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## CHAPTER 7: LANDSCAPE RESTORATION

### 7.1 CHAPTER GOALS

Landscape restoration is the integration and blending of the highway facility with the surrounding natural landscape. Constructed earthforms must reflect and consider the area's natural landforms to achieve Context Sensitive Solutions. Landscape restoration includes aesthetic considerations in earthform design of slopes, rounding and transitions between cuts and fills. Reclamation, revegetation and stabilization of disturbed soils for the purposes of erosion control are predicated on successful earthform design. Both BLM and USFS consider the success of this work to be critical to the success of the project.

The goals of this chapter are to describe the issues relating to preservation and restoration of native vegetation that are critical to the visual integration of the highway corridor with the surrounding landscape, and to define the steps necessary to achieve successful restoration of disturbed soils.

The ADOT Roadside Development Section and consulting landscape architects assume responsibility for landscape restoration requirements in the project contract documents. Other specific aspects of highway design for which Roadside Development is typically responsible include aesthetic decisions regarding slopes, bridges, walls, drainage structures, storm water controls and safety barriers. Refer to the Table of Contents for other chapters in this manual that describe these features in greater detail.

### 7.2 SCOPING AND NEPA PROCESSES

As natural resource agencies, BLM/USFS place a high value on the protection, preservation and enhancement of the natural environment. The project team should seek to integrate the highway corridor with the surrounding natural landscape. The success of this integration begins with the Scoping Document and continues through the design and construction process. The project team should carefully and fully explore implications to the design and landscape restoration requirements contained in the Document as described in other

chapters. The Document provides preliminary information from which Context Sensitive Solutions are developed and incorporated into the design construction documents. Those Solutions must be clearly defined in the construction documents to be biddable and constructable.

### 7.3 DESIGN

#### Slopes

Slope design must consider:

- Geotechnical soil and rock stability information.
- Existing topography and natural landforms.
- Revegetation potential and limitations.
- Management of storm water run-off.

Refer to Chapter 4 for additional information on earthwork and slope design and to Appendix E for Slope Design Details.

#### Existing Vegetation

Protect existing trees and natural vegetation within the project limits to minimize the visual impact of the new improvements. Preserving existing vegetation, *Figure 7.1*, will also reduce the amount of disturbed soil exposed to erosive forces.

- Protect existing vegetation from equipment by staking, flagging and/or fencing. When appropriate, establish damage penalties in the



*Figure 7.1 Salvaging existing vegetation.*

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Figure 7.2 Beautiful, large saguaro protected by gabion wall..

construction documents.

- Within the limits of disturbance, plants with outstanding value and/or character may be preserved by means of retaining walls, *Figure 7.2*.
- Protect existing vegetation from blasting damage by controlling sizes of explosive charges and through the use of temporary earth berms and/or blankets.
- Protect existing vegetation in drainage ways by minimizing changes to natural flow dynamics.

Considerations that may direct the design team to remove and/or salvage existing vegetation include:

- Where roots will be significantly damaged by new cut or fill slopes.
- Trees that may be downed by wind (Hazard Trees).
- Sight distance requirements.
- Tolerance for highway conditions.
- Plants that are diseased or in poor condition.
- Maintenance access to the tops of cut slopes and toes of fill slopes.
- Snow storage.
- Pullouts for vistas of scenic areas.
- Trees that will create potentially hazardous shading in winter.
- The presence of noxious or invasive plant species within the project limits.

Whether in the forest or desert, the design team should consider reducing the contrast between cleared and undisturbed areas in the following ways:

- Create an undulating cleared edge to break up the unnatural appearance of a straight line and

create a series of enclosures and openings.

- Feather the cleared edge by both reducing plant density and creating a gradation of low to tall vegetation, *Figure 7.3*, in a transition zone. When selecting vegetation for removal, consider the following:
  - Trees that may fall into the roadway if allowed to remain on site.
  - Understory shrubs that may not survive if the tree canopy is removed.
  - Plants that cannot tolerate snow-removal chemicals.



