CHAPTER THREE
Erosion Control and Revegetation Methodology Techniques and Materials

Roadside Berms and Sidecast Sites

Roadside berms are constructed for public safety at the roadside edge, to stockpile soils from nearby landslides, and to divert or contain water run off. Without revegetation treatment, the roadside berm becomes a vector for exotic weed invasion and a potential site for erosion. With revegetation in place, the berm has potential for providing an aesthetically pleasing appearance that is beneficial to wildlife, prevents water run off, and is an automobile barrier to steep roadside and pull off edges. The roadside berm should be uniform in height and width, and revegetated with seasonal, colorful, native plant materials. Exotic pest plant infestations must be maintained. The surface should be free of brush, debris and rocks, to facilitate maintenance.

The berm side facing the road should be seeded with low growing easily

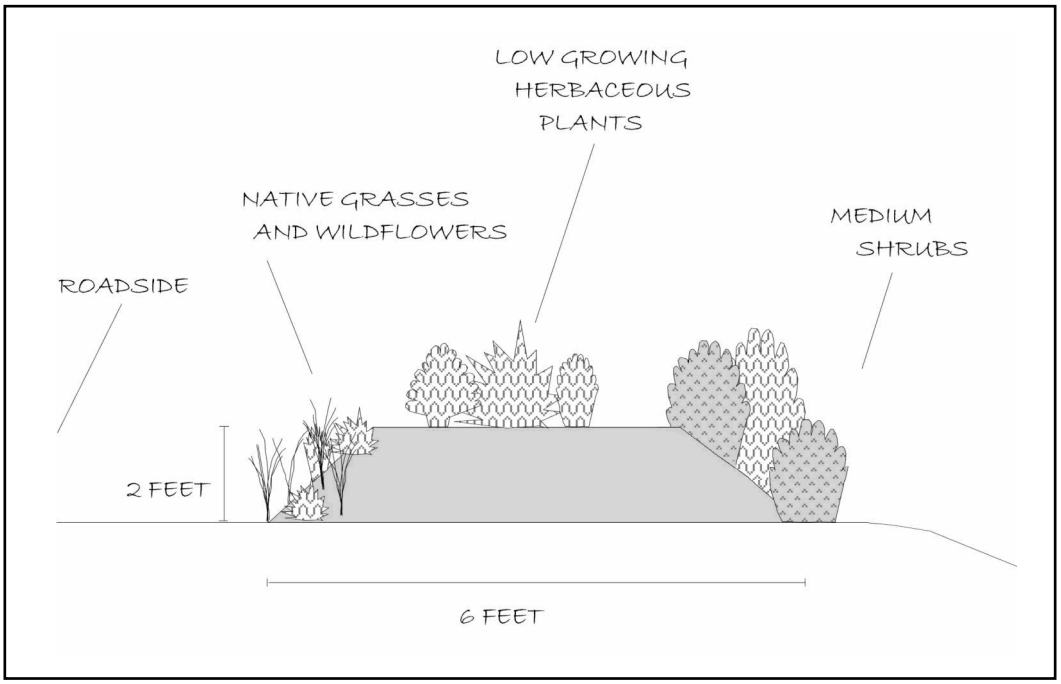


Figure 3.1. Schematic of berm restoration.

Table 3.1. Berm plant materials

BERM PLANT MATERIALS			
Berm Face	**Berm Top**	**Berm Backface**	**Temporary Dust and Erosion Control**
Nassella pulchra	*Eriogonum parvifolium*	*Salvia mellifera*	*Vulpia mycrostachys*
Bromus carinatus	*Mimulus aurantiacus*	*Eriogonum parvifolium*	*Hordeum vulgare*
Eschscholzia californica	*Epilobium cana*	*Artemisia californica*	*Eschscholzia californica*
Clarkia lewissii	*Elymus glaucus*	*Leymus condensatus*	

maintained native grasses and annual wildflowers. The berm top should be seeded with low growing, perennial, herbaceous plants, and the back face vegetated with medium sized native shrubs (Fig. 3.1 and Table 3.1.).

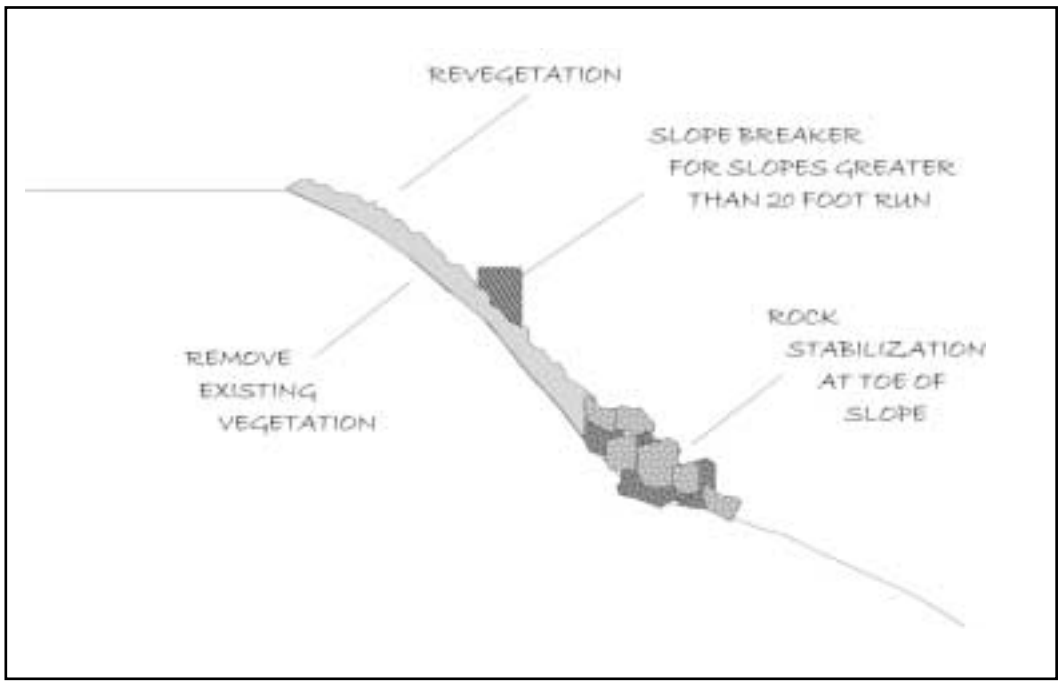


Figure 3.2. Schematic of sidecast and overcast for slopes greater than 20 foot run.

Sidecast and overcast are operations associated with periodic maintenance, such as cleaning out drainage, grading pullouts, and removal of slide debris. Soils overcast and side cast should be revegetated with native species and or temporary erosion control. Overcast sites on slopes and slides greater than 2:1 will require site preparation. Existing vegetation should be removed prior to overcasting fill materials, the toe of the overcast materials anchored with rock, and the site revegetated. Slopes with a greater than 20-foot run should have a terraced slope breaker installed (Fig. 3.2).

