State in roadside litter maintenance. Approved groups are assigned a section of highway for litter control and maintenance. Signs identifying the Program and the volunteer group are erected at the limits of the assigned area by ADOT (see Figure 71).

This program and applicable signing may be effected on State highways traversing National Forest land.

8.4.12 Parkways, Scenic and Historic Roadways and Scenic Byways

Conventional State highways that traverse National Forest land and that are designated as Parkways or Scenic and Historic Roadways, as provided in ARS41-512 through ARS41-518; or Scenic Byways, as promulgated by USFS, FHWA and Bureau of Land Management, should be signed. Signing for highways designated as Parkways or Scenic and Historic Roadways should be installed and maintained by ADOT. Signing for highways designated as Scenic Byway should be installed and maintained by USFS. These signs should be located at the beginning and ending limits of the designated roadway and should be repeated at intervals of at least 8 km (see Figure 72).

When a route is both an ADOT Parkway or Scenic and Historic Roadway and a National Forest Scenic Byway, then both signs will be used at the beginning of the route (portal) and only the ADOT sign will be used as the reassurance sign through the route.

Where a designated Forest road intersects a conventional State highway, signs should be installed by ADOT that identify the intersecting roadway as having such designation. Signing on the Forest road beyond the easement lines of the State highway should be installed and maintained by the USFS. These signs should also be installed at the beginning and ending limits of the designated roadway and repeated at intervals of at least 8 kilometers.

8.4.13 Forest Road Numbers

Route number signing for USFS roads should be installed on conventional State highways at intersections with Forest roads on which the USFS desires to "encourage" use by passenger cars. Route markers may also be installed for intersections with other Forest roads on which the USFS "accepts" passenger car use. Route markers should not be installed for Forest roads on which passenger car use is discouraged or prohibited.

When the USFS has installed "Forest Route Markers," MUTCD M1-7 (see Figure 73), on an intersecting road, ADOT will then furnish, install, and maintain the Forest Route Markers on the highway. Forest Route Markers indicate a main Forest access road.

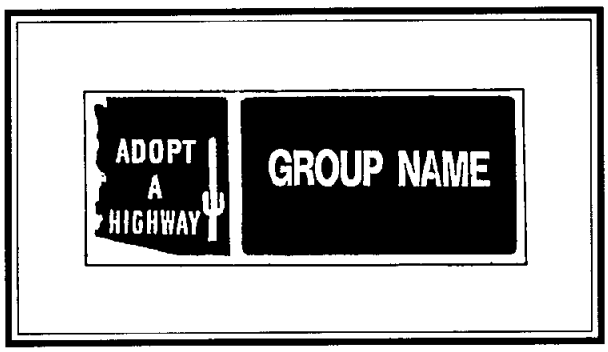


Figure 71 - Adopt-a-highway sign.

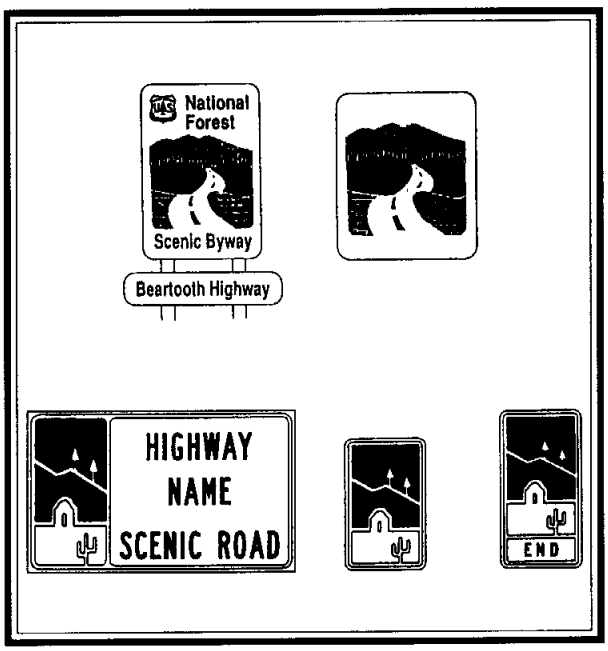


Figure 72 - Scenic Byway sign.

When the USFS has installed "Horizontal Route Markers," EM 7100-15 FM-1, on an intersecting road, the USFS will furnish the markers; ADOT will install and maintain them. Horizontal Route Markers may be installed on the highway with ADOT concurrence. These markers indicate a Forest road suitable for passenger vehicles.

8.4.14 Other Signing

Signs pertaining to Forest resource management, fire prevention, etc. may be used when they do not interfere with normal warning, regulatory and guide signs or present a significant obstacle to errant vehicles. Signing under this category includes, but is not limited to, fire prevention check points, truck crossings at timber haul roads, control burn areas and Smokey Bear fire rating signs. Miscellaneous signs should generally be furnished, installed and maintained by USFS; however, signs such as Truck Crossing Warning signs that are located in standard signing position and will remain in effect for substantial periods of time should be furnished, installed and maintained by ADOT. Specific locations for miscellaneous signing should be jointly determined by the USFS Forest Coordinator and the ADOT District Engineer. Signs furnished by USFS should conform with the MUTCD and USFS Standards for USFS Signs and Posters (see Figure 74).

8.4.15 Typical Signing Applications

Following are typical signing applications and examples:

- Fire Prevention Checkpoint signing should be installed in accordance with Figure 75, Fire Prevention Information Stations.
- guide signing on State highways at intersections with Forest roads should be installed in accordance with Figure 76, Typical Guide Signing on State highways at significant USFS roads.
- where a USFS road needs to be identified but where no specific destinations are signed, Forest Route Markers should be installed in accordance with Figure 77, Typical Route Markers at junctions of State highways and significant USFS roads.
- Truck Crossing Signs on USFS timber haul roads should be installed in accordance with Figure 78, Typical Truck Crossing.
- signing for Control Burn Areas should be installed in accordance with Figure 79, Typical Application of Signing for Control Burn Areas.

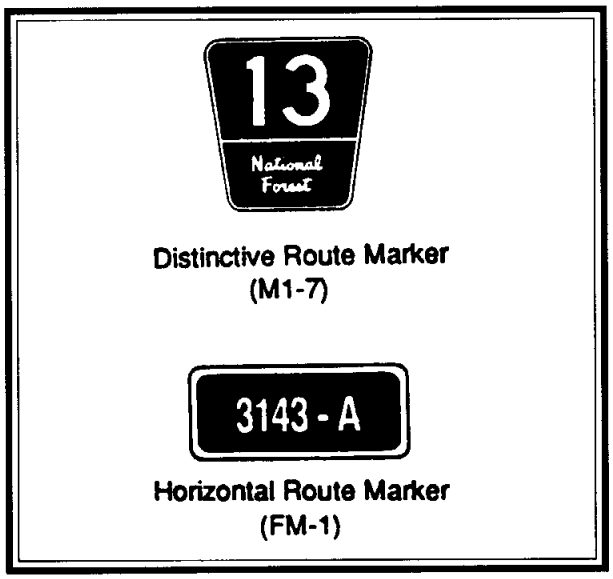


Figure 73 - Forest Route marker.

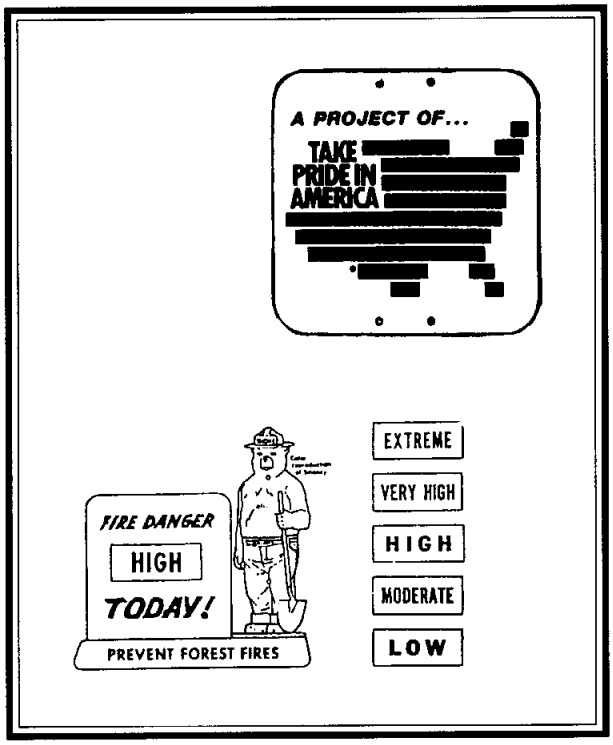


Figure 74 - Other miscellaneous National Forest signs.

- Figure 80 illustrates the typical application of Forest related signing.

(See Figures 75 - 80 on the following pages.)

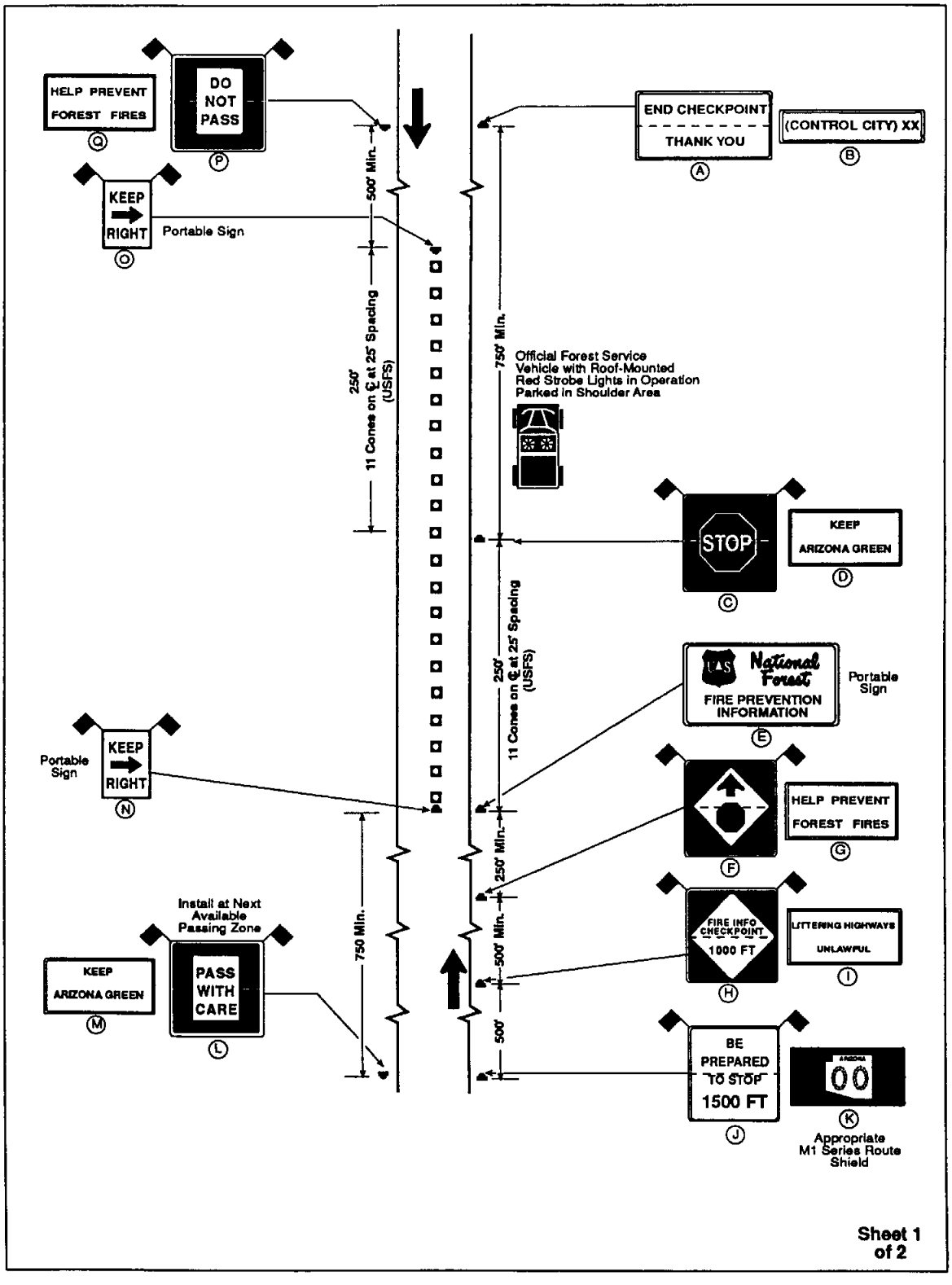


Figure 75 (a) - Fire Prevention Information Station, typical. (See Appendix F for metric conversions.)

SIGN LEGEND FOR FIGURE 1
FIRE PREVENTION INFORMATION STATIONS

SIGN	SIGN CODE	SIGN SIZE	COPY COLOR	SIGN BACKGROUND COLOR	PARENT PANEL COLOR	PARENT PANEL SIZE	FOLDED DOWN/UP	RESPONSIBLE AGENCY
A	N/A	48"x24"	White	Brown	N/A	N/A	up	USFS
B	N/A	48"X12"	White	Green	N/A	N/A	down	USFS
C	R1-1	48"x48"	White	Red	Black	52"x52"	up	ADOT
D	N/A	52"x26"	White	Green	N/A	N/A	down	ADOT
E	N/A	72"x48"	White	Brown	N/A	N/A	N/A (portable)	USFS
F	W3-1 or W3-1a	48"x48"	Black/ Red	Orange	Black	72"x72"	up	ADOT
G	N/A	72"x36"	Black	White	N/A	N/A	down	ADOT
H	N/A	48"x48"	Black	Orange	Black	72"x72"	up	ADOT
I	N/A	72"x36"	Black	White	N/A	N/A	down	ADOT
J	N/A	48"x48"	Black	Orange	N/A	N/A	up	ADOT
K	M1 Series	varies x 24"	Black	White	Green	48"x24"	down	ADOT
L	R4-2	24"x30"	Black	White	Black	52"x52"	up	ADOT
M	N/A	52"x26"	White	Green	N/A	N/A	down	ADOT
N	R4-7a	24"x30"	Black	White	N/A	N/A	N/A (portable)	USFS
O	R4-7a	24"x30"	Black	White	N/A	N/A	N/A (portable)	USFS
P	R4-1	24"x30"	Black	White	Black	48"x48"	up	ADOT
Q	N/A	52"x26"	Black	White	N/A	N/A	down	ADOT

GENERAL NOTES

1. All Existing Signs in Conflict with this Operation Shall be Covered Completely.
2. A Minimum of 500 Feet of Stopping Sight Distance Shall be Available for this Operation.
3. All Regulatory and Warning Signs Shall Have Two Fluorescent Orange Flags, 16 inch by 16 inch Minimum, as indicated on Sheet 1 of 2.
4. All Signs on Embedded Sign Posts Shall be Folded Down When this Station is Unmanned. Orange Cones and Portable Signs Shall be Removed and Maintained by the US Forest Service.

Sheet 2 of 2

Figure 75 (b) - Fire Prevention Information Stations, continued. (See Appendix F for metric conversions.)

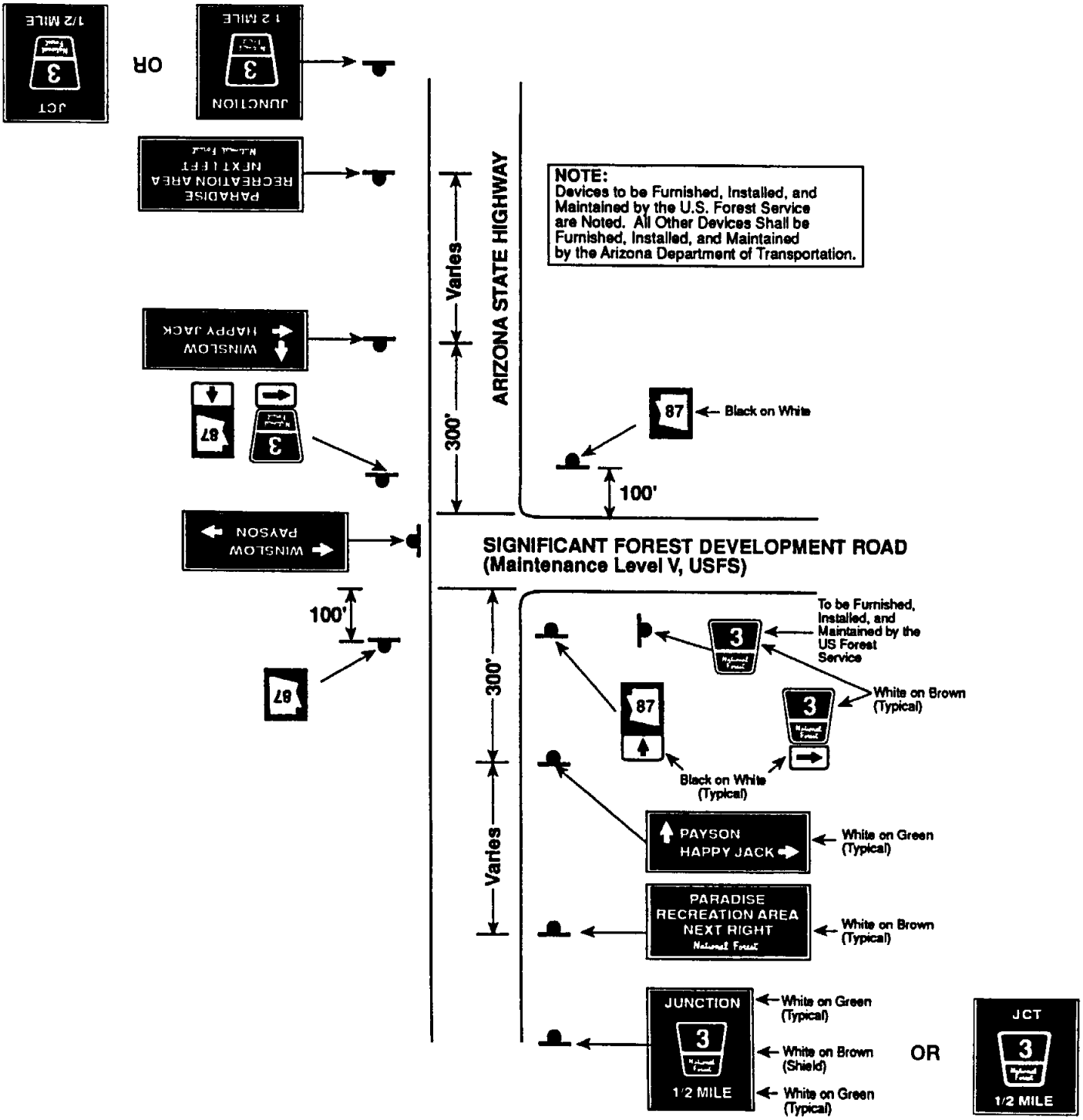


Figure 76 - Typical Guide Signing on State highways at significant USFS roads. (See Appendix F for metric conversions.)