Figure 7.3 Feathered by plant density and gradation.

During the design process, review the project limits for the presence of noxious and invasive plant species and treat as described in Chapter 11. Some invasive species will respond aggressively to any disturbance or change whether in the forest or desert.

### Disposal Methods for Vegetation

When road construction produces vegetative debris, the methods of disposal are typically described in the project contract documents. Noxious plant species must be disposed of such that plants and seeds are not dispersed. On-site disposal strategies include:

- Vegetation may be piled and burned and/or burned with an incinerator. (Burning does not kill all seed).
- Vegetation may be shredded or chipped for use as mulch on project slopes.
- Smaller, more easily decomposed leaves, needles, small branches, etc. may be salvaged and stockpiled with salvaged topsoil (discussed below). Prior to distributing this material over the surfaces of finished slopes, it may be combined with topsoil and bermed at the toes of embankment slopes to form temporary erosion



control berms. The designer should review this strategy for potential fire hazard.

- Vegetation can be buried.

Off-site disposal methods include removal to an approved disposal site. In forested areas, merchantable timber may be produced (refer to Chapter 2).

### Revegetation

The goal of revegetation is to stabilize disturbed soils against erosion, reduce sedimentation, and improve visual quality. Revegetation of disturbed soils is a legal requirement imposed by EPA/ADEQ, which enforce the National/Arizona Pollutant Discharge Elimination System (NPDES/AZPDES) (refer to Chapter 8). Because the success of revegetation efforts depends on weather conditions, it is important to optimize chances for success by close attention to the following:

#### **Slope ratios**

In general, flatter slopes will revegetate more successfully than steeper slopes. Slopes that are steeper than two feet horizontal for every vertical foot (2:1) are typically poor candidates for successful revegetation and erosion/sediment control. Flatter slopes may require more excavation and disturb a greater area.

#### **Topsoil Salvage**

Once constructed, most cut and fill slopes are sterile; that is, they are devoid of organic material, including mycorrhizal fungi which form beneficial associations with plant roots to aid in the uptake of water and nutrients. Organic matter and native mycorrhiza are typically found in the topsoil of undisturbed soils. The salvage of topsoil and its distribution over finished slopes may contribute to successful revegetation of those slopes. When appropriate, the design team should consider the following:

- Before any earth disturbing construction activities, any noxious or invasive plant species must be removed.
- Salvage and stockpile the top 12 inches of soil, including roots, detritus, leaves and small twigs.
- Limit stockpile height of the salvaged soil to less than five feet to preserve microbial organisms.
- Stockpiled soil may be staged at the tops and toes of future cut and fill slopes.

- Salvaged soil may be used in berms for erosion control of disturbed areas.
- During or following construction of large cut slopes, salvaged soil may be placed across the slope as a topdressing over the face of the slope.
- In addition to salvaged soil, add compost to slopes.

### Slope Finishes

Refer to Appendix E for Slope Design Details.

- **Mini-Benching:** In general, cut slopes are more difficult to revegetate successfully than fill slopes because they tend to shed more rainfall. Properly designed and constructed mini benches retain rain water where it falls, resulting in improved infiltration, *Figure 7.4*. Mini benches are discussed in detail in Chapter 4.



*Figure 7.4 Mini benching allows for more water retention thus giving seeds a better chance to take hold.*

- **Slope Roughening:** In order to create a proper environment for successful revegetation, it is imperative that the finished



