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Revegetation guidelines for stormwater pollution prevention plan (SWPPP) closure in central New Mexico

Jennifer Payne-Ross

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Unsuccessful post-construction seeding. The site is covered with tumbleweeds.

Same site after successful seeding. Blue grama (*Bouteloua gracilis*) is growing one month after seeding and applying supplemental water.

Jennifer Payne-Ross

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COMMITTEE APPROVAL

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My husband, Michael Ross, inspires me every day with his enthusiastic attitude, commitment, and kindness. His consistent encouragement on this project has been amazing.

ABSTRACT

A major challenge for construction stormwater permit holders in New Mexico is the closure of their Stormwater Pollution Prevention Plan (SWPPP) through successful revegetation of the post-construction sites. Successful revegetation of native plants is a difficult task to achieve. Without proper guidance, the SWPPP permit closure goal is exceptionally difficult to achieve in New Mexico. This paper examines comprehensive seeding guidance designed for contractors or other individuals without seeding experience that are responsible for permanent soil stabilization. When accurately followed and appropriately budgeted, the seeding guidance document developed in conjunction with this paper and presented in Appendix I. should greatly improve outcomes of native revegetation in New Mexico and successful SWPPP permit closures.

I. INTRODUCTION

Geophysical erosion is the process where the forces of wind, water, or ice move solids in the natural environment and deposit them elsewhere. When soil erosion occurs due to stormwater events, soil particles are loosened from their soil matrix by the force of raindrops and/or water streams, suspended in liquid solution, carried by gravity downhill and deposited as sediment at a new location when the carrying energy dissipates. This overland flow is generally termed stormwater runoff, with the processes of erosion and sediment deposition occurring in association with stormwater runoff (EPA1).

Erosion is a natural process, but it is accelerated with human land use changes such as construction development, deforestation, and agriculture. When lands have their native plant communities removed, the soil stabilizing and protective benefits that these plants provide are also removed. Native plants are adapted to the climate and soils of an area, and perennial plants develop extensive permanent root systems that bind to the soil and aid in holding it in place. The above ground portion of perennial plants may go dormant during the winter but much of the above ground biomass remains in place throughout the year and this biomass provides an important soil protection function by reducing the energy of raindrops. The above ground plant material absorbs much of the raindrop impact force and breaks raindrops into smaller, reduced energy droplets that are more likely to saturate into the soil instead of the full-energy drops hitting the soil, dislodging soil particles and then carrying them along as sediment with the increased stormwater runoff.

I. 1. STORMWATER SEDIMENT ISSUES

Sediment is the most common pollutant in rivers, streams, lakes and reservoirs according to the United States Environmental Protection Agency (EPA) (Glysson & Gray 2002). Fluvial sediment increases the load of Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) present in surface water bodies and can contribute to water quality impairment during storm events (FTN 2007.) Elevated TSS can indicate a higher concentration of pollutants such as bacteria, nutrients, pesticides, and metals. These

pollutants attach to soil particles and can be carried with the fluvial stormwater sediment into water bodies where they may be released or travel further downstream (FISRWG 1998).

Accelerated erosion from human use of land accounts for seventy percent of the total sediment in the United States, natural erosion produces the remaining thirty percent (MARC). The most concentrated sediment releases come from construction activities, both large and small in scale. Stormwater associated sediment degrades water quality for humans and wildlife in the following ways:

- Increases the potential for flooding by filling up storm drains and catch basins, impairing their ability to carry water away from roads and homes.
- Increases the cost of drinking water treatment; can also cause odor and taste problems.
- Sediment deposition in rivers can alter the flow of water and reduce water depth, decreasing recreation and navigation functions.
- Water polluted with sediment becomes cloudy which prevents animals from seeing food, clogs fish gills, lowers growth rates, affects fish egg and larvae development, and murky water impairs the growth of natural aquatic vegetation.
- The natural food chain in streams can be disrupted by sediment destroying habitat for small stream organisms, leading to massive declines in fish populations.

Annually, sixteen billion dollars of environmental damage results from sediment pollution in the United States (MARC).

I. 2. Construction Erosion and Sediment Pollution Mitigation – Federal Regulation

The issues of accelerated soil erosion, sediment transport and deposition in waterways that result from storm water events on bare construction lands are regulated under the Clean Water Act. Significant soil disturbance is cause by construction activities such as clearing, excavating and grading.

All construction projects that disturb one acre or greater of soil are required to obtain a State or EPA Stormwater permit prior to construction activities occurring. Most states are authorized to issue a Stormwater National Pollutant Discharge Elimination System (NPDES) permit, but in some states including New Mexico, the EPA remains as the permitting authority. In New Mexico a Stormwater Pollution Prevention Plan (SWPPP) must be submitted to the EPA and approved in order for a NPDES permit to be granted (EPA2).

The construction SWPPP is a plan that provides direction on how erosion and sediment transport will be minimized during construction activities through best management practices, and how the soil will be stabilized following construction.

1.3. Post-Construction Soil Stabilization Issues in New Mexico

A major challenge for construction stormwater permit holders in New Mexico is the closure of their SWPPP through successful revegetation of the post-construction sites. Final site stabilization of soil after construction activities have ceased is required by EPA to minimize future sediment effects from the construction activities during storm events.

Sites operating under a SWPPP permit may be closed through vegetation stabilization or non-vegetative stabilization. For vegetative stabilization the site must have established perennial native plant species within three years "that covers 70 percent or more of the density of vegetation prior to commencing earth-disturbing activities (EPA2)."

SWPPPs may also be terminated with permanent solutions installed across the post-construction area such as erosion control mats, riprap, or gabions. Geotextile solutions such as erosion control mats gradually break down and cease to fulfill their function due to intense environmental exposure in sunny New Mexico.

Revegetation is a soil stabilization solution that will remain in place. Native plants are self-sustaining because they are adapted to the local climatic regime. Perennial plants stabilize the soil with an extensive, permanent root system that typically grows to more

than twice the length and twice the total biomass below ground as the above ground portion of the plant.

The primary construction company most commonly terminates a construction SWPPP permit immediately after the site is seeded. Post-construction seeding nearly always occurs without consideration of: appropriate species in the seed mix, seasonal timing, soil compaction and pH, sufficient water and protection for seed germination, seedling development, and plant establishment. Under this common circumstance a post-construction SWPPP site that has been seeded generally fails to meet the criteria of final soil stabilization by revegetation. A former SWPPP site that does not meet the criteria for final soil stabilization is subject to fines by the EPA.

1.4. Statement of Objectives

For semi-arid and arid U.S. regions such as New Mexico, achieving the goal of at least 70 percent of the native background vegetation is very challenging. This paper will examine methods to increase successful revegetation for SWPPP closure. Factors affecting successful seeding that will be examined include: using appropriate native seed species, seeding methods and quantity, soil preparation and amendments, seed protection, seeding and soil stabilization of slopes, seasonal timing of seeding and moisture regimes, and appropriate site SWPPP closure.

II. METHODS

II.1. Climate

New Mexico's climate is generally characterized by low annual precipitation totals, low humidity, high evapotranspiration rate and forceful summer monsoon rains (WRCC). Adequate native revegetation across a large (one acre or greater) area is exceptionally difficult to achieve in the three year SWPPP timeframe when reliant only on natural precipitation. Lauenroth et al. (1994) studied how long the natural interval may be between optimum conditions for seed germination and growth of blue grama grass (*Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths), a common native grass species

in New Mexico that is regularly included in reseeding mixtures. The optimum conditions were found to occur very infrequently, possibly only every 30 to 50 years.

New Mexico's climate currently provides challenging conditions to achieve adequate growth of native seeded vegetation within three years to successfully terminate a SWPPP permit. This task is anticipated to become increasingly difficult with projected climate change in New Mexico. Climate models strongly indicate that temperature is expected to gradually increase across the southwestern United States (US) and cool season precipitation is projected to decrease according to most climate model projections (Christensen et al. 2007). The southwestern US is anticipated to have extended periods of drought which may commonly occur on multiple-year or decadal time scales (Goodrich 2007). Without adequate precipitation any revegetation project will fail, regardless of diligent seeding methods.

II.2. Current Status of Post-Construction Seeding in New Mexico

The construction company operates each project under a SWPPP permit. During active construction best management practices (BMPs) are used such as silt fencing and straw waddles as outlined in the SWPPP to control sediment from leaving the site. A sub-contractor with unspecified seeding experience often performs post-construction final soil stabilization work. The post-construction SWPPP revegetation actions are highly variable since no activity guidelines are set, only a final criterion standard. SWPPP authors rarely, if ever, develop detailed site-specific post-construction seeding guidance. A seed list may be included that is completely inappropriate to the area or no seed list may be included in the plan.

Lack of specific revegetation seeding guidance to the general construction contractor and to the seeding contractor sets the stage for unsuccessful post-construction soil stabilization. Construction companies are skilled in building structures, however they cannot be expected to be native revegetation experts. Successfully growing native species from seed in semi-arid climates requires specific knowledge, experience and guidance.

II.3. CURRENT SEEDING GUIDANCE

Seeding guidance for revegetation is available in books, online, from landscape designers or installers, and other sources. Great variability exists in the amount, quality, and regional or project applicability of guidance provided by different sources. The Los Lunas Plant Materials Center has produced a seeding publication, "Seeding Native Grasses in the Arid Southwest" that provides basic, informative regional specific seeding guidance (Dreesen 2008). Currently there are no comprehensive guidelines specific to semi-arid New Mexico with the goal of successful SWPPP closure through revegetation.

Erosion control guidance related to revegetation seeding for final soil stabilization involves topics such as hydraulic seeding and mulching, slope preparation, and soil roughness. Erosion control typically falls within the category of civil engineering, but for stabilization it needs to be melded with environmental science. The California Stormwater Quality Association has produced instructive online erosion control handbooks including the subjects of hydraulic mulch and hydroseeding (CASQA). Arizona Department of Transportation provides online details regarding its "Erosion/Sediment & Water Quality Protection Best Management Practices (BMP)" including slope preparation (ADOT). San Diego State University's Soil Erosion Laboratory has produced soil roughness guidance to reduce post-construction soil erosion (Forrest et al. 2000). Other general erosion control resources with current articles, research and professional discussion forums include "Erosion Control: Official Journal of the International Erosion Control Association" (Erosion) and the Erosion Control Network (ECN).

Seed lists for native species that are appropriate to a given project area are very difficult to obtain. Typically a site-specific survey needs to be conducted by a biologist in order to appropriately revegetate a site. In lieu of a site-specific survey, it is most common for a seed list to be used that is inappropriate to the area being seeded in terms of climate, soils, exotic/weedy species, or other factors. Site-specific surveys are not commonly conducted for seed list development due to lack of time, budget and planning. For

effective soil stabilization through revegetation a basic ecological understanding of the area and an associated appropriate seed list are essential components.

Comprehensive guidance for revegetation is rarely available for erosion control. Most often the various components such as seeding methods, site preparation and seed lists are available as separate resources.

II.4. COMPREHENSIVE SEEDING GUIDANCE

The construction contractors who are responsible for post-construction final soil stabilization follow seeding guidelines provided to them. Although they are tasked with the responsibility, construction companies are generally not skilled in the scope of native revegetation. Appropriate post-construction soil stabilization for erosion and sediment control is an interdisciplinary complex of ecological biology, landscape architecture and civil engineering.

Comprehensive seeding guidelines that include all necessary components of site work for SWPPP final stabilization through revegetation are needed for successful permit closure.

III. RESULTS

"Guidelines for Storm Water Pollution Prevention Plan (SWPPP) Closure Through Revegetation Seeding in Valencia, Bernalillo, Sandoval, Los Alamos, and Santa Fe Counties" was developed as a comprehensive SWPPP seeding guidance document for central New Mexico in fulfillment of the professional project requirement for the Master's of Water Resources at the University of New Mexico.

This guidance is designed to create successful projects as an easy step-by-step instructional document where the audience or end user is someone with little to no revegetation seeding experience. The main body of the document is relatively short, only approximately one-quarter of the document is contained in the main body. In an effort to

keep the guidance as simple and direct as possible the bulk of detailed information is contained in appendices, with bulleted items and brief paragraphs in the main body.

Each section of the seeding guidance is discussed in the following two main sections.

III.1. PRE-CONSTRUCTION

For a successful revegetation project it is important to have the seeding plan in place prior to beginning construction. Proper site revegetation is expensive and an adequate budget must be set aside for the post-construction work. The revegetation work actions should be integrated into the construction timeline. This is particularly important because some actions need to occur prior to construction such stockpiling topsoil and other actions require pre-planned timely implementation for project efficiency.

III.1.1. SCHEDULE SEEDING

Seeding during the warm season is generally most effective due to overall higher germination rates than during other seasons. Some warm season species require high nighttime temperatures for germination; including blue grama (*Bouteloua gracilis*), which is a frequently seeded and important native reclamation species across much of New Mexico (Anderson 2003).

Seeding between set start and end warm season dates enables the best seed protection. The amount of time that the seed is in the ground prior to watering should be minimized as much as possible. Between the time of seeding and germination seeds are subject to environmental stressors such as drying out or being carried away by birds, ants, mice and other animals. If seeded prior to the warm season, the seed should have permanent protection such as rock mulch placed over it because straw mulch is quickly blown away with the strong spring winds in New Mexico.

III.1.2. STOCKPILE TOPSOIL

Native topsoil is the most fertile growth medium for native plants. It contains exactly the correct nutrients, microbes and mycorrhizal fungi for optimal growth. Preserving the pre-

construction topsoil for post construction seeding greatly increases vegetation reestablishment. Plant growth and biological activity improves steadily as the percentage of topsoil increases in the post-construction soil mixture (Claassen 1994). Stockpiling native topsoil also avoids the unnecessary cost and less effective solution of adding soil amendments and/or purchasing topsoil post-construction. Stockpiling also avoids the potential for weed seeds to be introduced with the foreign soil.

III.1.3. PLAN POST-SEEDING WATERING

In arid and semiarid regions precipitation is the "master input" that controls biological processes. Important native restoration species in New Mexico such as blue grama (*Bouteloua gracilis*) only become established during the warm season when the evaporative loss of soil moisture is high. Consistent summer moisture is necessary to provide adequate moisture for germination, root development, and plant establishment (Dressen 2008).

Monsoon rains over the past decade have becoming increasingly variable, providing unreliable warm season moisture for native plant establishment. With projected climate changes in New Mexico precipitation is anticipated to remain unpredictable (Christensen et al. 2007) with extended periods of drought (Goodrich 2007). It is not possible to achieve successful SWPPP closure through revegetation within the required 3-year timeframe without reliable precipitation shortly after warm season seeding.

A reliable water application plan for post-seeding watering needs to be selected before construction begins because the watering system logistics can be time consuming to develop. Aspects requiring advance planning include: adequate set aside of funds, choosing and designing the method of water application, locating and insuring access to a hydrant or other reliable water source, incorporation of the watering schedule (including the start date) into the overall construction schedule, ordering fire hose, sprinklers, and/or other supplies. Quick implementation of the watering system post-construction is important for timely warm season seeding and plant growth.

III.1.4. Determine Hydraulic Seeding Areas

Areas planned for hydraulic seeding may require mini-benching or other soil erosion control techniques applied prior to seeding. These areas require additional planning and time for proper implementation. A hydroseeding contractor will need to be scheduled and budgeted. These issues need to be incorporated into the overall construction schedule and budget in order for timely implementation of post-construction seeding work.

III.2. Seeding Procedure

III.2.1. Determine Ecoregion

The EPA has delineated New Mexico into Level III and more discrete Level IV ecoregions. Ecoregions provide a widely accepted ecosystem mapping standard where areas of similar type, quality, and the quantity of environmental resources are classified together. Species seed lists by ecoregion classification are appropriate because ecoregions are designed to serve as a spatial framework for the assessment and management of ecosystems and ecosystem components (EPA3). An ecoregion reference map is provided in Appendix I.

III.2.2. Review Ecoregion Information

Reading the ecoregion description should allow the user to verify that the project is located in the correct ecoregion. If the user has a basic knowledge of vegetation, reviewing the species list may also allow for verification of correct ecoregion.

Each ecoregion occurring with Valencia, Bernalillo, Sandoval, Los Alamos and Santa Fe counties was cross-referenced with widely utilized New Mexico native plant lists and maps by William Dick-Peddie. Commercial seed availability was then checked for each ecoregion species list, only species with seed availability are included. Ecoregion species lists were then reviewed by Dr. Timothy Lowrey who is a University of New Mexico (UNM) biology professor and curator of the UNM herbarium, and Judith Phillips who is

a native and xeric plant gardening author, consultant, and instructor in the UNM landscape architecture program.