Rock-Lined Channel

A rock-lined channel is used in places where high flows of surface water may destabilize surface soils, banks, and channels. A rock-lined channel will dissipate water energy. The channel may be installed at the outflow of a culvert, runoff drain, or "v" ditch. The size of rock to be installed is dependent on the steepness of slope and volume of water energy to be dissipated. Sizing of rock is determined by engineering calculations. Rock size should increase as the slope or potential water flow volume increases.

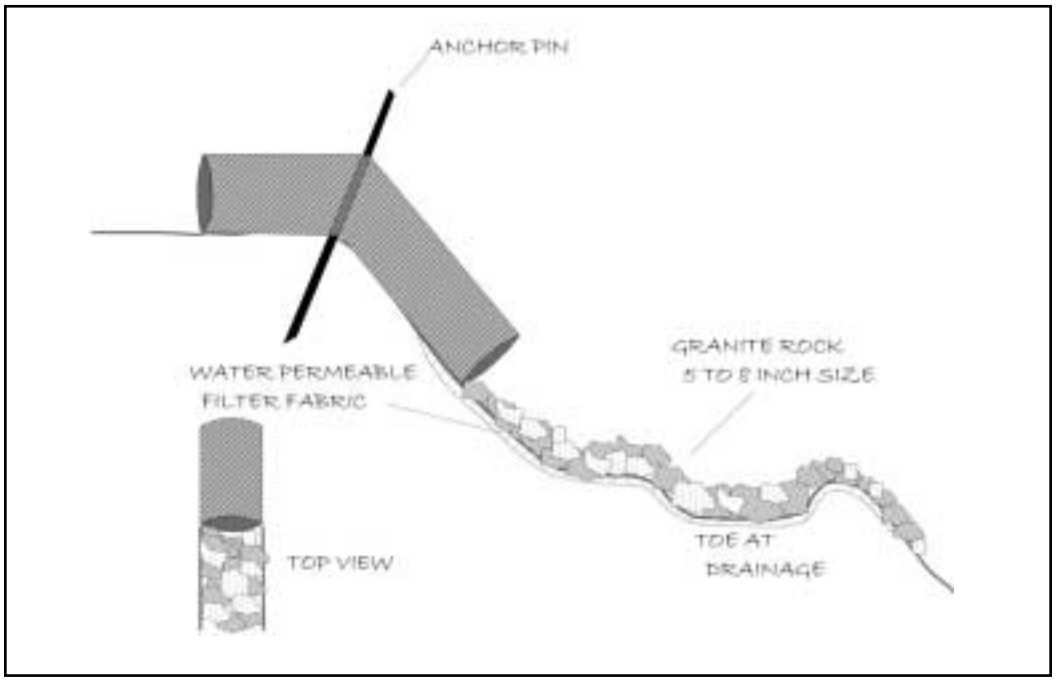


Figure 3.3. Schematic of energy dissipator.

Energy Dissipators

An energy dissipator commonly consists of rock, woody debris, or vegetation installed as a direct barrier to deflect, dissipate, or reduce the energy of flowing water and migrating soils. As mentioned above, with any rock-lined channel the size of rock should increase as the slope or potential water flow volume increases (Fig. 3.3.).

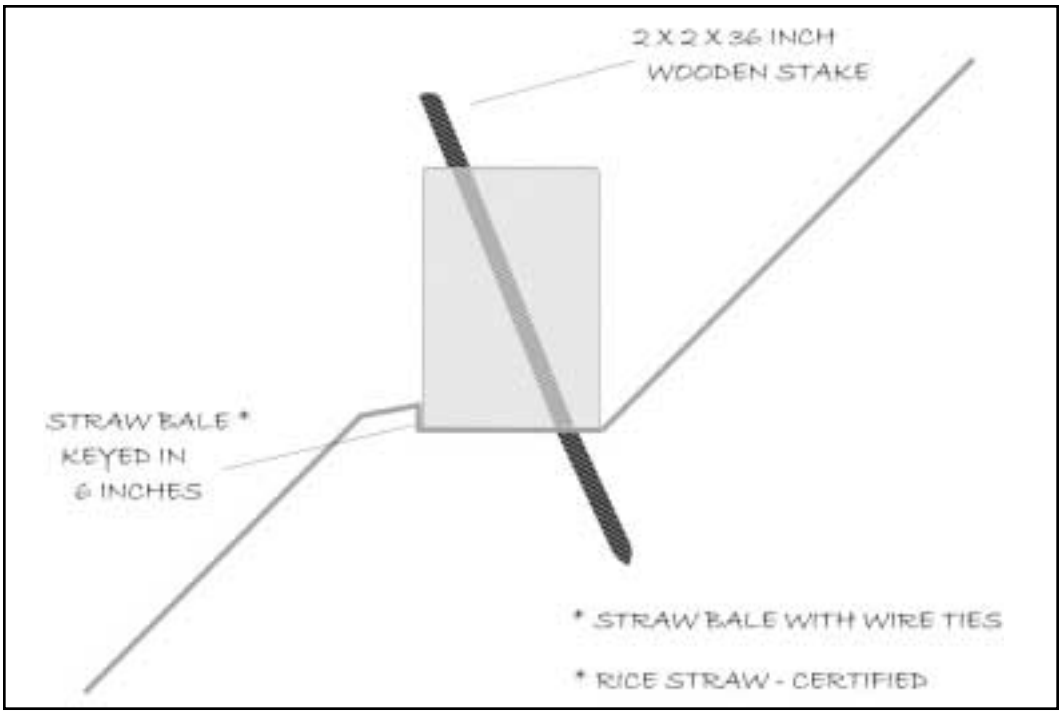


Figure 3.4. Schematic of a slope breaker. Non-biodegradable nylon rope or webbing on straw bales should be removed after the site is stable.