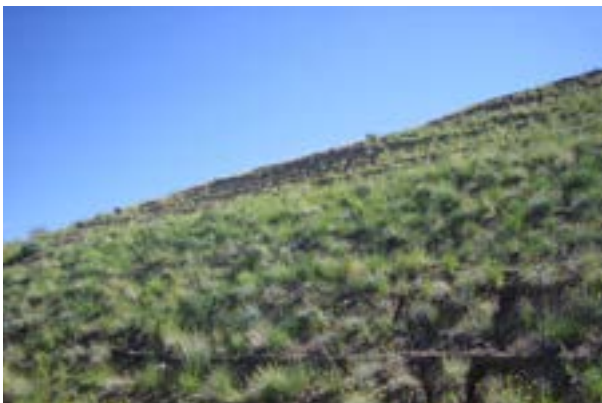
*Figure 7.5 Slope roughening keeps the soil loose and friable so that seeds may take root.*

soil surface remains loose and friable, *Figure 7.5*, to help applied seed may take root. It is also important that slope finishes remain “rough” and uncompacted to allow precipitation to infiltrate. Achieving such slope conditions typically requires close coordination between two contractors: (1) the earthmoving contractor who performs grading and ripping and (2) the revegetation contractor who applies seed and mulch. If the soil of a completed slope becomes crusted over from rainfall or compacted from vehicles, it is imperative that slope be ripped again before the seeding.

### Seeding

Large highway projects may result in the disturbance of hundreds of acres of soil. In order to address restoration at that scale in a cost effective and timely fashion, disturbed soils are typically reclaimed by applying compost, fertilizers and soil amendments, seed and mulch. The following concerns should be considered during the design process:

- In addition to using ADOT Standard and Stored Specifications, the landscape architect should prepare Special Provisions to address unique project conditions.
- Successful revegetation, *Figure 7.6*, greatly depends on slope ratios and on preparation of the finish grade prior to applying seed. Refer to Chapter 4 for more information.
- **Compost:** Compost should be applied at the times and rates specified in the contract documents.
- **Fertilizers and soil amendments:** Inorganic fertilizers and soil amendments should be tilled into the soil before seed is



*Figure 7.6 Successful revegetation using seeding on a cut slope.*

applied as described in the project contract documents. In general, Nitrogen (N) and Phosphorus (P) should be applied in a slow-release, low solubility form. Incorporation of such fertilizers into the soil minimizes the movement of Nitrogen and Phosphorus into waterways and aquifers.

- **Seed mixes:** Seed is typically applied as a mix of several species:
  - ◆ Seed mixes should reflect the plant species that are native to the project area. When a project includes several biotic communities, appropriate seed mixes should be developed for each zone.
  - ◆ Multiple seed mixes where appropriate are prepared for ADOT highway projects: one mix to be applied to areas within the clear zone; another mix to be applied to areas outside of the clear zone; and another for areas near drainage structures or wetlands. Tree species are not included in the clear zone and drainage structure mixes (refer to Chapter 4 for a description of clear zone).
  - ◆ The designer should research seed availability to help ensure that desired seed mix species will be commercially available at time of construction. The development of seed mixes should be coordinated by the landscape architect with seed suppliers and ADOT Roadside Development.
  - ◆ Seed mixes should include species that can be relied on to establish themselves under difficult conditions and should allow for both immediate and long-term stabilization. Typically, a seed mix includes both annual and perennial species of wildflowers grasses, shrubs and trees. Seed mixes should include a mix of warm and cool season species reflecting local, seasonal rainfall patterns.
  - ◆ ADOT project specifications require compliance with federal and state seed laws. These specifications spell out requirements concerning testing, labeling, purity and viability. Both federal and state seed laws contain provisions that address issues of