Each ecoregion covers a wide range of conditions including soil types, elevation, aspect, steepness/slope, and microclimates. It is important to seed a wide diversity of species as an attempt to address as many variable conditions as possible.

In-stock seed supply can vary throughout or across years. Selecting a seed supplier will largely depend upon their seed availability of the species needed. Utilizing a range of grasses, shrubs and perennials will best allow for all ecological niches on the project site to be filled with appropriate species.

III.2.3. Determine Seeding Rates

Each ecoregion seed list provides the seeding rate of each species in pounds per acre of pure live seed (PLS). A standard seeding rate of 60 pounds per acre of PLS is set for all ecoregions and seed lists. The seeding rate of each species is not adjusted to a total rate of 60 pounds of PLS for the entire list because it is likely that not all species on an ecoregion seed list will be available at the time of ordering. The individual seeding rate of each species is provided so after the final seed list has been determined based on availability, the quantity of each species can be adjusted proportionally for the final seed mix rate of 60 pounds of PLS per acre.

The seeding rate is appropriately high without the development of a project-specific seed list. Each ecoregion covers a wide range of conditions including soil types, elevation, aspect, steepness/slope, and microclimates. A wide diversity of species should be seeded in order to address as many variables as possible; a minimum of 12 species should be seeded. It is likely that not all species on the ecoregion species list will be correct for the project site and the high seeding rate will allow for the appropriate species to be available in great enough quantity that open niches for weedy annual species will be minimized or eliminated on the site.

PLS is a seed industry standard that provides a descriptive measure of the quantity of seed that will germinate. This allows the purchaser to compare the quality and value of different seed lots; a less expensive seed lot may have a lower rate of PLS than a more expensive lot (LBJ).

III.2.4. Soil Preparation

Proper soil preparation will enhance the growth of seeded vegetation and aid in reducing soil erosion. Important aspects of proper soil preparation are: soil compaction, surface roughness, addition of native topsoil, soil pH and avoiding adverse soil amendments.

III.2.5. Seeding on Slopes Greater Than or Equal to 3:1 (horizontal:vertical)

The successful revegetation of slopes is difficult but very important because slopes are extremely erodible. The root systems of perennial native vegetation provide slope stabilization and reduce sediment losses.

Well-planned and implemented slope work aids in erosion control and revegetation success. Mini-benches are similar in structure to the widely used and successful traditional terrace farming. Properly designed and constructed mini benches capture rainwater where it falls, slowing run-off and increasing water retention.

Slopes equal to or greater than 3:1 (horizontal:vertical) in steepness need to be hydraulically seeded, also known as hydroseeding. A two-step application process should always be used with a high quality hydraulic product to for longevity and proper slope protection.

III.2.6. Seeding on Slopes Less Than or Equal to 3:1 (horizontal:vertical)

All flat or gently sloping areas should be drill seeded because this allows for the best seed-to-soil contact, which is essential for the seeds to take up soil moisture. Important

aspects of drill seeding are placing the seeds at the correct depth, not compacting the soil while seeding, and only seeding the native species provided on the ecoregion seed list.

III.2.7. SEED PROTECTION: MULCH

Seeds require protection against wind, birds, small mammals and insects carrying them away, and protection against drying out with environmental exposure before adequate water is provided for germination. Seedling development and plant maintenance also greatly benefit with protection from environmental extremes of drought, heat, and freezing temperatures.

It is important to choose the correct type of mulch: either rock, straw, or hyromulch, based on how long the mulch will need to provide protection before the site receives consistent moisture for germination. Straw provides only provides brief seed protection, ranging from days to weeks depending on winds and other environmental conditions.

It is essential that straw, hay, or hyromulch is crimped properly and is certified to be weed free. Contaminated mulch can introduce invasive species that become established ahead of the native species. Invasive species quickly dominate an area and prevent native species from becoming established. This results in a failed revegetation project and facilitates the introduction of invasive species to the surrounding areas (Barclay 2004).

III.2.8. SUPPLEMENTAL WATERING

Adhering to a pre-planned watering schedule will insure adequate germination and growth. During initial germination and seedling development the top few inches of soil needs to remain moist. As seedlings progress the soil should progressively be watered more deeply and less frequently.

III.3. APPENDICES

III.3.1. Appendix I. Ecoregion Map for Valencia, Bernalillo, Sandoval, Los Alamos and Santa Fe Counties

This EPA ecoregion reference map allows for the seeding project to be located within the correct ecoregion.

III.3.2. Appendix II. New Mexico Ecoregions: Valencia, Bernalillo, Sandoval, Los Alamos, and Santa Fe Counties

This appendix is a guide to all of the ecoregions contained in Valencia, Bernalillo, Sandoval, Los Alamos, and Santa Fe counties. Each ecoregion section contains an EPA description, cities or landmarks contained within the ecoregion, and a list of commercially available species with both common and scientific names, the vegetation type, relevant habitat notes and seeding rate.

III.3.3. Appendix III. Commercial Suppliers of New Mexico Native Seed

Reputable seed suppliers provide knowledgeable, accurate, and expedient service.

III.3.4. Appendix IV. Soil Surface Roughening Techniques

Heavy equipment photos and associated descriptions of soil surface roughening techniques provide instructional aids. The rainfall simulation testing results chart shows the statistical effectiveness of each technique under normalized erosion and runoff conditions.

III.3.5. Appendix V. Mini-benching Construction Specification

This diagram shows mini-benching construction specifications.

III.3.6. Appendix VI. Hydraulic Seeding Contractors in New Mexico

The contractors listed specialize in hydraulic seeding. It is not a recommended list of contractors. Each contractor should be interviewed regarding successful projects, references, techniques, hydraulic product knowledge and recommendations, and equipment.

III.3.7. APPENDIX VII. CERTIFIED WEED FREE HAY AND STRAW IN NEW MEXICO

Certified weed free straw and hay bears easily recognizable twine and/or labels as pictured in this appendix. The NMSU Noxious Weed Free Certification Program is the responsible certification organization.

The list of certified weed free straw and hay growers is provided for reference only and is not a list of recommended growers. Each grower should be interviewed regarding straw or haw quality assurance, references, and other relevant information.

IV. CONCLUSIONS

Successful revegetation of native plants is a difficult task to achieve. Without proper guidance, the SWPPP permit closure goal of seventy percent site coverage with native, perennial plant species within three years of construction completion is exceptionally difficult to achieve in New Mexico. Comprehensive seeding guidance designed for contractors or other individuals without seeding experience and who are responsible for permanent soil stabilization should greatly improve successful SWPPP permit closures. The guidance must be accurately followed and the final stabilization work must be appropriately budgeted for success.

This initial guidance document is limited in geographic scope. Updated guidance with additional ecoregion seed lists and additional and improved techniques will be needed to continually improve the process and outcomes of native revegetation in New Mexico.

APPENDIX I. REVEGETATION SEEDING GUIDELINES FOR STORMWATER POLLUTION PREVENTION PLAN (SWPPP) CLOSURE IN CENTRAL NEW MEXICO

The document beginning on the next page in this appendix is written as a stand-alone guidance document and is presented in its original stand-alone format. This document in this appendix concludes the paper.

Revegetation Seeding Guidelines for Stormwater Pollution Prevention Plan (SWPPP) Closure in Central New Mexico

Blue grama (*Bouteloua gracilis*) one month after seeding and applying supplemental water

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UNM Water Resources Program

4/15/2013

ABSTRACT

A major challenge for construction stormwater permit holders in New Mexico is the closure of their Stormwater Pollution Prevention Plan (SWPPP) and National Pollutant Discharge Elimination System (NPDES) permit through successful revegetation of post-construction sites. Successful revegetation of native plants within three years is a difficult task to achieve. Without proper guidance, the SWPPP permit closure goal through revegetation is exceptionally difficult to achieve in semi-arid New Mexico. This document provides comprehensive seeding guidance designed for contractors or other individuals without seeding experience that are responsible for permanent soil stabilization. When accurately followed with appropriate planning and budget, the seeding guidance document should significantly improve outcomes of native revegetation in central New Mexico and successful permit closures.

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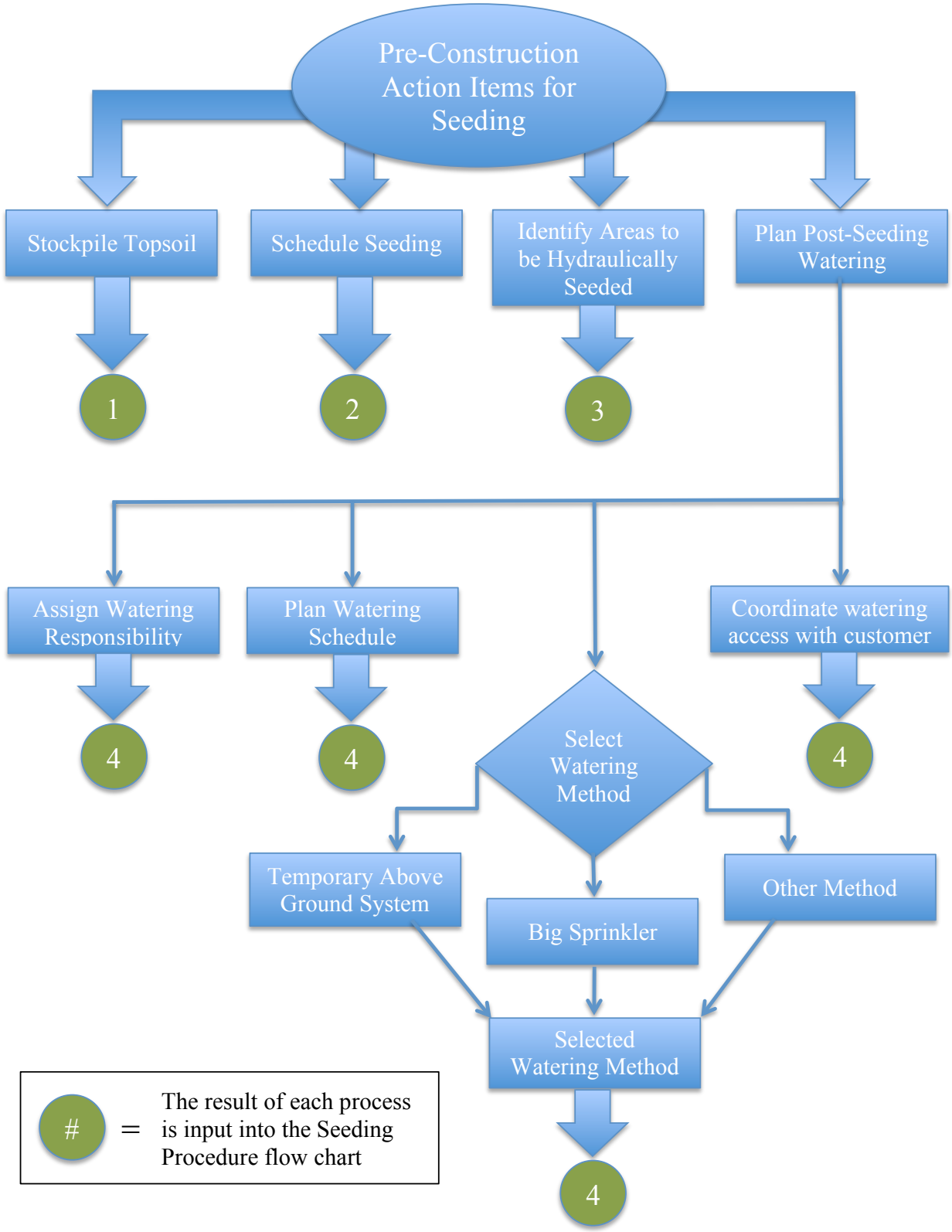
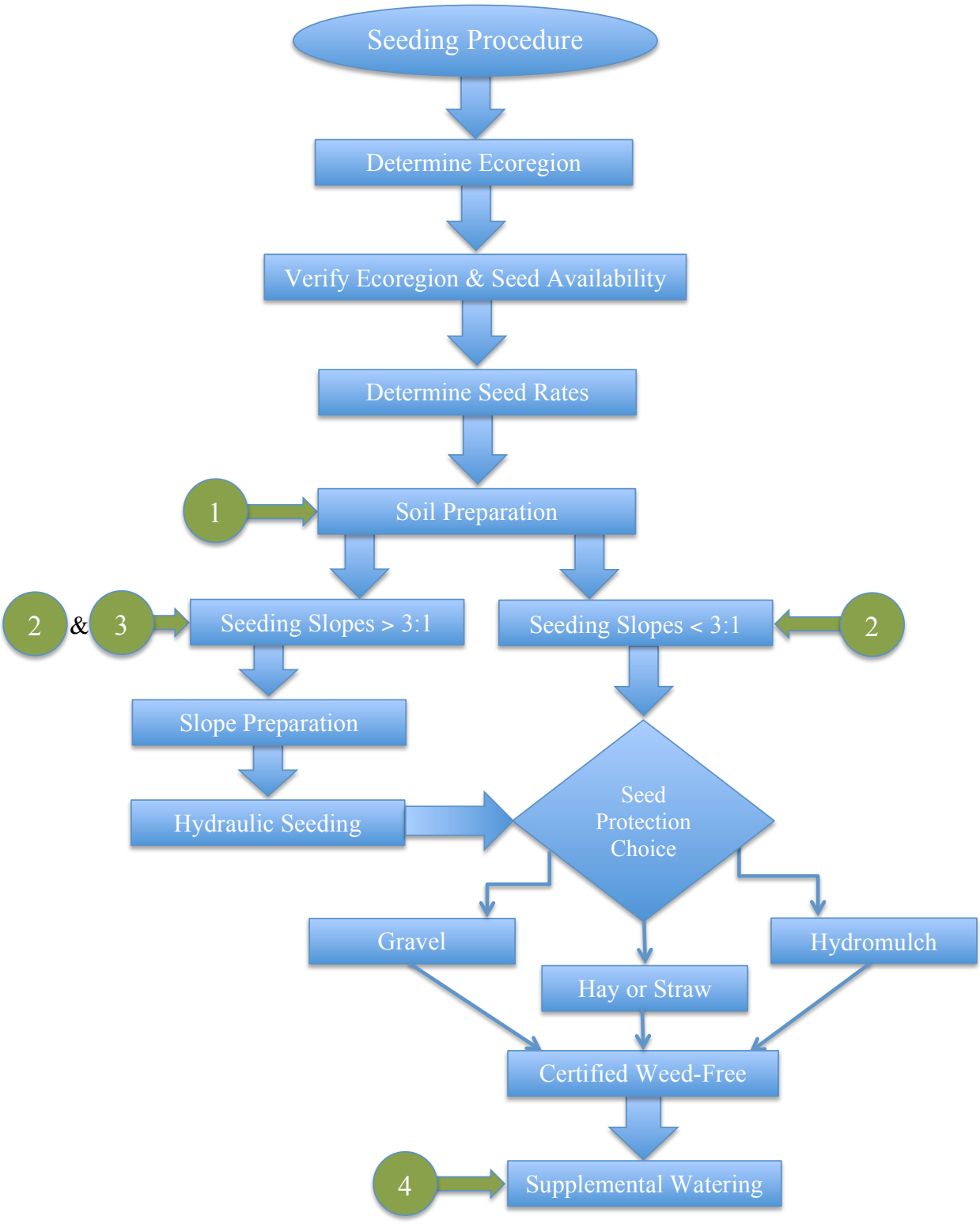


Pre-Construction Flowchart of Seeding Action Items



Seeding Procedure Flowchart

I. PRE-CONSTRUCTION

Sediment is the most common pollutant in rivers, streams, lakes and reservoirs according to the United States Environmental Protection Agency (EPA) (Glysson & Gray 2002). The most concentrated sediment releases come from construction activities, both large and small in scale.

The construction SWPPP is a plan that provides direction on how erosion and sediment transport will be minimized during construction activities through best management practices, and how the soil will be stabilized following construction. Native revegetation is a permanent, self-sustaining soil stabilization solution adapted to the local semi-arid climate. Perennial plants stabilize the soil with an extensive, permanent root system. Seeding native plants requires pre-planning and careful early assistance for quick and successful establishment.

I.1. SCHEDULE SEEDING

- Seeding: Earliest start is June 1. All seeding work must be completed by August 15. Seeding work in higher elevation climates must be completed by August 1.