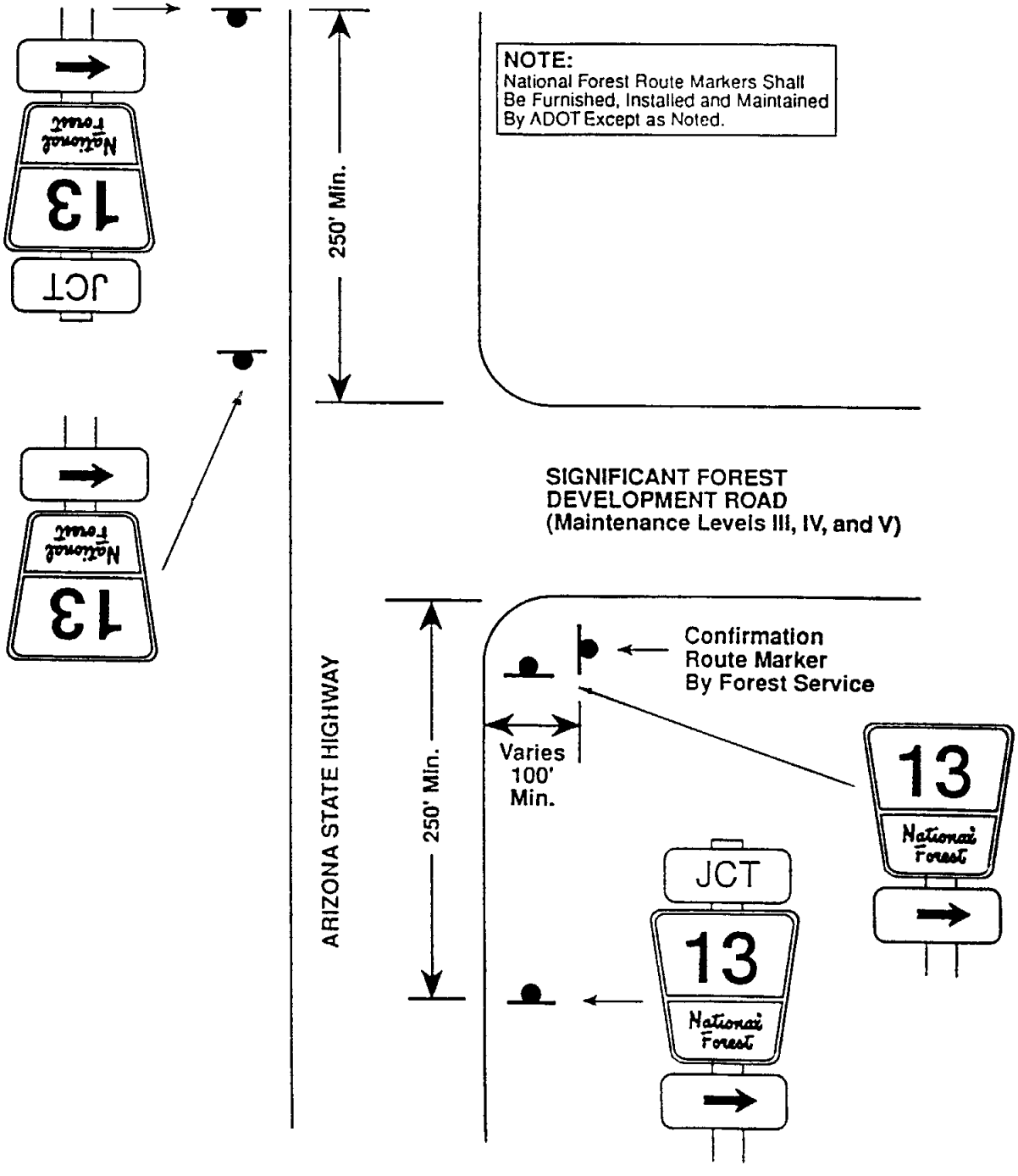
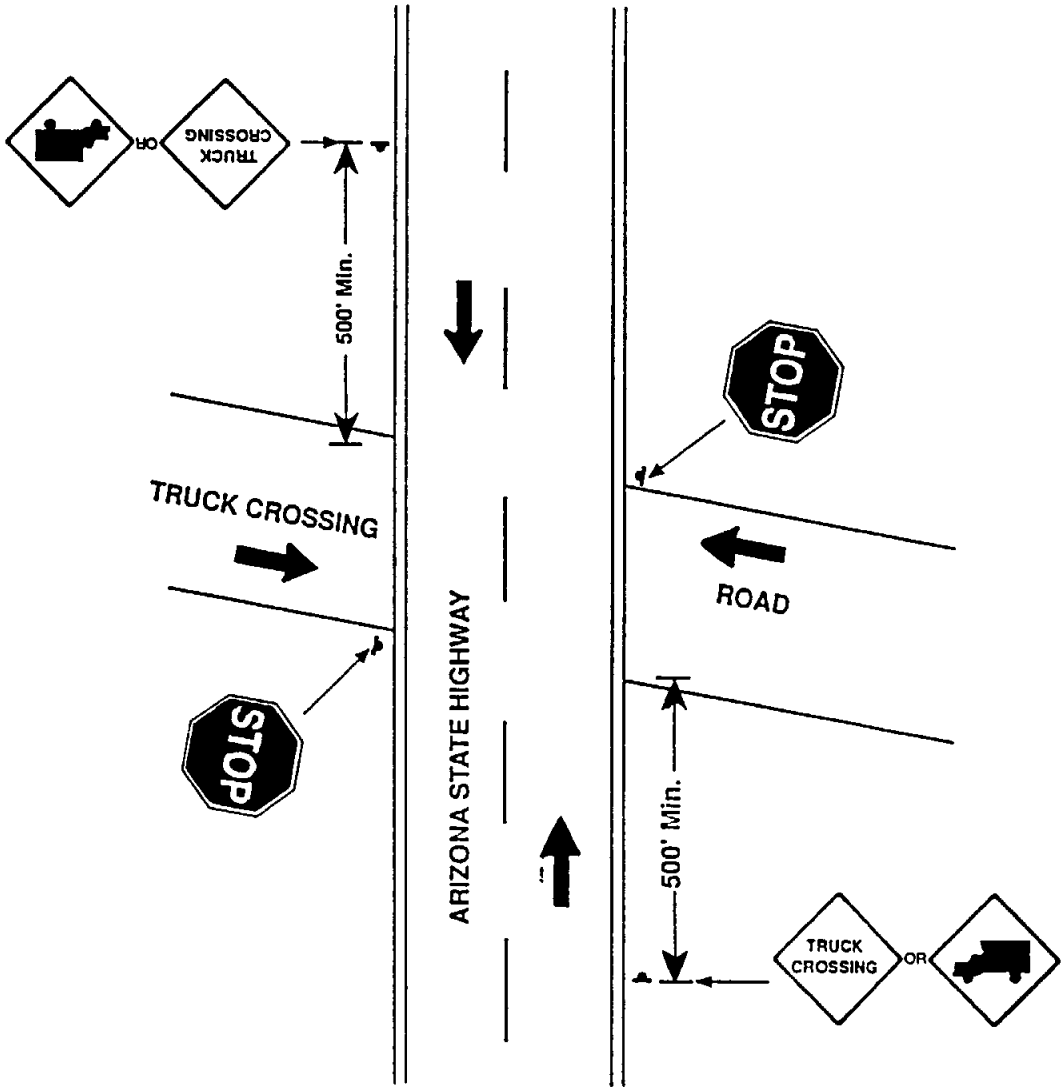


Figure 77 - Typical Route Markers at junctions of State highways and significant USFS roads. (See Appendix F for metric conversions.)



DURATION	INSTALLATION AND MAINTENANCE	SUPPORTS
Short-Term	US Forest Service	Embedded or Temporary
Long-Term	ADOT	Embedded

Figure 78 - Typical Truck Crossing. (See Appendix F for metric conversions.)

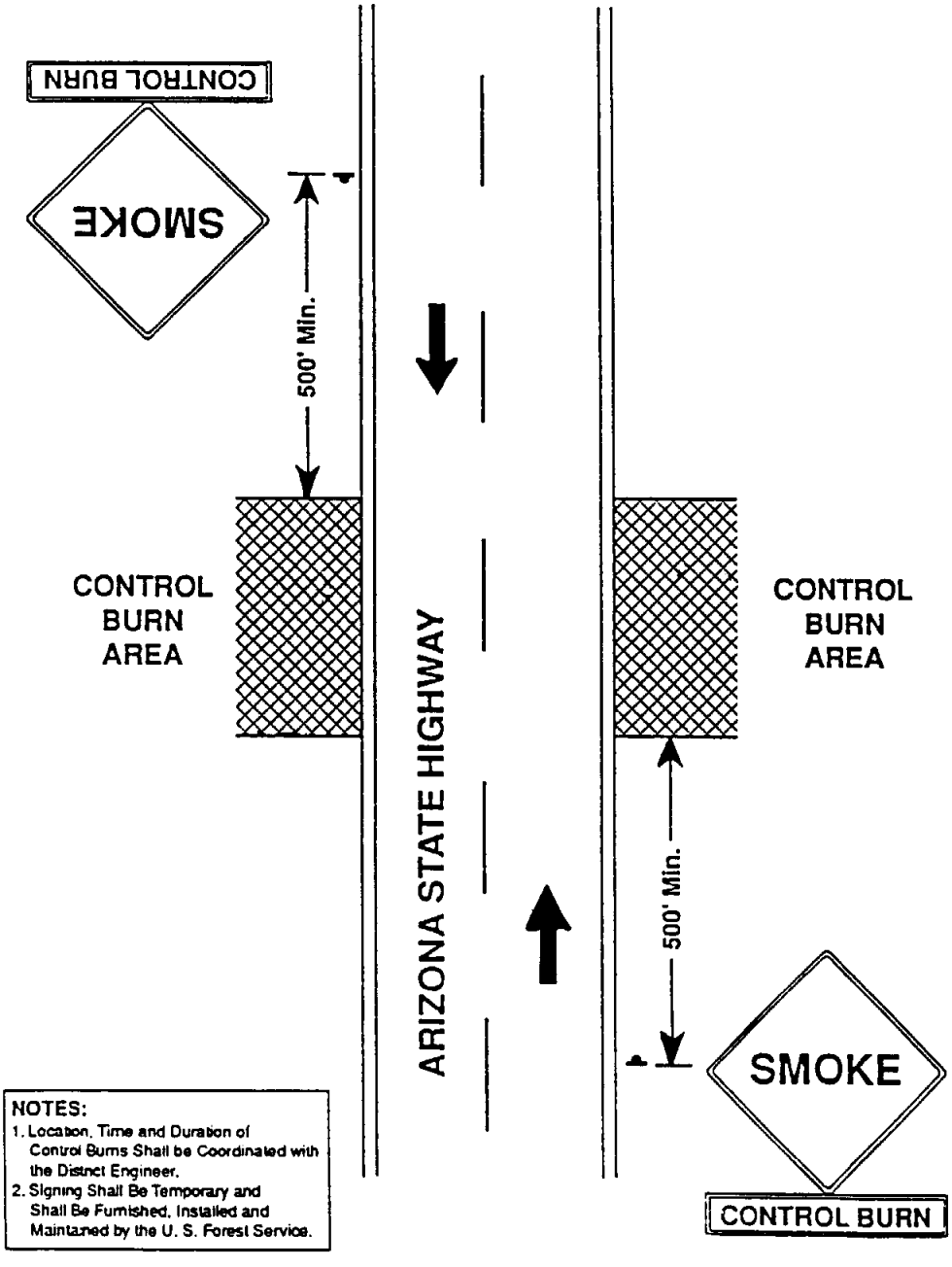


Figure 79 - Typical application of Signing for Control Burn Areas. (See Appendix F for metric conversions.)

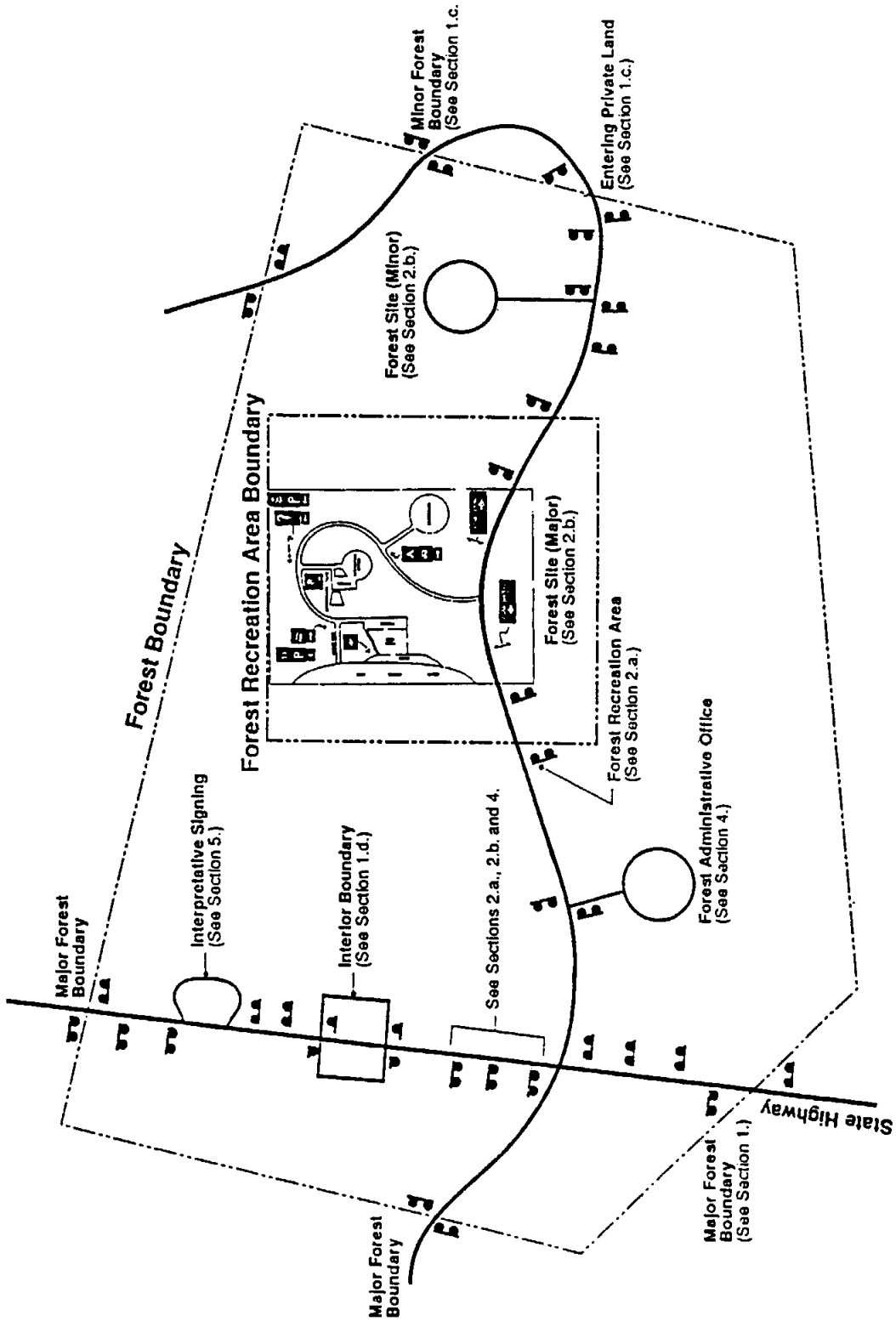


Figure 80 - Typical Forest signing.

MISCELLANEOUS STANDARDS 9

9.1 ADOT/USFS Design and Review Process for Miscellaneous Standards

The USFS may desire to provide input on some standard ADOT roadway details and features, such as roadside barrier, fencing, and paving standards. This input will typically reflect NEPA decisions and the transition from the ADOT roadway to National Forest land access.

9.2 Roadside Barriers

9.2.1 Goals

Establish a cost-effective set of guidelines for the type, application and installation of roadside barriers to be utilized statewide on State roadways crossing National Forest land.

9.2.2 Functions of Roadside Barriers

Roadside barriers function to shield the motorist from natural or built obstructions along the roadside.

9.2.3 Existing Guidelines and Design Parameters

Roadside barrier placement is typically the decision of the design engineer, and is generally installed at non-traversable slopes or when fixed objects are located within the recovery area (see Reference 4).

Hinge points on pavement preservation projects depend on a number of factors, including, but not limited to, the following:

- recommended pavement treatment,
- location of existing hinge points,
- existing subgrade slopes,
- availability of embankment material in area (as an alternative,
- existing and desirable offset for roadside barrier.

On a number of existing roadways it is desirable to install Type 'B' guard rail (0.5 m offset) when reconstructing the existing guard rail. This may also be desirable when constructing a new barrier installation on roadways with narrow shoulders in order to provide an acceptable shy line offset.

9.2.4 Disadvantages of Roadside Barriers

Roadside barriers are, themselves, a roadside obstruction, although less so than that of the obstruction or slope that the barrier shields from the motorist.

Entrapment of wildlife can also be a problem with barriers installed in wildlife movement areas.

Roadside barriers create a visual impact. A trade-off may be involved in determining whether or not to install a barrier to retain a positive visual element, such as significant riparian vegetation.

9.2.5 Types and Finishes

Barriers may be comprised of concrete, W-beam guard rail, weathered steel, wood posts, steel posts, and hardware as required. The USFS may have input on type of barrier for specific projects, as well as input on significant resources and wildlife along the corridor, which could effect decisions on the type, placement and finish (see Figure 81). Where a nonstandard barrier is installed, the Annual Highway Maintenance Plan should address replacement stock (see Chapter 11). Finishes may include galvanized steel, acid etched steel, self weathering steel and masonry facing.

9.2.6 Recommendations

Following are general recommendations for use of barriers on National Forest land:

- The use of slope flattening with more extensive slope easements is desirable. The temporary additional disturbance will have to be evaluated versus the long term effect on life cycle costs, aesthetics, maintenance and safety aspects associated with the use of roadside barriers.

- Although limited in effectiveness, game reflectors should be used in known migratory corridors regardless of whether or not roadside barriers are installed. If barriers are installed where big game is

or later becomes a problem, selective placement of gaps should be made to permit a suddenly trapped animal a recognizable outlet. This would entail relaxation of the minimum allowable gap rule of 60 m in these unique situations only. Gaps would be permitted as long as the surrounding terrain would support the use of end treatments at these locations and, this should be used only if slope flattening is not a viable option.

- Route continuity should be a primary goal of all parties involved as it affects, among other things, driver expectancy. The entire route must be examined for past and scheduled future projects to ensure corridor consistency when determining appropriate slopes and/or barrier placement requirements. Consideration should also be given to the type and finish of the barrier, to maintain a consistent corridor.

Guidelines for route continuity should also address:

- types of terminal sections and end treatments
- wildlife corridor solutions
- a policy on roadside barrier vs. protection of adjacent resources.

9.3 Wire Fence

Following are guidelines for the design and construction of wire fence for use statewide on all National Forest land.

9.3.1 Functions of Wire Fence

All fence along transportation facility corridors serve to control access and prevent cattle and other livestock from entering a vehicle path.

Game fence, while providing all the above functions, also accommodates the movement of game and other wildlife across the highway easement.

9.3.2 Guidelines for Selecting Fence Type

Type 1, Barbed 4 Wire Fence (Std. C-12.10) is normally installed along the easements of all rural highways (except Interstate Routes 8, 10, 15, 17, 19, and 40).

Along rural Interstate Routes, Type 2, Barbed 5 Wire Fence (Std. C-12.10) is required. The extra wire strand provides additional protection against the indiscriminate entry or crossing of the roadways by animals.

For Interstate Routes with parallel frontage roads, the Barbed 4 Wire Fence would be constructed along the easement line and the Barbed 5 Wire Fence would be installed along the access control line. The access control line is usually located between the frontage road and the mainline roadway.

Both Type 1 and Type 2, Barbed Wire Fence will provide the required access control and will restrict livestock and other animals from entering the roadway, however, wildlife movement must also be considered. Upon request of the Arizona Game and Fish Department, the Barbed Wire Game Fence (Std. C-12.10) will be constructed in lieu of either fence type.

Modifications and revisions to these three fence types from that shown on the Standard Drawings should not be considered on a project-to-project basis. Revisions for the purpose of accommodating personal preference should be avoided. Any request for revising the standard fence should be accompanied by supporting documentation to justify the proposed change (see Reference 23 and 24, Appendix D).