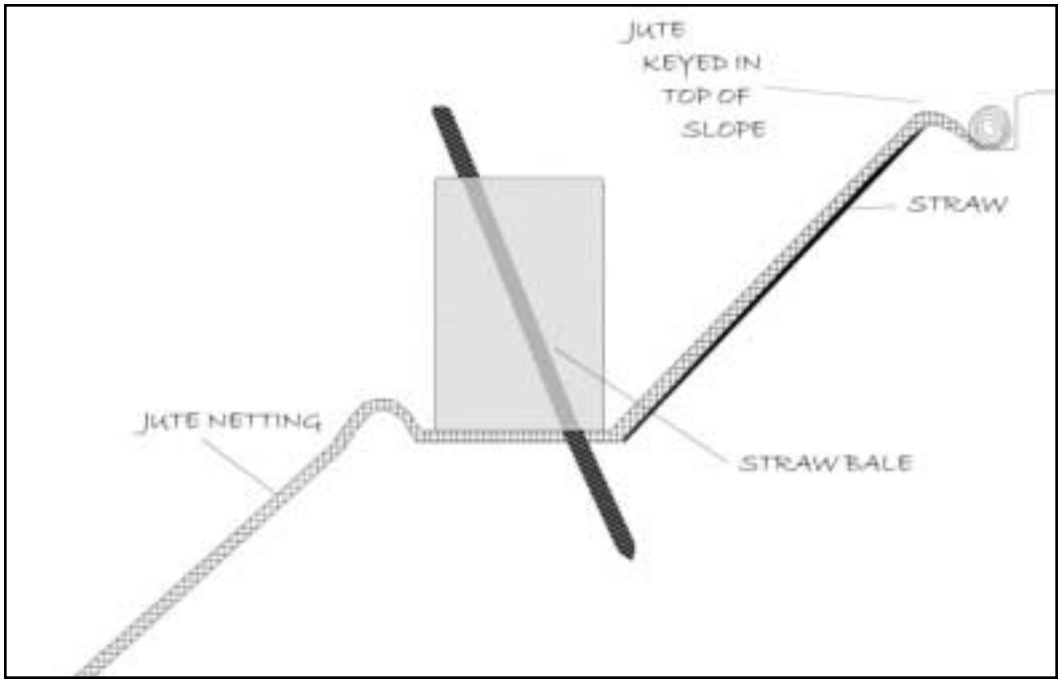


Figure 3.5. Schematic of slope breaker with jute netting and straw.

Straw Bale Slope Breakers

A straw bale slope breaker is installed to decrease surface erosion on steep slopes. The slope breaker consists of straw bales installed on a contour perpendicular to the fall-line of the slope. The bales are pinned with 2X2 wooden stakes, "keyed" into an excavated terrace, and unconsolidated soil tamped around the base to anchor the bales. The soil surface tension is then distributed over a lesser length of slope, and the toe of each run is stabilized by the bales (Fig. 3.4 and Fig. 3.5).

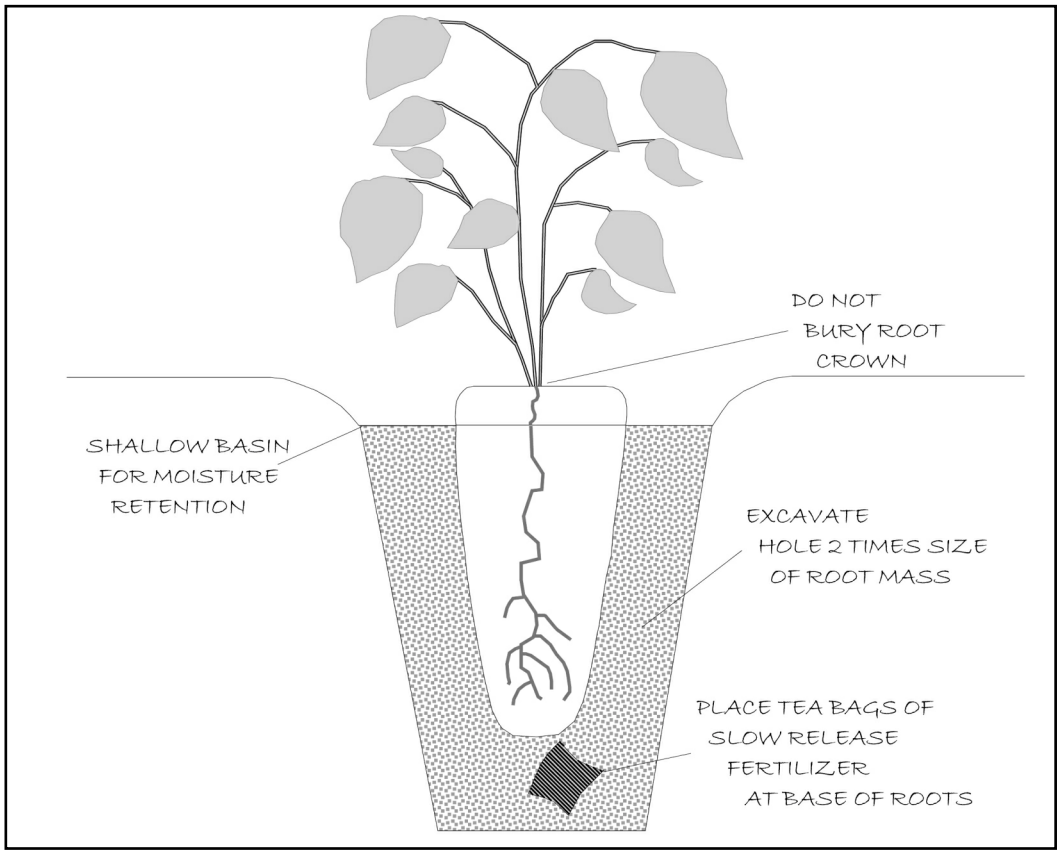


Figure 3.6. Schematic of planting techniques.

Planting Live Plants (Fig. 3.6).

- Utilize a dibble, trowel, shovel, auger or other specialized tool, open a hole twice as deep and as wide to accommodate the live plant.
- Set the live plant into the hole and lightly compact the surrounding soil to "set" the plant.
- Saturate the soil immediately surrounding the plant with water to a depth of 14".

Protecting Live Plants

The collar and screen method is recommended for tree and shrub species, although some conifers have proven equally successful when planted without root protection. One-gallon size nursery containers (collars) with the bottoms removed are placed in excavated holes. The collars are placed in the

hole with approximately 1" protruding above grade and 0.3 oz. of Osmocote 14-14-14 is placed in the bottom of the hole prior to planting. The plant is then installed and backfilled with native soil so that the soil levels inside is the same as the level outside the collar. If seeds are used, the seed should be planted at the appropriate depth for the species, usually twice its diameter. Plantings will be protected from animal browsing and from insects with a screen of fine wire mesh or rigid seedling protection tubes (Tubex or equal). The screen also provides some shade and protection from wind. The screen is attached to the collar with wire. Close monitoring of plants to detect animal or insect damage is essential. If heavy browsing or antler rubbing by deer is detected on young trees, complete wire cage protection will be required.