- noxious and invasive plant species. Tags and laboratory test results for each seed species furnished by the contractor must be provided to the field inspector prior to beginning seeding operations. Multiple species seed mixes will be combined at project site after approval by the Engineer.
- **Seed application rates:** The landscape architect will specify application rates in pounds of Pure Live Seed (PLS) per acre in the project contract documents.
  - **Seed application techniques:** Seed is typically applied by drilling or by hydraulic equipment (hydroseeding), *Figure 7.7*.
    - ◆ Drilling ensures positive seed/soil contact and seed coverage. It requires slopes flatter than 3:1 that are free of rock to be effective. Also, seed drills may not be able to apply some seeds in the mix that are very large, very small, with long awns or those that tend to clump.
    - ◆ Hydroseeding, is more commonly employed on ADOT projects. Seed, tackifier and wood fiber are mixed in a slurry and hydraulically applied to prepared soil. This method allows for application to steep and rocky slopes or slopes where equipment access is difficult.
  - **Mulches:** Once applied to prepared soil, seed should be covered with mulch to provide protection from predation, solar exposure and erosion. In order to be effective, mulch needs to remain in place as a protective mat following its application.
- The project contract documents require that mulch be maintained in place by the contractor for 45 days. Mulches are generally one of two types:
- ◆ **Straw.** Straw, *Figure 7.8*, provides superior erosion control and insulation against heat and moisture loss. It is typically blown onto the prepared soil by mechanical means. All wheat straw must be free from noxious and invasive weeds in compliance with the standards and procedures of the North American Weed Management Association (NAWMA) or the Arizona Crop Improvement Association (ACIA).
  - ◆ **Hydraulically Applied Straw.** Hydraulic equipment can generate pressure sufficient to apply material over greater distances than can mechanical equipment. The use of Hydraulically Applied Straw requires prior approval by the Engineer. Straw must be certified as weed free under NAWMA.
  - ◆ **Wood fiber.** Only in rare instances will wood fiber be approved as a mulch material. Wood fiber does not provide erosion control or moisture retention as effectively as straw. Wood fiber is typically applied by hydraulic equipment; therefore, it may be applied over greater distances than straw. On roughened slopes, it may be necessary to apply mulch from more than one angle in order to avoid “shadowing.”
- **Tackifier:** Tackifier is used to stabilize the applied mulch on the slope. When straw mulch is used, the tackifier is applied in



*Figure 7.7 Slope on the right has been hydroseeded.*



*Figure 7.8 Straw provides superior erosion control and insulation against heat and moisture loss.*

combination with a small amount of wood fiber to hold the straw in place. When hydraulically applied straw or wood fiber is used as mulch, tackifier and straw or wood fiber are applied in the same application. There are several different types of tackifiers and the performance of most types will vary with project weather conditions. The project contract documents should provide the contractor with the appropriate methods, rates and materials to be used.

- **Mobilization:** Seed application uses specialized equipment that will be required at the job site according to the general contractor's earthmoving schedule. To maintain compliance with SWPPP and provide adequate erosion protection, the seeding contractor may be required to mobilize numerous times. For complex or large projects, the project contract documents should include a separate bid item providing for multiple mobilizations.
- **NOT requirements:** As described in greater detail in the *ADOT Erosion and Pollution Control Manual*, ADOT and the contractor must comply with the ADEQ/EPA Statewide Permit regarding storm water permits and provide to ADEQ or EPA a Notice of Termination (NOT) at the conclusion of construction. Successful revegetation is an essential component of final stabilization. The ADOT protocol for determining final stabilization may be found at the ADOT Storm Water Program website listed at the conclusion of this chapter.

### **Native Plant Salvage**

Native vegetation should be considered for salvage. Issues related to plant salvage include:

- **Cost:** Operations related to meeting ADOT-approved levels of plant salvage and replanting are described in ADOT Roadside Development's website listed at the conclusion of this chapter.
- **Appropriate species:** The design team should review the requirements of Arizona Native Plant Law, 404 Permit and NEPA documents as well as discuss the subject with appropriate BLM/USFS representatives. In addition, the design team should consider salvaging species that

are difficult to regenerate naturally or are important for local wildlife. Salvaged plants must be able to sustain themselves at the conclusion of the two-year Establishment Period.