9.3.3 Location and Alignment of Fence

Wire fence will typically be constructed along a line parallel to, and 150 mm inside of, the (right of way) line as shown on Standard Drawing C-12.10. Varying the fence line offset to avoid small trees will not be required; however, large trees should be avoided to the extent possible by varying the offset distance, on or off the easement, as approved by the Engineer. Light clearing within 300 mm to 450 mm of the fence line will be required. Clearing will be restricted to the minimum necessary to construct the fence and should be in accordance with Subsection 903-3.01 of the Specifications. The USFS restricts clearing and may require fence placement to follow terrain or other features, rather than a straight line. Before removing any trees, the contractor should first obtain the Engineer's approval (see Section 10.8.1). A tree is defined as a woody plant having a diameter of 100 mm or more at a distance of 300 mm above the ground.

Figure 81 - The nonreflective, self-weathering steel finish (left) may be more appropriate in some locations than the more reflective, galvanized finish (right).

9.3.4 Location of Cattle Guards and Gates

During the design phase, the project leader should meet with representatives from ADOT District and the USFS at the project site to determine the locations for cattle guards and gates. When appropriate, the grazing permittees or a representative from the local grazing association should also be asked to provide input for locating these items.

For further information on locating cattle guards and gates, refer to Section 9.7.

9.4 Snow Fence

Where snow drifting is a problem, a vegetative windbreak is preferable to snow fence. If snow fence is required, a neutral color is preferable over orange, and the fence should be removed during off seasons to minimize visual impacts (see Section 11.5.4).

9.5 Truck Escape Ramps on National Forest Land

Truck escape ramps are an essential safety feature in areas where there are long descending grades that may cause truck brakes to fail and result in a loss of control. Location and design guidelines for truck escape ramps are outlined in ADOT's Truck Escape Ramp Policy prepared by the Traffic Engineering Section in January of 1987.

Since hilly terrain is frequently encountered through National Forest land, there is some likelihood that truck escape ramps will be required on State Highways that traverse National Forest land. Due to the special environmental considerations associated with National Forest land, additional NEPA input may be provided by the USFS to augment ADOT's 1987 policy.

9.5.1 Proposed Guidelines

The two, primary negative aspects of truck escape ramps are the visual impact and the disruption of native vegetation (see Figure 82). To minimize the negative impacts, the following should be considered in locating, designing and constructing truck escape ramps on National Forest land:

- when possible, locate escape ramps in areas where the ramp can be constructed on a natural upgrade to reduce the required ramp length
- solicit input from the USFS and landscape architects in the location and design process, assess the impact on visual quality objectives, and consider alternatives.

9.6 Obliteration of Roads

Forest roads in a project area that are determined not to be necessary for Forest management purposes must be revegetated (National Forest Management Act). The USFS makes this determination through the "Access Management Process" (see Section 2.4). Roads needing revegetation are usually obliterated first. Revegetation is usually accomplished through planting and seeding, although natural means are preferable in some situations.

Prior to the obliteration of a road, a decision must be made regarding the restoration of the road template to the original ground line. Adverse soil and water impacts could result from disturbing constructed slopes that are stable and revegetated. An environmental assessment process should be used to evaluate the benefits and costs involved in various road obliteration and revegetation techniques in each situation.

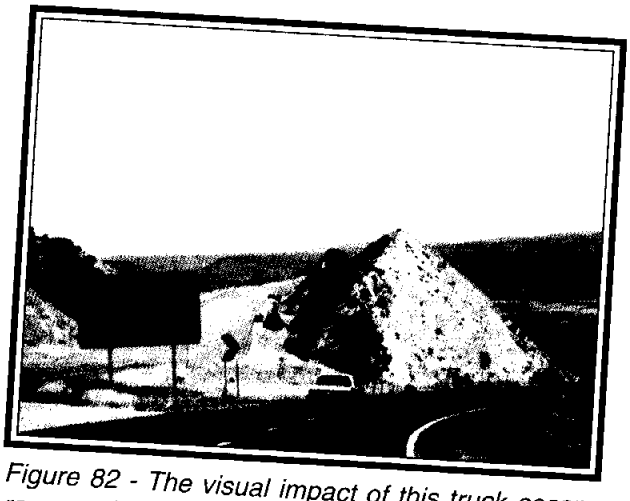


Figure 82 - The visual impact of this truck escape ramp could be reduced by flattening and rounding the slopes for better revegetation.

Following are measures to be considered in obliteration and revegetation of roads:

- road may need to be effectively filled, drained and blocked
- temporary culverts and bridges should be removed and natural drainage configuration reestablished
- road should be returned to resource production through revegetation (including ripping, scarification, fertilizing, and seeding)
- sideslopes may need to be reshaped and stabilized (see Figure 83)
- natural revegetation should be allowed to occur or continue, which may result in abandonment of the existing condition, and/or adding fencing or other barriers to restrict use
- the visual impact of road from significant viewing areas should be considered, with a natural appearance being preferable.

9.7 Intersections with Forest Roads and Other Minor Roads

Intersections provide convenient, safe, practical access to recreational areas, private property, and businesses; provide access control for highways; and create additional drainage crossings.

The location and the type of surfacing required for intersections depends on a number of factors, including, but not limited to the following:

- defining Road Management Objectives, including the road's purpose, type of use, and quantity of use (see Section 2.4)
- providing sufficient sight distance for safe use by both the mainline traffic and the intersecting traffic.
- providing a vertical profile grade that will support Forest road use
- evaluating the performance of existing surfacing on intersections with similar use in the vicinity of an intersection to be surfaced
- identifying the traffic management strategy for the Forest road, e.g., to encourage, accept, discourage, or prohibit use by the general public.

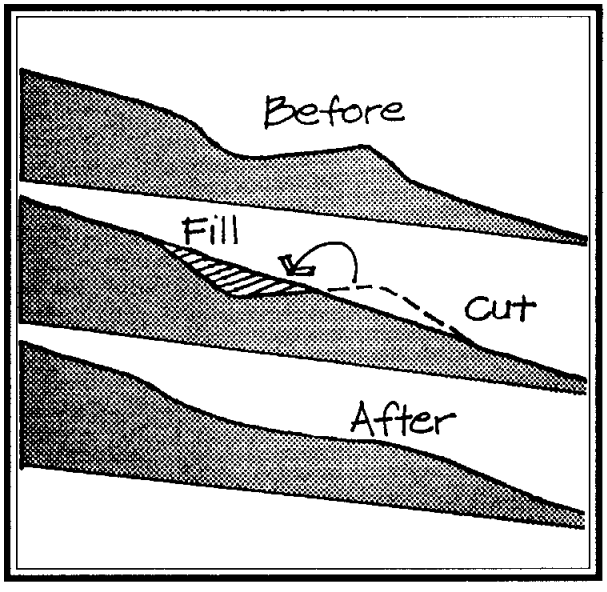


Figure 83 - Road obliteration in an area where the old roadway is reshaped.

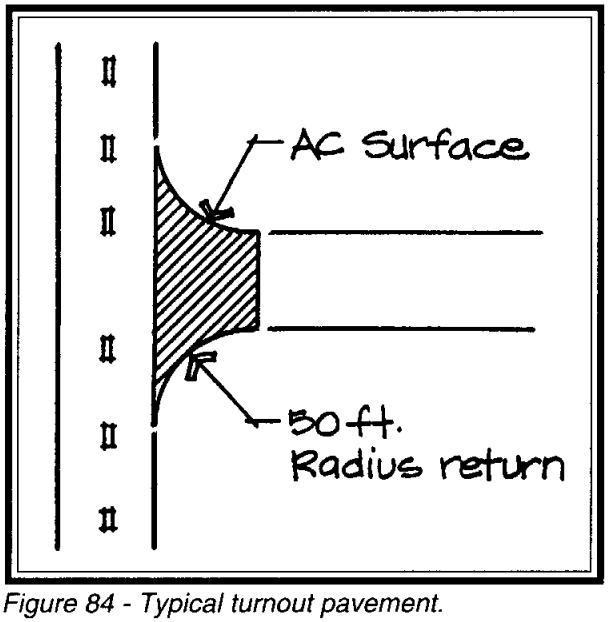


Figure 84 - Typical turnout pavement.

The vertical alignment of unpaved intersecting roads should slope away from the highway for a reasonable distance to prevent water in wheel tracks from running onto the highway.

Entrances where public use is encouraged or accepted should be paved to the easement or cattle guard, which is normally about 15 m from the edge of the mainline pavement (see Figure 84).

An intersection should provide at least two car lengths distance between the highway shoulder and edge of easement when a gate is installed at the edge of the easement.

The highway edge stripe (fog line) may be broken at or continued through intersections. When a Forest road is intended for use by prudent drivers in passenger cars, the stripe should be broken, indicating use is accepted or encouraged. When a road is not intended for such use, the stripe should be continued through the intersection to discourage use.

Special design considerations may be necessary at some intersections where the quantity and type of traffic on an intersecting Forest road may cause unacceptable impacts on the highway unless special provision is made. Examples of such problems and possible solutions are:

(1) The Forest road traffic tracks unacceptable quantities of mud onto the highway resulting in slick pavement and a traffic hazard. A possible solution is to surface the Forest road with aggregate for enough distance from the highway for most mud to track off vehicles before entering the highway.

(2) The Forest road is located on a steep downgrade to the highway, which when combined with heavy truck traffic and blade maintenance of Forest road, results in the cattleguard at the easement line filling with material faster than maintenance crews can respond. Cows walk across the cattleguard onto the highway, creating a traffic hazard. A possible solution is to extend the asphalt surfacing 15 m past the cattle guard onto the Forest road.

These types of problems and solutions need to be identified jointly by ADOT and the USFS. ADOT is limited by State law on spending funds outside the Highway easement. The USFS is often limited by Congressionally appropriated funds inadequate for the management of the Forest Development Road System. With fiscal and funding limitations, the agencies need to work together to find solutions which will increase highway user safety.

CONSTRUCTION 10

10.1 Goals of Construction Administration

In addition to the goals of building a project on schedule, within the budget, safely, and with quality, resource-related goals need to be incorporated on roadways crossing National Forest land. These are:

- implementing temporary and permanent erosion control measures
- implementing mitigation measures, to fulfill NEPA requirements
- protecting riparian areas and other significant resources during construction
- staying within the designated construction limits.

10.2 ADOT/USFS Interaction During Construction

Once the project is awarded, it is important to establish a clear chain of command during construction. A typical chain of command chart, which depicts appropriate communications on an ADOT construction project on National Forest land is shown in Figure 85. Issues should be resolved at the lowest level possible.

The "Partnering" agreement between the agencies will help facilitate communication during construction. Ideally, decisions made during the design process need to transfer to construction (see Section 3.4.1). The USFS should participate in ADOT-sponsored "Partnering Teams." Partnering is defined as the cooperative management of project development activities and construction contracts. The goals of Partnering include building trust and recognizing the capabilities of, and establishing an alliance with, other team members. Partnering should generally include the following steps:

(1) Establishing initial contacts and defining the roles of key agency representatives.
(2) Establishing common project objectives and guidelines.
(3) Establishing and following an issue/problem resolution process
(4) Establishing and following a joint evaluation process.

The result of these steps should be appropriately documented.

The typical role of the USFS representative(s), during construction, is to:

- monitor the progress of the contract
- assist the ADOT Resident Engineer (RE) in addressing or clarifying the intent of provisions or measures which involve National Forest land and resources
- monitor the construction to insure the intent is being met
- provide coordination with other involved agencies, such as the State Game and Fish Department, US Fish and Wildlife Service, etc.

The USFS should channel input and communication through the RE, and not deal directly with the contractor unless specific arrangements have been authorized by the RE. Exceptions involve the USFS law enforcement authority and responsibility for fire control. In emergency situations, incidents relating to fire, safety, or the irretrievable loss of resources, the USFS has the authority to deal directly with the involved party, including the contractor.

10.3 Changes and Modifications to Project Plans

If mitigation measures are being implemented by the contractor in a manner that is not in conformance with the environmental documents, the matter needs to be brought to the immediate attention of the RE.

When changes in the work are required, costs and environmental effects need to be reviewed prior to permitting the contractor to proceed with the work.

These measures may have to be negotiated with the contractor and added as a change order to the construction project. The use of the Force Account item is one option available to the RE to respond to changes required for environmental mitigation. Records, including photographs, should be kept so that these issues can be better incorporated into the construction documents on future projects.

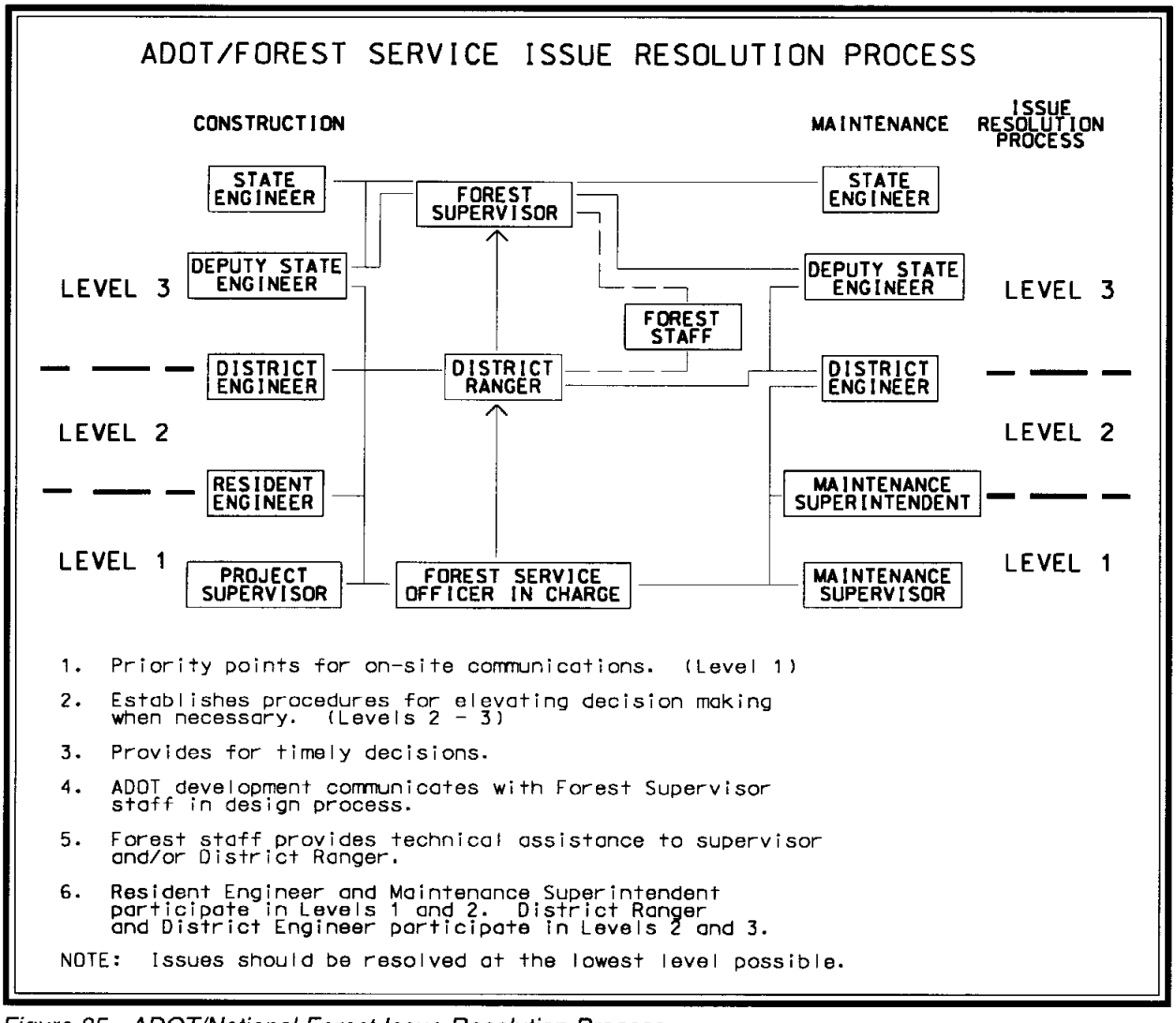


Figure 85 - ADOT/National Forest Issue Resolution Process.

Biological evaluations and other NEPA documents may have to be revised to account for discrepancies in mitigation measures which are not implemented as planned.

10.4 Temporary Access

Most temporary construction access needs will be identified during the planning and design process, so that environmental and mitigation decisions can be addressed at this stage.

Contractors, however, may request additional temporary access roads to fences, bridge sites, cut and fill slopes, staging areas, hot plant sites, crushing sites, decking (timber staging) areas or detours which are unplanned.

If areas are not addressed in the contract it is possible that they are not covered in the environmental documents. Contractors need to understand that additional environmental documentation may be required in these cases, before additional areas can be made available.

The contractor should try to identify any needs that require work outside of the established clearing limits at the Partnering session, which would allow the USFS to evaluate impacts in a more timely manner. If a new need arises after the project is under construction, a method of environmental analysis should be determined, and agreed upon by all parties, with a reasonable schedule for completion. This process could be agreed upon in advance, at the Partnering session, if needed.

10.5 Borrow Material and Excess Material/Waste Sites

10.5.1 Defining Waste (Excess) Materials

Waste/excess materials disposal is concerned with generally unusable by-products from construction projects or maintenance work. ADOT designers attempt to limit quantities of unusable by-products by balancing cut/fill materials on all projects.

Excess material consists of solid by-products of highway construction, reconstruction and maintenance, and of unusable materials source by-products including removed vegetation, timber, stumps and slash. Some projects generate large quantities of waste material.

The following are not considered excess materials: used cans, oils, machine and equipment parts, paint, fresh concrete, wash water from concrete operations, cement, hazardous materials, plastic and rubber products, discarded metals, building materials, etc. This unacceptable waste should be disposed of, properly, at a designated landfill or other acceptable disposal facility. Each Ranger has discretion regarding acceptable waste to be placed on National Forest land.

10.5.2 Disposal of Excess Material

While a job is in progress, if a need for borrow or disposal of excess material (dirt or rock) arises, which was not planned for, the USFS must be involved in evaluating options on National Forest land.

Excess material classified as potentially usable for others can be placed temporarily at an existing or depleted source with the intention of later utilization through the proper permitting process (see Chapter 7). A waste site can store both usable and unusable materials. If both usable and unusable waste materials are stored at the same site, the two should not be mixed. If the material is to be stored only for short periods, it can be left in stock piles, otherwise it should be leveled, contoured and revegetated at the end of the associated project according to the development plan. Interim storage stabilization may be required for slopes, for erosion control, in certain situations.

With some exceptions, each excess material area should have an approved development plan and a Plan of Operations for disposal. For the environmental documentation discussed under the permitting process, all areas will meet NEPA requirements prior to permit approval (see Chapter 7).

Excess material disposal should comply with State and Federal water quality standards, to ensure that debris generated during road construction is kept out of streams and to prevent slash and debris from subsequently obstructing channels, and to ensure debris dams are not formed which obstruct fish passage or which could result in downstream damage from high water flow surges after dam failure. Excess material will be designed, machine placed and compacted where the potential of failure into a sensitive area exists. A safety factor will be required where deemed necessary by the USFS.

As a preventative measure, construction debris and other newly generated roadside slash developed along roads near streams (in the streamside management zone) should not be deposited in stream channels, including ephemeral and intermittent streams.

Possible options for excess material disposal during construction are:

- identifying a site within the project limits
- locating an existing materials source or waste site
- identifying a new undisturbed site that would benefit from excess material
- locating a depleted or unusable materials site which could be rehabilitated with excess material
- raising the roadway grade
- flattening the fill slopes
- stockpiling material for future use
- hauling to the next phase of the project
- adding berms to otherwise flat areas.

See Section 10.8.2 for information regarding disposal of vegetative waste material generated on a construction project and Section 3.5.2.