Pole Cuttings of Willows

Willows can be established in areas of year-round moisture by use of pole cuttings. Willow poles 5/8" to 1-1/2" diameter are cut 60" long during the dormant season (approximately November to February). The poles are installed 12"- 36" deep into pre-augured holes (Fig. 3.7). Willows should be planted within 24 hours of cutting unless they are kept in water. They can also be kept moist and cool (wrapped in plastic and refrigerated) to extend the

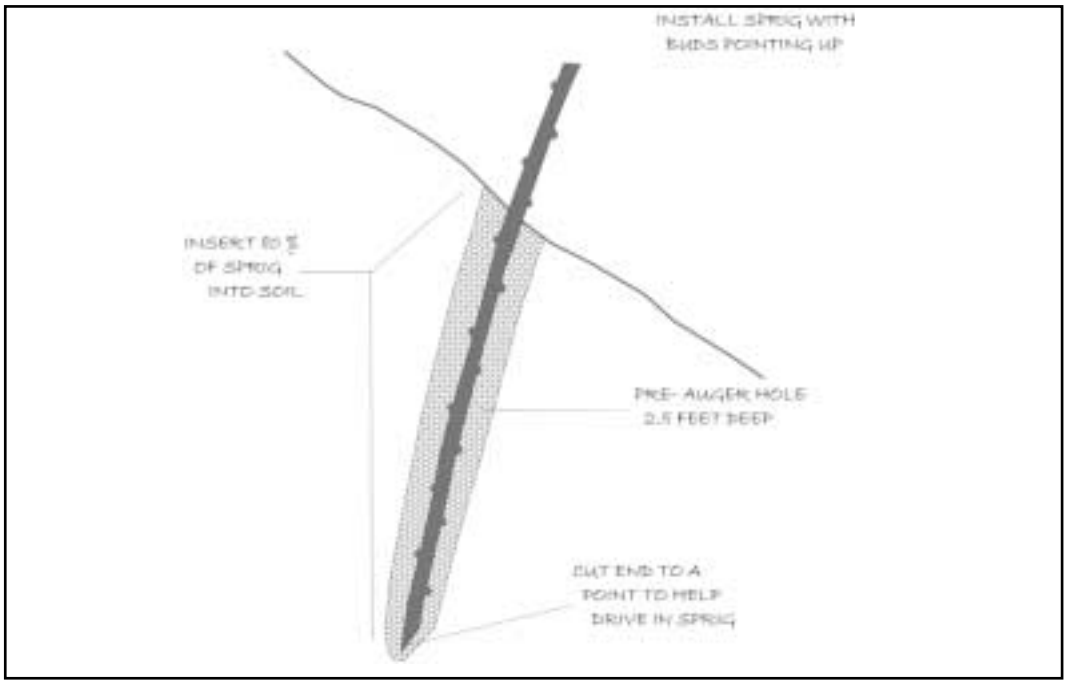


Figure 3.7. Schematic of willow planting.

holding time up to 72 hours.

Willow Wattles

Willow wattles are willow pole cuttings bundled together into six to eight foot long logs, then anchored into side hills, drainage channels, and wet seeps to contain runoff, and anchor unstable wet saturated soils. Willow poles should be cut when dormant, without leaves and buds. The bundles can be tied with twine. The wattle is installed into an excavated trench and the wattle buried. Two inch stakes are driven through the wattle to anchor it in place (Fig. 3.8).

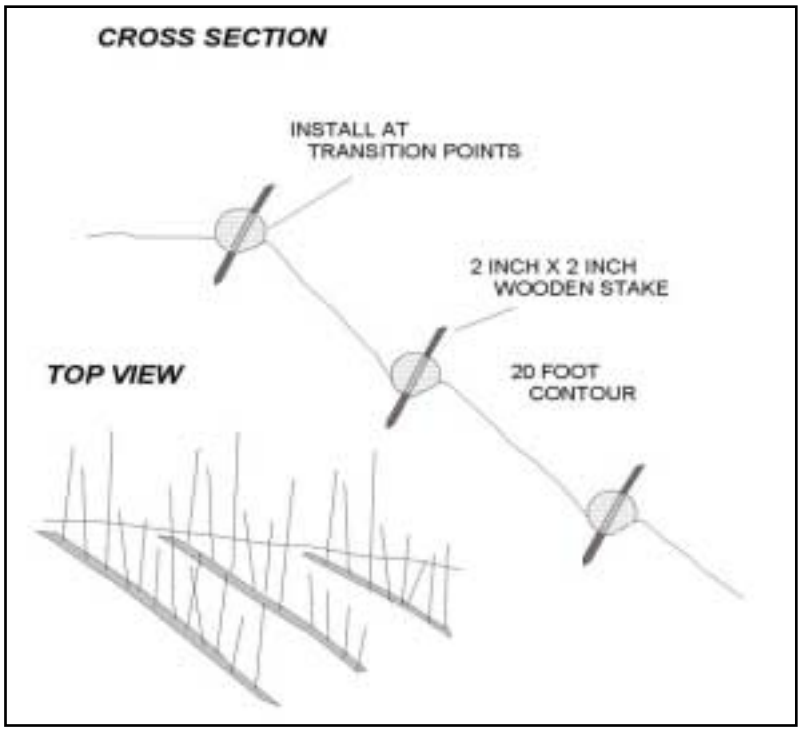
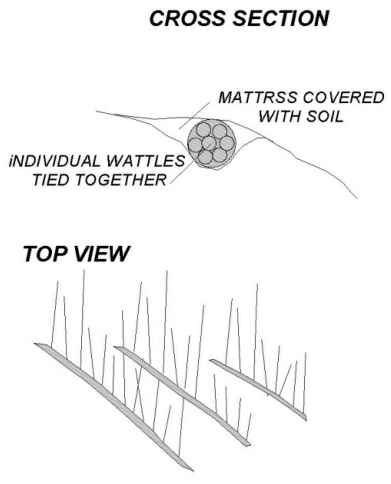


Figure 3.8. Schematic of willow wattle installation.

Figure 3.9. A willow mattress.

A wattle mattress can be constructed by tying several wattles together in a bundle and treating it the same as a single wattle.



Silt Fencing

Silt fence is used to keep fine soils from migrating into waterways. The easiest way to install long sections of silt fence is to dig a trench the length of the fence. The bottom of the fabric is placed into the trench and covered with dirt so water cannot flow freely under the fence. The last stake of one section is interlocked with the first stake of the next section. This overlap helps contain any runoff at the intersection of two sections of silt fence (Fig. 3.10).