  Reason for seeding dates:
  High nighttime temperatures are required for many native species to germinate.
  Seedlings need time during the warm growing season to become established before winter.
  Seeding too late will cause a project to fail.

- Coordinate with the landscaping contractor and the customer for all seeding work to be performed between June 1 and August 15. The seeding work will commonly need to be delayed until the next summer after construction is completed. If delayed until the following summer, strategize for the landscaping contract to be extended or amended as appropriate to meet the seeding date requirements.

- Suggestions for selecting a landscaping contractor:
  - Check references
    - Request references from previous native seeding jobs.
    - Ask reference sources specifically about: timeliness of job beginning and completion, quality of work, quality of materials, quality of equipment, and project success.
    - Hire a landscaping contractor who has a history of meeting the project timelines, who provides good quality throughout the project and has successful projects. There is enormous value in checking references; it will improve project efficiency, improves success and result in significant cost savings.

I.2. STOCKPILE TOPSOIL

- Topsoil must be removed to a depth of 8 inches from the entire area that will be cleared or graded and stockpiled. Topsoil must be saved and set aside for successful seeding.

  Topsoil is the upper, outermost layer of soil that contains the highest concentration of organic matter and microorganisms. Plants generally concentrate their roots in and obtain most of their nutrients from this layer.

- Prevent accidental use of stockpiled topsoil. Use signage to clearly label it: "TOPSOIL: FOR POST-CONSTRUCTION SEEDING ONLY." The stockpiled topsoil must have best management practice (BMP) protections to prevent soil loss during construction.

I.3. PLAN POST-SEEDING WATERING

Water is absolutely essential for native plant germination and seedling development. Summer rains are highly variable and cannot be relied on for adequate moisture. A planned initial watering period will greatly improve the odds of a permanently successful seeding project.

Pre-construction planning allows for timely implementation. Decisions made with all supplies ordered and ready for use is essential to meet the critical and short seeding timeframe.

- Coordinate with the customer to:

  - Clearly identify the responsible party who will be performing the post-seeding watering (i.e. the landscaping contractor or other construction contractor).

  - Ensure the watering schedule and access to a hydrant or other water source will work with the customer's schedule. Plan for pedestrian, traffic and other areas as necessary with hose-protection ramps or other accommodations.

- Determine water application method.
  Watering method must be able to cover entire seeded area.
  Pre-construction planning allows for most expedient watering implementation.

  Suggested watering methods:

  - "Big Sprinkler": Maximum radius at full pressure is 210 feet. Requires attachment to fire hydrant or other water source. See http://bigsprinkler.com/.

  - PVC Spinkler Sytem: May be a temporary above ground system or a permanent below ground system.

  - Water truck: Restricted spray radius. This water application technique is very limited and is primarily useful only around the edge of sites.

- Plan watering schedule and incorporate into overall construction schedule.

  Water applications must be started by:
  - August 15 for Sandoval, Santa Fe, and Los Alamos counties, completed by October 1.
  - August 30 for Bernalillo and Sandoval counties, completed by October 15.

  Site should be watered for a minimum of 42 days for successful germination and seedling growth. See Section II.8. "Supplemental Watering" for a suggested schedule and detailed watering information.

  For accurate watering a flow meter needs to be installed.

I.4. DETERMINE HYDRAULIC SEEDING AREAS

Evaluate the planned post-construction gradient and slopes. Slopes greater than 3:1 (horizontal:vertical) will require hydraulic seeding.

- If hydraulic seeding will be needed, refer to "Seeding on slopes greater than 3:1" in Section II for guidance.

Areas planned for hydraulic seeding may require mini-benching or other soil erosion control techniques applied prior to seeding. These areas require additional planning and time for proper implementation. A hydroseeding contractor will need to be scheduled and budgeted. These issues need to be incorporated into the overall construction schedule and budget in order for timely implementation of post-construction seeding work.

A list of hydraulic seeding and mulching contractors in New Mexico is provided in Appendix VI.

- Suggestions for selecting a hydraulic seeding and hydraulic mulching contractor:

  - Discuss the project with potential contractors. The contractor should ask questions about the project such as: the project goals, site location, slope dimensions and steepness, how long the hydraulically applied products will need to provide slope protection and provide seed protection, if any critical areas need to be protected. Tell the potential contractor that a two-step process is needed, that a seed list and the seeding rate will be provided to the contractor. See section II.5.B. HYDRAULIC SEEDING for additional information on hydraulic seeding.

  - Check references

    - Request references from previous native seeding jobs.
    - Ask reference sources specifically about: timeliness of job beginning and completion, quality of work, quality of materials, quality of equipment, and project success.
    - Hire a hydraulic seeding contractor who has a history of meeting the project timelines, who provides good quality throughout the project and has successful projects. There is enormous value in checking references; it will improve project efficiency, improves success and result in significant cost savings.

II. SEEDING PROCEDURE

II.1. DETERMINE ECOREGION

The EPA has delineated New Mexico into discrete Level IV ecoregions, where areas of ecosystem likeness are classified together. Seed lists are organized by ecoregions due to similarity in habitat, climate, and soils, which all determine the composition of native species.

Determine what ecoregion the project is located in. Refer to the "Ecoregion Map for Valencia, Bernalillo, Sandoval, Los Alamos and Santa Fe Counties" in Appendix I. to identify the zone number of the project.

Example 1: Santa Fe is located in ecoregion 22h.
Example 2: South of Cochiti Reservoir areas that are immediately adjacent to the Rio Grande are ecoregion 22g.

II.2. REVIEW ECOREGION INFORMATION

Find the ecoregion written description and its associated seed list in Appendix II.

- Read the ecoregion description to verify that you have matched the project site to the correct ecoregion.

- Review the seed list for your project's ecoregion. Verify species availability with commercial seed suppliers. Granite Seed and Curtis & Curtis provide good selections of New Mexico native seeds. For a list of seed suppliers, see Appendix III.

- Send your seed list to seed suppliers to verify availability. Choose a supplier who can provide a minimum of 12 of the species listed on the seed list. All the listed species are available commercially but the in-stock supply may vary.

    - Seeding is much more likely to be successful with the widest range of plant types and species whenever using general seed lists. A wide diversity of species allows for variations within a habitat to be filled by the appropriate species. Not all species will germinate and mature in all microhabitats where they are seeded.

II.3. DETERMINE SEEDING RATES

- Determine the pounds of pure live seed (PLS) for each species.
    Note: The total seed weight provided by the seed supplier will be much greater than the pounds of PLS weight due to the presence of non-viable seeds and other material such as chaff and plant debris.

- Determine acreage of the area to be seeded, all slopes and flat areas.

- Review the available seed list sent by the supplier and the recommended pounds of PLS/acre for each species.

- Proportionally adjust the seeding rate of each species so that the total rate is 60 pounds of PLS/acre for all ecoregions.

Note:Species with very high seeding rates may need to be adjusted down more than those with low seeding rates to allow for all species to remain at reasonable seeding rates.

The high seeding rate of 60 pounds PLS/acre is necessary:

1.) To compete against the invasive weed seeds that are likely present in the soil.
2.) To provide an adequate number of seeds for the species that are appropriate to the area. Not all species in the seed mix will germinate and mature due to microclimate, soil, etc differences between sites within the same ecoregion. For example, different species will be present and/or abundant on a south-facing versus a north-facing slope. The wide variety of species in the mix and high seeding rate attempts to enable those species best suited to each microclimate to become established in sufficient numbers to achieve the SWPPP goal of 70% coverage within 3 years.

Example of available seed species prorated to a total of 60 Pounds of PLS/Acre:

Ecoregion 21c. Crystalline Mid-Elevation Forests ecoregion:

Scientific Name	**Common Name**	**Veg Type**	**Habitat Notes**	**Seeding Rate: Pounds PLS/acre**	**Adjusted Seeding Rate: Pounds PLS/acre**
Andropogon gerardi	Big bluestem	Warm Grass		7	5
Bouteloua curtipendula	Sideoats grama	Warm Grass	Shallow well-drained rocky sites.	3 to 6	5
Bouteloua gracilis	Blue grama	Warm Grass		2 to 3	3
~~Elymus glaucus~~	~~Blue wildrye~~	~~Cool Grass~~	~~Aspen zone up to spruce/fir zone~~	~~5~~	~~5~~ Not available at the time of ordering
Festuca arizonica	Arizona fescue	Cool Grass		3	2
Linum lewisii	Blue flax	Perennial		8	7
Oenothera elata ssp. hirsutissima (Synonym: Oenothera hookeri)	Hooker evening primrose	Biennial		2	1
Pascopyrum smithii (Synonym: Agropyron smithii)	Western wheatgrass	Cool Grass		10	8

Ratibida columnifera	Prairie coneflower	Perennial		2	1
Rhus trilobata	Three leaf sumac	Shrub		5 to 10	7
Rosa woodsii	Woods rose	Shrub		20 to 30	15
Schizachyrium scoparium	Little bluestem	Warm Grass		3 to 4	3
Symphoricarpos oreophilus	Mountain snowberry	Shrub		5	3

Note: The seed supplier may be able to proportionally adjust the PLS/acre rate of each species to a total rate of 60 pounds PLS/acre.

II.4. SOIL PREPARATION

Proper soil preparation will enhance the growth of seeded vegetation and aid in reducing soil erosion.

- Topsoil: The stockpiled topsoil should be evenly distributed across the top of all areas to be seeded and tilled or similarly blended into the upper 12 inches of soil.
- Soil pH: pH of soil should be within the range of 6.5 – 7.8.

    - pH testing is most accurately conducted using a soil pH meter, which can be purchased relatively inexpensively at any garden or home improvement store. Follow the meter testing instructions: dig a small hole in the soil 2-4 inches deep, loosening the soil and removing twigs or other debris. Fill the hole with distilled water until a muddy pool is at the bottom of the hole. Insert the test probe into the mud. Hold the tester in the mud for 60 seconds and take a reading.

    - Take several soil pH measurements across the site. A single reading may be anomalous; it's best to generally average the site pH from several locations.

- Soil amendments

    - Fertilizer should never be used because it can burn native seedlings. Additionally, weed species are generally enhanced by nitrogen fertilizers, allowing them to outperform native species.

    - No soil amendments, other than native topsoil blended into the upper 12 inches of soil, are needed for native plants.

- Soil compaction

The upper 1-2 feet of soil cannot be heavily compacted. Native plants require pore spaces in the soil for root soil moisture, gas exchange, and elongation.

- Compaction anywhere on the site is not to exceed either: 200 pounds per square inch (PSI) or 75-85% of the maximum dry density.

Note: a "soil compaction tester" may be purchased from a forestry supplier or at Amazon.com.

If soil compaction exceeds either of these specifications the soil must be tilled or ripped a minimum of 12 inches deep.

- Surface roughness

A roughened soil surface is much less erodible than a smooth, rolled, or compacted surface. A roughened surface improves seed germination, slows runoff and increases infiltration, which traps sediment and reduces the volume of sediment-laden runoff.

Soil roughening works in well with most soil stabilization techniques, such as hydraulic seeding and mulches that can be applied over the surface roughness treatment. The surface roughness provides a permanent slope surface arrangement that works in conjunction with the short-term soil stabilization and permanent vegetation to provide an effective erosion control system.

- Soil roughening techniques using heavy equipment for erosion control (Forrest et al.):

1. Bulldozers can be used to track-walk up and down slopes less than 3:1. Compared to bare soil control (smooth, compacted surface) track-walking reduces erosion by 52%. Track-walking must be oriented up and down slopes, if track-walked across a slope erosion is accelerated. (Figure 1 in Appendix IV.)

2. Sheep's-foot rollers, normally used for compacting soils, can be employed to "dimple" the soil surface. Compared to bare soil control (smooth, compacted surface) sheep's-foot rolling reduces erosion by 54%. (Figure 2 in Appendix IV.)

3. Tines on the backside of bulldozers can be used on the contour to create surface roughness (Figure 3 in Appendix IV.)

4. Imprinting equipment, invented to address re-vegetation issues in desert climates can create a unique, moisture holding and vegetation supportive depression in the soil. Compared to bare soil control (smooth, compacted surface) imprinting reduces erosion by 76%. (Figure 4 in Appendix IV.)

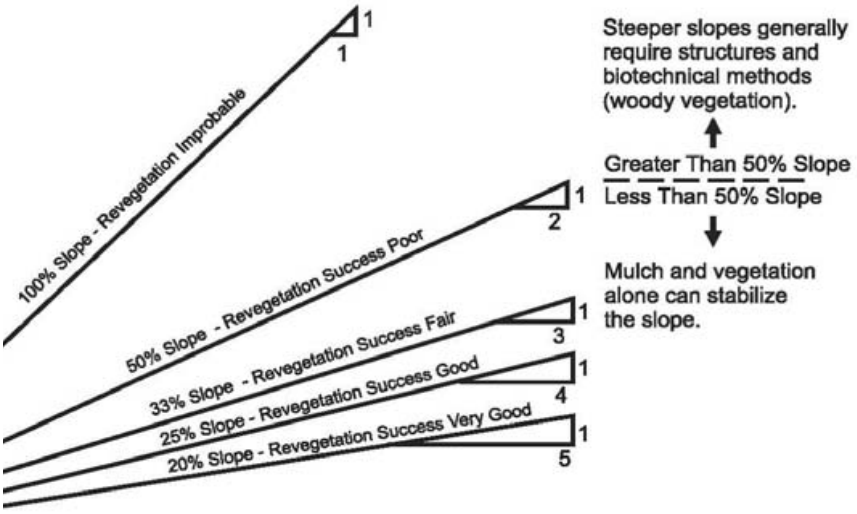
5. Slope boarding is beneficial in creating contour erosion-reducing soils structure and also assists in keeping seed and mulch on a steep slope (Figure 5 in Appendix IV.)

Additional soil roughening information is provided in Appendix IV.

II.5. SEEDING ON SLOPES STEEPER THAN 3:1 (HORIZONTAL:VERTICAL)

Slopes are notoriously difficult to establish native vegetation on. Successfully growing native vegetation on slopes is essential because bare slopes erode very easily when precipitation and

wind occur. The root systems of perennial native vegetation provide slope stabilization and reduce sediment losses.



This illustration shows the likelihood of success when only vegetation is used to stabilize slopes of varying steepness.

Figure 1. Slope steepness and revegetation success without the use of structural controls. (Coburn, et al.)

II.5.A. SLOPE PREPARATION: MINI-BENCHES

Mini-benching is a stormwater best management practice (BMP) used on difficult slopes that are steep and/or very long to promote vegetation growth and reduce erosion. Properly designed and constructed mini benches capture rainwater where it falls, slowing run-off and increasing water retention. This results in improved infiltration and increased water retention for vegetation establishment in arid environments. (ADOT1)

Mini-benching BMP pre-vegetation

Mini-benching with seeded vegetation

Mini benches will soften in appearance over several years. Including larger shrubs in the seed mix can also help to blend slopes with surrounding vegetative cover.

- Where to use: mini-benching is useful on large cut slopes (more than 15 feet high), slopes that are steeper than 3:1 or slopes constructed in highly erodible soils.

- Soil compaction: the top 12" or more of soil must be only loosely compacted with compaction not to exceed 75-85% of the maximum dry density. Native seeds require pore spaces in the soil to allow for root development, and to provide water and air to the roots for water uptake and gas exchange. Tracked type wheels more evenly distribute the weight of the equipment across a larger area to reduce compaction and beneficially add to soil roughness.

- When to construct: Mini benches are constructed from the top of a cut slope down, as the slope is constructed; dimensions depend on the slope ratio. Refer to the ADOT Erosion and Pollution Control Manual (Chapter 5, Part One) for information regarding detailing and construction.

(ADOT1 & ADOT2)

Mini-benching construction specifications are provided in Appendix V.

II.5.B. HYDRAULIC SEEDING

All slopes equal to or greater than 3:1 need to be hydraulically seeded, also known as hydroseeding. The hydraulic seeding process uses a slurry of seed and small amount of mulch that is sprayed from a truck or tank over prepared ground.

Seed being hydraulically applied to slope

- A 2-step application should always be used to insure essential seed-to-soil contact for germination and rooting. A 1-step application method should never be used because a great deal of mulch is included in the slurry and interferes with seed-to-soil contact.

  - 2-Step Application Method: the first step applies the seed directly to the soil, along with tackifier and a small amount of mulch to cushion the seed as it goes through the pump. The second step applies the mulch along with some tackifier to adhere the mulch in place. Tackifiers aid in slope stabilization and help adhere the hydraulic slurry in place on the slope.