Some acceptable excess material can be used/disposed of for various small scale ADOT and USFS needs requiring materials of unspecified quality. Such small scale work requires a permit, although each area does not require a Development Plan or Plan of Operations unless the work has potentially significant land surface impacts (see Chapter 7).

10.6 Dust Control

Road surface treatments for dust abatement are prescribed on the basis of traffic levels, road design standards, soils and geology. These treatments include the application of water, dust oil, penetration oil, magnesium chloride, lignin sulfonate, calcium chloride, aggregate surface, chip-seal, or paving.

The RE should monitor dust levels and provide for dust control adjacent to recreation areas, cabin/campground areas, and other uses of National Forest land during the project.

10.7 Fire Control

The USFS needs to provide Fire information and monitoring of the Fire Control Plan throughout the construction project.

Arizona Department of Environmental Quality (ADEQ) requirements, notification procedure, agencies' responsibilities, and contractor's responsibility, in the special provisions, need to be clarified during the Partnering meetings.

10.8 Clearing Limits and Vegetation Protection During Construction

10.8.1 Clearing and Grubbing

Staking of clearing limits, including top of cut, toe of fill, warping, laying back cut slopes, rounding, access areas, staging areas and all other limits of construction, is required prior to clearing. Where timber is involved, up to six months may be required in order to inventory the timber and complete the transfer to ADOT (see Section 10.8.3). On projects where clearing is required around existing vegetation, cultural resources or other significant resources, the clearing limit stakes should be checked by both ADOT and the USFS prior to clearing, to allow for minor adjustments in the field.

If work is needed beyond the clearing limits, separate environmental documentation and authorization may be required.

Trees to salvage for transplant should be tagged before the contractor is on the job or required to be tagged promptly after the award of the contract. Trees to be saved in place, located within or adjacent to the construction area, should be clearly marked and brought to be attention of the contractor. A walk-through should be held before clearing and grubbing, and transplants can be approved at that time.

If the project includes wide medians or a large right-of-way with areas not needed for the construction project, areas designated to be protected on the plans may need to be visually flagged or protected with a physical barrier. Fencing or concrete barriers may be required (see Figure 86). Early installation of the easement fence may be desirable to protect the site from off road vehicles or animals, and to limit contractor operations.

10.8.2 Disposal Methods

Methods of on-site disposal of vegetative matter may include:

(1) Piling and burning, or burning with an incinerator (see Figure 87).
(2) Chipping. Chips could be used on the project, by blowing on the slopes, or sold commercially.
(3) Scattering. Limited slash can be scattered if it does not result in a fire hazard.

Project-specific guidelines should be provided by the USFS.

Off-site disposal methods include the removal to an approved disposal sites. Large limbs and non-merchantable (cull) logs may be cut into manageable lengths and stockpiled in designated areas for fuelwood if approved by the District Ranger.

10.8.3 Merchantable Timber, Cacti, and Other Vegetation

When merchantable timber or cacti must be cleared from within the project limits of a highway construction project, the exact quantity of timber and/or cacti must be measured, its value determined, and it must be sold by the USFS to ADOT prior to commencement of construction. ADOT will then transfer the material to its contractor for utilization, sale or disposal.

For the USFS to determine quantities of merchantable timber, the clearing limits of the project must be established on the ground by ADOT. This cannot be done until geometric design has been completed.

Clearing limits are usually established by "slope staking" limits of cuts and fills and adding the appropriate additional width for clearing beyond the staked limits. Staking accuracy is required for an accurate timber inventory, and must reflect slope rounding, warping and laying back ends of cut slopes.

Once clearing limits are established, USFS employees measure (cruise) included timber and make an appraisal of current market value. USFS employees will mark the trees that have been cruised, and only the trees that have been marked are allowed to be cut. The sale is then completed to ADOT. When thousands of trees are involved, the cruising, appraisal and sale may take up to six months. Less time is required for smaller quantities of timber, perhaps only a few weeks for less than 100 trees. Snow covered ground will delay both slope staking and timber cruising. Additional time should be allowed when it is anticipated the ground will be snow covered. In the event of design changes during construction that require additional trees to be cleared, these trees must not be cut until they are measured, marked and sold to ADOT. Failure to observe such a procedure must be investigated as a timber theft under current USFS policy. Civil and criminal penalties may result.

There may be occasions when the USFS, due to reasons of national policy, may require ADOT to assure utilization of included wood products within the project limits. For example, burning and burial of certain wood products may be prohibited, and the wood would then be piled in an approved location for utilization as firewood.

10.9 Temporary Erosion Control

ADOT should submit a temporary erosion control plan for approval by USFS prior to ground disturbance. Contract administration personnel should assure that the contractor's plan for temporary erosion control measures, that those measures meet contract and BMP requirements, and that the measures are kept current as the project progresses. Protective measures apply to all areas of disturbed, erosion-prone, unprotected ground subject to erosion during the project (see Section 6.3.2.1).

Temporary erosion control must stay in compliance with NPDES requirements (see Section 6.3.4). The contractor should operate and maintain temporary erosion control features in a functional condition. When depth of materials in these facilities reach

Figure 86 - Jersey barriers were installed here for safety and to protect adjacent vegetation.

Figure 87 - Air curtain incinerator limits smoke and particulates.

three-fourths capacity, the facility should be cleaned and restored to their original condition.

If, through project monitoring, it is determined that erosion control measures are not adequately being addressed, the issue resolution process agreed upon in Partnering should be followed.

10.9.1 Timing of Construction Activities

The scheduling of operations during periods when the probabilities for rain and runoff are low may decrease the need for erosion control. Equipment should not be operated when ground conditions are such that unacceptable soil displacement results, as determined by the RE.

Erosion control work needs to be kept current. Construction of drainage facilities and performance of other contract work which will contribute to the control of erosion and sedimentation should be carried out in conjunction with earthwork operations or as soon thereafter as practicable. The area being graded at a site at any one time should be limited, and the time that an area is without protective cover, e.g. vegetation or matting, should be minimized. Erosion control work must be kept current with precipitation and runoff.

Mechanical and vegetative surface stabilization measures should be periodically inspected, as necessary, to determine effectiveness. In some cases, additional work may be needed to ensure that the vegetative and/or mechanical surface stabilization measures continue to function as intended.

10.9.2 Water Concentrations

When the contractor's operations create temporary water concentrations, those concentrations should be mitigated by temporary erosion control measures.

10.9.3 Diversion of Flows Around Construction Sites

Flow must sometimes be guided or piped around construction sites. Flow in streamcourses should be detained in rock-lined basins, or diverted, if necessary, to protect water and related resources. Diversion structures should be made of non-erodible material, such as concrete barrier, rock, or straw bales with plastic covering. A soil dam with plastic covering is not sufficient. A stream diversion, if needed, should be in place prior to the commencement of other work effecting turbidity, and the flow restored to the natural streamcourse as soon as practical. All stream diversions included in construction documents must comply with State and Federal water quality standards as they are implemented (see Section 6.4.1.2).

10.9.4 Water Source Requirements

Water source development is sometimes needed to supply water for road construction and dust control. Separate USFS or other agency approval may be required to pump water from an existing stream or pond, depending on water rights and use. Problems may arise when cofferdams or water holes are built in streams. In many instances earth fill is used as a dam. This practice creates sediment problems during installation and removal. Cofferdams and water holes should be built out of sandbags filled with clean sand or gravel, or other methods that will not contribute to nonpoint source pollution. Also, at no time should downstream water flow be reduced to a level that may be detrimental to aquatic resources, fish passage, or other established uses (see Section 6.4.1.2).

Damage to resources caused by the contractor's operations should be repaired by the contractor in a timely and agreed upon manner, to the extent practical, to restore and prevent further resource damage.

Overflow from water holding developments should be piped directly back to the stream. Approaches should be kept as close to perpendicular as possible to the stream. Streambank excavation should be kept to the minimum needed for entry and exit, and should be gravel surfaced as appropriate.

ADOT construction personnel, in conjunction with USFS resource specialists, should evaluate streams in which water developments may be constructed. Water holes and other improvements should be developed prior to rainy season or winter, to avoid damage.

10.10 Spill Prevention Containment and Countermeasures

The risk of pollutants entering a watercourse is increased during the servicing and maintenance of construction equipment. This risk is minimized by

selecting service and refueling areas well away from wet areas and surface water, and by using berms around such sites to contain spills. Spill prevention, containment, and countermeasures (SPCC) plans are required if the volume of fuel exceeds 2500 liters in a single container or if total storage at a site exceeds 5000 liters. SPCC plans need to be reviewed and certified by a registered professional engineer.

Pollutants, such as fuels, lubricants, bitumens, raw sewage, wash water from concrete or aggregate operations and other harmful materials, should be prevented from being discharged into or near rivers, streams, impoundments, and other drainageways.

Soil contaminated with smaller spills should be hauled off the project and disposed of according to State and Federal regulations.

10.11 Riparian Awareness

Personnel involved in construction of highways should be properly trained in the identification, importance and protection of riparian areas and values. The USFS may want to participate at the prebid, preconstruction or later meetings to address riparian awareness with the RE, contractor, subcontractor, and equipment operators.

10.12 Archeological/Cultural Awareness

If any archeological or cultural resources are discovered during construction, the RE should stop work in that area immediately and report findings to the ADOT archeologist for evaluation. The USFS must also be notified immediately of such findings.

10.13 Traffic Control During Construction

Projects on National Forest land will generally require weekend and holiday shutdowns, which will require strict enforcement by the RE. These issues should be clearly identified in contract documents.

10.14 Revegetation

The success of revegetation on construction projects relies heavily on the attention to detail during the implementation phase. For example, correct installation techniques are important to the effectiveness of matting for successful seeding results (see Figure 88).

Contractors often request seed and plant substitution immediately prior to scheduled seeding or planting times. On projects on National Forest land, readily available commercial seed and plant species may not be appropriate or acceptable for substitution. Seed species substitutions should have input from the USFS prior to acceptance by the RE.

Seed delivered to a construction site must meet State and Federal seed laws regarding labeling, shipping and test dates. State seed inspectors are available to assist the RE in the review and acceptance of seed sampling, labels, and shipments prior to acceptance on a project.

Seeding must be accomplished in phases on large projects to meet NPDES requirements (see Section 6.3.4). This requirement will necessitate additional contractor coordination and monitoring by the RE, and could result in additional involvement by the USFS (see Section 10.15).

10.15 Acceptance of Work

10.15.1 Phased Acceptance

The RE may request the USFS to review work in progress for input on interim work (phased acceptance) prior to payments. Phased acceptance is considered to be final acceptance for that portion of the work.

10.15.2 Final Project Acceptance

The USFS, ADOT and the contractor should meet prior to final acceptance of the project and conduct a final project walk-through and inspection. This will allow all project owners/stakeholders an opportunity to review the project and insure compliance with the intent of the project contract documents. Identification of a final punch list should be established at this time in order to reach agreement and resolve any

remain-ing construction issues. Upon completion of the punch list items, the RE should contact the District and/or Resident Engineer for final acceptance of the project.

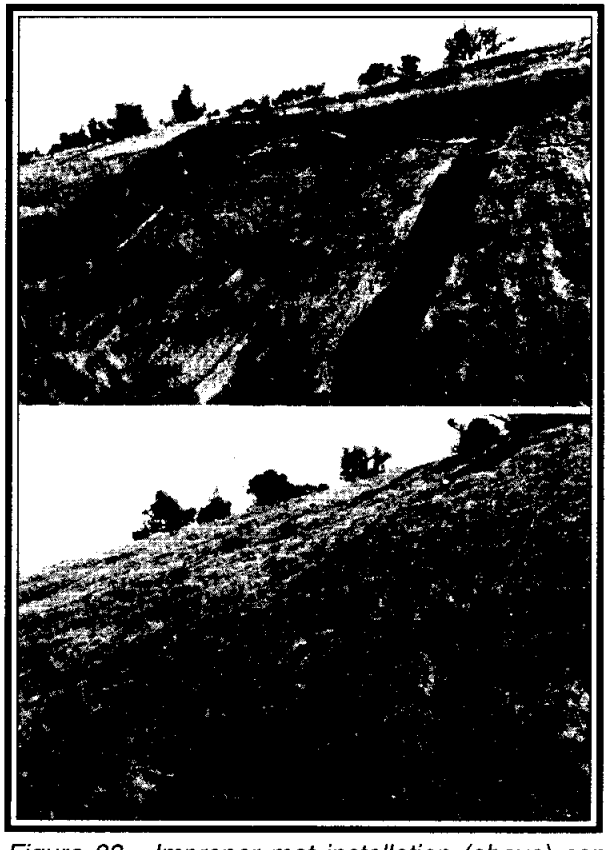


Figure 88 - Improper mat installation (above) can result in erosion. Proper installation (below) accelerates revegetation. The matting must have an adequate overlap where two sections are joined. The anchoring process should be per the manufacturer's specification.

MAINTENANCE 11

11.1 Maintenance Goals

Maintenance goals for existing and proposed State Highways on National Forest land are as follows:

- maintain safe and functional roadways and related structures, rest areas, and maintenance yards, while protecting and preserving visual quality, environmental resources, and cultural resources associated with the National Forest land
- establish a clear understanding of cooperating agencies' responsibilities, procedures and actions, through development of annual maintenance plans and guidelines
- monitor maintenance operations and results and evaluate as necessary to increase effectiveness.
- incorporate maintenance/land manager input during the design and construction processes to improve the quality of the roadways and the efficiency of maintenance programs
- complete and/or monitor environmental mitigation requirements to insure that commitments are fulfilled.

11.2 Design Input/Maintenance Planning

11.2.1 Design Input/Review

Personnel that will be involved in the maintenance and management of new and reconstructed roadways and facilities should be involved in the review process. At a minimum this should include the ADOT District Maintenance Supervisor, Natural Resource Maintenance Regional Manager, and Forest District Ranger and Forest Engineer. Reviews should be at the concept, 60% and 90% plan levels. Written comments regarding the plans should be submitted to the ADOT Project Manager for transmittal to the designers.

11.3 ADOT/USFS Maintenance Plan and Review Process

11.3.1 Annual Highway Maintenance Plan

ADOT and the USFS should agree on an Annual Highway Maintenance Plan which outlines the responsibilities and timing of maintenance operations for roadways, rest areas, maintenance yards and other related facilities.

ADOT maintenance forces should prepare an Annual Highway Maintenance Plan for all routine maintenance operations anticipated to occur within the following year. Items requiring USFS coordination should be addressed within this Plan (see Section 11.3.4). The Plan should document the specific work plans, schedule and locations for each task. Each task description should be presented as a separate entity for individual review.

The Annual Highway Maintenance Plan should be submitted to the Forest District Ranger, for distribution and review. The USFS should review each task individually, either approving, conditionally approving, or requesting further discussion on individual items. Within three weeks of submittal, the USFS should submit written comments regarding the Plan to the ADOT District Maintenance Supervisor.

Within two weeks of receipt of comments, a coordination meeting should be held to go over any task descriptions that were not approved. The goal of the meeting is to revise and agree upon these tasks, or identify what further steps need to be taken to gain approval or resolve the issue. At a minimum, this meeting should be attended by the ADOT Maintenance Supervisor, ADOT Maintenance Foreman, ADOT Natural Resource Management Group representative, ADOT District Maintenance representative, USFS District Ranger, and Forest Engineer. If necessary, the issue resolution process regarding maintenance should be followed to reach consensus between the agencies (see Figure 85).

11.3.2 Interagency Field Review

Routine field reviews of ongoing maintenance practices and problems should be made for all highways on National Forest land. These reviews should be scheduled at least annually. At a minimum, they should be attended by the ADOT maintenance foreman, ADOT maintenance supervisor, ADOT District maintenance representative, USFS District Ranger, and Forest Engineer. Findings of the field review

should be documented by an ADOT representative, and distributed to the attendees within two weeks.

11.3.3 Correction of Deficiencies

Any deficiencies identified in the Annual Highway Maintenance Plan coordination meetings and field reviews should be documented. A list of all necessary projects should be prepared and prioritized. Those deficiencies that can not be corrected in the course of routine maintenance activities should be submitted through the ADOT "PeCos" system as special maintenance projects or should be submitted for inclusion in the ADOT 5-year highway capital investment program.

11.3.4 Items that Require ADOT/USFS Coordination

In developing an Annual Highway Maintenance Plan, the following issues and activities require coordination between ADOT's maintenance forces and the USFS:

- equipment parking
- waste disposal areas
- storage and staging areas
- vegetation management activities
  - selective tree removal
    - sight distance
    - winter pavement shading
  - brushing
  - mowing
  - herbicide use
    - general applications
    - spot treatments
  - fertilization and seeding
- snow removal and storage
- de-icing materials
- drainage maintenance activities
  - culverts and bridges
  - lead-off ditches
  - crown ditches
- shoulder maintenance activities
  - grading
  - build-up
- slope maintenance
  - drainage
  - vegetated slopes
  - rock/soil slopes
- nonstandard roadside barriers.

USFS activities requiring coordination with ADOT District Highway Traffic Division include the following:

- slash burning and other controlled burns
- logging across highways
- temporary road access to highways.

11.4 Environmental Documentation

11.4.1 Identification of Critical Resources

Within the Annual Highway Maintenance Plan, critical and unique visual, cultural, and natural resources, including wetlands and riparian areas, that could be affected by maintenance activities should be identified. The identified resources should correspond to those contained in the specific Forest Plan. This information should be provided to ADOT by the USFS prior to development of the plan.

In addition to the locations of critical resources, the Annual Highway Maintenance Plan should describe any activities that are restricted or limited within each area. If any resources require buffer zones, these should be identified, also. For instance, salt may not be used for de-icing near a threatened/endangered species site.

Personnel involved in maintenance of highways should be properly informed and have necessary training in the identification, importance, and protection of critical resources and values.

11.4.2 Environmental Documentation

Most operation and maintenance activities are covered in the original NEPA document, and no further environmental documentation is necessary. Special activities, where the USFS wants to maintain some control or influence, should be included in the easement stipulations. Work outside of the easement boundaries may require additional documentation.

11.5 Maintenance Practices

11.5.1 Equipment Parking

All maintenance equipment should be stored or parked overnight in approved locations. During routine daily operations, vehicles may be parked for

short periods at developed pullouts, parking areas and other locations specifically delineated within the Annual Highway Maintenance Plan (see Figure 89). When designated parking areas are not located in areas where they are needed, ADOT should request USFS approval of an area.

Figure 89 - Parking in a non-designated area can result in damage to vegetation and other resources.

11.5.2 Storage/Staging and Waste Disposal Areas

For routine maintenance and minor construction projects undertaken with maintenance personnel, storage, staging and waste disposal areas should be identified in the project plans or documentation, for review by the USFS. Areas designated for waste/ excess material disposal should be identified in the Annual Highway Maintenance Plan. Materials should not be sidecast indiscriminately on shoulders, embankments, in drainageways or at retaining wall locations (see Sections 11.5.6, 11.5.7 and 11.5.11). Existing storage yards and waste disposal areas should be utilized to the fullest extent possible.

The possibility of joint use of USFS yards for temporary storage (to expedite efficient moving, storage and distribution of materials) should be investigated and coordinated with the USFS as part of the Annual Highway Maintenance Plan. The potential for reuse or placement of select waste materials by the USFS should also be investigated and coordinated with the Forest Engineer (see Chapter 7).

11.5.3 Vegetation Management Activities

11.5.3.1 Selective Tree Removal

Sight Distance

Current standards for calculating sight distance are outlined in ADOT's policy statement, PGP-2C-0-0 (Wayland Sizemore, September 1986), for intersection sight distance. These standards should be incorporated into any new intersections or design projects. This document should also be used to evaluate sight distance requirements along existing roadways, where vegetation has grown in the shoulder area, and may be causing sight distance limitations.