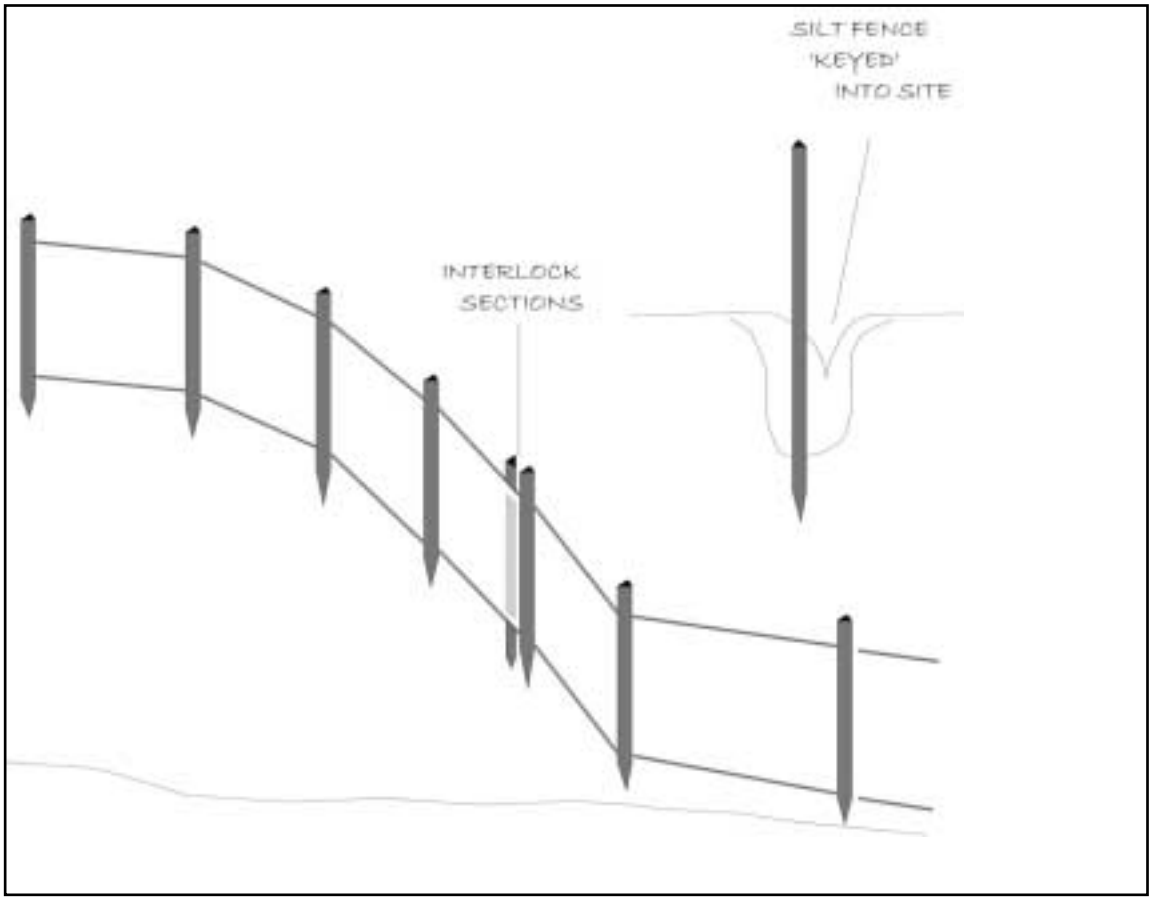


Figure 3.10. Silt fence installation.

Hand Seeding and Direct Seeding

Hand seeding is an effective method of planting small areas accessible by foot. As with any type of seeding, soil preparation, and seed to soil contact is critical. On roadside berms, and sidecasts, seed may be striped off adjacent plants in the fall when ripe, and simply scattered over the disturbed soils. Seeds should then be raked and tamped in.

Tractor Cleating

Preparing the soil surface for seeding is important to successful seed germination and seedling development. Walking a bull dozer tractor up and down a slope will imprint the tractor cleat into the soil surface. The parallel cleat indentations provide a moisture-retaining mini "terrace" from which seed will germinate.

Bio-mulching

Bio-mulching may be accomplished at the restoration site as long as there is an abundant supply of herbaceous native plants that contain ripe seed. Portions of the seed baring plant are pruned back, stem and all thrown into a chipper and the resulting mulch scattered over the area to be seeded. Care must be exercised to avoid mulching with exotic plant material containing viable plant parts or seeds.

Hydroseeding

Mechanical Hydro-seeder apparatus: Seeding shall be performed by a mechanical hydroseeder. Seed shall be uniformly mixed placing seed, mulch, fertilizer, and binder into mix tank in this order. Seed shall be applied in a two-step operation. First place seed and mix a mulch/fertilizer slurry. Second, apply remaining mulch/binder.

Broadcast Seeding

Mechanical Power Drawn Seeder: Sowing shall be performed by a mechanical power drawn broadcast seeder capable of uniformly mixing and broadcasting all seed listed in the appended Seed and Plant Specifications and Rates. Seed will planted no deeper than one-eighth (1/8) inch. Seeding operation shall be kept as close as possible to the contours and not up and

down slopes. After seeding, cover seed using drag mat. Then compact with land roller, such as a cultipacker.

Topsoil Relocation and Inoculation

An inexpensive an often-effective method of inoculating barren cut slopes and soils low in nutrients. Topsoil and/or fill soil from adjacent "intact" soil site is simply scooped up and placed over a disturbed cut devoid of topsoil. Weed control is the primary concern when using native topsoil, as the soil may contain non-native pest plant seed.

Fertilization

Site specific soil tests should be conducted to determine soil nutrient conditions and detected deficiencies remedied during plant installation. Deficiencies in soil nutrients can limit plant growth and project success. Slow release fertilizers and supplements containing nutrients indicated by soil tests should be mixed with soil in lower half of planting hole before plant installation. Nutrient addition to hydroseed mix should be a slow release type, and used only where indicated by soil analysis. Nutrient application should be to enhance planting success, but managed not to aid population or establishment of exotic plant species.

Mycorrhizal Fungi

Mycorrhizal inoculum consists of spores, mycelium, and root fragments in a solid carrier suitable for direct planting, hydro-seeding, and imprinting, and drill seeding. The mycorrhizal fungi aid in nutrient uptake, primarily phosphorus. The fungi are reported to increase soil aggregation and improve soil aeration. Mycorrhizal inoculation is responsive at low-soil fertility levels. The University of California recommends the nutrient levels should be below at least one of the following with phosphorus level being the most critical: Nitrogen 50 parts per million (ppm)), Phosphorus 34 ppm), manganese 27 ppm), and Zinc 12 ppm).

The recommended rate of application is based on propagules/per hectare. Typically, 8,900,00 propagules are specified per hectare. The inoculum may be applied via mechanical hydroseeding apparatus, a land imprinter or by dry broadcasting and incorporation into the soil.

Erosion Control Products

There are a variety of products used for erosion control methods. These products are easily available and in most cases, are cost effective. Most products are used to stabilize loose soils and aid plant material as it sets roots into slopes. Some products are used for moisture retention in more dry applications. Many restoration activities would not be successful without the use of these products.

Jute netting

Jute netting is a commonly used natural fiber net designed to hold soil, straw, and seed in place on slopes and water channels.

Coconut fiber or coir

Coconut fiber or coir mats are biodegradable, long lived mats for used for soil erosion and plant support.

Geo-grid

Geo-grid is an extruded plastic honeycomb of cells designed to retain soil and root growth in unstable soils and slopes.

Straw wattles

Straw wattles consist of straw and/or hay filled plastic net tubes placed on a contour in a slightly excavated trench and attached to the slope with a wooden stake. The straw may consist of native grass straw, barley, wheat, or rice. Proper installation of the straw wattle is essential to insure successful erosion control. The ground should be trenched (especially on slopes) and the wattles laid in the trenches, butted tightly end to end. The wattles also need to be staked to the ground with wooden stakes or willow cutting used as stakes. If you have access to willow cuttings and the wattles are being laid in an area where willows will grow, a double benefit is gained. Wattles should be placed on the contour of the slope, approximately 10 - 20 feet apart, depending on the site conditions.