- **Appropriate quantities:** The design team should review existing conditions in the project area and seek to establish similar conditions in the Right-Of-Way.
- **Contractor access:** Salvage operations typically occur prior to earthwork. Therefore, the salvage contractor may need to construct pioneer roads to gain access to the desired plants and boulders. For projects in areas with rugged topography, this access may be a constructability and restoration issue and affect salvage costs.
- **Once-move:** Salvaged plants may be once-moved: they are transplanted in a single operation from their original growing locations into areas that will remain outside the limits of disturbance. This technique is appropriate for plants that do not transplant easily, such as saguaro cacti, *Figure 7.9*. Temporary irrigation may be required for these relocated plants.
- **Temporary nurseries:** Salvaged plants may be relocated to an on-site nursery, or series of nurseries, *Figure 7.10*. The design team should attempt to identify appropriate nursery sites within the project limits. These sites will require restoration. Note that while in temporary nurseries, salvaged plants may require irrigation and care similar to a commercial nursery.
- **Container sizes:** A variety of sizes may be required to maximize chances for survival



*Figure 7.9 Salvaged plants may be once-moved, such as large cacti.*



- and to develop a varied plant palette.
- Appropriate final planting locations:
    - ◆ Salvaged plants should be placed at locations where they are self-sustaining and will naturalize constructed slopes and disturbed areas.
    - ◆ Where feasible, salvaged plants can be intermixed with plants that have been protected in place during construction.
    - ◆ Salvaged plants can be located to screen undesirable views.
    - ◆ Salvaged plants can be located in more highly visible areas, *Figure 7.11*, such as cut/fill transitions and parking areas.
    - ◆ Salvaged plants can be concentrated in order to create resource islands that can provide seed for surrounding areas.
    - ◆ Plants should not be located in areas where they will interfere with maintenance activities.
    - ◆ Establishment Period: A part of the project contract documents, the Establishment Period describes contractor obligations regarding maintenance and survival rates for transplanted plants for a given length of time (generally two years following installation). Salvaged plants will typically require a temporary irrigation system. Smaller plant species may also require temporary protection from predation. Temporary irrigation equipment and plant protection should be removed at the conclusion of the Establishment Period.



*Figure 7.10 Salvaged plants may be relocated to an on-site nursery.*

### **Container-Grown Stock**

Container-grown stock typically consists of tree or shrub species native to the project area supplied by an approved nursery. They can be installed where the design team determines that more rapid revegetation of disturbed slopes is needed (for example: bridge embankment slopes adjacent to natural drainages that serve as wildlife corridors).

- Select species that are native to the project area.
- Container stock will require temporary irrigation until established. This Establishment Period is typically two years.
- Container stock will typically require protection from predation from wildlife during the Establishment Period. Protective sleeves and fencing are commercially available for this purpose. Sleeves may be removed at the end of the landscape establishment period or remain in place until desired as defined in the project contract documents.

### **Live Cuttings and Pole Plantings**

Dormant branches cut from riparian trees (e.g. cottonwood and willow) may be planted directly into moist riparian soils where rooting and establishment can take place.

- Cuttings should be gathered and planted in late winter/early spring before trees leaf out.
- Branches may be 1-4" diameter and should be stripped of leaves.
- Install branches with same orientation as original sap flow.



*Figure 7.11 Salvaged plants can be located in highly visible areas.*

**Noxious and Invasive Vegetation**

If allowed to become established, noxious and invasive vegetation, *Figure 7.12*, pose significant economic and ecological threats to the long-term biological health of an area. The term “noxious weed” has legal ramifications: both the State of Arizona and the federal government publish lists of noxious weed species (refer to Chapter 11 for links to state and federal websites listing noxious weeds). An “invasive plant” is one that grows and spreads rapidly, replacing desirable native plants. Invasive plants are covered by federal and state executive orders.