Each Forest should clarify its position regarding the removal of vegetation in the ADOT easement, with a written policy to be incorporated into the Annual Highway Maintenance Plan. This should also address opportunities and requirements for salvage timber sales associated with removal of trees for sight distance.

Potential sight distance problems should be assessed in the field by the multi-agency review team, and problem areas documented. A clearing plan will be prepared for any areas requiring vegetation removal, to be included in the Annual Highway Maintenance Plan.

Visual impacts of tree removal and pruning should also be considered for any vegetation removed from the ADOT easement. Techniques such as feathering the edges of cut lines and creating variety, by varying the size of open spaces, can help reduce visual impacts. Refer to USFS Visual Management reference documents for specific visual guidelines. If tree removal or pruning are necessary, branches should be pruned back to the trunk, and tree stumps cut flush to the ground line, ground in place or grubbed.

If trees are removed from the ADOT easement, the skid marks and any other disturbed areas should be reseeded at the next appropriate season.

Shading Pavement in Winter

Shading of pavement during the winter months, combined with drainage problems, has resulted in icy conditions on some highways in timber areas (see Figure 90). Winter shading problems should be assessed in the field by a multi-agency review team,

Figure 90 - Winter shading of pavement, combined with drainage deficiencies, can result in lingering patches of ice on the roadway.

and problem areas documented. Impacts of alternatives, including de-icing agents and associated costs, should be evaluated, and a course of action determined. A clearing plan will be prepared for any areas requiring vegetation removal, to be included in the Annual Highway Maintenance Plan. The Plan should also address opportunities and requirements for salvage timber sales associated with removal of trees for winter shading.

As with any removal of vegetation, visual and other environmental considerations should be addressed. Disturbed areas will need to be reseeded.

11.5.3.2 Brush Removal for Sight Distance

Requirements for brush removal areas for sight distance should correspond to those for tree removal. Brush removal should only be considered in areas where significant hazards exist, and when adequate resources are available to remove all stumps and reseed.

Mowing machines should not be used to remove trees and brush.

11.5.3.3 Mowing of Shoulders

Mowing can be an effective means to control vegetation within recovery areas, and other areas that need to remain open for visibility or other considerations. Mowing should be limited to areas with vegetation with trunks no larger than 50 mm in diameter. The appropriate recovery area and existing problems should be identified during design for all new construction projects, during field review, and in the preparation of the Annual Highway Maintenance Plan.

11.5.3.4 Herbicide Use

Herbicide use on National Forest land is regulated by NEPA guidelines for the USFS. Environmental analysis needs to be done on a site specific basis for applications within specific forests. The specific type

of environmental documentation depends upon the type and range of the proposed application. NEPA work must be tiered to a Worst Case Risk Assessment.

There are two primary types of herbicide application for which environmental documentation could be applied within each Forest. The first is spot application to control weeds around traffic control and safety devices, such as signs and roadside barriers. The goal of this document would be to establish the specific herbicides that could be used on an ongoing annual basis to control weeds, the rates of application, and any monitoring activities required.

The second type is the general application to specific areas, to control the establishment and spread of noxious weeds. The goal of this type of document would be to evaluate the alternatives for a program to control the specific weed infestation.

The environmental documentation would prescribe specific application rates, locations and procedures, which would be incorporated into the Annual Highway Maintenance Plan for each Forest, as applicable.

11.5.3.5 Fertilization of Plant Materials

Plantings and seed applications should incorporate slow release organic fertilizers, to eliminate the need for follow-up fertilization. Should annual field reviews indicate the need for spot applications of fertilizer, they should be coordinated on a case by case basis, through the annual maintenance planning process.

11.5.4 Snow Removal

Snow removal is addressed in ADOT's Winter Storm Management Plan, which prioritizes snow removal operations on each road. Where applicable, this plan should be incorporated into the Annual Highway Maintenance Plan, by reference.

The current general practice of blading snow to the side of the road is an acceptable practice. The impacts of melt water on road surfaces and embankments and the probability of sediment production resulting from snow removal operations should be minimized. Following several plowings, cinders can build up on the shoulder, unintentionally blocking or rerouting drainage. Maintenance forces should periodically monitor accumulations through the end of the snow season.

Tree planting for snow control, or living fences, have very limited applications, but should be considered where appropriate (see Section 9.4). Since snow drifting is a problem in open areas, living fences can be an incongruous visual element, unless properly designed. In areas where living fences are not suitable, seasonal snow fences should be considered, as part of the Winter Storm Management Plan. Aesthetics should be considered when selecting the fence type, material and color, with a neutral color preferable over a highly visible color, such as orange. A snow berm can be used as an alternative to a snow fence in some areas.

11.5.5 De-icing Materials

The Winter Storm Management Plan, and supporting documents, includes a statewide schedule for application of de-icing agents. Based upon soil regimes, water quality and related factors, the schedule specifies which de-icing agents, salts and alternatives, can be applied. The main de-icers used by ADOT are magnesium chloride, calcium chloride, quick salt, calcium magnesium acetate, and road salt per ADOT publications. No Ethylglycol may be used in the Forest.

ADOT is also monitoring the long term environmental effects of de-icing applications. Updates should be distributed to the USFS as they become available.

Removal of trees which shade the pavement is a long term option to reduce expenses and environmental effects of de-icing application agents. Refer to Section 11.4.4.1 B of the ADOT Winter Storm Management Plan for specific guidelines (see Reference 20).

11.5.6 Drainage Maintenance Activities

The major concern regarding the proper function of drainage facilities is that their failure may cause the road to wash out with associated down slope and down stream impacts. Close attention should be paid to drainage features and details during the design review process, in order to minimize follow-up maintenance and reconstruction.

11.5.6.1 Temporary Water Concentrations

When maintenance operations create temporary water concentrations, those concentrations should be mitigated by temporary erosion control measures (see Chapter 6 and Section 10.9).

11.5.6.2 Drainage Features

Drainage features should be reviewed during the annual field review. Where water has been concentrated by design elements such as ditches and culverts, maintenance operations should assure that both the facilities and energy dissipaters function as designed. If they are not functioning as designed, a determination should made at that time whether immediate action is required, or whether the deficiencies can be corrected in the next Annual Highway Maintenance Plan.

If immediate action is required and taken, the facility should be repaired to its original designed condition, unless it is determined by ADOT & USFS that the design is not appropriate. If substantial additional features are needed, they should be designed and coordinated as a second phase. This could be included in the Annual Highway Maintenance Plan proposal, and evaluated by the Forest Service, or submitted as a design project, through the ADOT process.

11.5.6.3 Stream Channel Disruption

Highway maintenance operations should minimize disruption of stream channel hydraulics. Operations should minimize the disturbance of existing soil and plant cover. Removal of soil and plant cover on ditches and slopes that are not directly adjacent to streams can still impact water quality, through increased sediment flow ultimately reaching area streams. Ditch and channel maintenance activities should be accomplished with equipment that is adequately sized to minimize disturbance. Silt and debris should only be removed to the level of existing plant bases.

Operations involving a disturbance into "navigable waters of the United States," may require a 404 Permit, prior to commencing (see Section 6.3.5).

11.5.7 Ditch Cleaning and Shoulder Maintenance Activities

Smooth transitions must be maintained between the edge of the pavement and the adjacent road ditch or shoulder material, for traffic safety. This requires occasional build-up or grading of the shoulders and cleaning of ditches below cut slopes. If grading operations require the removal of vegetation, this should be addressed in the Annual Highway Maintenance Plan. The limits of clearing should not exceed the original designed clear zone. If possible, material should only be removed from the ditches and shoulders to the point of existing plant bases. A loader and a dump truck should be used rather than a grader. Any activities requiring the removal of plant cover should be reseeded, or otherwise revegetated.

Disposal of excess material derived from routine maintenance activities should be limited to designated areas (see Section 11.5.2).

In areas requiring build-up of the shoulders, consideration should be given to using select material removed from nearby areas, such as drainages and shoulders. If none is available, fill should be hauled in from approved sources. National Forest land should not be disturbed solely for the purpose of producing fill material unless at an authorized material source site.

11.5.8 Slope Maintenance

There are two categories of slopes that require maintenance: vegetated slopes and rock or soil slopes. The primary issue regarding slopes is the potential for erosion.

For at least the first year or two, ditches related to cut slopes will need to be cleaned. Rock and soil slopes need to be monitored regularly for stability. Due to precipitation, freeze and thaw, and other factors, these slopes tend to require routine maintenance. With regular observation and slope cleaning, the risk of large materials falling into the roadway can be reduced. Such activities may included scaling of large boulders and conglomerate, cleaning of benches, minor reinforcement, or seeding to establish vegetation. Slopes requiring maintenance that will have minimal negative impacts should be identified as projects within the Annual Highway Maintenance Plan.

Factors that indicate potential slope problems include an increase in exposed rock and boulders, increased cracks in rock faces, sedimentation of toe ditches, accumulated material in benches, and undercutting of existing vegetation at the tops of slopes (slope eyebrows). In evaluating potential solutions to problem slopes, local geological and soil characteristics should be considered, and tested if necessary.

ADOT assesses the safety of rock slopes throughout the State, and develops maintenance and

construction projects, based upon the safety rankings. These go through the environmental analysis and design processes, as necessary. Additional slopes may be identified during field reviews, or routine observation, that may be proposed for inclusion in the Annual Highway Maintenance Plan, or submitted for consideration as design projects.

11.5.9 Unpaved Surfaces

Although the majority of the roads that ADOT maintains on Forest land are paved, there are some that are unpaved. Surfacing of roads requires environmental documentation and coordination. There is the potential to apply new technologies such as plant resin based soil stabilizers to environmentally sensitive locations.

Maintenance practices for unpaved roads include grading, dust control and repair or improvement of the drainage facilities. These practices should be accomplished in a manner that does not rely on or generate excess material, such as imported fill material, built up shoulders, or numerous ditches. Pipes can be laid in small dips to improve drainage. Since specific requirements vary from region to region, specific plans should be developed that respond to local environmental and traffic characteristics.

11.5.10 Fences

Fences are installed along easement lines to control indiscriminate entry or crossing of the roadway by vehicles, pedestrians or animals. The maintenance of all fences within the easement will remain the responsibility of ADOT District Maintenance forces.

11.5.11 Walls

Walls and related structures should be checked regularly for bulges, cracks, settling, or other problems. Minor repairs should be accomplished as soon as possible.

Waste material should not be deposited near wall sections. All waste materials should be hauled to designated waste disposal areas (see Section 11.5.2).

11.5.12 Roadside Barriers

When nonstandard roadside barriers have been installed, extra quantities of the barrier should be stockpiled for routine maintenance requirements. These requirements should be specified in the Annual Highway Maintenance Plan.

11.6 Emergency Procedures

11.6.1 Emergency Contingency Plans

Roadway related emergencies include flooding, fire, slope failures, winter storms and accidents. These often necessitate road closures, and short term repairs to roadway facilities. They also often involve personnel from a wide variety of agencies, including ADOT, USFS, the Arizona Department of Public Safety, local law enforcement agencies and local public works agencies. In order to effectively be prepared to handle emergency situations, Emergency Contingency Plans should be developed for each Forest or ADOT district.

Emergency Contingency Plans should include chapters outlining specific procedures for each of the following types of emergencies (plus any additional applicable types): fire; flooding, including road and structural failures; winter storm procedures; oil and hazardous material spills; and traffic accidents. An Incident Command System approach should be considered. In each case, the personnel involved from each agency, with phone numbers, will be identified, the responsibilities of each agency or individual outlined, and procedures for road closures, notifications and short term repairs should be defined. Emergency Contingency Plans should be updated annually to account for reorganizations, and refined procedures.

11.6.2 Emergency Maintenance Procedures

Maintenance procedures that are required as a result of emergencies or natural disasters generally need to begin immediately after the incident (see Figure 91). In order to maintain traffic, protect resources or populations, operations are often implemented in the field without extensive plans or documentation. Emergency relief funding can be offered to agencies to repair facilities. Projects implemented under these circumstances are categorically excluded under NEPA.

Repairs should be prioritized according to a predetermined set of criteria, such as the repair of a structure on the main route, repair of a structure on

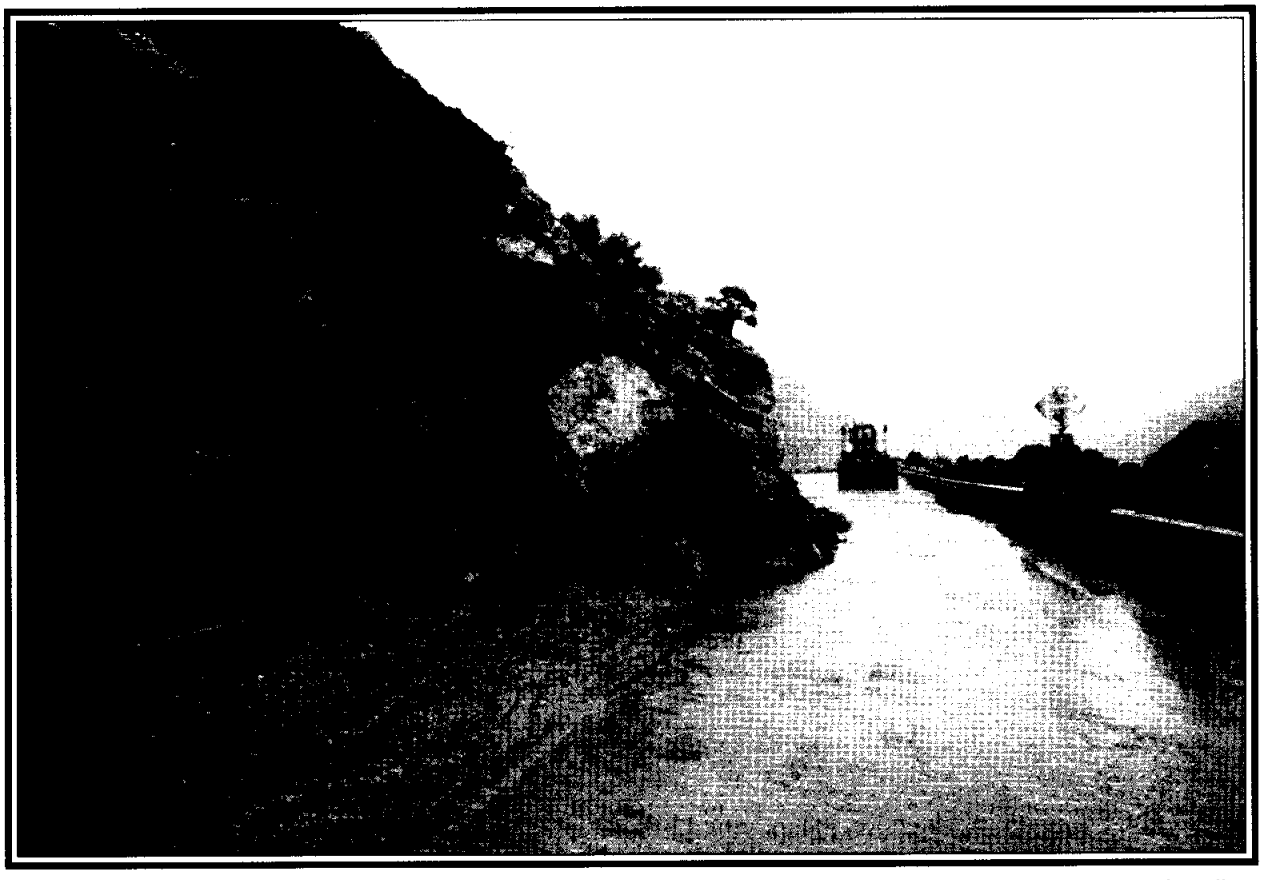


Figure 91 - Maintenance forces must respond quickly after an emergency, such as a slide, or when flooding occurs.

a secondary route, repair of a drainage system, revegetation work, etc.

Emergency repairs and maintenance operations should focus on restoring features to the state they were in prior to the incident, or as close as possible to function in a similar manner with the least impacts to the area. Features that were not existent prior to the incident should not be added immediately after an incident, with emergency funds. For instance, an undersized culvert should not be upgraded to a bridge following the incident, under normal procedures.

If there are additional features or design considerations that need to be added, these can be evaluated within three to six months of the incident. During this additional time, all concerned parties can have input on the solution, and necessary environmental considerations can be addressed. Emergency funds are generally applicable for up to two years following the incident. During this time, projects and priorities can be evaluated with more discretion than may be exercised in the midst of a crisis, assuring the best use of limited funding. Some proposed measures may be identified as non-emergency or low priority, and be handled through normal capital improvement planning procedures.

APPENDICES

Aggradation—To fill and raise the level of (the bed of a stream) by deposition of sediment.

Area—A location within a materials source site which is defined for specific purpose(s).

Aspect—A position or sidee facing one direction.

BCT—Breakaway Cable Terminal (guard rail).

Best Management Practice (BMP)—Preventive or mitigating practice that is the most practical and effective means of controlling erosion and other potential nonpoint sources of pollution from highways.

Borrow site—A source where quantities of rock material or soil material are taken for use in construction of embankments, subgrades or other facilities.

Bridge—A structure, including support, erected over a depression or an obstruction, such as water, highway or railway, and having a track or passageway for carrying traffic or other moving loads. A bridge has an opening measured along the center of the roadway of more than 6 meters between undercopings of abutments or springlines of arches, or extreme ends of openings for multiple boxes; it may also include multiple pipes, where the clear distance between openings is less than half of the smaller contiguous opening.

Colluvial—Soils that have been transported from their origin through the erosion processes created by gravity and slope; soil composition is dependent on the parent material. A colluvial slope contains a mixture of soil and rock, and may exhibit more stability than a soil slope.

Color—The visual aspect of form that is caused by reflective light.

Complex slope ratio—An embankment constructed of variable, or multiple slope ratios, rather than a uniform slope ratio - transitions are smoothed out in the field to create an undulating slope.

Common variety mineral materials—Earth construction material including rock or stone, sand and gravel, pumice aggregate, pumicite, cinders and soil materials suitable for compacted earth structures - Ref: FSM 2880.5.

Controlled blasting—The controlled use of explosives and blasting accessories in carefully spaced and aligned or staggered drill holes to produce specific free surfaces or shear planes in the rock along the predetermined excavation backslope. Controlled blasting techniques include presplitting, cushion (trim) blasting, and a special version of controlled blasting using horizontal holes (lifters). The primary difference between presplitting and cushion blasting are the closer drill hole spacing and increased evidence of obvious drill hole scars in the final face which result with presplitting.

Conventional highway—All highways and streets that are not freeways.

Cushion blasting—A controlled blasting technique where drill holes are widely spaced, with the initial detonation in front of the desired final cut face. Cushion blasting is recommended for rock slopes requiring a final appearance.

Decking Area—A temporary log storage and staging area during tree clearing.

Development plan—Long-term, overall site management direction for material source and waste sites.

Driver expectancy elements—The recurring elements along a roadway corridor, (such as curves (radius), horizontal and vertical curves, design speed, clear zone or obstacle set back from the travel lane, shoulder and lane width, etc.) that might surprise a driver if a sudden exception occurred.

Embankment—Fill slope or elevated area created with fill or borrow material.

Ephemeral—Periodic, seasonal or responding to precipation events.

Fines—Inorganic solid particles that have a grain diameter between 0.0006 and 0.02 millimeters.

Fly rock—Rock which flies through the air after a blast. Elimination of fly rock is a goal of controlled blasting.

Form—The contour and structure of a visual element.

Freeway—A highway with full control of access and with all cross roads separated in grade from pavements for through traffic.

Gabion—A wire basket usually filled with stone which is used for erosion control/slope protection.

Game reflectors—Reflectors placed along a roadway at known wildlife movement areas to warn motorists.

Geotechnical investigation—Exploration of soil and rock resources to determine potential for use or to determine design parameters for design of earth slopes, structural embankments, or structure foundations.