- Choosing a hydraulic seeding product.

  The two important aspects in choosing hydraulic seed products are: longevity and slope. Discuss these items with your hydraulic seeding contractor to choose appropriate products. Mulch and tackifier are involved in the slurry for hydraulic mulching, as well as seed in

hydraulic seeding slurry. Based on the project needs, the hydraulic seeding contractor may recommend a pre-mixed product such as a Flexible Growth Medium or an Engineered Fiber Matrix.

◆ Longevity: calculate how long the hydroseed will need to remain in place until the late-summer monsoons arrive. If uncertain when the project will be completed and the slope will be hydroseeded, be conservative. With increasingly unpredictable monsoon seasons and frequently low winter moisture, overestimate the time the hydraulic application will need to remain in pace before moisture arrives will provide the most success. To insure the most stable slope and the best seeding results, estimate the hydraulic application will need to remain in place for a minimum of 16-24 months.

- Suggested product: Flexterra or Pro-matrix by Profile Products or similar. http://www.profileevs.com/hydraulic-erosion-control-products-hecps

◆ Slope: length, steepness, and critical area protection. Very long slopes, slopes that are very steep (greater than 2:1), and critical areas that need to be protected (i.e. building, lake or river) below the slope are all situations that pose site-specific challenges. These slopes need a hydraulically applied matrix that is extremely strong and long-lasting.

- Suggested product: CocoFlex or Flexterra by Profile Products or similar http://www.profileevs.com/hydraulic-erosion-control-products-hecps

- Avoid using wood chips or bark in a hydromulch; wood products perform poorly in semi-arid climates.

- Hydraulic seeding products are highly variable in quality. A high quality product should always be used in order to provide temporary slope stabilization and durable seed protection until adequate moisture allows for germination and seedling development.

◆ Seeding rate: the hydraulically applied seeding rate is 45 pounds of PLS per acre. (See Section II.3. for additional details.)

A list of hydraulic seed and mulch contractors in New Mexico is provided in Appendix VI.

II.6. Seeding on Slopes Less Than or Equal to 3:1

Gradual slopes and flatter areas should be drill seeded. Drill seeding allows for good seed-to-soil contact, which is essential for the seeds to take up soil moisture.

Drill seeder attached to a tractor

- Drill Seeding Depth

  Seed placement depth is a critical factor affecting seedling emergence and survival. A shallow seeding depth generally yields high rate of seedling emergence, but more soil moisture is generally found with increasing depth.

- Most native grasses should be seeded ¼- to ½-inch deep.
  For all-around seeding in moderate climates, the drill seeder should be set to 3/8-inch depth.

- Some cool-season native grasses such as wheatgrass and Indian ricegrass can be seeded deeper, between ½- and 1-inch deep.
  For cooler climates with regular winter snowfall, the drill seeder should be set to ½-inch depth or for very cold winter climates to ¾-inch depth.

- Drill Seed Application

  The site should be drill seeded in two passes at a 90° angle. Half of the seed is to be drilled with each pass. If half the seed mix exceeds the drill seeder capacity, three passes may be utilized, with the third pass at a 45° angle.

  - The amount of driving in the same direction should be minimized to prevent over-compaction.

II.7. SEED PROTECTION: MULCH

Mulch greatly aids in preserving the limited soil moisture of semi-arid New Mexico and providing erosion protection until a vegetative cover can be established.

- Certified Weed Free.
  Certified noxious weed free materials are essential, especially if hay or straw is used. Using contaminated mulch often results in an unsuccessful project due to faster germinating weeds outcompeting the native species for site establishment. Additionally, this can introduce noxious weeds into a new area and disrupt the local ecology.

  Purple and yellow twine is used to certify bales and forges that meet the standards of the North American Weed Free Forage Certification Program. An orange label is used to identify products certified by the New Mexico State University (NMSU) Seed Certification program.

- A variety of materials can provide effective mulch such as gravel, straw or hydromulch. When choosing mulch material, consider how long the mulch will need to stay in place prior to, and during supplemental watering or monsoon rains.

  - Gravel mulch: a single thin or intermittent layer of ¾- to 1-inch rounded gravel. No fractured face or crushed gravel to avoid mineral precipitates from potentially leaching out of the rock. Nighttime cooling aids soil moisture by allowing dew formation between and under rocks. Beyond initial mulch material, gravel permanently aids the seeded plant community through soil moisture retention.

- If gravel is used, the site should be seeded in sections with the mulch applied immediately after seeding by driving backward as the gravel is feathered out across each section. This prevents the gravel from being compacted into the soil. The mulch equipment should be tracked or use low pressure high flotation tires to reduce soil compaction.

◆ Certified weed free hay or straw, firmly crimped into the soil. The mulch should be applied so it is dense enough to shade the soil and prevent wind desiccation.

- The appropriate applied thickness of straw or hay mulch generally corresponds to an application rate of 1 to 2 tons per acre.

- Proper crimping is essential. If the straw or hay is not firmly crimped it can all easily be blown off site during a windstorm,

◆ Hydraulically applied mulch. If relying only on natural precipitation, a quality hydromulch applied over a drill-seeded or hydraulically seeded area can provide soil stabilization and seed protection for a long time. Verify the mulch is weed free and avoid wood chips or wood bark in the mulch. Refer to section **II.5.B. HYDRAULIC SEEDING** for additional information on hydraulically applied mulch.

- Avoid using wood chips or bark as a mulch. Wood products perform poorly in semi-arid climates.

A list of certified weed-free hay and straw suppliers in New Mexico is provided in Appendix VII.

II.8. SUPPLEMENTAL WATERING

Water is absolutely essential for native plant germination and seedling development. Summer rains are highly variable and cannot be solely relied on for adequate moisture. Adhering to a pre-planned watering schedule will insure adequate germination and growth. During initial germination and seedling development the top few inches of soil needs to remain moist. As seedlings progress the soil should progressively be watered more deeply and less frequently.

The site should be watered for a minimum of 42 days for successful germination and seedling growth in all ecoregions:

Date Range	Watering Frequency	Time of Watering	Water Applied per Watering Event (Rainfall Equivalent)	Number of Applications
Days 1-14	2 x day	Morning	.20 inch	14
		Evening	.20 inch	14
Days 15-28	1 x day	Morning or Evening	0.40 inch	14
Days 29-42	Every other day	Morning or Evening	.50 inch	7

*If schedule is cost prohibitive, during the first 14 days only morning watering may be employed. Best results will be achieved with watering twice daily during the first 14 days.

- How to determine the correct amount of water to apply:

  1.) Measure the area in acres that is wetted by each "Big Sprinkler" location.
  - Determine wetted square footage of the circle ($pi*r^{2)}$:
    Measure the radius (in feet).
    Square the radius.
    Multiply the answer by pi (3.142). → This is the circular square footage.

  Example: Radius = 50 feet
  50 feet*50 feet = 2,500 ft^2
  2,500 ft^2*3.412 = 7,855 ft^2 → Circular square footage

  If circular square footage is not needed, just multiply the rectangular length*width to determine square footage.

  Example: 78.55 feet * 100 feet = 7,855 ft^2

  - Convert to acreage: (1 Acre = 43,560 ft^2)
    Divide the circular square footage by 43,560 ft^2

  Example: 7,855 ft^2/43,560 ft^2 = .18 acres

  2.) Determine how many gallons to apply per "Big Sprinkler" location for desired inches of rain equivalent.

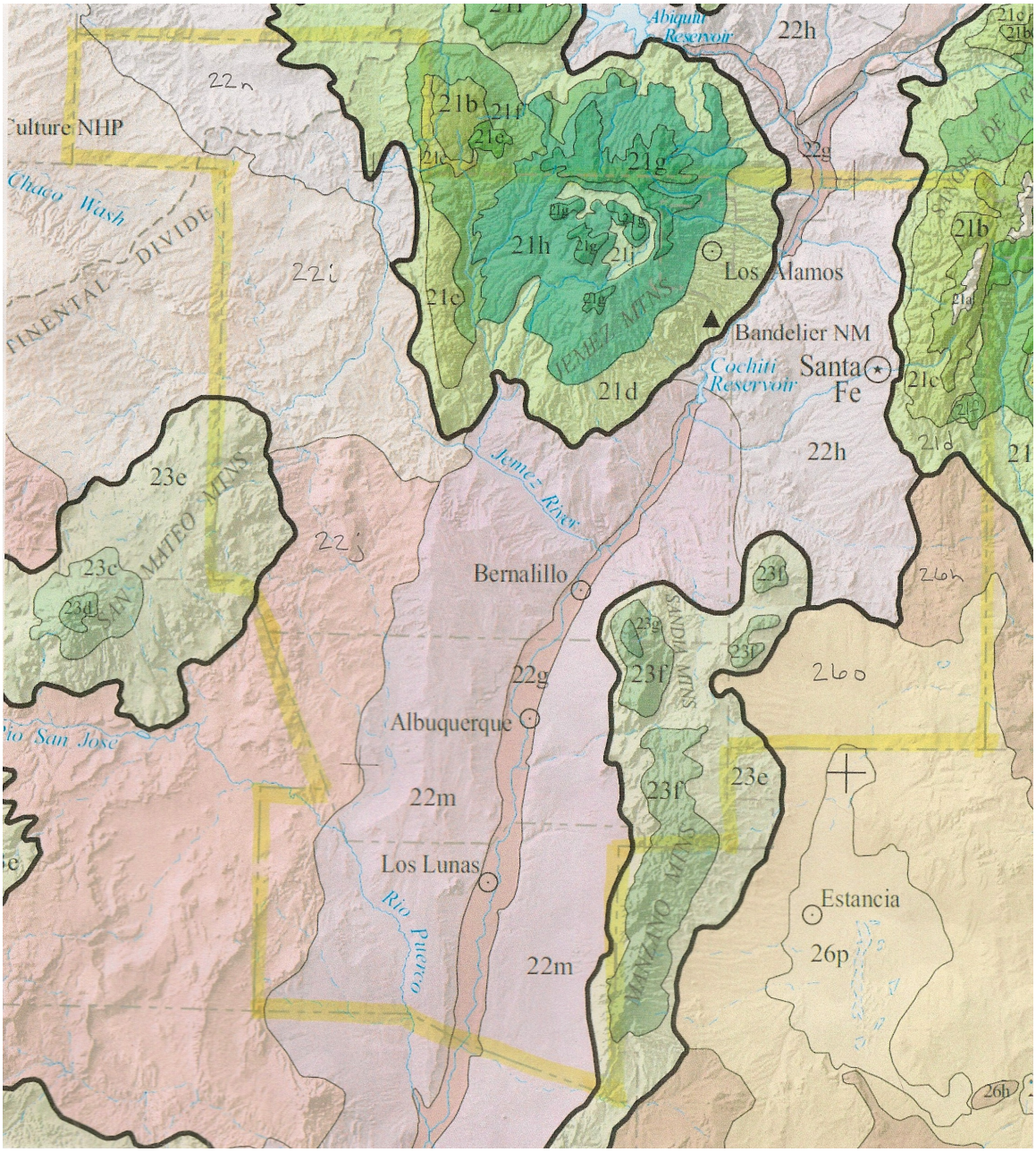
  Equivalent inches of rain and gallons of water:

$$\text{Gallons} = \frac{\text{Desired inches of rain} * \text{Wetted acreage} * 6272640\ in^2}{231\ in^3}$$

  Conversions: 6272640 in^2 = 1 acre, 231 in^3 = 1 gallon

  Example: Gallons = (0.2 inches * 0.18 acres * 6272640 in^2 per acre) / 231 in^3
  Gallons needed to apply .20 inches of water on .18 acres = 977

APPENDIX I. ECOREGION MAP FOR VALENCIA, BERNALILLO, SANDOVAL, LOS ALAMOS AND SANTA FE COUNTIES



(USEPA3)

US EPA Level IV Ecoregion Map: this ecoregion reference map allows for the seeding project to be located within the correct ecoregion.

"Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources; they are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components." (USEPA3)

APPENDIX II. NEW MEXICO ECOREGIONS: VALENCIA, BERNALILLO, SANDOVAL, LOS ALAMOS, AND SANTA FE COUNTIES

All ecoregion descriptions provided in this Appendix are taken directly from "Ecoregions of New Mexico," produced by the United States Environmental Protection Agency (EPA) (USEPA3).

21. Southern Rockies

"The Southern Rockies are composed of high elevation, steep, rugged mountains. Although coniferous forests cover much of the region, as in most of the mountainous regions in the western United States, vegetation, as well as soil and land use, follows a pattern of elevational banding. The lowest elevations are generally grass or shrub covered and heavily grazed. Low to middle elevations are also grazed and covered by a variety of vegetation types including juniper-oak woodlands, ponderosa pine, aspen, and Douglas-fir. Middle to high elevations are largely covered by coniferous forests and have little grazing activity. The highest elevations have alpine characteristics. Numerous perennial mountain streams with decidous riparian vegetation support coldwater fisheries and serve as wildlife corridors." (USEPA3)

21a. "The **Alpine Zone** occurs on mountain tops above treeline, beginning at about 11,000 to 11,500 feet in New Mexico. It includes alpine meadows as well as steep, exposed rock, talus, and glaciated peaks. Annual precipitation ranges from 25 to greater than 50 inches, falling mostly as snow. Vegetation includes low shrubs, cushion plants, and wildflowers and sedges in wet meadows. The forest-tundra interface is sparsely colonized by stunted, deformed Englemann spruce, subalpine fir, and sometimes bristlecone pine and snow willow (krummholz vegetation). Ecoregion 21a is snow-free only 8 to 10 weeks annually. Snow cover is a major source of water for lower, more arid ecoregions." (USEPA3)

No seed list for ecozone 21a. due to lack of commercially available seed.
This ecoregion only occurs at one location in Santa Fe County on United States Forest Service (USFS) land. A SWPPP is unlikely here due to its inaccessibility and habitat fragility. Seeding in this area would be under USFS oversight.

21b. "The **Crystalline Subalpine Forests** ecoregion occupies a narrow elevational band on the steep, forested slopes of the mountains, becoming more extensive on the north slopes. The elevation range in New Mexico is generally 9000 to 11,500 feet, just below the Alpine Zone (21a). Dense forests are dominated by Englemann spruce and subalpine fir; aspen locally dominates some areas. Subalpine meadows also occur. Forest blowdown, insect outbreaks, fire, and avalanches affect the vegetation mosaic. Soils are weathered from a variety of crystalline and metamorphic materials, such as gneiss, schist, and granite, as well

as some areas of igneous intrusive rocks. Recreation, logging, mining, and wildlife habitat are the major land uses." (USEPA3)

Included in this ecoregion: Santa Fe Ski Area

No seed list for ecozone 21b. due to lack of commercially available seed. *Festuca arizonica* is the only seed species that may be available commercially. Permanent structures and roads are very uncommon in this ecoregion. Nearly all land in this ecoregion is USFS land. In the rare event that a SWPPP may be opened in this ecoregion, a site-specific survey must be done and coordinated with commercially available plants for site stabilization due to lack of commercially available seed.

21c. "The **Crystalline Mid-Elevation Forests** are found mostly in the 8000 to 10,000 feet elevation range on crystalline and metamorphic substrates. Natural vegetation includes ponderosa pine, aspen, Douglas-fir, and areas of limber pine. A diverse understory of shrubs, grasses, and wildflowers occurs. The variety of food sources supports a diversity of bird and mammal species. Forest stands have become denser in many areas due to decades of fire suppression. Land use includes wildlife habitat, livestock grazing, logging, mining, and recreation." (USEPA3)

Included in this ecoregion: road to Santa Fe ski area

Commercially available species for 21c. Crystalline Mid-Elevation Forests ecoregion:

Scientific Name	Common Name	Veg Type	Habitat Notes	Seeding Rate: Pounds PLS/acre
Andropogon gerardi	Big bluestem	Warm Grass		7
Bouteloua curtipendula	Sideoats grama	Warm Grass	Shallow well-drained rocky sites.	3 to 6
Bouteloua gracilis	Blue grama	Warm Grass		2 to 3
Elymus glaucus	Blue wildrye	Cool Grass	Aspen zone up to spruce/fir zone	5
Festuca arizonica	Arizona fescue	Cool Grass		3
Linum lewisii	Blue flax	Perennial		8
Oenothera elata ssp. hirsutissima (Synonym: Oenothera hookeri)	Hooker evening primrose	Biennial		2
Pascopyrum smithii (Synonym: Agropyron smithii)	Western wheatgrass	Cool Grass		10
Ratibida columnifera	Prairie coneflower	Perennial		2
Rhus trilobata	Three leaf sumac	Shrub		5 to 10
Rosa woodsii	Woods rose	Shrub		20 to 30

Schizachyrium scoparium	Little bluestem	Warm Grass		3 to 4
Symphoricarpos oreophilus	Mountain snowberry	Shrub		5

(Payne 2013)

To determine seeding rate refer to page 3, section II.3. "Determine Seeding Rates."