Silt fence

Silt fencing is designed to contain surface silt from entering sensitive areas, particularly water ways. Silt fence consists of woven filter fabric attached to oak stakes. The fabric is designed to contain muddy runoff from a site long enough for the silt to be filtered out as the water slowly flows through the fence.

Hydro mulch paper

Paper mulch is made from ground up paper and cardboard. It is mixed in a tank with water, fertilizer, and grass seed then sprayed on areas where restoration and erosion control is desired. The purpose is to help prevent erosion and keep the seed moist during germination. It is an excellent way to seed large, steep, inaccessible areas. Paper mulch works well with large seeds, mostly annuals with rapid germination and high seedling vigor. Paper mulch is combined with a tackifier (usually cornstarch) to solidify and harden the paper mulch, thereby protecting the earth from rain droplets.

Hydro mulch wood

Wood mulch is mostly ground up wood fiber wood chips. Wood fiber is beneficial for small seed.

Hydropost

Hydropost compost mulch is compost mulch that improves soil structure, increases biological soil activity, and provides an enriched seedbed for seedling establishment. Hydropost can be applied either wet and/or dry.

Hydro blanket

Use and specify Hydro-Blanket wherever quick, dense vegetation is required and on severe slope where the threat of soil loss, water contamination or excessive runoff dictates an effective treatment. Hydro-Blanket is easy to load, mix, and apply. Hydro-Blanket is designed to work well in all types of hydraulic seeding equipment. The standard application rate for Hydro-Blanket is 3000 pounds per acre on slopes with a length of 100 feet or less. When the length of slope is greater than 100 feet and the water shed is diverted away from the face of the slope, we recommend a graduated

application rate. The MBFM is to be mixed at 40 pounds per 100 gallons of water for mechanically agitated equipment and 25-30 pounds per 100 gallons of water for jet agitated machines (when utilizing a hose, reduce the load rate of Hydro-Blanket to water by 20%). The applicator can spray from 2 more directions (when possible) to avoid the "shadowing effect" and assure coverage of 95% of the soil surface. Rough textured sites may require additional product to increase coverage of the surface area. Preferred 2 Step D.O.T. Method: Hydraulically apply seed, fertilizer and other additives as specified, along with 25% of the recommended rate of MBFM to cover a pre-measured area. In a second application, apply 75% of the recommended application rate to cover and protect the seed bed.

Tackifier

Tackifier is a binder added to the hydroseed mixture. Tackifer products include Fishstick, and "M: binder.

The following links may be helpful in further information and purchase of these products.

http://www.4-sod.com/sandbags/s.html
http://www.conwedfibers.com/
http://www.erosioncontroltech.com/
http://www.fixsoil.com/products/landlok.html
http://www.greenfix.com/
http://www.hydro-blanket.com/
http://www.nedia.com/koirmat1.html
http://www.ricewattles.com/
http://www.rolanka.com/
http://www.siltfencing.com/products.html
http://www.soilguard.com/
http://www.strawwattles.com/ski.html
http://www.tackifier.com/
http://www.terra-mulch.com/hydraulicmulches/index_hyd.html
http://www.woodrecycling.com/re-fiber/wood.html

Native Plant Material Selection

This section provides recommendations for plant material selection and applications. Proper selection of plants and seeds will facilitate project success. Seed selection is based upon specific applications or desired ecological outcomes such as erosion control, revegetation, habitat enhancement, and aesthetics. Selecting seeds from existing plant associations and native plant habitats will provide the appropriate assemblage of plants at the erosion control or restoration site.

Seeds and seed mixes may also be selected based on adaptability and performance rather than for recreation or simulation of native habitat. Often, site and soil conditions that require revegetation are much different than those that preexisted on site prior to disturbance. Therefore, plant material best adapted to perform at the site should be chosen. For example, on cut slopes deficient of nitrogen, *Lupine*, *Trifolium*, and *Lotus* spp. would be selected as part of a revegetation mix because they fix nitrogen in the soil. The use of legumes is a practical and less time consuming method for harsh sites that equipment cannot access, or for sites where soil amendments alone cannot adhere to steep slope faces. Soil amendments can be broadcast or included in hydroseed mixes, but this practice may enhance the exotic seed germination and growth.

Use of non-native annual grass and forb seed is appropriate for fast cover and surface stabilization on sites that are geologically unstable. These types of seeds are also used for nurse crops to assist in establishment of slower growing, longer-lived plants. Use and the rate of application of annual cover crops depend on specific outcomes including erosion control, surface coverage, aesthetics, and site conditions.

Use of Site Specific Seed

Local site specific seed is adapted to the regional climate and edaphic conditions and has developed genetic traits to cope with variation in site and climatic variation. Local plant materials may contain morphological traits specific to local insect and avian populations. Introductions of native plant materials from other than local stock could potentially result in hybridization. Loss of plant vigor is a possible inherited genetic outcome of the use of non-regional plant stock.

Use of Regional Ecotypes

Local site-specific seed may not be available at the time of the revegetation or be available in the quantity or quality required for a particular

project. A regional ecotype is a plant collected and/or propagating from local habitats and site conditions over a larger area such as a watershed or bioregion. Plant materials collected from a bioregion may be similar in plant form and time of flowering thereby assuring performance and adaptability at the revegetation site. Some species of plants are dissimilar over a regional gradient. For instance, cliff buckwheat displays variation from the northern to the southern areas of the Big Sur Coast. On the other hand, California brome is uniform in habitat and form along most of coastal central California. While there are highly variable climatic and edaphic conditions found along the Highway One corridor, use of regional plant materials would be best. Adaptability and performance may be especially hindered if plant materials originate from sites that differ in altitude from that of the target restoration site. We define the limits of regional ecotype use as the Big Sur region, a 76-mile stretch of mountain range beginning at the San Luis Obispo county Line and ending at the Carmel River.

Use of Cultivars and Annual Cover Crops

Annual cover crops and cultivars should be used for short-term erosion control, site stabilization, and dust control. Cover crops may also be used as a nurse crop for slower-growing long-lived native plant species. Use of annual cover crops should be confined to annual plants that do not persist, reseed, and compete with natural native plant regeneration. Appropriate annual cover crops include crop barley, oats, and annual fescue. Inappropriate covers include non-native plants such as Soft chess (*Bromus hordaceous*), and Hycon rose clover (*Trifolium hirtum*). Both of these species can persist long-term and compete with regenerating native plants. Annual plant cultivars such as Regreen sterile wheat may be used. Regreen was especially developed for reclamation and erosion control projects. It grows fast, is a bi-annual providing two years of cover and will not reproduce viable seed.