Hardscape—All structural elements that are not a part of the natural terrain, such as, paving, sidewalks, guard rail, walls, drainage culverts, etc.

Hinge point—The point at which the outside (rear) guardrail post meets grade.

ID-Interdisciplinary—A group of people from various professions including: engineering, biology, hydrology, landscape architecture, etc.

Intermodal—Interaction or connection between or among more than one mode (of transporation).

IRM-Integrated Resource Management—A land management philosophy, which recognizes that all natural resources are connected through an intricate series of interrelationships. An interdisciplinary approach to project design is used to define resource relationships and integrate procedural requirements.

Laid back slope—A relaxed, indifferent or easy-going slope; also a cut slope with slope ratio flattened to blend with swales in the natural landform, or with the ends contoured back to meet natural grade.

Lifters—Horizontal drill holes, which "lift" the excavated material upon detonation.

Line—A visually continuous contour or edge of a form. A straight line usually has an unnatural appearance in the landscape.

Local access road—A highway or street, including National Forest roads, that serves primarily to provide access to adjacent land.

Material source—A defined location from which material is obtained for construction purposes.

Minor drainage structures (Minor miscellaneous structures)—All highway structures not defined as a "bridge" are considered minor drainage structures or minor miscellaneous structures, retaining walls, etc. Reference is also made to the USFS Handbook, FSH7709.56b-Drainage Structures Handbook, where culverts are divided between major culverts and minor culverts.

Mitigate (mitigation)—To make milder, less severe.

NBIS—National Bridge Inspection Standards.

NPDES—National Pollution Discharge Elimination Systems, a permit required under the Clean Water Act.

Overburden—Unsuitable surface material of soil or mixed soil and rock that overlies the proposed rock material source - also the soil and rock covering the area to be blasted. The amount of overburden affects the size of explosive load required to break up the rock by blasting.

Pecos System—Maintenance planning and accounting system utilized by ADOT.

PIP-Project Implementation Process—An interdisciplinary approach to project design used by the Forest Service to adequately identify resource interrelationships, predict the effects of projects, and assure that planned projects are consistent with Forest Plans and other appropriate laws and regulations. An interdisciplinary approach identifies the resources involved, defines the resource interrelationships, and predicts the effects or impacts of the project.

Pit—See Material source

Plan of Operations—Short term, individual project plan for the entry, removal or disposal of rock material.

Plating—Soil placed in designated areas for revegetation. Native or imported soil, which may not meet "topsoil" specifications, (is sometimes used).

Presplitting—A method of blasting where drill holes are closely spaced, and the initial detonation is along the final desired cut face. Drill hole scars are left in the final face, creating an unnatural appearance.

Presplitting is recommended for slopes where the remaining holes are not visible from the road or other nearby viewpoints. Presplitting is considered to produce safe slopes, with minimum rockfall along roadways.

Production blasting—The main fragmentation blasting resulting from more widely spaced production holes drilled throughout the main excavation area. This type of blasting is used to break up and excavate large quantities of rock.

Pullout—An additional lane or area designated for slow vehicles to temporarily pull over allowing faster traffic to pass.

Quarry—A source where rock material usually requires blasting and manufacturing prior to utilization. Manufacturing refers to crushing, screening, blending, etc.

Ravel—Surface erosion on the face of a new cut slope.

Reclamation—Those actions performed during or after mineral or rock source excavation activities to shape, stabilize, revegetate, or otherwise treat the affected lands in order to achieve a safe and ecologically stable condition and land use that is consistent with the resource development plan (FSM 2840.5).

Recovery area—The roadside border area, starting at the edge of the travelway, that is available for corrective action by errant vehicles. Also an area at the end of an airport runway.

Rehabilitation—Restoring a disturbed area to a condition similar to its original condition.

Riparian—Pertaining to an area influenced by a natural course of water.

Ripping—Roughening of a soil slope with equipment to a depth specified.

Rip rap—Sized rock specified by class (representing a range of size by volume and weight) used for bank protection, to control erosion or to protect soil in a drainageway.

Roadside Barrier—A protective device intended to reduce the severity of highway accidents by preventing errant vehicles from entering hazardous areas and by redirecting an errant vehicle parallel to the direction of travel while holding the deceleration rate to a tolerable level.

Roughhead slope—A slope where the final surface is treated with heavy equipment to create 0.3 m - 1 m deep irregularities, to encourage water infiltration and seed germination.

Rounded slope—A slope with the top excavated back in a curved shape, normally 1.5 m - 7 m, to blend with natural grade at the top.

Route continuity—See Driver expectancy

Scale—A progressive classification of size.

Scaling—The removal of hazard rocks on roadway cut slopes; scaling can be done with sprayed water or manually.

Shy distance—The distance of a perceived obstacle that could cause a driver to steer away from it.

Site—A location within a source which is reserved for specific uses (such as, stockpile site, hot plant site).

Slash—Debris left from a timber harvest, composed of branches, twigs and needles/leaves.

Sliver cuts—Thin cuts of less than 2.5 m which are difficult to remove without leaving an adjacent track drill access road at the top of the cut.

Slope ratio—Rise:Run (vertical:horizontal), for example a 1:3 slope will rise one (1) meter for every three (3) meters of run.

Soffit fill—A temporary fill constructed to serve as a form for structural concrete.

Structure identification—Procedures are established by the National Bridge Inspection Standards and refer to the Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges prepared by the FHWA.

Test pit—An excavation from which material is obtained for test purposes.

Texture—The grain or surface quality of a visual element.

Topsoil—Specified productive A-horizon soil for

use in restoration projects (typically is the upper layer of overburden); the nutritive soil layer.

Trimline—The desired final line of a new cut slope.

Turnout—An intersecting roadway.

Type 1 Roads—Conventional State highways.

Type 2 Roads—All highways, streets and roads, including national forest roads, that access conventional State highways; local access roads.

Unsuitable or unusable material—Soil or rock material which is not appropriate or needed for contract.

Warping—Cut slope warping refers to a non-parallel cut slope. Major warping is achieved by excavating 6 m - 12 m back from the typical projected top/toe of slope to create variety in land form along a corridor. Minor warping is achieved by creating an irregular, jagged cut face, for added texture and shading. Fill slope warping refers to site specific steepening or flattening of fill slopes to create undulations, or to avoid significant resources near the toe of the fill.

Waste Fill—Excess earth, rock and vegetation debris.

16-R3-92-0025

MEMORANDUM OF UNDERSTANDING
ON PROCEDURES RELATED TO
STATE HIGHWAYS OVER NATIONAL FOREST LANDS

This Memorandum of Understanding (MOU) by and between the Arizona Department of Transportation, Highways Division, hereinafter called ADOT, and the United States Department of Agriculture, Forest Service, hereinafter called USFS, establishes procedures for coordinating the location, design, construction, management, operation, maintenance, signing, access, protection, conservation of environment, and other matters related to State highway development, use, and occupancy of National Forest Lands.

It is mutually recognized that:

ADOT is responsible for planning, designing, constructing and perpetuating public highways of the State Highway System for the safety and benefit of the traveling public; and may also be responsible for projects on County roads which are Federal-aid secondary routes; and

USFS is responsible for the protection and multiple-use management of National Forest System lands and resources for the use and benefit of the public, and for integration of the development of public highway systems with Forest transportation systems needed to accomplish this purpose; and

Since many public highways traverse National Forest lands, ADOT will need authorization to use such lands for highway easements, waste areas, material sources, and highway construction and maintenance operations; and

Since many National Forest access, development, and administrative facilities are appurtenant or adjacent to public highways, USFS needs to confer with ADOT before developing physical improvements which may have an effect on highway administration; and

Since State highway construction, operation, and maintenance may have direct and indirect environmental effects on National Forest Resources and USFS administration of National Forest Lands, ADOT needs to confer with USFS during the planning, design, and construction phases of projects; and

Since lack of advance coordination and full understanding may result in disputes which inconvenience the public and are costly and time consuming to reconcile; and

In recognition of the responsibilities, interests, and limitations set forth above, and the mutual benefits of established procedures to facilitate agreement on specific highway matters on National Forest Lands and on other matters requiring coordination between the two agencies, ADOT and USFS mutually agree as follows:

I. COORDINATION

A. General

Nothing in this document shall preclude any activities which are not documented herein and which are mutually agreed between ADOT and USFS.

For projects which involve Federal funding, the Federal Highway Administration (FHWA) shall be consulted during highway development and construc-

tion, and necessary approvals shall be obtained. To satisfy the requirements of 40 CFR Part 1501.5, ADOT, USFS, and FHWA will jointly agree to lead agency responsibility. In cases where FHWA is providing Federal funding, FHWA will normally be the lead Federal agency and USFS will be the cooperating agency. In all other cases involving National Forest lands, USFS will normlly be the lead agency. USFS will act as "Agency Official" for purposes of compliance with 36 CFR Part 800 for all projects on National Forest land.

Two regularly scheduled meetings shall be held between ADOT and USFS each year. The first meeting, usually held in April, is the Forest Highways Meeting. Attendees will include, but not be limited to, the State Engineer; the Regional Engineer, Southwest Region, USFS; and a representative from FHWA. The other meeting, usually held in September, will be conducted to discuss the State Five-Year Highway Construction Program, other activities of mutual interest occurring on National Forest lands, and to review and update this MOU as needed. Attendees shall include representatives from ADOT, FHWA, and each National Forest.

USFS shall participate in ADOT-sponsored "Partnering Teams". Partnering is defined as the cooperative management of project development activities and construction contracts. The goals of partnering include building trust and recognizing the capabilities of, and establishing an alliance with, other team members. Partnering shall generally include the following steps: (1) establishing initial contacts and defining the roles of key agency representatives, (2) establishing common project objectives and guidelines, (3) establishing and following an issue/problem resolution process, and (4) establishing and following a joint evaluation process. The result of these steps shall be appropriately documented.

B. Highway Development

ADOT and each Forest Supervisor in Arizona shall designate highway development coordinators who will represent their respective agencies on matters of mutual interest. ADOT and USFS coordinators shall facilitate the review and approval of State highway projects crossing National Forest lands.

ADOT shall notify USFS of highway projects proposed on National Forest lands. Notification shall be sent to the Forest Supervisor's office. Forest coordinators shall ensure that appropriate people on the Forest review and provide input, and shall prepare a consolidated response for the Forest Supervisor's signature.

In the event that a State highway project crosses multiple Forests, a highway development coordinator from one Forest will be chosen to coordinate the review process among all Forests involved, and transmit a consolidated response to ADOT.

C. Construction and Reconstruction

The ADOT District Engineer shall advise the appropriate Forest Supervisor in writing of award of contract and furnish the name and title of his on-the-job representative whom the Forest Supervisor or his designated representative should contact regarding matters related to the work. To maintain contracting lines of authority, the Forest Supervisor or his designated representative shall normally consult with the ADOT District Engineer or his designated representative on matters pertaining to project construction. Deviations shall be as mutually agreed.

The ADOT District Engineer shall contact the appropriate Forest Supervisor for any changes that will affect National Forest lands beyond those anticipated in the original contract. The Forest Supervisor will act promptly to provide approval.

D. Maintenance

ADOT shall coordinate with the local USFS District Ranger all maintenance activities which involve additional clearing, slash disposal, disposal of slough material, changes in road drainage patterns, materials sources and storage, rock scaling, and similar actions which involve National Forest lands. USFS shall expedite review on maintenance items requiring USFS concurrence.

ADOT shall submit to the Forest Supervisors an annual plan for proposed chemical (de-icing agents and pesticides, including herbicides) applications for the subsequent calendar year. Such annual plans shall be forwarded on or before the 15th day of August of each year. Emergency proposals may be submitted any time. The plans shall include the following information: (1) the highways or segments thereof crossing National Forest land upon which the chemical application is to be made, and the individual National Forest involved, (2) the approximate dates of application, (3) the identity of the chemicals proposed to be applied, including the name, formulation, carrier or spreader, and the method of application thereof, (4) the standards of application and protective procedures proposed to be followed, including the maximum area to be treated and the dosage or rate of application, and (5) the protection of water courses, vegetation, personnel, and wildlife to be used. The Forest Supervisors shall review ADOT's proposed annual plan for chemical applications and submit to ADOT an acceptance or request for modification within 30 days of receipt.

USFS shall assist ADOT maintenance forces with matters related to equipment parking and materials storage, emergency communications needs, material sources, and designated slough and slide material disposal areas.

USFS and ADOT shall jointly concur on planned USFS activities which may have an impact on highway maintenance. Under normal conditions, the local USFS District Ranger or the Forest Supervisor should contact ADOT District Engineer or his representative.

II. HIGHWAY DEVELOPMENT

A. Definitions

Corridor Study - a study to determine the best route for a highway between logical termini, usually several miles apart, when more than one corridor route is feasible-.

Study Area - the total area in which various corridor alternatives will be considered.

Corridor - a strip of land between the corridor study termini through which a highway could be feasibly located. It is generally about 1/2 mile wide, but could be more or less depending on the site-specific conditions. The actual highway route within the corridor is determined during the location study and field survey.

Location Study - the process by which the actual proposed route within a corridor is determined. It involves consideration of various field conditions to determine the appropriate horizontal and vertical alignment of the highway. The location is further refined through field survey and design.

Scoping - this includes the National Forest management Act (NFMA) review, and public involvement to determine issues to be addressed during the environmental analysis under the National Environmental Policy Act (NEPA).

Alternatives - developed in response to issues that surface during scoping, including alternate corridors within the study area, and alternate locations within the preferred corridor.

B. Project Scheduling

Prior to placing a new project on the Five Year Construction Program, ADOT shall notify the affected Forest Supervisor, who will have 30 days to provide comments on the proposal. ADOT and USFS shall concur as to whether a corridor-level study is warranted, if a Location/Design Concept Study is needed, or if the project may proceed as a finite project.

C. Corridor-Level Planning

1. Corridor Study

ADOT shall prepare a corridor study when there is a need to determine the scope and route for highway construction or reconstruction between logical termini. Various corridor alternatives, usually not to exceed 1/2 mile in width, shall be evaluated.

ADOT and USFS shall jointly identify and reach a consensus on the key engineering and environmental issues to define the scope of the study. ADOT shall conduct environmental analysis to a level of detail to allow assessment of general environmental impacts of each corridor alternative. ADOT shall invite public comment on the proposed corridor and the alternatives analysis.

2. Environmental Documentation

USFS shall review ADOT's corridor evaluation for consistency with the Forest Plan. Environmental documentation (See Section III for requirements) is necessary at this phase if the preferred corridor is determined to be inconsistent with the Forest Plan.

ADOT and USFS will jointly agree to a corridor alternative. USFS shall provide a formal written acceptance of the preferred alternative, and shall issue an appropriate decision document to amend the Forest Plan if necessary.

D. Location Study

ADOT shall conduct a Location Study to determine the location for the highway within the selected corridor. Various route locations within the corridor shall be identified and evaluated. The results of the Location Study shall be summarized in a Location/Design Concept Report (L/DCR.

ADOT shall provide a level of design that allows for determination of impacts for each alternative being considered. This may include, but would

not be limited to, approximate horizontal and vertical alignments, structure locations, limits of ground disturbance, roadway cross-section, earthwork estimates, and mitigation measures.

1. Location/Design Concept Report

ADOT shall submit a Draft and Final L/DCR for USFS review and comment.

USFS shall provide written comments to ADOT within 30 days of receiving the L/DCR.

ADOT shall incorporate USFS comments into the Final L/DCR, and provide written disposition of comments.

USFS shall provide written approval of the Final L/DCR, within 30 days of its receipt.

2. Environmental Documentation

ADOT shall conduct environmental analysis concurrently with the development of the L/DCR to determine the impacts expected to occur from implementation of each alternative.

ADOT shall submit a draft environmental document (see Section III for requirements) to USFS for review and comment.

USFS shall provide written comments on the document within 30 days.

ADOT shall incorporate USFS comments as appropriate, and provide written disposition of all comments.

ADOT shall submit a final environmental document to USFS for approval.

USFS shall issue an appropriate decision document within 30 days of receipt of the final environmental document

E. Finite Project Planning

Finite projects are individual projects for which a Corridor Study or Location Study is not needed.

1. Project Assessment

ADOT shall prepare a Project Assessment (PA) to identify scope, environmental issues, development considerations, agency involvement, and cost.

ADOT shall invite USFS to attend a field review, prior to the development of the Initial PA, to identify and discuss key engineering and environmental issues.

ADOT shall submit the Initial PA to USFS for review and comment.

USFS shall review the Initial PA and, in consultation with ADOT, shall determine the level of environmental analysis required. USFS shall provide written comments to ADOT within 20 days of the receipt the Initial PA.

ADOT shall incorporate USFS comments into the Final PA, and provide written disposition of all comments. ADOT shall then submit the Final

PA to USFS for their concurrence.

USFS shall provide written notice of their concurrence to ADOT within 15 days of their receipt of the Final PA.

2. Design Concept Report

ADOT shall prepare a Design Concept Report (DCR) when detailed design criteria are needed to further define the project scope. The process for submittals and reviews shall be as outlined in Section D., 1. titled "Location/Design Concept Report".

3. Environmental Documentation

ADOT shall conduct environmental analysis for each finite project according to the process outlined in Section D., 2. titled "Environmental Documentation".

F. Individual Project Design

ADOT shall incorporate design guidelines which are jointly developed by ADOT and USFS in the design of highways crossing National Forest lands.

1. Initial Design (30%)

ADOT shall begin preparation of plans and specifications for highway projects using the criteria in the approved PA, DCR, and environmental document.

ADOT shall submit plans to the Forest Supervisor's Office for review at the 30% level of completion.

USFS shall provide written comments on the plans within 30 days of their receipt.

ADOT shall provide written disposition of comments prior to the next level of review.

2. Preliminary Design (60%)

ADOT shall continue preparation of the plans to a 60% level of completion. Comments received at the 30% level shall be incorporated in the 60% plans, as appropriate.

ADOT shall submit plans to the Forest Supervisor's office for review at the 60% level of completion.

ADOT and USFS shall jointly participate in an office/field review, if deemed necessary by either agency, to be held after distribution of the 60% plans. ADOT shall notify USFS of the field/office review at least 3 weeks in advance.

USFS shall provide written comments to ADOT within 30 days of the field or office review. A Landscape Plan, an Erosion Control and Revegetation Plan, and a Fire Plan may also be provided by USFS if deemed necessary.

ADOT shall provide written disposition of comments prior to the next submittal.

3. Final Design (95%)

ADOT shall continue preparation of plans and specifications to a 95% level of completion.

ADOT shall submit the 95% plans to USFS for review.

USFS shall provide tentative plans approval, proposed Construction Stipulations, and all final comments within 30 days of receiving the 95% plans and specifications.

4. Final Design (100%)

ADOT shall incorporate all comments and contents from the above-referenced plans into the final plans and specifications, or contact USFS to resolve any outstanding issues.

ADOT shall submit the 100% plans and specifications to USFS for a final back-check and review. ADOT shall clearly identify any changes to the plans and specifications that have occurred since the 95% submittal.

USFS shall notify ADOT within 14 days if any changes are required to obtain final project approval, including Construction Stipulations.

5. Contract Documents

ADOT shall submit final, signed and sealed plans and specifications (Contract Documents) and signed copies of the Construction Stipulations to USFS.

USFS will provide final written project approval within 7 days of receiving the Contract Documents.

ADOT shall transmit all addenda to USFS in a timely manner.

III. ENVIRONMENTAL DOCUMENTATION

Environmental documents will be prepared under the lead agency's policies, procedures, and guidelines at an appropriate level to satisfy each agency's interests and concerns to the extent possible. ADOT shall have primary responsibility for preparing all environmental documents. USFS, acting as Federal Agency Official, shall provide appropriate direction and guidance to ensure the timely completion of all documents and final approval.