21d. "The **Foothill Woodlands and Shrublands** ecoregion is the low elevation portion of the Southern Rockies, and extends from southern Wyoming through Colorado and into New Mexico. In New Mexico, it is a transition area from the higher elevation forests to drier and lower plains (Ecoregion 26) and plateaus (Ecoregions 20, 22). Within the region, some flora and fauna species on the east side (Great Plains) may differ from those found to the west (Great Basin influence). This semiarid region has rolling to irregular terrain of hills, ridges, and footslopes, with elevations mostly 6000 to 8500 feet, and a variety of rock and soil types. In New Mexico, pinyon-juniper and oak woodlands are dominant." (USEPA3)

Included in this ecoregion: Los Alamos & Bandelier National Monument

Commercially available species for 21d. Foothill Woodlands and Shrublands ecoregion:

Scientific Name	Common Name	Veg Type	Habitat Notes	Seeding Rate: Pounds PLS/acre
Achnatherum hymenoides (Synonym: Oryzopsis hymenoides)	Indian ricegrass	Cool Grass	Coarse textured & sandy soils, drought tolerant.	6 to 8
Berlandiera lyrata	Chocolate flower	Perennial		3 to 4
Bouteloua curtipendula	Sideoats grama	Warm Grass	Shallow well-drained rocky sites.	3 to 6
Bouteloua gracilis	Blue grama	Warm Grass		2 to 3
Cercocarpus montanus	Mountain mahogany	Shrub		10
Ericameria nauseosa (Synonym: Chrysothamnus nauseosus)	Rubber rabbitbrush	Shrub		1
Fallugia paradoxa	Apache plume	Shrub		1 to 2
Hesperostipa neomexicana (Synonym: Stipa neomexicana)	New Mexico feathergrass	Cool Grass	Sandy, hot, dry sites.	6
Muhlenbergia wrightii	Spike muhly	Warm Grass		2
Pascopyrum smithii (Synonym: Agropyron smithii)	Western wheatgrass	Cool Grass		10
Pleuraphis jamesii (Synonym: Hilaria jamesii)	Galleta	Warm Grass		2 to 5
Rhus trilobata	Three leaf sumac	Shrub		5 to 10

Schizachyrium scoparium	Little bluestem	Warm Grass		3 to 4
Sphaeralcea coccinea	Scarlet globemallow	Perennial		1
Sporobolus cryptandrus	Sand dropseed	Warm Grass	Adapted to shallow, calcareous & sandy sites. (Calcareous soils are relatively alkaline (high pH).)	1

(Payne 2013)

To determine seeding rate refer to page 3, section II.3. "Determine Seeding Rates."

21g. "The steep, mountainous **Volcanic Subalpine Forests** ecoregion is composed of Tertiary or Quaternary volcanic rocks, primarily in the southern extension of the San Juan Mountains from Colorado and in parts of the Brazos, Jemez, and Taos mountains of New Mexico. Relatively young geologically, the high, rugged mountains still contain some large areas of intact habitat. Englemann spruce, subalpine fir, and aspen forests support a variety of wildlife." (USEPA3)

Included in this ecoregion: Highest elevation regions of Jemez Mountains

No commercially available seed list for ecozone 21g.
Festuca arizonica is the only seed species that may be available commercially. Permanent structures and roads are very uncommon in this ecoregion. Nearly all land in this ecoregion is USFS land. In the rare event that a SWPPP may be opened in this ecoregion, a site-specific survey must be done and coordinated with commercially available plants for site stabilization due to lack of commercially available seed.

21h. "The **Volcanic Mid-Elevation Forests** ecoregion occurs at elevations of about 7500 to 10,000 feet and is composed of igneous rocks of andesite and basalt. The majority of the region is found in the Jemez Mountains with smaller, scattered areas to the north and east. Forests of ponderosa pine, Douglas-fir, and aspen occur. Land use includes wildlife habitat, livestock grazing, logging, and recreation." (USEPA3)

Included in this ecoregion: Jemez mountains, except highest elevations.

Commercially available species for 21h. Volcanic Mid-Elevation Forests ecoregion:

Scientific Name	Common Name	Veg Type	Habitat Notes	Seeding Rate: Pounds PLS/acre
Bouteloua gracilis	Blue grama	Warm Grass		2 to 3
Castilleja linariaefolia	Narrowleaf Indian paintbrush	Perennial		1
Cercocarpus montanus	Mountain mahogany	Shrub		10

Deschampsia caespitosa	Tufted hairgrass	Cool Grass		1 to 2
Elymus glaucus	Blue wildrye	Cool Grass	Aspen zone up to spruce/fir zone	5
Festuca arizonica	Arizona fescue	Cool Grass		3
Festuca brachyphylla (Synonym: Festuca ovina var. brachyphylla)	Sheep fescue	Cool Grass	Well-drained, medium textured soils	10
Hesperostipa comata (Synonym: Stipa comata)	Needle and thread	Cool Grass	Shallow, calcareous, sandy, & gravelly sites. (Calcareous soils are relatively alkaline (high pH).)	8
Linum lewisii	Blue flax	Perennial		8
Lobelia cardinalis	Cardinal flower	Perennial		1 to 4
Muhlenbergia wrightii	Spike muhly	Warm Grass		2
Ratibida columnifera	Prairie coneflower	Perennial		2
Rhus trilobata	Three leaf sumac	Shrub		5 to 10
Robinia neomexicana	New Mexican locust	Tree		10
Schizachyrium scoparium	Little bluestem	Warm Grass		3 to 4
Symphoricarpos oreophilus	Mountain snowberry	Shrub		5

(Payne 2013)

To determine seeding rate refer to page 3, section II.3. "Determine Seeding Rates."

21j. "The **Grassland Parks** ecoregion, occurring primarily in Colorado, consists of high intermontane valleys with sufficient water availability to support grasslands and wet meadows. In New Mexico, the ecoregion is found in the Valle Grande/Valle San Antonio area in the Jemez Mountains, in the Moreno Valley and Costilla-Comanche-Valle Vidal areas in the Sangre de Cristo Mountains, and on top of Johnson Mesa near Raton. Grasslands with bunchgrasses are dominant, and include Parry's oatgrass, Arizona fescue, Idaho fescue, Thurber fescue, mountain muhly, bluebunch wheatgrass, needle-and-thread grass, Junegrass, and slender wheatgrass. There are only a few trees or shrubs, and if present, they are widely scattered and mature. Some springs and wetlands occur. Large elk herds are found in the valley parklands." (USEPA3)

Included in this ecoregion: Valles Caldera National Preserve

Commercially available species for 21j. Grassland Parks ecoregion:

Scientific Name	Common Name	Veg Type	Habitat Notes	Seeding Rate: Pounds PLS/acre
Bouteloua eriopoda	Black grama	Warm Grass		2 to 3
Bouteloua gracilis	Blue grama	Grass Grass		2 to 3
Deschampsia caespitosa	Tufted hairgrass	Cool Grass		1 to 2

Elymus glaucus	Blue wildrye	Cool Grass	Aspen zone up to spruce/fir zone	5
Festuca arizonica	Arizona fescue	Cool Grass		3
Festuca brachyphylla (Synonym: Festuca ovina var. brachyphylla)	Sheep fescue	Cool Grass	Well-drained, medium textured soils	10
Hesperostipa comata (Synonym: Stipa comata)	Needle and thread	Cool Grass	Shallow, calcareous, sandy, & gravelly sites. (Calcareous soils are relatively alkaline (high pH).)	8
Iris missouriensis	Rocky Mountain Iris	Perennial		12
Linum lewisii	Blue flax	Perennial		8
Ratibida columnifera	Prairie coneflower	Perennial		2
Rhus trilobata	Three leaf sumac	Shrub		5 to 10
Schizachyrium scoparium	Little bluestem	Warm Grass		3 to 4
Symphoricarpos oreophilus	Mountain snowberry	Shrub		5

(Payne 2013)

To determine seeding rate refer to page 3, section II.3. "Determine Seeding Rates."

22. Arizona/New Mexico Plateau

"The Arizona/New Mexico Plateau represents a large transitional region between the drier shrublands and wooded higher relief tablelands of the Colorado Plateaus (20) in the north, the lower, hotter, less vegetated Mojave Basin and Range (14) in the west, and forested mountain ecoregions that border the region on the northeast (21) and south (23). Local relief in the region varies from a few feet on plains and mesa tops to well over 1000 feet along tableland side slopes. The Continental Divide splits the region, but is not a prominent topographic feature. The region extends across northern Arizona, northwestern New Mexico, and into Colorado in the San Luis Valley. Gunnison prairie dogs are a keystone species in many of the sagebrush ecosystems and their burrows provide habitat for other wildlife including burrowing owls, weasels, badgers, and a variety of snakes." (USEPA3)

22g. "Once containing a perennially flowing, meandering, braided river, the **Rio Grande Floodplain** ecoregion has undergone many human alterations to its landscape and hydrology over the past 400 years. The once-shifting Rio Grande had mosaics of riparian woodlands and shrublands along with a variety of wetland meadows, ponds, and marshes. The gallery forest, or bosque, of cottonwood and willow with understories of coyote willow, New Mexico olive, false indigo, and seepwillow depended on this dynamic system. A long history of irrigation and drainage canals, levees and jetty jacks, and upstream dams have altered river flows and narrowed and straightened the stream channel. Conversion to cropland, orchards, small rural farms and ranchos, and urban and suburban uses have also

altered the region. Cottonwood and willow, dependent on spring flooding, have been widely replaced by invasive saltcedar and Russian olive." (USEPA3)

Commercially available species for 22g. Rio Grande ecoregion:

Scientific Name	Common Name	Veg Type	Habitat Notes	Seeding Rate: Pounds PLS/acre
Achnatherum hymenoides (Synonym: Oryzopsis hymenoides)	Indian ricegrass	Cool Grass	Coarse textured & sandy soils, drought tolerant.	6 to 8
Artemisia filifolia	Sand sage	Shrub		0.5
Atriplex canescens	Four-wing saltbush	Shrub	Tolerates alkaline (basic / high pH) soils very well.	6 to 8
Baileya multiradiata	Desert marigold	Perennial		2
Berlandiera lyrata	Chocolate flower	Perennial		3 to 4
Bouteloua curtipendula	Sideoats grama	Warm Grass	Shallow well-drained rocky sites.	3 to 6
Bouteloua gracilis	Blue grama	Warm Grass	Loams and sandy loam soils	2 to 3
Distichlis spicata (Synonym: Distichlis stricta)	Inland saltgrass	Warm Grass	Highly saline/alkaline soils w/ poor drainage or high water table	10
Elymus canadensis	Canada wildrye	Cool Grass	Sandy soils of river banks and open plains	7
Ericameria nauseosa (Synonym: Chrysothamnus nauseosus)	Rubber rabbitbrush	Shrub		1
Gaillardia pulchella	Firewheel	Annual		10
Helianthus annuus	Annual sunflower	Annual	Most areas	10
Panicum obtusum	Vine mesquite	Warm Grass	Flood plains	3 to 5
Pascopyrum smithii (Synonym: Agropyron smithii)	Western wheatgrass	Cool Grass	Wide range of soils	10
Penstemon ambiguus	Bush penstemon	Shrub		5
Pleuraphis jamesii (Synonym: Hilaria jamesii)	Galleta	Warm Grass		2 to 5
Rhus trilobata	Three leaf sumac	Shrub		5 to 10
Ribes aureum	Golden currant	Shrub		5 to 10
Setaria macrostachya	Plains bristlegrass	Warm Grass	Fine to coarse textured soils; drought resistant	7
Sporobolus airoides	Alkali sacaton	Warm Grass	Salty, clayey, bottomland sites.	2 to 3

Sporobolus cryptandrus	Sand dropseed	Warm Grass	Adapted to shallow, calcareous & sandy sites. (Calcareous soils are relatively alkaline (high pH))	1

(Payne 2013)

To determine seeding rate refer to page 3, section II.3. "Determine Seeding Rates."

22h. "The **North Central New Mexico Valleys and Mesas** is an area of mostly pinyon pine and juniper savanna, and mesa and valley topography similar to some other parts of Ecoregion 22. Situated between portions of the Southern Rockies (21) to the east and west, and dominated by young geologic features of the Espanola rift basin and ancestral Rio Grande floodplain, ecological differences are apparent. It has a cooler climate with slightly greater precipitation, streams tend to have more water flow, and there is a different species mix of flora and fauna compared to 22i, 22j, or 22m. It differs from 22f in geology, topography, and vegetation; from 22i and 22m in elevation, climate, and vegetation. It has a mix of geology, mostly Tertiary sedimentary or Tertiary and Quaternary volcanic rocks." (USEPA3)

Included in this ecoregion: Santa Fe

Commercially available species for 22h. North Central New Mexico Valleys and Mesas ecoregion:

Scientific Name	Common Name	Veg Type	Habitat Notes	Seeding Rate: Pounds PLS/acre
Achnatherum hymenoides (Synonym: Oryzopsis hymenoides)	Indian ricegrass	Cool Grass	Coarse textured & very sandy soils, drought tolerant.	6 to 8
Berlandiera lyrata	Chocolate flower	Perennial		3 to 4
Bouteloua curtipendula	Sideoats grama	Warm Grass	Shallow well-drained rocky sites.	3 to 6
Bouteloua gracilis	Blue grama	Warm Grass		2 to 3
Ericameria nauseosa (Synonym: Chrysothamnus nauseosus)	Rubber rabbitbrush	Shrub		1
Pascopyrum smithii (Synonym: Agropyron smithii)	Western wheatgrass	Cool Grass		10
Pleuraphis jamesii (Synonym: Hilaria jamesii)	Galleta	Grass		2 to 5
Rhus trilobata	Three leaf sumac	Shrub		5 to 10
Sphaeralcea coccinea	Scarlet globemallow	Perennial		1

Sporobolus cryptandrus	Sand dropseed	Grass	Adapted to shallow, calcareous & sandy sites. (Calcareous soils are relatively alkaline (high pH).)	1
Stipa neomexicana	New Mexico feathergrass	Grass	Sandy, hot, dry sites.	6
Zinnia grandiflora	Desert zinnia	Perennial		5

(Payne 2013)

To determine seeding rate refer to page 3, section II.3. "Determine Seeding Rates."

22i. "The **San Juan/Chaco Tablelands and Mesas** ecoregion of plateaus, valleys, and canyons contains a mix of desert scrub, semi-desert shrub-steppe, and semi-desert grasslands. Shadscale, fourwing saltbush, mormon tea, Indian ricegrass, galleta, and blue and black gramas are typical. It is more arid, has generally lower elevations, and less pinyon-juniper than the Semiarid Tablelands (22j) to the south or Ecoregion 22n to the east. It is mostly composed of gently dipping Tertiary and Cretaceous sedimentary rocks. Oil and gas production occurs mostly in the northern part of the region. It contains the upper reaches of the Rio Puerco, an area of severe erosion due to geology, topography, and human influences." (USEPA3)

Commercially available species for 22i. San Juan/Chaco Tablelands and Mesas ecoregion:

Scientific Name	Common Name	Veg Type	Habitat Notes	Seeding Rate: Pounds PLS/acre
Achnatherum hymenoides (Synonym: Oryzopsis hymenoides)	Indian ricegrass	Cool Grass	Coarse textured & sandy soils, drought tolerant.	6 to 8
Atriplex canescens	Four-wing saltbush	Shrub	Tolerates saline/alkaline (basic / high pH) soils very well.	6 to 8
Atriplex confertifolia	Shadscale saltbush	Shrub	Tolerates alkaline soils. NM elev: 5,000 to 6,500 feet.	5 to 7
Bouteloua eriopoda	Black grama	Warm Grass		2 to 3
Bouteloua gracilis	Blue grama	Warm Grass		2 to 3
Krascheninnikovia lanata (Synonym: Ceratoides lanata)	Winterfat	Shrub		2 to 4
Distichlis spicata (Synonym: Distichlis stricta)	Inland saltgrass	Warm Grass	Highly saline/alkaline soils w/ poor drainage or high water table	10

Ephedra viridis	Green mormon tea	Shrub	Cold desert, sandy slopes	10
Ericameria nauseosa var. bigelovii (Synonym: Chrysothamnus nauseosus var. bigelovii)	Rubber rabbitbrush	Shrub		1
Pleuraphis jamesii (Synonym: Hilaria jamesii)	Galleta	Warm Grass		2 to 5
Sporobolus airoides	Alkali sacaton	Warm Grass	Salty, clayey, bottomland sites.	2 to 3
Sporobolus cryptandrus	Sand dropseed	Warm Grass	Adapted to shallow, calcareous & sandy sites. (Calcareous soils are relatively alkaline (high pH).)	1
Zinnia grandiflora	Desert zinnia	Perennial		5

Seeding *Atriplex confertifolia*: seed should be drilled ½ to ¾ in. deep in well-prepared seedbeds. Adjust the depth for different soil types (shallower for fine-textured moist soils). Spring and mid-summer planting dates have been more successful than fall planting dates.