Use of Hand Collected Seed

Collecting seeds by hand with hand crews is a viable option as a seed source. The benefits include surety of the origin of the seed. A potential downside to using collected seed immediately on a project is related to seed viability. The ability to assess project performance without the benefit of seed testing and analyses is problematic. Field collected material should be stored in paper bags open to the air and allowed to dry to prevent seed molds and related pathogens from damaging seeds. Once dried, seeds may be stored at 4 degrees C to maximize seed viability in storage. It is a common occurrence to encounter insects in field collected seed. High infestations will reduce the percent of viable seed considerably, if left untreated. Field collected seed should be fumigated and/or frozen for a short time (12 hours), to kill pests.

Special care should be taken to collect from non-infested plants whenever possible. Germination tests should be conducted prior to seeding to assess seeding rates.

(PLS) Pure Live Seed Standard

Seeds used for erosion control and revegetation must comply with California State agricultural laws. Grass, herbaceous plant, and wildflower seed shall be true to type listed in the seed specification. All seed shall be furnished in bags or containers clearly labeled to show the name and address of the supplier, the seed name, the lot number, net weight, the percent of weed seed content and the guaranteed percentage of purity and germination. All brands furnished shall be free from such noxious seeds as Russian or yellow star thistle, European Bindweed, Johnson Grass and Leafy Spurge.

Site specific seed should be cleaned, and tested to assure quality and conformance with specifications. The seed supplier should furnish a signed statement certifying that the seed furnished is from a lot that has been tested by a recognized laboratory for seed testing within six months prior to the date of delivery. Seed and seed labels shall conform to all current State and Federal regulations and will be subject to the testing provisions of the Association of Official Seed Analysis.

Most native seed should have a minimum germination and minimum purity of eighty-five percent (85%). Seed shall not exceed 1.5-% weed content. If seed available does not meet a minimum purity and germination percentage specified, the seed supplier must compensate for a lesser percentage of purity or germination by furnishing sufficient additional seed to equal the specified product. Product comparison shall be made on the basis of pure live seed in pounds. The formula used for determining the quantity of pure live seed (PLS) shall be:

Pounds of Seed x (Purity x Germination) = Pounds of Pure Live Seed (PLS)

Seed Mixes and Ratios for Specific Habitat Types

Plant materials and seeds are specified at quantities and rates in order to ultimately replicate or simulate the cover, density, and diversity of pre-existing plant community types. Seed specifications serve as a guide to recreate pre-existing cover and density values. Seed mix components should be analyzed in terms of the specific performance of each species within the mix. Factors relating to performance include; germination and seedling vigor, root to shoot growth rates, and the ultimate size and targeted density of the species planted.

Native Plant and Erosion Control Practices

Identification of Objectives

Identification of objectives of the erosion control and revegetation requires a site analyses and clearly stated objectives. Table 3.2 lists a matrix

Best Management Practices (BMP) Matrix		
Highway One Site Conditions	**Desired Outcome**	**BMP Recommendations**
Overcast Loose Soils: Soils that are temporarily stockpiled or sidecast along the highway during maintenance activities or slide material cleanup.	Temporary Erosion Control	R1. R4.
Roadside berm or sidecast soils: Soils that are placed on the roadside that will remain as a barrier or fill.	Permanent Erosion Control	R4. R5.
	Restoration/ Revegetation Aesthetics	R4. R5. R9.
Engineered cut slope	Temporary Erosion Control	R1.
	Site Stabilization Permanent Erosion Control	R4. R6. R9.
	Restoration/ Revegetation	R4. R5. R6. R9.
Unstable cut or fill slope	Temporary Erosion Control	R1.
	Site Stabilization	R4.
Engineered fill areas	Temporary Erosion Control	R1.
	Site Stabilization Permanent Erosion Control	R4. R6. R8. R9.
	Restoration/ Revegetation	R4. R5. R6. R9.
Outfall of culverts and drainage ways	Erosion control	R10. R12.
Construction or maintenance within sensitive habitat	Site stabilization Revegetation	R4. R5. R6. R9.
Construction or maintenance within riparian habitat	Protection of riparian habitat	R7. R11.

Table 3.2. Best management practices for treatment sites

BMP Key
R1. Hydroseed paper fiber mulch plus annual cover crop (vulpia, bromus, or sterile Regreen).
R2. Hydroseed wood fiber mulch plus annual cover crop.
R3. Hydroseed hydro-post plus wood fiber plus annual cover crop.
R4. Hydroseed hydropost plus permanent native seed mix.
R5. Straw blowing.
R6. Install erosion mat or blanket.
R7. Install willow pole wattles.
R8. Install hay bale slope breakers.
R9. Install straw wattles and/or plant live plants from propagules.
R10. Install rock lined channel
R11. Install silt fence
R12. Install energy dissipaters

conditions, outcomes and a key for Best Management Practices that can be used along the Big Sur coast. The Table lists distinctions between temporary and permanent objectives, and their related recommendations.

Erosion Control Cover Standards

Erosion control-cover standards measure and evaluate the severity of erosion features and provide a corrective action that is relative to the severity

Table 3.3. Erosion control standards

EROSION CONTROL STANDARDS	
CLASSIFICATION	**SUGGESTED REMEDIATION**
Class 1.No soil loss or erosion: topsoil layer intact, well dispersed accumulation of litter from past year's growth plus smaller amounts of older litter.	No action required
Class 2. Soil movement slight and difficult to recognize: small deposits of soil in form of fans or cones at end of small gullies or fills, or as accumulations back of plant crowns or behind litter, litter not well dispersed or no accumulation from past year's growth obvious.	Re-seed (as per temporary erosion control or specific habitat) Apply loose straw and/or 'flakes' as needed Apply only to gullies and or accumulation. Control or divert source of erosion
Class 3. Soil movement or loss more noticeable, topsoil evident, with some plants on pedestals or in hummocks: rill marks evident, poorly dispersed litter and bare spots not protected by litter.	Re-establish and compact surface grade in eroded areas Re-seed (as per temporary erosion control or specific habitat) Apply loose straw and/or 'flakes' as needed Control or divert source of erosion Install straw wattles and/or silt fence
Class 4.Soil movement and loss readily recognizable: topsoil remnants with vertical sides and exposed plant roots; roots frequently exposed: litter in relatively small amounts and washed into erosion protected patches.	Re-apply and compact soil Re-establish surface grade in eroded areas Re-seed (as per temporary erosion control or specific habitat) Apply loose straw and/or 'flakes' as needed Control or divert source of erosion Install straw wattles and/or silt fence
Class 5.Advanced erosion; active gullies with steep sidewalls: well-developed erosion pavement on gravelly soils, litter mostly washed away.	Re-apply and compact soil Re-establish surface grade in eroded areas Haul in and place fill materials/rock Re-seed (as per temporary erosion control or specific habitat) Apply loose straw and/or 'flakes' as needed Control or divert source of erosion Install straw wattles and/or silt fence

of the site characteristics. The success of erosion control should be assessed by site stability, cover of planted species, and the successful establishment of planted species. Table 3.3 describes conditions and suggested remediation methods.