Noxious and invasive plants species are frequently problematic because they are typically able to



*Figure 7.12 Cuscuta L., dodder, a plant species on the Arizona State Noxious Weed list.*

quickly and efficiently colonize disturbed areas. Highways and their associated disturbed slopes provide abundant opportunities for these plant species to establish and spread into surrounding landscapes. Roadways can provide “linear routes” for invaders by conveying them along the entire disturbed area into new landscapes. It is critical that efforts be made to minimize the chances for the introduction and establishment of noxious and invasive plants in highway corridors:

- Begin control of noxious and invasive plant species of the project right-of-way area during the design phase as per Chapter 11.
- The construction documents should specify the contractor’s responsibilities for noxious and invasive plant control during the entire contract period.
- The contractor must provide control prior to ground-disturbing activities as per the specifications. Project staging areas should be free of noxious or invasive plants. Where these

species are present, a control plan should be developed in coordination with ADOT and BLM/USFS.

- Equipment transported from outside of the BLM/USFS district should be cleaned prior to entering the project area. If necessary and in consultation with BLM/USFS, identify site(s) where equipment can be cleaned. All mud and plant debris should be removed and contained as directed in ADOT’s *Erosion and Pollution Control Manual*.
- If operating in areas infested with noxious and invasive plant species, clean all equipment before leaving the project site as described above.
- Inspect material sources on site and ensure that they are weed-free before use and transport. Treat weed-infested sources for eradication: strip and stockpile contaminated material for proper disposal. Document and closely inspect those areas where treated soils are used during construction to ensure that any noxious and invasive plant species transported to the site are promptly detected and controlled.
- Maintain stockpiled material in a weed-free condition.

**Existing Boulders**

Where they exist in the project area, consider salvaging boulders from the surface prior to



*Figure 7.13 Salvaged boulders should be placed in groups for a more natural appearance.*

earthmoving activities. These should be moved using slings or other equipment that won’t mar the weathered surfaces. Similar to salvaged plant material described above, the project contract documents should provide direction regarding final

locations. In general, boulders placed in groups, *Figure 7.13*, appear more natural than when placed alone.

## 7.4 CONSTRUCTION

As discussed throughout this manual, the integration of the highway into the surrounding landscape is of central concern to both BLM and USFS. Aesthetic considerations in earthform design of slopes, rounding and transitions between cuts and fills are the foundation for successful landscape restoration. Revegetation of these constructed slopes is a critical component of integrating highways with their surroundings. In addition, NEPA and other environmental documents may provide specific requirements for the restoration of the project area. Finally, as described in Chapter 8, ADOT is legally obligated to revegetate and stabilize soils disturbed by construction. The application of storm water BMPs must be coordinated with slope construction and revegetation. It is crucial during construction that field staff closely attend to the project contract documents as they relate to revegetation. Issues as varied as the condition of the finished grade (compacted or loose, crusted or friable), the timing of seed applications (for large cut and fill slopes), the inspection of seed mixes, tackifiers and composts and the review of proper application techniques will all affect the successful restoration of the project.

## 7.5 ADDITIONAL RESOURCES

ADOT Roadside Development Section:

<http://www.azdot.gov/business/engineering-and-construction/roadway-engineering/roadside-development>

ADOT Stored Specifications:

<http://www.azdot.gov/business/ContractsandSpecifications/Specifications>

ADOT Methodology for Determining Final Stabilization (NOT Criteria):

[http://www.azdot.gov/docs/default-source/roadway-engineering-library/methodology-for-determining-final-stabilization-\(not-criteria\).pdf?sfvrsn=2](http://www.azdot.gov/docs/default-source/roadway-engineering-library/methodology-for-determining-final-stabilization-(not-criteria).pdf?sfvrsn=2)

Visual Impact Assessment for Highway Projects:

<http://www.contextsensitivesolutions.org/content/reading/visual-impact-2/>

ADOT Erosion and Pollution Control Manual:

<http://www.azdot.gov/business/engineering-and-construction/roadway-engineering/roadside-development/erosion-and-pollution-control-manual>

State Noxious Weed Lists (R3-4-244 and R3-4-245):

<https://plants.usda.gov/java/noxious?rptType=State&statefips=04>

Federal Noxious Weed List:

<http://plants.usda.gov/java/noxious?rptType=Federal>

Executive Order 13112:

<http://www.invasivespeciesinfo.gov/laws/execorder.shtml>

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