(Payne 2013)

To determine seeding rate refer to page 3, section II.3. "Determine Seeding Rates."

22j. "With some similarities to Ecoregion 20c, the **Semiarid Tablelands** consists of mesas, plateaus, valleys, and canyons formed mostly from flat to gently dipping sedimentary rocks, along with some areas of Tertiary and Quaternary volcanic fields. The region contains areas of high relief and some low relief plains. Bedrock exposures are common. Grass, shrubs, and woodland cover the tablelands. The vegetation is not as sparse as in Ecoregion 22i to the north or 22m to the east. It lacks the denser pine forests of the higher and more mountainous Ecoregion 23. Scattered junipers occur on shallow, stony soils, and are dense in some areas. Pinyon-juniper woodland is also common in some areas. Saltbush species, alkali sacaton, sand dropseed, and mixed grama grasses occur." (USEPA3)

Commercially available species for 22j. Semiarid Tablelands ecoregion:

Scientific Name	Common Name	Veg Type	Habitat Notes	Seeding Rate: Pounds PLS/acre
Achnatherum hymenoides (Synonym: Oryzopsis hymenoides)	Indian ricegrass	Cool Grass	Coarse textured & sandy soils, drought tolerant.	6 to 8
Atriplex canescens	Four-wing saltbush	Shrub	Tolerates saline/alkaline (basic / high pH) soils very well.	6 to 8

Atriplex confertifolia	Shadscale saltbush	Shrub	Tolerates alkaline soils. NM elev: 5,000 to 6,500 feet.	5 to 7
Baileya multiradiata	Desert marigold	Perennial		2
Bouteloua curtipendula	Sideoats grama	Warm Grass	Shallow well-drained rocky sites.	3 to 6
Bouteloua eriopoda	Black grama	Warm Grass		2 to 3
Bouteloua gracilis	Blue grama	Warm Grass		2 to 3
Krascheninnikovia lanata (Synonym: Ceratoides lanata)	Winterfat	Shrub		2 to 4
Distichlis spicata (Synonym: Distichlis stricta)	Inland saltgrass	Warm Grass	Highly saline/alkaline soils w/ poor drainage or high water table	10
Ericameria nauseosa (Synonym: Chrysothamnus nauseosus)	Rubber rabbitbrush	Shrub		1
Gaillardia pulchella	Firewheel	Annual		10
Panicum obtusum	Vine mesquite	Warm Grass	Flood plains.	3 to 5
Pleuraphis jamesii (Synonym: Hilaria jamesii)	Galleta	Warm Grass		2 to 5
Setaria macrostachya	Plains bristlegrass	Warm Grass		7
Sphaeralcea coccinea	Scarlet globemallow	Perennial		1
Sporobolus airoides	Alkali sacaton	Warm Grass	Salty, clayey, bottomland sites.	2 to 3
Sporobolus cryptandrus	Sand dropseed	Warm Grass	Adapted to shallow, calcareous & sandy sites. (Calcareous soils are relatively alkaline (high pH).)	1
Zinnia grandiflora	Desert zinnia	Perennial		5

Seeding *Atriplex confertifolia*: seed should be drilled ½ to ¾ in. deep in well-prepared seedbeds. Adjust the depth for different soil types (shallower for fine-textured moist soils). Spring and mid-summer planting dates have been more successful than fall planting dates.

(Payne 2013)

To determine seeding rate refer to page 3, section II.3. "Determine Seeding Rates."

22m. "Part of one of the deeper physiographic basins of the Rio Grande rift, the **Albuquerque Basin** ecoregion is lower in elevation, drier, and warmer than surrounding ecoregions to the north, east, and west. The basin is filled with thick sediments of mostly Quaternary and some Tertiary age, with a few areas of volcanic rocks and lava-capped mesas. Extending from the La Bajada Escarpment on the north to near Socorro in the south, the region contains some diverse features and transitional characteristics. Unlike most of

Ecoregion 22 which has mesic soils, 22m has a largely thermic soil temperature regime. There is a mix of sand scrub and desert grassland vegetation. Native vegetation includes black grama, sand dropseed, mesa dropseed, blue grama, galleta, sand sage, alkali sacaton, threeawns, and scattered yucca. Juniper occurs primarily in the north. Urban and suburban land uses are spreading. The Santa Fe Group aquifer, the drinking water source for Albuquerque and most of the Middle Rio Grande Valley, has seen some groundwater declines in recent years, along with increases in contaminants." (USEPA3)

Commercially available species for 22m. Albuquerque Basin ecoregion:

Scientific Name	Common Name	Veg Type	Habitat Notes	Seeding Rate: Pounds PLS/acre
Achnatherum hymenoides (Synonym: Oryzopsis hymenoides)	Indian ricegrass	Cool Grass	Coarse textured & sandy soils, drought tolerant.	6 to 8
Atriplex canescens	Four-wing saltbush	Shrub	Tolerates alkaline (basic / high pH) soils very well.	6 to 8
Baileya multiradiata	Desert marigold	Perennial		2
Bouteloua curtipendula	Sideoats grama	Warm Grass	Shallow well-drained rocky sites.	3 to 6
Bouteloua eriopoda	Black grama	Warm Grass		2 to 3
Bouteloua gracilis	Blue grama	Warm Grass		2 to 3
Gaillardia pulchella	Firewheel	Annual		10
Krascheninnikovia lanata (Synonym: Ceratoides lanata)	Winterfat	Shrub		2 to 4
Penstemon ambiguus	Bush penstemon	Shrub		5
Dalea purpurea (Synonym: Petalostemum purpureum)	Purple prairie clover	Perennial		8
Pleuraphis jamesii (Synonym: Hilaria jamesii)	Galleta	Warm Grass		2 to 5
Sphaeralcea coccinea	Scarlet globemallow	Perennial		1
Sporobolus airoides	Alkali sacaton	Warm Grass	Salty, clayey, bottomland sites.	2 to 3
Sporobolus cryptandrus	Sand dropseed	Warm Grass	Adapted to shallow, calcareous & sandy sites. (Calcareous soils are relatively alkaline (high pH))	1
Sporobolus flexuosus	Mesa dropseed	Warm Grass	Sandy soils; soil stabilization at 3,000 to 5,000 feet.	1

Sporobolus giganteus	Giant dropseed	Warm Grass	Deep, sandy soils, useful for stabilizing dunes.	2 to 3
Zinnia grandiflora	Desert zinnia	Perennial		5

(Payne 2013)

To determine seeding rate refer to page 3, section II.3. "Determine Seeding Rates."

22n. "Similar to Ecoregion 22h, the **Near-Rockies Valleys and Mesas** ecoregion is an area of mostly pinyon-juniper woodland, juniper savanna, and mesa and valley topography, with influences of higher elevation vegetation in drainages from the adjacent Southern Rockies (21). Its geology differs from Ecoregion 22h, with older Tertiary and Cretaceous sedimentary rocks. It has generally higher elevations, greater precipitation, and more juniper than Ecoregion 22i to the west. Canyon streams flow intermittently out of the Rockies into the Canon Largo watershed, a tributary to the San Juan River." (USEPA3)

Commercially available species for 22n. Near-Rockies Valleys and Mesas ecoregion:

Scientific Name	Common Name	Veg Type	Habitat Notes	Seeding Rate: Pounds PLS/acre
Achnatherum hymenoides (Synonym: Oryzopsis hymenoides)	Indian ricegrass	Cool Grass	Coarse textured & sandy soils, drought tolerant.	6 to 8
Atriplex confertifolia	Shadscale saltbush	Shrub	Tolerates alkaline soils. NM elev: 5,000 to 6,500 feet.	5 to 7
Bouteloua curtipendula	Sideoats grama	Warm Grass	Shallow well-drained rocky sites.	3 to 6
Bouteloua eriopoda	Black grama	Warm Grass		2 to 3
Bouteloua gracilis	Blue grama	Warm Grass		2 to 3
Krascheninnikovia lanata (Synonym: Ceratoides lanata)	Winterfat	Shrub		2 to 4
Ericameria nauseosa (Synonym: Chrysothamnus nauseosus)	Rubber rabbitbrush	Shrub		1
Fallugia paradoxa	Apache plume	Shrub		1 to 2
Gaillardia pulchella	Firewheel	Annual		10
Pleuraphis jamesii (Synonym: Hilaria jamesii)	Galleta	Warm Grass		2 to 5
Purshia tridentata	Antelope bitterbrush	Shrub		1 to 3
Rhus trilobata	Three leaf sumac	Shrub		5 to 10
Sphaeralcea coccinea	Scarlet globemallow	Perennial		1

Sporobolus cryptandrus	Sand dropseed	Warm Grass	Adapted to shallow, calcareous & sandy sites. (Calcareous soils are relatively alkaline (high pH).)	1
Seeding *Atriplex confertifolia*: seed should be drilled ½ to ¾ in. deep in well-prepared seedbeds. Adjust the depth for different soil types (shallower for fine-textured moist soils). Spring and mid-summer planting dates have been more successful than fall planting dates.				

(Payne 2013)

To determine seeding rate refer to page 3, section II.3. "Determine Seeding Rates."

23. Arizona / New Mexico Mountains

"The Arizona/New Mexico Mountains are distinguished from neighboring mountainous ecoregions by their lower elevations and associated vegetation indicative of drier, warmer environments, due in part to the region's more southerly location. Forests of spruce, fir, and Douglas-fir, common in the Southern Rockies (21) and the Wasatch and Uinta Mountains (19), are only found in limited areas at the highest elevations in this region. Chaparral is common at lower elevations in some areas, pinyon-juniper and oak woodlands are found at lower and middle elevations, and the higher elevations are mostly covered with open to dense ponderosa pine forests. These mountains are the northern extent of some Mexican plant and animal species. Surrounded by deserts or grasslands, these mountains in New Mexico can be considered biogeographical islands." (USEPA3)

23e. "The **Conifer Woodlands and Savannas** ecoregion is an area of mostly pinyon-juniper woodlands, with some ponderosa pine at higher elevations. It often intermingles with grasslands and shrublands. Although elevations are higher than surrounding Ecoregion 22 areas, the boundaries tend to be transitional. The region is generally cooler, with more uniform winter and summer seasonal moisture compared to Ecoregion 23b. It lacks the milder winters, wetter summers, chaparral, Madrean oaks, and other species of Ecoregion 23b." (USEPA3)

Commercially available species for 23e. Conifer Woodlands and Savannas ecoregion:

Scientific Name	Common Name	Veg Type	Habitat Notes	Seeding Rate: Pounds PLS/acre
Achnatherum hymenoides (Synonym: Oryzopsis hymenoides)	Indian ricegrass	Cool Grass	Coarse textured & sandy soils, drought tolerant.	6 to 8
Aristida purpurea	Purple three-awn	Cool Grass	Rocky or sandy plains; slopes to 5,000 ft	6
Berlandiera lyrata	Chocolate flower	Perennial		3 to 4

Bouteloua curtipendula	Sideoats grama	Warm Grass	Shallow well-drained rocky sites.	3 to 6
Bouteloua gracilis	Blue grama	Grass		2 to 3
Cercocarpus montanus	Mountain mahogany	Shrub		10
Ericameria nauseosa (Synonym: Chrysothamnus nauseosus)	Rubber rabbitbrush	Shrub		1
Fallugia paradoxa	Apache plume	Shrub		1 to 2
Koeleria macrantha (Synonym: Koeleria cristata)	Prairie junegrass	Cool Grass		1 to 2
Pascopyrum smithii (Synonym: Agropyron smithii)	Western wheatgrass	Cool Grass		10
Pleuraphis jamesii (Synonym: Hilaria jamesii)	Galleta	Warm Grass		2 to 5
Rhus trilobata	Three leaf sumac	Shrub		5 to 10
Robinia neomexicana	New Mexican locust	Tree		10
Schizachyrium scoparium	Little bluestem	Warm Grass		3 to 4
Sphaeralcea coccinea	Scarlet globemallow	Perennial		1
Sporobolus cryptandrus	Sand dropseed	Warm Grass	Adapted to shallow, calcareous & sandy sites. (Calcareous soils are relatively alkaline (high pH).)	1
Hesperostipa neomexicana (Synonym: Stipa neomexicana)	New Mexico feathergrass	Cool Grass	Sandy, hot, dry sites.	6
Zinnia grandiflora	Desert zinnia	Perennial		5

(Payne 2013)

To determine seeding rate refer to page 3, section II.3. "Determine Seeding Rates."

23f. "The **Rocky Mountain Conifer Forests** are found at elevations from about 7000 to 9600 feet in the mountains east of the Rio Grande. With similarities to Ecoregion 23c, ponderosa pine and Gambel oak are common, with mountain mahogany and a dense understory. Some Douglas-fir, southwestern white pine, and white fir occur in a few areas. Blue spruce may occasionally be found in cool, moist canyons. In the Sandia and Manzano mountains, white fir and Douglas-fir are more extensive than in other parts of the region. Current forests have been shaped by fire and fire suppression. It differs from Ecoregion 23c by some of the flora, fauna, and water quality characteristics that more closely resemble the Southern Rockies (21). The region is geologically diverse with volcanic, sedimentary, and some intrusive and crystalline rocks." (USEPA3)

Commercially available species for 23f. Rocky Mountain Conifer Forests ecoregion:

Scientific Name	Common Name	Veg Type	Habitat Notes	Seeding Rate: Pounds PLS/acre
Bouteloua gracilis	Blue grama	Warm Grass		2 to 3
Cercocarpus montanus	Mountain mahogany	Shrub		10
Elymus glaucus	Blue wildrye	Cool Grass	Aspen zone up to spruce/fir zone	5
Elymus smithii (Synonym: Agropyron smithii)	Western wheatgrass	Cool Grass		10
Festuca arizonica	Arizona fescue	Cool Grass		3
Festuca brachyphylla (Synonym: Festuca ovina var. brachyphylla)	Sheep fescue	Cool Grass	Well-drained, medium textured soils	10
Iris missouriensis	Rocky Mountain Iris	Perennial		12
Linum lewisii	Blue flax	Perennial		8
Oenothera elata ssp. hirsutissima (Synonym: Oenothera hookeri)	Hooker evening primrose	Biennial		2
Rhus glabra	Smooth sumac	Shrub		20
Robinia neomexicana	New Mexican locust	Tree		10
Rosa woodsii	Woods rose	Shrub		20 to 30
Schizachyrium scoparium	Little bluestem	Warm Grass		3 to 4

(Payne 2013)

To determine seeding rate refer to page 3, section II.3. "Determine Seeding Rates."

23g. "The **Rocky Mountain Subalpine Forests** ecoregion occurs east of the Rio Grande at high elevations, generally above 9500 feet. It includes parts of the Sandia Mountains, Capitan Mountains, and Sierra Blanca. The peak elevations are mostly above 10,000 feet, with Sierra Blanca Peak nearing 12,000 feet. There are some differences in flora, fauna, geology, and water quality from the subalpine ecoregion (23d) to the west. The major forest trees include Engelmann spruce, corkbark fir, blue spruce, white fir, and aspen. Some Douglas-fir occurs at lower elevations. There are a few small inclusions of montane grassland. A mix of geology occurs in the region. Sierra Blanca and the Capitan Mountains are composed of Tertiary volcanics and Tertiary intrusives, while the Sandia Mountains to the north have a core of Precambrian rocks capped by Pennsylvanian sedimentary rocks." (USEPA3)

No commercially available seed list for ecoregion 23g.