On projects where construction is confined within the edges of existing pavement, ADOT shall provide advance notification of the project to USFS. USFS shall notify ADOT within 30 days if any concerns need to be addressed.

USFS, in consultation with ADOT, shall determine the required level of environmental analysis for projects where new ground disturbance is expected to occur, whether by contract or ADOT personnel. ADOT shall provide environmental analysis for these projects consistent with USFS's Integrated Resource Management (IRM) process and lead agency standards. Environmental documents shall meet the requirements of the National Environmental Policy Act (NEPA) of 1969.

ADOT shall conduct initial project scoping, consistent with the IRM process. Documentation of scoping will normally consist of a Project Assessment (PA), which will meet the requirements of a Feasibility Report. USFS shall review the documents and determine if the project can be categorically excluded from further study. When this is the case, USFS shall issue a Decision Memo to this effect.

For projects where additional study is required to determine environmental effects, ADOT shall conduct an environmental analysis for USFS review. USFS, in consultation with ADOT, shall determine the appropriate level of environmental documentation. For projects where the environmental analysis indicates that the environmental effects are not expected to be significant, ADOT shall document the analysis in an environmental Assessment (EA) for USFS review. USFS will issue a Decision Notice upon completion of an acceptable EA. For projects where the environmental analysis indicates that the environmental effects are expected to be significant or significant public controversy is expected, ADOT shall document the analysis in an Environmental Impact Statement (EIS) for *USFS* review. USFS will issue a Record of Decision upon completion *of* an acceptable EIS.

USFS shall make available to ADOT any existing reports, records, inventories or other data useful in the preparation of environmental documents. ADOT shall compile a chronologically-filed record of all data used in the environmental evaluation process, known as the "project record", and will convey this record to USFS at the completion of the environmental evaluation.

For Federally funded projects, USFS will submit to ADOT and FHWA a determination as to whether any lands impacted are of the types outlined in 49USC, Section 303 (commonly referred to as Section 4 (f) properties). Upon determination that impacted lands qualify as Section 4 (f) properties, an evaluation will be conducted and documented in the Environmental Assessment that there is or is not any prudent or feasible alternative to eliminate the taking of such property for the project.

IV. CONSTRUCTION AND MAINTENANCE

ADOT shall control operations under its contracts to assure work is in accordance with approved plans and agreements and the intent of approved environmental mitigation measures.

ADOT shall prevent and control soil erosion within the right-of-way and on adjacent National Forest lands, brought about as a result of the construction, operation and maintenance of the highway; and shall stabilize all earth cut and fill slopes or other areas on which ground cover is destroyed. methods of erosion prevention and control to be employed upon adjacent National Forest lands shall be approved in advance by USFS.

V. TRAFFIC ENGINEERING

A. Traffic Control Devices

All traffic control devices including signs, markings, and traffic control signals shall be in conformance with the current edition of the "Manual on Uniform Traffic Control Devices for Streets and Highways" (MUTCD), as provided in Title 23, U.S. Code, Section 402(A), and as amended by the Director pursuant to Articles I and VII, Section 28-108 of the Arizona

Revised Statutes, as amended. Signing shall also conform to guidelines which are jointly developed by ADOT and USFS for highways crossing National Forest lands.

B. Access Control

ADOT has the responsibility for the safety of the traveling public on State highways. To help assure this protection. USFS will consult with ADOT to develop concurrence for new permanent roads to be constructed by USFS (or under its authorization) which will connect within the highway easement of State and U.S. highways. Access roads. driveways, slow vehicle turnouts, and scenic viewpoints shall conform with the provisions of the current edition of "A Policy on Geometric Design of Highways and Street" American Association of State Highway and Transportation Officials.

USFS will issue no permits to other parties for construction of roads on National Forest lands which lead to proposed connections with State or U.S. highways until such parties have obtained an approved access permit from ADOT. Conversely, ADOT will issue no encroachment permits to other parties until such parties have obtained an approved easement from USFS.

New permanent approaches to State and U.S. highways on National Forest lands will be at the expense of USFS or its permitted. Future maintenance of such approaches within ADOT highway easement shall be by and at the expense of ADOT.

Temporary approaches required by USFS during fire fighting operations or other emergencies may be constructed as necessary without formal approval by ADOT. ADOT District Maintenance Supervisor shall be notified as soon as practical. Obliteration of such temporary approaches and restoration measure necessary will be at no expense to ADOT. USFS agrees to take every precaution during such emergencies to safeguard the highway users.

VI. EASEMENTS

ADOT shall obtain easements for construction and operation of State Highways across National Forest lands. The various National Forests in Arizona have differing authorities for issuing easements. ADOT and USFS shall jointly prepare a flow chart, which shall be attached as Appendix I to this MOU, which describes in detail the procedures required to obtain easements for highway projects on each National Forest. The flow chart may be updated as mutually agreed, and updates may be incorporated in this MOU without amendment of the document.

USFS and ADOT will cooperate in determining the adequate easement dimensions required to permit proper erosion control and soil stabilization features to be accommodated.

A. United States Department of Transportation (DOT) Easement

A DOT Easement will be granted for public roads or highways which are part of the Federal-aid system, or which are constructed under provisions of 23 USC. Upon completion of approved environmental documents and final design, ADOT will submit an application for a DOT Easement to the FHWA. The FHWA will determine if the application is in proper order and, if so, request a letter of consent from the appropriate USFS Officer. USFS will furnish a letter of consent to the issuance of the easement to ADOT through the FHWA. Such letter of consent will authorize immediate right-of-entry by

ADOT to construct the highway. The easement will be granted by the FHWA in accordance with Federal Highway Administration Regulations.

B. Special Use authorizations

Occupancy of National Forest land for highway-related uses outside of the public road or highway easement may be authorized by either temporary or annual special use authorizations. Such uses can include borrow pits, maintenance sites, material sources, waste areas, temporary channel changes, access roads, and other similar items. ADOT shall obtain special use authorizations for uses outside of the easement prior to initiating activity in the affected area.

VII. THIRD PARTY OCCUPANCY

The grant of a highway easement to ADOT by USFS does not include the grant of any rights for non-highway purposes, facilities or occupancy by third parties. In the case of a public utility with which ADOT has been negotiating permit provisions on a State highway outside the National Forest boundary, ADOT may discuss with that utility, provisions which appear applicable on the same highway over National Forest land. ADOT will not issue a permit for the latter, but will advise the Forest Supervisor of its recommendations. ADOT will also advise the utility that it must apply to USFS for a permit for the land involved.

ADOT and USFS will consult before any third party occupancy permits or other encumbrances are acted upon.

VIII. STATE HIGHWAY ADJUNCTS

ADOT and USFS shall jointly review and agree to the location. design and perpetuation of all highway turnouts, widening for scenic viewpoints, rest areas, historical and interpretive signing within ADOT highway easement.

On new construction projects, details for such adjuncts will be incorporated into and made a part of the construction plans to be approved by USFS. If such adjuncts are developed after highway construction, details of agreed actions will be made a matter of record by both parties. Descriptions of the lands included in approved adjuncts will be included in the State highway easement.

Designated State Parkways, Historic and Scenic roads and those routes designated by USFS as Scenic Byways shall be jointly reviewed and agreed upon. Recommendations and interpretive plans shall be prepared for these routes as required by each. These plans shall be prepared in a consistent manner and shall complement each other. Signing of these routes shall be as defined in Section IV of this document.

IX. CONCLUSIONS

This MOU may be amended or supplemented by mutual agreement between the signers or their successors. This MOU may be terminated by either party after 60 days written notice to the other. Detailed procedures as set forth in the appendices and exhibits may be amended from time to time by mutual agreement.

Nothing herein shall be construed as obligating the parties to expend, or as involving the parties in any contract or other obligation for the future payment of money in excess of appropriations authorized by law and administratively allocated for this work.

No member of, or delegate to Congress or Resident Commissioner shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

This MOU supersedes the M W signed by the Regional Forester January 24, 1978 and the ADOT State Engineer May 22, 1978.

We have read the foregoing and agree to accept and abide by the procedures herein.

U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE

BY: Larry Johnson
REGIONAL FORESTER

DATE: 3/30/92

STATE OF ARIZONA, acting by and through the ARIZONA DEPARTMENT OF TRANSPORTATION, HIGHWAYS DIVISION

BY: Gary K. Johnson
STATE ENGINEER

DATE: 4/13/92

ATTEST:

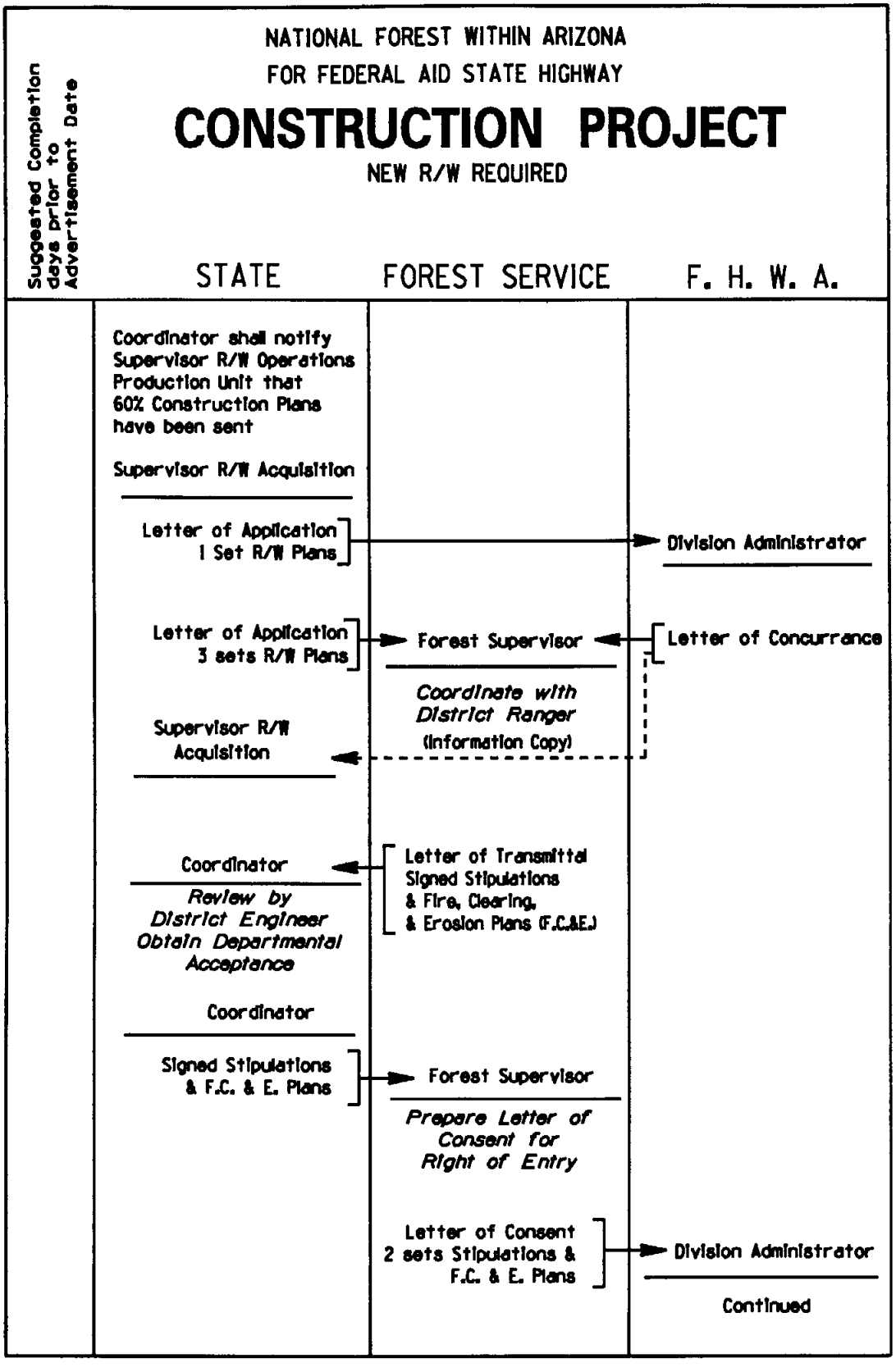
4/14/92
DIRECTOR, ARIZONA DEPARTMENT OF TRANSPORTATION

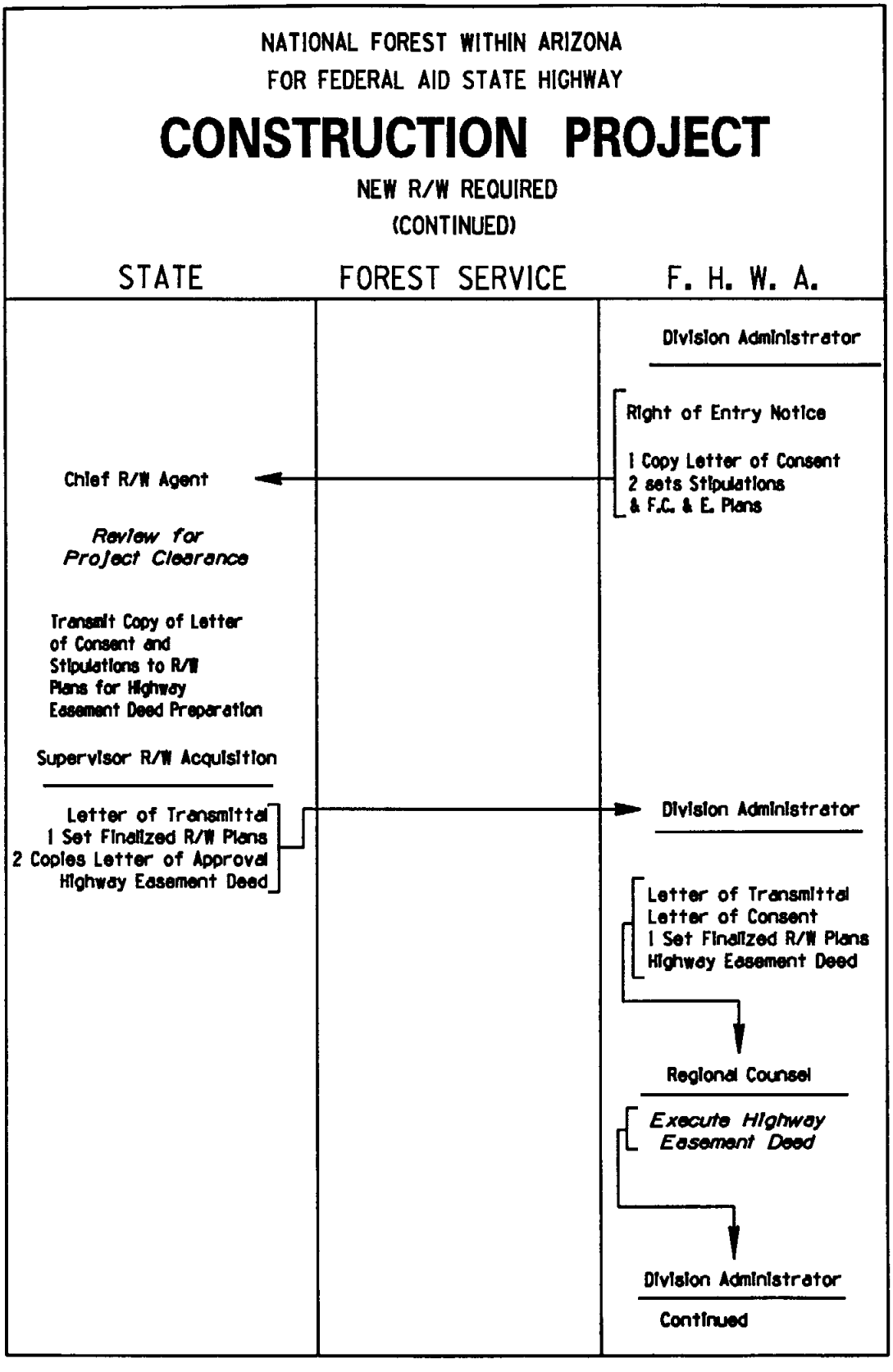
NATIONAL FOREST WITHIN ARIZONA

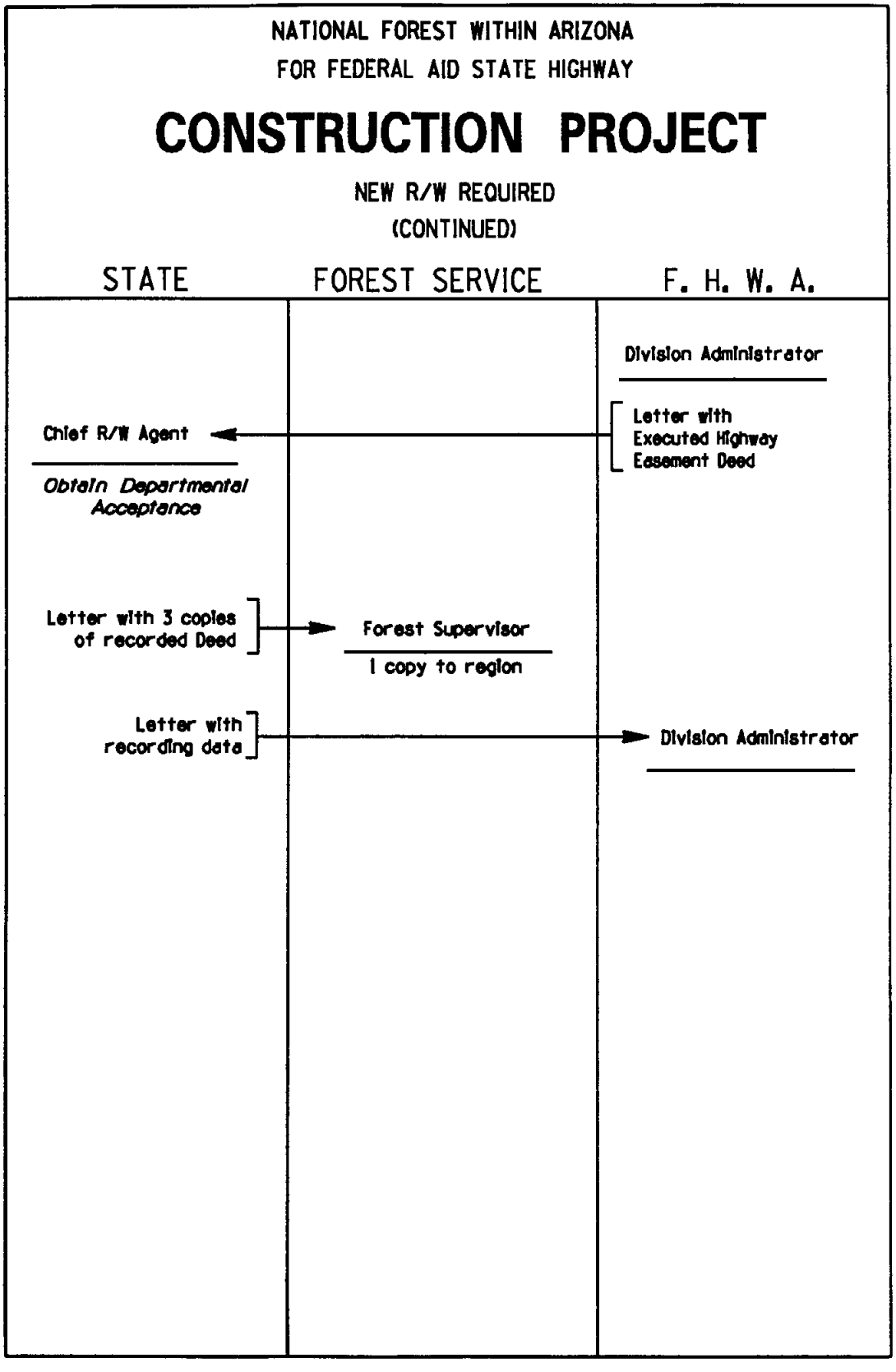
MAINTENANCE / CONSTRUCTION PROJECTS

NO NEW R/W REQUIRED

STATE	FOREST SERVICE	F. H. W. A.
No R/W Action Required	No R/W Action Required	No R/W Action Required