Festuca arizonica is the only seed species that may be available commercially. Permanent structures and roads are very uncommon in this ecoregion. Nearly all land in this ecoregion is USFS land. In the rare event that a SWPPP may be opened in this ecoregion, a

site-specific survey must be done and coordinated with commercially available plants for site stabilization due to lack of commercially available seed.

26. Southwestern Tablelands

"The Southwestern Tablelands flank the High Plains (25) with red hued canyons, mesas, badlands, and dissected river breaks. Unlike most adjacent Great Plains ecological regions, little of the Southwestern Tablelands is in cropland. Much of this region is in sub-humid grassland and semiarid rangeland. The eastern boundary represents a transition from the more extensive cropland within the High Plains (25) to the generally more rugged and less arable land within the Southwestern Tablelands (26) ecoregion. The natural vegetation in this region is mostly grama-buffalograss, with some juniper-scrub oak-grass savanna on escarpment bluffs. Prairie fires were likely important in maintaining the grasslands and suppressing encroachment of shrub and woody species. Pronghorn antelope is the most common large native mammal of the region." (USEPA3)

26h. "Scattered, dissected areas with pinyon and juniper woodlands on the uplands characterize the **Pinyon-Juniper Woodlands and Savannas** ecoregion. Occurring in Colorado and New Mexico, the region is a continuation or an outlier of the pinyon-juniper woodlands found in Ecoregion 21d in the Southern Rockies (21). Soils tend to be thin, and for most of the region are formed in materials weathered from limestone, sandstone, and shale. Rock outcrops are common. In central New Mexico, much of the region is often associated with the Paleozoic Glorieta Sandstone and other limestone and shale rocks. In the north, the region includes a few hills and peaks of volcanic or mixed geology that have some small areas of montane coniferous forest. Annual precipitation in the New Mexico portion ranges from 12 to 16 inches, with the highest precipitation found in areas closest to the mountains. Land use is primarily wildlife habitat and rangeland." (USEPA3)

Commercially available species for 26h. Pinyon-Juniper Woodlands and Savannas ecoregion:

Scientific Name	Common Name	Veg Type	Habitat Notes	Seeding Rate: Pounds PLS/acre
Achnatherum hymenoides (Synonym: Oryzopsis hymenoides)	Indian ricegrass	Cool Grass	Coarse textured & sandy soils, drought tolerant.	6 to 8
Berlandiera lyrata	Chocolate flower	Perennial		3 to 4
Bouteloua curtipendula	Sideoats grama	Warm Grass	Shallow well-drained rocky sites.	3 to 6
Bouteloua gracilis	Blue grama	Grass		2 to 3
Cercocarpus montanus	Mountain mahogany	Shrub		10

Ericameria nauseosa (Synonym: Chrysothamnus nauseosus)	Rubber rabbitbrush	Shrub		1
Festuca arizonica	Arizona fescue	Cool Grass		3
Koeleria macrantha (Synonym: Koeleria cristata)	Prairie junegrass	Cool Grass		1 to 2
Linum lewisii	Blue flax	Perennial		8
Pascopyrum smithii (Synonym: Agropyron smithii)	Western wheatgrass	Cool Grass		10
Ratibida columnifera	Prairie coneflower	Perennial		2
Rhus trilobata	Three leaf sumac	Shrub		5 to 10
Schizachyrium scoparium	Little bluestem	Warm Grass		3 to 4
Sphaeralcea coccinea	Scarlet globemallow	Perennial		1
Sporobolus cryptandrus	Sand dropseed	Warm Grass	Adapted to shallow, calcareous & sandy sites. (Calcareous soils are relatively alkaline (high pH).)	1
Stipa neomexicana	New Mexico feathergrass	Cool Grass	Sandy, hot, dry sites.	6

(Payne 2013)

To determine seeding rate refer to page 3, section II.3. "Determine Seeding Rates."

26o. "The **Central New Mexico Plains** are slightly drier than Ecoregion 26n to the east, with more shortgrass steppe and less midgrass prairie. It has generally higher elevations and more mesic soils than the somewhat lower elevations and thermic soils of 26n. The region is composed of mostly Permian rocks compared to the Triassic materials of Ecoregion 26n. Livestock grazing is the dominant land use. Pronghorn antelope are common as well as coyote and a variety of raptors." (USEPA3)

Commercially available species for 26o. Central New Mexico Plains ecoregion:

Scientific Name	Common Name	Veg Type	Habitat Notes	Seeding Rate: Pounds PLS/acre
Achnatherum hymenoides (Synonym: Oryzopsis hymenoides)	Indian ricegrass	Cool Grass	Coarse textured & sandy soils, drought tolerant.	6 to 8
Aristida purpurea ?	Purple three-awn	Cool Grass	Rocky or sandy plains; slopes to 5,000 ft	6
Atriplex canescens	Four-wing saltbush	Shrub	Tolerates alkaline (basic / high pH) soils very well.	6 to 8

Bouteloua curtipendula	Sideoats grama	Warm Grass	Shallow well-drained rocky sites.	3 to 6
Bouteloua eriopoda ?	Black grama	Warm Grass		2 to 3
Bouteloua gracilis	Blue grama	Warm Grass		2 to 3
Krascheninnikovia lanata (Synonym: Ceratoides lanata)	Winterfat	Shrub		2 to 4
Panicum obtusum	Vine mesquite	Warm Grass	Flood plains	3 to 5
Pascopyrum smithii (Synonym: Agropyron smithii)	Western wheatgrass	Cool Grass		10
Pleuraphis jamesii (Synonym: Hilaria jamesii)	Galleta	Warm Grass		2 to 5
Ratibida columnaris	Prairie coneflower	Perennial		2
Schizachyrium scoparium	Little bluestem	Warm Grass		3 to 4
Sitanion hystrix ?	Bottlebrush squirreltail	Cool Grass		8 to 10
Sorghastrum nutans	Indian grass	Grass	Deep, moist soils; heavy clays to coarse sand.	4 to 6
Sphaeralcea coccinea	Scarlet globemallow	Perennial		1
Hesperostipa comata (Synonym: Stipa comata)	Needle and thread	Cool Grass	Shallow, calcareous, sandy, & gravelly sites. (Calcareous soils are relatively alkaline (high pH).)	8
Hesperostipa neomexicana (Synonym: Stipa neomexicana)	New Mexico feathergrass	Cool Grass	Sandy, hot, dry sites.	6
Sporobolus cryptandrus	Sand dropseed	Warm Grass	Adapted to shallow, calcareous & sandy sites. (Calcareous soils are relatively alkaline (high pH).)	1
Sporobolus flexuosus	Mesa dropseed	Warm Grass	Sandy soils; soil stabilization at 3,000 to 5,000 feet.	1
Zinnia grandiflora	Desert zinna	Perennial		5

(Payne 2013)

To determine seeding rate refer to page 3, section II.3. "Determine Seeding Rates."

APPENDIX III. COMMERCIAL SUPPLIERS OF NEW MEXICO NATIVE SEED

Granite Seed and Erosion Control
Website: www.graniteseed.com
Location: Lehi, Utah
Phone: (801) 768-4422

Location: Denver, Colorado
Phone: (888) 577-5650

Curtis & Curtis Inc.
Website: http://www.curtisseed.com/
Location: Clovis, New Mexico
Phone: (575) 762-4759
Email: seed@curtisseed.com

APPENDIX IV. SOIL SURFACE ROUGHENING TECHNIQUES

The results of the "Caltrans Erosion Control Pilot Study" showed that soil roughening should be considered as a vital step in soil preparation for re-vegetation and erosion control. Laboratory testing was conducted at the San Diego State University Soil Erosion Research Laboratory during the years 1998-2000 (Forrest, et al.).

Figure 1. Grouser tracks on a bulldozer can be used as a surface roughening technique when the tracks go up and down a slope. However, if the tracks go across a slope, erosion is accelerated. (Erosion Control Network)

Figure 2. A sheep's foot roller can be used to "dimple" a slope as long as the action is not taken to an extreme, smooth and compacted surface. (Erosion Control Network)

Figure 3. Tines on the back side of a dozer, or similar agricultural tillage equipment, when applied on the contour and perpendicular to water flow, can increase infiltration and reduce erosion. (Erosion Control Network)

Figure 4. The resulting roughness created from imprinting creates an opportunity for water to and sediment to be collected and fosters the germination and growth of seed. (Erosion Control Network)

Figure 5. Slope boarding is generally applied to cut slopes and can provide and underlying structural support to hydraulic seed and mulching applications. (Erosion Control Network)

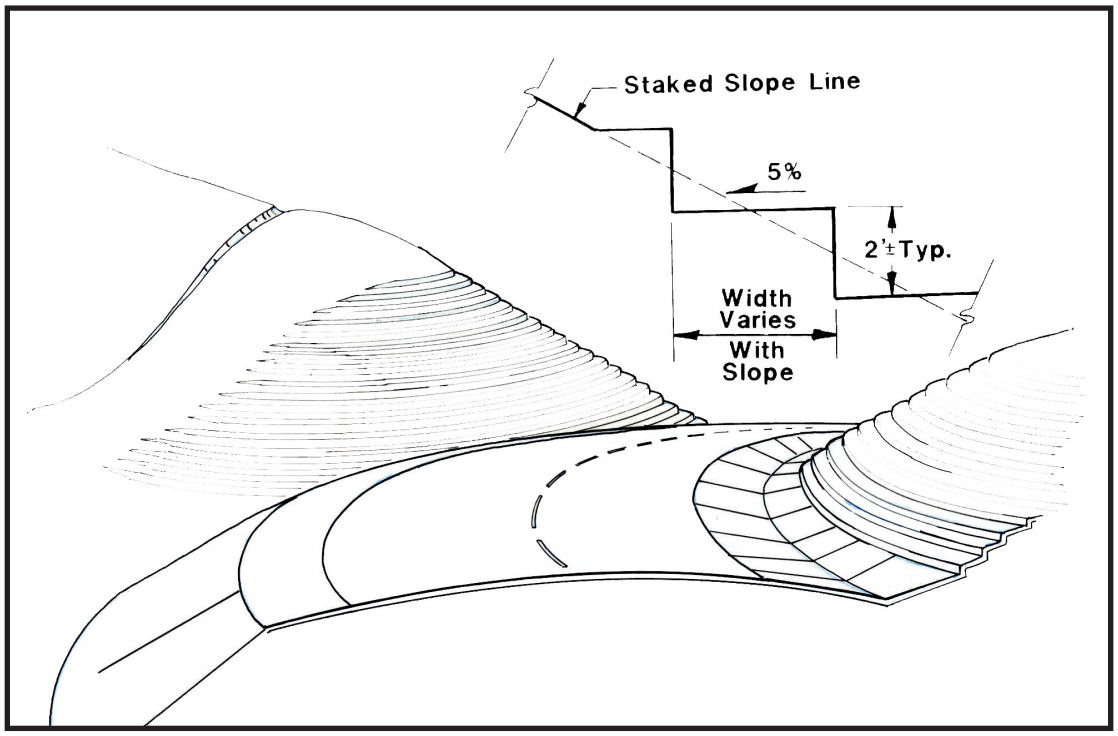
RESULTS OF RAINFALL SIMULATION TESTING FOR ROUGHNESS

Treatment	Measurement	Statistic	Storm						Average Increase (+) Decrease (-)
			5-yr (1)	5-yr (2)	10-yr (1)	10-yr (2)	50-yr (1)	50-yr (2)	
Smooth	Normalized Erosion Rate (kg/m²/mm)	Mean	0.06	0.07	0.16	0.09	0.12	0.09	
		St. Dev.	0.03	0.07	0.04	0.01	0.02	0.02	
		% of Smooth	100%	100%	100%	100%	100%	100%	**0%**
	Runoff (L)	Mean	255.7	364.4	419.2	470.3	422.3	611.0	
		St. Dev.	11.9	35.1	19.6	9.7	10.6	20.3	
		% of Smooth	100%	100%	100%	100%	100%	100%	**0%**
Imprinted	Normalized Erosion Rate (kg/m²/mm)	Mean	0.03	0.02	0.03	0.02	0.03	0.02	
		St. Dev.	0.03	0.19	0.11	0.12	0.04	0.05	
		% of Smooth	49%	26%	18%	25%	22%	19%	**76% (-)**
	Runoff (L)	Mean	222.3	415.6	380.8	446.6	464.4	501.8	
		St. Dev.	13.3	96.1	49.4	84.0	21.1	37.8	
		% of Smooth	87%	114%	91%	95%	110%	82%	**4% (-)**
Ripped	Normalized Erosion Rate (kg/m²/mm)	Mean	0.04	0.07	0.12	0.08	0.15	0.06	
		St. Dev.	0.18	0.03	0.07	0.04	0.01	0.09	
		% of Smooth	66%	99%	75%	88%	121%	71%	**12% (-)**
	Runoff (L)	Mean	154.2	276.3	387.3	416.3	373.5	443.4	
		St. Dev.	75.6	17.0	29.8	24.7	7.0	79.2	
		% of Smooth	60%	76%	92%	89%	88%	73%	**19% (-)**
Sheepsfoot	Normalized Erosion Rate (kg/m²/mm)	Mean	0.03	0.03	0.02	0.05	0.06	0.04	
		St. Dev.	0.03	0.14	0.06	0.03	0.04	0.03	
		% of Smooth	58%	46%	14%	56%	51%	46%	**55% (-)**
	Runoff (L)	Mean	361.3	374.8	525.1	511.8	503.3	584.4	
		St. Dev.	11.9	71.3	26.7	22.5	26.0	24.3	
		% of Smooth	141%	103%	125%	109%	119%	96%	**12% (+)**
Trackwalked	Normalized Erosion Rate (kg/m²/mm)	Mean	0.04	0.04	0.05	0.04	0.04	0.07	
		St. Dev.	0.11	0.05	0.08	0.06	0.09	0.04	
		% of Smooth	80%	60%	30%	40%	30%	80%	**52% (-)**
	Runoff (L)	Mean	218.7	448.3	460.7	468.5	410.6	579.9	
		St. Dev.	48.0	26.8	35.5	38.4	49.7	36.0	
		% of Smooth	86%	123%	110%	100%	97%	95%	**2% (+)**

(Forrest, et al. 2000; Erosion Control Network)

APPENDIX V. MINI-BENCHING CONSTRUCTION SPECIFICATION

Minibenches/Slope Roughening



All information in this section taken directly from:
Arizona Department of Transporation. Stormwater Program Manuals: Erosion and Pollution Control Manual.

5.1.3 Minibenches/Slope Roughening

Definition

Terracing and roughening are techniques for creating furrows, terraces, serrations, stair-steps or track-marks on the soil surface.

Purpose

- To improve water infiltration.
- To increase the effectiveness of temporary and permanent soil stabilization practices.

Appropriate Applications

- Large engineered slopes, primarily cuts in rural settings.
- Soils prone to erosion.
- Prior to application of permanent seeding.

Limitations

- Not appropriate on rock slopes.

- Must be constructed as slope is cut.
- If a slope exists above the minibench, water diversion structures must be constructed to divert this upslope stormwater around the minibench. This will prevent upslope runoff from washing out a newly constructed minibench.

Standards and Specifications

Planning Considerations

- Minibenching and slope roughening shall be constructed from the top of a cut slope down.

Design

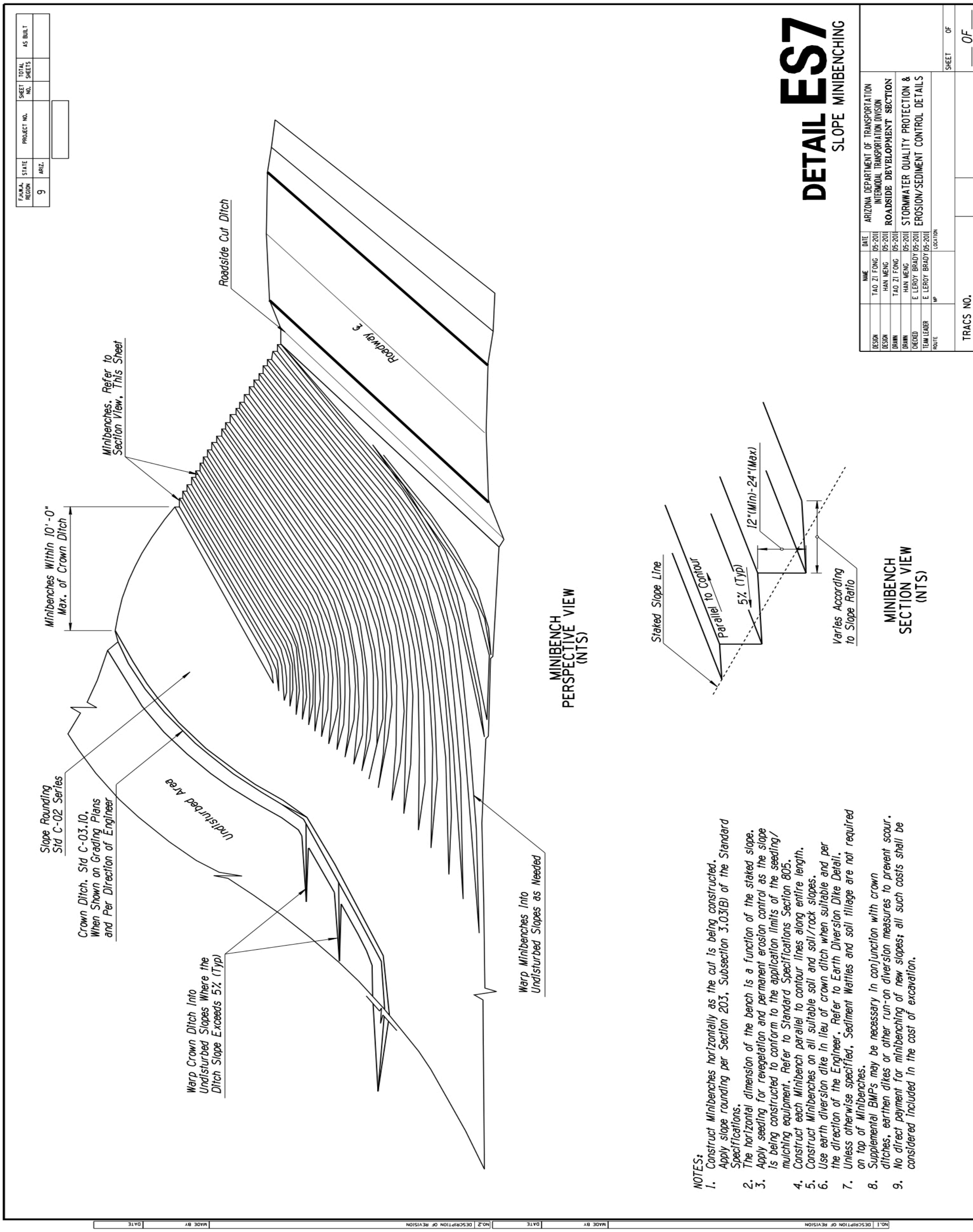
- Minibenches, terraces, furrows, and other horizontal roughening techniques shall follow the contour.

Inspections and Maintenance

- Follow inspection schedule required in the CGP Part IV.H.
- Where horizontal roughening falls away from the contour, additional BMPs may be required to protect the slope.

(ADOT2)

For additional assistance with mini benching details contact the Arizona Department of Transportation. Tao Fong (tfong@azdot.gov) may be of assistance.


F.H.W.A. REGION
STATE
PROJECT NO.
SHEET NO.
TOTAL SHEETS
AS BUILT
9
ARIZ.
Slope Rounding
Std C-02 Series
Minibenches Within 10'-0"
Max. of Crown Ditch
Crown Ditch. Std C-03.10.
When Shown on Grading Plans
and Per Direction of Engineer
Minibenches. Refer to
Section View, This Sheet
Warp Crown Ditch Into
Undisturbed Slopes Where the
Ditch Slope Exceeds 5% (Typ)
Undisturbed Area
Roadside Cut Ditch
Roadway ℄
Warp Minibenches Into
Undisturbed Slopes as Needed
MINIBENCH
PERSPECTIVE VIEW
(NTS)
Staked Slope Line
Parallel to Contour
5% (Typ)
12"(Min)-24"(Max)
Varies According
to Slope Ratio
MINIBENCH
SECTION VIEW
(NTS)
NOTES:
1. Construct Minibenches horizontally as the cut is being constructed. Apply slope rounding per Section 203, Subsection 3.03(B) of the Standard Specifications.
2. The horizontal dimension of the bench is a function of the staked slope.
3. Apply seeding for revegetation and permanent erosion control as the slope is being constructed to conform to the application limits of the seeding/mulching equipment. Refer to Standard Specifications Section 805.
4. Construct each Minibench parallel to contour lines along entire length.
5. Construct Minibenches on all suitable soil and soil/rock slopes.
6. Use earth diversion dike in lieu of crown ditch when suitable and per the direction of the Engineer. Refer to Earth Diversion Dike Detail.
7. Unless otherwise specified, Sediment Wattles and soil tillage are not required on top of Minibenches.
8. Supplemental BMPs may be necessary in conjunction with crown ditches, earthen dikes or other run-on diversion measures to prevent scour.
9. No direct payment for minibenching of new slopes; all such costs shall be considered included in the cost of excavation.
DETAIL ES7
SLOPE MINIBENCHING
NAME
DATE
DESIGN TAO ZI FONG 05-2011
DESIGN HAN MENG 05-2011
DRAWN TAO ZI FONG 05-2011
DRAWN HAN MENG 05-2011
CHECKED E LEROY BRADY 05-2011
TEAM LEADER E LEROY BRADY 05-2011
ROUTE
MP
LOCATION
ARIZONA DEPARTMENT OF TRANSPORTATION
INTERMODAL TRANSPORTATION DIVISION
ROADSIDE DEVELOPMENT SECTION
STORMWATER QUALITY PROTECTION &
EROSION/SEDIMENT CONTROL DETAILS
SHEET OF
TRACS NO.
___ OF ___
NO.1 DESCRIPTION OF REVISION
MADE BY
DATE
NO.2 DESCRIPTION OF REVISION
MADE BY
DATE
V:/ROADSIDE\users\b1525\
3:01:08 PM
4/26/2011
V:\Roadside\RdsdDev\ERO_BMPs\RDS_Updated_BMPs\ES7_Mini_Benching.dgn

(ADOT1)

APPENDIX VI. HYDRAULIC SEEDING CONTRACTORS IN NEW MEXICO

Hydraulic seeding Contractor	Address	Contact	Phone
814 Solutions LLC	Albuquerque NM	Sam Stribling	505-872-0846
Armarc Landscapes	Las Cruces NM	Armando Orta	505-523-5501
Majestic Views Construction	Las Cruces NM	Carabjal Everardo	575-522-8453
Paul Gelb	Albuquerque NM	Paul Gelb	505-821-5969
StormCo LLC	Bernalillo NM	Kenya Chavez	505-867-4040
TerrawoRX LLC	Serving the entire state	E. B. Spencer Burr	505-321-3717
The Meadow Man	Sante Fe NM	Gabriel Roybal	505-316-4236
Turf Blasters, Inc.	Servicing the entire state	Doug Holmgren	1-800-NEW-TURF

This list is not of recommended contractors, it is provided only as a resource contact list.

APPENDIX VII. CERTIFIED WEED FREE HAY AND STRAW IN NEW MEXICO

APPENDIX VII.A. HOW TO IDENTIFY CERTIFIED WEED FREE STRAW AND HAY:

1. Purple and yellow twine as pictured below is used to certify bales and forges that meet the standards of the North American Weed Free Forage Certification Program. (NMSU)

2. The orange label shown below is used in the Certified Noxious Weed Free Program for products that require another form of labeling besides twine. (NMSU)

Products with other colors of labels have not been certified by the New Mexico State University (NMSU) Seed Certification program. To verify, ask for a Certificate of Inspection that will accompany all products certified by NMSU. (NMSU)

All certified weed free information was taken from the NMSU Noxious Weed Free Certification Program. Accessible online at: http://aces.nmsu.edu/ces/seedcert/certified-weed-free-fora.html.

APPENDIX VII.B. PREVIOUS AND CURRENT GROWERS OF CERTIFIED WEED FREE STRAW AND HAY

This list of certified weed free suppliers was taken from the NMSU Noxious Weed Free Certification Program. Accessible online at: http://aces.nmsu.edu/ces/seedcert/certified-weed-free-fora.html.

This list is not of recommended growers, it is provided only as a resource contact list.

Barry Lyles: Artesia, NM. (575) 513-4532 (Alfalfa and Grass Hay)

Bio-Grind, Inc.: Ruidoso Downs, NM. (575) 937-3690 (Certified Compost/Mulch)

Bud Deerman: Able to handle all of New Mexico and most of the US. Has CRC # for government agency transactions. (575) 233-4286 (Alfalfa, Tiff grass)

Curtis & Curtis: Clovis, NM. (575) 762-4759 (Grass/Straw Hay)

Danny Orris: Bosque, NM. (505) 235-8618 (Alfalfa)

Dr. John Harlacker: La Mesa, NM. (915) 539-1707 (Alfalfa)

Environmental Erosion Controls, LLC: Pertalta, NM. (505) 859-0881 (Erosion Control Materials)

Epifanio Romero: Llano, NM. (505) 587-2000 (Timothy grass hay)

Felipe Sanchez: Jarales, NM. (505) 250-0265 (Alfalfa)

Frank Garay: Arrey, NM. (575) 267-5263 (Alfalfa)

Gro-Well Brands: Albuqurque, NM. (505) 877-8672/1-800-955-3245 (Mulch, compost, wood chips, and other materials)

Glen Adair: Clovis, NM. (575) 760-9333 (Certified Wheat Straw)

J-Bar Company: Joe Lambert, Canyon, TX. (806) 655-2022 (Certified Wheat Straw)

J & M Baling, Mike Grady: Farmington, NM. (505) 326-0145 or (505) 330-4968 (Straw)

Joe Blair: Lordsburg, NM. (520)429-0913 (Alfalfa)

JSJ Farm: Carlsbad, NM. (575) 706-5276 (Alfalfa)

Leonard Scott: Navajo Agricultural Products Industry (NAPI). (505) 566-2675 (Straw)

Miller Feed and Supply: Albuquerque, NM. (575) 897-2444 (Alfalfa, Timothy grass)

Mulch & Seed Innovations: Centre, AL. (256) 927-8823 (Erosion Control Slope Stabilizers)

Ogaz Farms: Garfield, NM. (575) 644-3242 (Alfalfa)

Sierra Feed Store: Truth or Consequences, NM. (575) 894-3994 (Alfalfa)

Silver Dollar Racing and Shavings. (575) 375-2636 (Erosion Control Materials / Mulches)

Ted Stallings: Clovis, NM. (575) 763-4300 (Straw)

SouthCross Farms (Brad Bingham): Amarillo, TX. (806) 679-5858 (Certified Wheat Straw)

Willie Joe Koenig: Las Cruces, NM. Delivery available. (575) 642-6267 (Alfalfa, Straw)

(NMSU)

REFERENCE LIST

Anderson, Michelle D. 2003. Bouteloua gracilis. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/

Arizona Department of Transporation. Roadside Development. Accessible online at: http://www.azdot.gov/Highways/Roadway_Engineering/Roadside_Development/Resources.asp.

Arizona Department of Transporation. Stormwater Program Manuals: Erosion and Pollution Control Manual. Accessible online at: http://www.azdot.gov/inside_adot/OES/Water_Quality/Stormwater/Erosion_Pollution_Control_Manual.asp

Barclay, Angela D., Julio L. Betancourt, Craig D. Allen. 2004. Effects of seeding ryegrass (Lolium multiflorum) on vegetation recovery following fire in a ponderosa pine (Pinus ponderosa) forest. International Journal of Wildland Fire, 13, 183-194.

California Stormwater Quality Association. 2003. California Stormwater BMP Handbook Construction: EC-3 Hydraulic Mulch and EC-4 Hydroseeding. Accessible online at: www.cabmphandbooks.com

Christensen, J.H., B. Hewitson, A. Busuioc, A. Chen, X. Gau, I. Held, R. Jones, R. Kolli, W. Kwon, R. Laprise, V. Magana Rueda, L. Mearns, C. Menendez, J. Raisanen, A. Rinke, A. Sarr, and P. Whetton. 2007. Regional climate projections. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp. 847-940.

Claassen, V.P. and R.J. Zasoski. 1994. The effects of topsoil reapplication on vegetation reestablishment. State of California Department of Transporation Technical Report # FHWA-CA-TL-94/18.

Cobourn, John, Steven R. Lewis, JoAnne Skelly. Stabilize steep slopes with plants and erosion control structures. [Online]. University of Nevada Cooperative Extension. May be accessed online at: www.unce.unr.edu/publications/files/nr/2010/fs1047.pdf

Dick-Peddie, William A. 1993. New Mexico vegetation past, present, and future. University of New Mexico Press. Albuquerque.

Dreesen, David R. 2008. Seeding Native Grasses in the Arid Southwest. New Mexico Natural Resources Conservation Service. Accessible online at http://www.nm.nrcs.usda.gov/news/publications/SeedingNativeGrasses.pdf

Erosion Control Network: "The Effect of Surface Roughness on Soil Erosion." May be accessed online at
http://www.erosioncontrolnetwork.com/articles/articles_detail.aspx?n=108

Erosion Control: Official Journal of the International Erosion Control Association. May be accessed online at http://www.erosioncontrol.com.

Federal Interagency Stream Restoration Working Group (FISRWG) (15 Federal agencies of the US gov't). 1998. Stream Corridor Restoration: Principles, Processes, and Practices. GPO Item No. 0120-A; SuDocs No. A 57.6/2:EN 3/PT.653. ISBN-0-934213-59-3.

Forrest, Carol L, Michael V. Harding, Nancy Gardiner, Howard H. Chang. 2000. Caltrans Erosion Control Pilot Study. Accessible online at
www.fws.gov/fire/ifcc/esr/Library/IECA%20ECPSpaper.pdf.

Glysson, Douglas G. and John R. Gray. 2002. Total Suspended Solids Data for Use in Sediment Studies. U.S. Geological Survey. Presented at: Turbidity and Other Sediment Surrogates Workshop, April 30 – May 2, 2002, Reno, NV.

Goodrich, Gregory B. 2007. Influence of the Pacific Decadal Oscillation on Winter Precipitation and Drought during Years of Neutral ENSO in the Western United States. Weather and Forecasting, Volume 22. Boston, MA, pp. 116-124.

Lady Bird Johnson Wildflower Center. Seed definitions. [Online]. The University of Texas at Austin. May be accessed online at
http://www.wildflower.org/suppliers/definitions.php

Lauenroth, W.K., O.E. Sala, D.P. Coffin, and T.B. Kirchner. 1994. The importance of soil water in the recruitment of Bouteloua gracilis in the shortgrass steppe. Ecological Applications 4:741–749.

Mid-America Regional Council. Winter Watershed Tip: What is Sediment Pollution? Kansas City, Missouri. May also be accessed online at:
www.epa.gov/nps/toolbox/other/KSMO_Sediment.pdf

New Mexico State University. NMSU Noxious Weed Free Certification Program. Accessible online at: http://aces.nmsu.edu/ces/seedcert/certified-weed-free-fora.html.

Payne, Jennifer. Personal communications, observations and attendance at a State of New Mexico workshop on how to reach soil final stabilization in New Mexico.

Payne, Jennifer. 2013. New Mexico ecoregion species lists of commercially available seed. Seed list reviewed by Dr. Timothy Lowrey and Judith Phillips.

Purdue University. Estimating Soil Loss with the USLE. Maybe accessed online at
cobweb.ecn.purdue.edu/~sedspec/sedspec/doc/usleapp.doc

United States Environmental Protection Agency. After the storm. Washington, DC. May also be accessed online at http://www.epa.gov/weatherchannel/stormwater.html

United States Environmental Protection Agency. EPA construction general permit. Washington, DC. May also be accessed online at http://cfpub.epa.gov/npdes/stormwater/cgp.cfm

United States Environmental Protection Agency; Western Ecology Division. Ecoregions of New Mexico. [Online]. Accessible online at: http://www.epa.gov/wed/pages/ecoregions/nm_eco.htm#Ecoregions%20denote

United States Department of Agriculture. RUSLE R – Factor Values for New Mexico (map). May be accessed online at http://www.nm.nrcs.usda.gov/Technical/fotg/section-1/maps.html

TMDLS FOR TURBIDITY, SEDIMENT, TSS, CHLORIDE, SULFATE, AND TDS FOR SUBSEGMENTS 100309, 100602, AND 100603 IN THE RED RIVER BASIN, LOUISIANA
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