NATIONAL FOREST WITHIN ARIZONA
FOR FEDERAL AID STATE HIGHWAY
CONSTRUCTION PROJECT
NEW R/W REQUIRED
Suggested Completion days prior to Advertisement Date
STATE
FOREST SERVICE
F. H. W. A.
Coordinator shall notify Supervisor R/W Operations Production Unit that 60% Construction Plans have been sent
Supervisor R/W Acquisition
Letter of Application 1 Set R/W Plans
Division Administrator
Letter of Application 3 sets R/W Plans
Forest Supervisor
Letter of Concurrance
Coordinate with District Ranger
(Information Copy)
Supervisor R/W Acquisition
Coordinator
Letter of Transmittal Signed Stipulations & Fire, Clearing, & Erosion Plans (F.C.&E.)
Review by District Engineer Obtain Departmental Acceptance
Coordinator
Signed Stipulations & F.C. & E. Plans
Forest Supervisor
Prepare Letter of Consent for Right of Entry
Letter of Consent 2 sets Stipulations & F.C. & E. Plans
Division Administrator
Continued

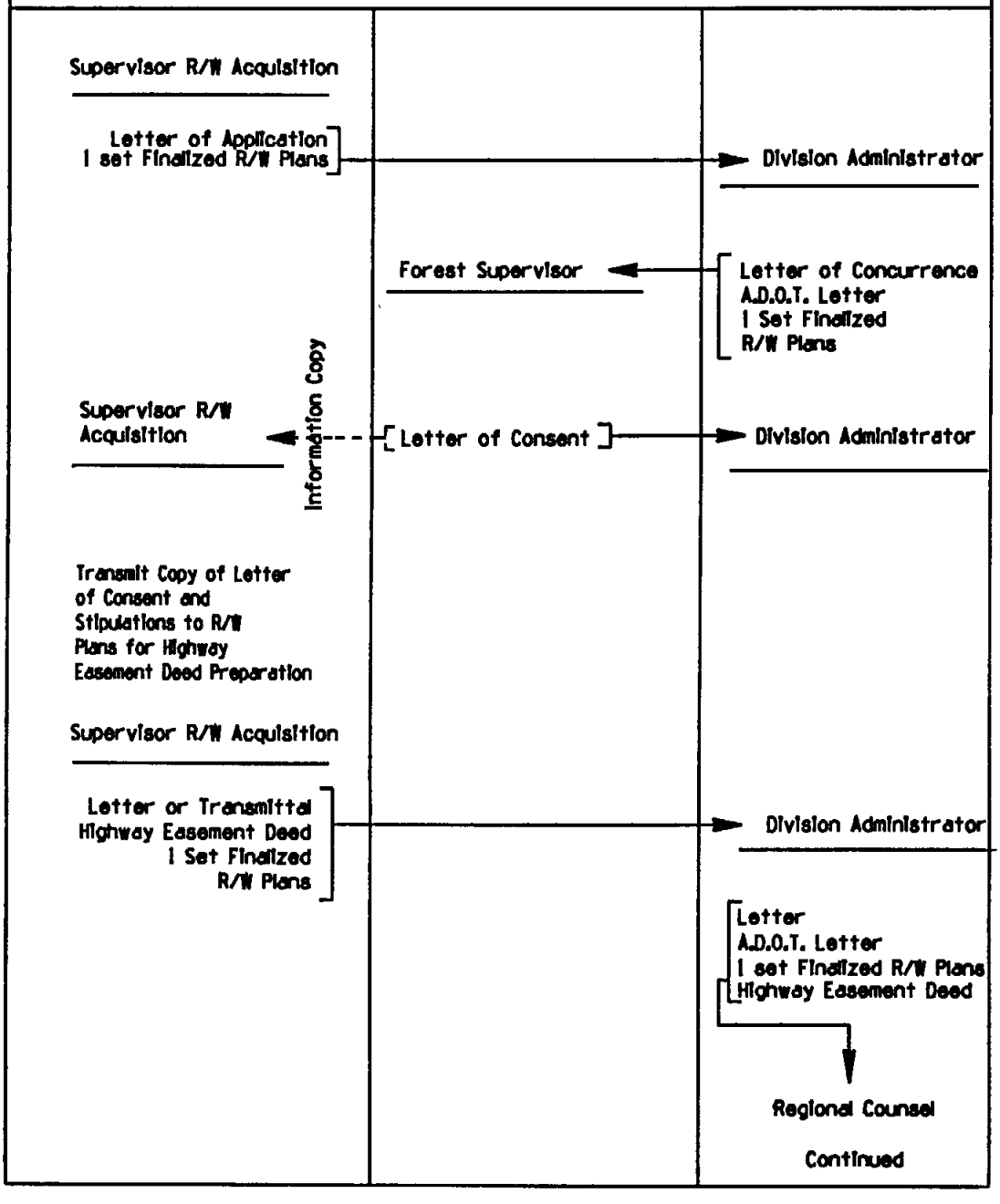

NATIONAL FOREST WITHIN ARIZONA
FOR FEDERAL AID STATE HIGHWAY
CONSTRUCTION PROJECT
NEW R/W REQUIRED
(CONTINUED)
STATE
FOREST SERVICE
F. H. W. A.
Division Administrator
Right of Entry Notice
1 Copy Letter of Consent
2 sets Stipulations
& F.C. & E. Plans
Chief R/W Agent
Review for
Project Clearance
Transmit Copy of Letter
of Consent and
Stipulations to R/W
Plans for Highway
Easement Deed Preparation
Supervisor R/W Acquisition
Letter of Transmittal
1 Set Finalized R/W Plans
2 Copies Letter of Approval
Highway Easement Deed
Division Administrator
Letter of Transmittal
Letter of Consent
1 Set Finalized R/W Plans
Highway Easement Deed
Regional Counsel
Execute Highway
Easement Deed
Division Administrator
Continued


NATIONAL FOREST WITHIN ARIZONA
FOR FEDERAL AID STATE HIGHWAY
CONSTRUCTION PROJECT
NEW R/W REQUIRED
(CONTINUED)
STATE
FOREST SERVICE
F. H. W. A.
Division Administrator
Letter with Executed Highway Easement Deed
Chief R/W Agent
Obtain Departmental Acceptance
Letter with 3 copies of recorded Deed
Forest Supervisor
1 copy to region
Letter with recording data
Division Administrator

NATIONAL FOREST WITHIN ARIZONA
FOR FEDERAL AID STATE HIGHWAY

DEPARTMENT OF TRANSPORTATION EASEMENT

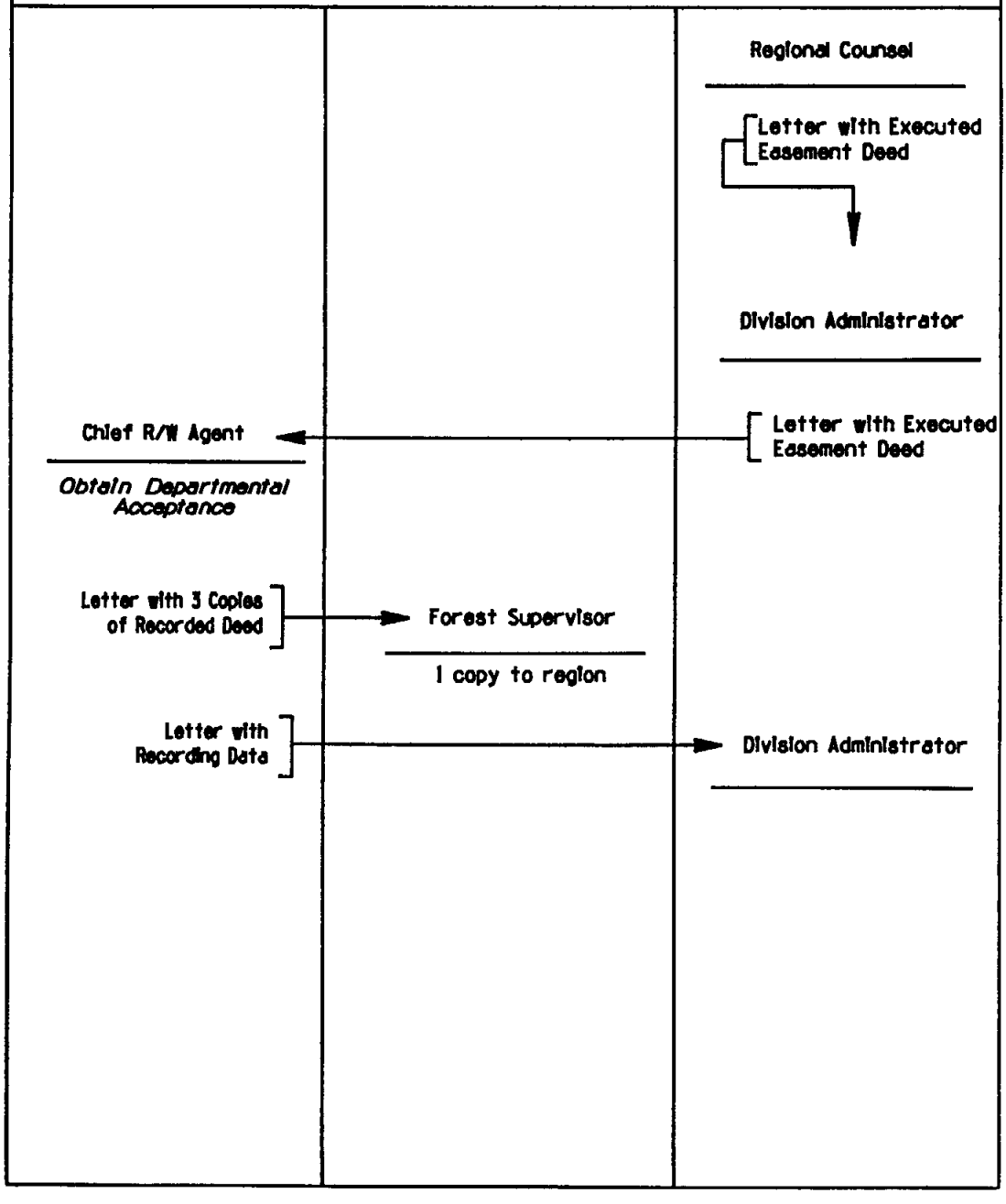
REPLACEMENT OF PRIOR GRANTS TO HIGHWAY EASEMENT DEED
EXISTING ROADS - NO CONSTRUCTION OR RECONSTRUCTION



NATIONAL FOREST WITHIN ARIZONA
FOR FEDERAL AID STATE HIGHWAY

DEPARTMENT OF TRANSPORTATION EASEMENT

(CONTINUED)



A. Project Scoping Phase

1. Corridor Study
   Environmental Overview
2. Location/Design Concept Report
   Environmental Analysis
3. Project Assessment
   Scoping Report/Environmental Determination

B. Five Year Construction Program Approval

1. Tentative 5 Year Construction Program
2. Final 5 Year Construction Program

C. Pre-Construction Phase

1. Initial Design (30% Plans Complete)
   Surveys and Mapping
   Typical Roadway Sections
   Initial Design Layout
   Initial Drainage Report
   Initial Interchange and Intersection Layouts
   Initial Traffic Control and Construction Phasing
   Traffic Analysis Report
   Geotechnical, Pavement Design and Initial Materials Memo
   Structure Selection Reports and Foundation Design
   Initial R/W and Preliminary R/W Plans
   Initial Quantities and Cost Estimate

2. Preliminary Design (60%) Plans Complete)
   Typical Roadway Sections
   Plan and Profile Drawings
   Final Drainage Report
   Preliminary Interchange and Intersection Layouts
   Major Structure Plans
   Proposed Traffic Control and Construction Phasing
   Traffic Signal and Lighting Plans
   Signing and Pavement Marking Plans
   Utility Plans
   Preliminary Landscape and Environmental Mitigation Plans
   Final R/W Plans
   Draft Special Provisions
   Preliminary Quantities and Cost Estimate
   Final Materials Memo

3. Final I Design (95% Plans Complete)
   Complete Set of Construction Documents for Final Review

4. Final II Design (100% Plans Complete)
   Complete Set of Construction Documents for Bid Advertisement

General References

1 Arizona Department of Transportation (ADOT). 1986. Highway Plans Services Guide for Highway Geometric Design (Section 8-19).

2 Arizona Department of Transportation (ADOT). 1990. Highway Plans Services Office Memo, Guidelines for Shoulder Buildup Design.

3 Arizona Department of Transportation (ADOT). 1991. Construction Standards (C-Stds).

4 Arizona Department of Transportation (ADOT). 1993. Highway Development Design Guidelines. 137pp .

5 Arizona Department of Transportation (ADOT). Roadside Design Guide.

6 Arizona Department of Transportation (ADOT). Erosion and Pollution Control Manual, 1993 (Draft).

7 Arizona State Land Department, Forestry Division. 1993. Tree Seedling Distribution Program. 5pp.

8 AASHTO. 1977. Guide for Selecting, Locating, and Designing Traffic Barriers.

9 AASHTO. 1988. Roadside Design Guide.

10 AASHTO Highway Subcommittee on Design Task Force for Environmental Design. 1991. A Guide for Transportation Landscape and Environmental Design. 163pp.

11 Colorado Division of Highways. 1977. Glenwood Canyon, I-70, Architectural and Planning Handbook, Phase Two - Preliminary Design.

12 Society of American Foresters, Karl F. Wenger, ed. 1984. Forestry Handbook, Second Edition. 1335pp .

13 U. S . Department of Agriculture, Forest Service. 1977. National Forest Landscape Management, Volume 2, Roads, Agricultural Handbook No. 483. 62pp.

14 U.S. Department of Agriculture, Forest Service. Southwestern Region. Integrated Resource Management, The Road to Ecosystem Management. Fourth Edition. 28pp.

Maintenance References

15 Arizona Department of Transportation (ADOT). 1991. Roadside Vegetation Management Program.

16 Arizona Department of Transportation (ADOT). 1991. Deicing of State Highways.

17 Arizona Department of Transportation (ADOT). To Be Published. Guideline Manual for Snow Management.

18 Arizona Department of Transportation (ADOT). Traffic Engineering Guide and Procedures #2C-0-0.

19 Arizona Department of Transportation (ADOT). Maintenance Manual.

20 Arizona Department of Transportation (ADOT). Winter Storm Management Plan.

21 U.S. Department of Agriculture, Forest Service. 1990. Unites States Forest Service Handbook.

Photo References

22 Figure 1 - photo courtesy of: Arizona Department of Library, Archives, and Public Records.

Wire Fence References

23 ADOT, Highways Division, Standard Specifications for Road and Bridge Construction, Edition of 1990, Section 903-Wire Fence.

24 ADOT, Highways Division, Construction Standard Drawings, January 1991.
C-12.10, Type 1, Barbed Wire (4 Wire)
C-12.10, Type 2, Barbed Wire (5 Wire)
C-12.10, Barbed Wire (Game Fence)
C-11.10 through C-11.20, Cattle Guard

25 ADOT, Highways Division, Construction Manual for Road and Bridge Construction, Edition of 1986 and current revision, Chapter IX, Section 903.00.

Following is an outline of contents of a typical General Blasting Plan:

- names and experience of blasting supervisors
- methods for and locations of explosives transportation, storage and use
- traffic control and other public safety precautions
- general methods and approach to blasting, which account for the full range of geologic settings and physical conditions present on the project
- method and equipment for pre-blast survey, environmental monitoring, and anticipated peak particle velocity levels
- equipment intended to be used in or support of blasting operations
- method of containment to prevent rock material from escaping the construction limits, and contingency measures for unanticipated rock fall.

Most slopes will need additional, site specific, blasting designs, as one blasting plan does not fit every slope on the project. The blasting pattern plan for specific cuts should include the following features: the drill hole grid, explosive types, sonic velocity and seismic velocity of the rock, and delays in timing.

On some projects, the contractor is also required to submit specific blasting plans prior to proceeding with each blast. Following is an outline of contents of a typical Specific Blasting Plan:

- station limits of proposed shot
- scale drawings showing plan and section views of all variations of the proposed drill pattern, including clearing limits, free face, burden, blast hole spacing, drill hole location, subdrill depths, lift height, blast hole diameters, and blast hole angles
- loading diagram showing powder factor, type and amount of explosives, primers, initiators, and locations and depths of stemming for all substantial variations within the pattern
- initiation method and sequence of blast holes, including delay times and delay system
- manufacturer's data sheets for all explosives, primers, and initiators to be employed
- fly rock control measures
- estimated quantities of cubic yards of rock in-place and linear feet of goth production and controlled blast drill hole
- location and attitude of significant fracturing, rock type changes, faulting, and special circumstances to be accounted for in the plan
- identification of environmental monitoring method, equipment and location.

"Hard metric conversion" dimensions have been used throughout this manual. With a "hard" conversion, the inch-pound dimension is approximated with a new, rounded, rationalized metric number that is convenient to work with and easy to remember. For example, a common dimension of 2' - 6" converts to exactly 762 mm (a "soft" conversion or exact number). The "hard" conversion of 2' - 6" is 750 mm, which is an "even" metric number. The "hard" conversion technique should be applied with metric dimensions where possible.

COMMON CONVERSIONS

Quantity	From Inch-Pound Units	To Metic Units	Multiply by
Length	mile	km	1.609 344
	foot	m	0.304 8
	inch	mm	25.4
Area	square mile	km^2	2.590 00
	acre	m^2	4 046.87
	square yard	m^2	0.836 127 4
	square foot	m^2	0.092 903 0
Volume	cubic yard	m^3	0.764 555
	cubic foot	m^3	0.028 316 8
	gallons	L	3.785 41

Quantity	From Metric Units	To Inch-Pound Units	Divide by
Length	kilometer	mile	1.609 344
	meter	feet	0.304 8
	millimeter	inch	25.4
Area	square kilometers	square mile	2.590 00
	square meters	acre	4 046.87
	square meters	square yard	0.836 127 4
	square meters	square feet	0.092 903 0
Volume	cubic meters	cubic yards	0.764 555
	cubic meters	cubic feet	0.028 316 8
	liters	gallons	3.785 41

(Continued on page 138)

Common Dimensions and Distances

Feet	Meters (m)	Miles	Kilometers (km) "hard"	"soft"
1	0.3	1	1.5 km	(1.609 344)
5	1.5	5	8 km	(8.046 72)
10	3	10	15 km	(16.093 44)
15	4.5	15	25 km	(24.140 16)
20	6	20	30 km	(32.186 88)
25	7.5	25	40 km	(40.233 6)
30	9	30	50 km	(48.280 32)
35	10.5	35	55 km	(56.327 04)
40	12	40	65 km	(64.373 76)
45	13.5	45	70 km	(72.420 48)
50	15	50	80 km	(80.467 2)

AASHTO adopted Metric Design Speeds Values

English Value (mph)	Metric Equivalent (kmph) "hard"	"soft"
30	50	(31.1 mph)
35 & 40	60	(37.3 mph)
45	70	(43.5 mph)
50	80	(49.7 mph)
55	90	(55.9 mph)
60 & 65	100	(62.1 mph)
70	110	(68.4 mph)

Common Pipe Sizes

Pipe Size Inches	Millimeters "hard"	"soft"
6" dia.	150 mm	152 mm
12" dia.	300 mm	305 mm
15" dia.	380 mm	381 mm
24" dia.	610 mm	610 mm
36" dia.	910 mm	914 mm

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