Erosion control seeding

Temporary erosion control mix is comprised of fast growing non-invasive annual grasses, annual forbs, and fast growing native herbaceous plants. These plants are applied to provide fast cover in areas that will be subject to future disturbances from grading, excavations, and fill operations (Table 3.4).

Table 3.4. Temporary erosion control species list

TEMPORARY EROSION CONTROL SPECIES LIST AND RATES			
SCIENTIFIC NAME	**COMMON NAME**	**APPLICATION RATE**	**APPLICATION**
Hordeum vugare	Crop barley	40 pounds/ acre	Temporary cover/nurse crop-performs well on rich soils-will not reseed
Vupia mycrostachys	Annual fescue	25 pounds/acre	Temporary cover –performs on poor, rocky soil-will reseed
Agropyron x triticum	Regreen sterile wheat	40 pounds/acre	Temporary cover-most soil conditions-will not reseed
Eschscholzia californica	California poppy	8-12 pounds/acre	Most soil types, poor soils and slopes-will reseed
Lupinus nanus	Sky lupine	6 pounds/acre	Poor soils-will fix nitrogen

Long-term erosion control and revegetation

Long-term erosion control may be accomplished by the use of native perennial grasses. Below is a list of appropriate grass and plant species for the Big Sur bioregion (Table 3.5).

Table 3.5. Long-term erosion control grass species list and rates

LONG--TERM EROSION CONTROL GRASS SPECIES LIST AND RATES			
SCIENTIFIC NAME	**COMMON NAME**	**APPLICATION RATE**	**APPLICATION**
Bromus carinatus	California Brome	40 pounds/ acre	Erosion control-revegetation Will grow on all soils-will reseed. Nurse crop with other shrubs and plants
Elymus glaucus	Blue wild rye	25 pounds/acre	Erosion control-revegetation Will grow on all soils. Will reseed. Nurse crop with other shrubs and plants-prefers northern exposure
Nassella pulchra	Purple needle grass	40 pounds/acre	Revegetation-long lived. Will grow on poor rocky soils and slopes
Melica imperfecta	Small flowered melic	8-12 pounds/acre	Revegetation-long lived. Will grow on poor rocky well-drained soils and slopes
Nassella lepida	Foothill needle grass	6 pounds/acre	Revegetation-long lived Will grow on poor rocky soils and slopes
Hordeum brachyantherum	Meadow barley	30 pounds/acre	Erosion control-revegetation Will grow on all soils. Will reseed. Nurse crop with other shrubs and plants-prefers wet and seasonally moist locations.

Nitrogen fixing plants

The greatest limiting factor to plant performance on disturbed sites and cut slopes is nutrient availability, particularly nitrogen. Nitrogen fixing plants are found throughout the Big Sur Coast and typically occupy the same site conditions as that found on erosion control or revegetation sites. Legumes fix nitrogen in the soil, improve permeability of soil, and provide cover on sites typically devoid of vegetation. Table 3.6 shows appropriate nitrogen fixing plants for the Big Sur Coast.

Table 3.6. Nitrogen fixing species list and rates

NITROGEN FIXING SPECIES LIST AND RATES			
SCIENTIFIC NAME	**COMMON NAME**	**APPLICATION RATE**	**APPLICATION**
Lupinus albifrons	Silver bush lupine	8-10 pounds/ acre	Perennial, upright large stature grows in disturbed places associated with coast sage scrub. Used for revegetation on harsh sites and loose soil and fill sites.
Lupinus arboreus	Tree lupine	8-10 pounds/acre	Perennial, large stature grows in disturbed places associated with coast sage scrub. Used for revegetation on harsh sites and loose soil and fill sites.
Lupinus benthamii	Bentham's annual lupine	6-8 pounds/acre	Perennial, compact shrub grows in disturbed places associated with coast sage scrub. Used for revegetation on harsh sites and loose soil and fill sites.
Lupinus nanus	Sky lupine	4-6 pounds/acre	Annual, fast growing, diminutive flowering plant. Revegetation of roadside berms, cut and fill slopes
Troifolium wildenovii	Tomcat clover	2-3 pounds/acre	Annual, fast growing, Revegetation of roadside berms, cut and fill slopes. Performs well on poor soil sites
Trifolium gracillentum	Pinpoint clover	2-3 pounds/acre	Annual, fast growing, Revegetation of roadside berms, cut and fill slopes. Performs well on poor soil sites
Lotus stigosus	Bishops lotus	2-3 pounds/acre	Short-lived annual. Grows well on disturbed cut slope locations and poor soils
Lotus purshianus	Spanish clover	4-5 pounds/acre	Short-lived annual. Grows well on disturbed cut slope locations and poor soils most wooded locations.
Lotus benthamii	Bentham's lotus	4-5 pounds/acre	Perennial, low growing. Grows well on cut slopes, and roadside berms

Coastal Sage Scrub community seed mix

The Coastal sage scrub community found throughout the Central Coast consists of a diverse community of annuals and perennials. Table 3.7 shows the species list and application rates of coastal sage scrub species that could be used in restoration projects along the Big Sur Coast.

Table 3.7. Coastal sage scrub species list and rates

COASTAL SAGE SCRUB SPECIES LIST AND RATES (a regional seed specification)			
SCIENTIFIC NAME	**COMMON NAME**	**APPLICATION RATE (acre)**	**APPLICATION**
Ceanothus thrysiflorus	Blue blossum	5 pounds/acre	Revegetation of fill slopes
Eriogonum parviflora	Cliff buckwheat	5 pounds/acre	Revegetation of roadside berms, cut and fill slopes. Beneficial insectary plant
Artemesia californica	California sage	3 pounds/acre	Revegetation of most poor soil sites and harsh conditions
Lupinus arboreus	Tree lupine	4 pounds/acre	Perennial, large stature grows in disturbed places associated with coast sage scrub. Used for revegetation on harsh sites and loose soil and fill sites.
Salvia mellifera	Black sage	4 pounds/acre	Perennial compact shrub. Grows on well-drained slopes. Appropriate for revegetation of fill slopes and roadside berms.
Lotus purshiananus	Purshe's lotus	2.5 pounds/acre	Short-lived annual. Grows well on disturbed cut slope locations and poor soils most wooded locations. Nitrogen fixing plant.
Nassella lepida	Foothill needlegrass	3.5 pounds/acre	Revegetation-long lived Will grow on poor rocky soils and slopes
Rhamnus californica	Coffee berry	4 pounds/acre	Revegetation-long-lived shrub. Beneficial for wildlife habitat.
Bacharris pilularis	Coyote bush	3 pounds/acre	Revegetation-long-lived shrub. Beneficial for wildlife habitat.

Monitoring and Reporting Program

A monitoring and reporting program is required to document progress and success of implementing revegetation of Coast Highway restoration sites. The monitoring program specifies a three to ten year timeline or until success standards are met. Standards for the percent cover, density, and species richness and survival for each site may be based upon baseline vegetation analyses of each existing and adjacent plant community impacted as a result of the land disturbance. The following standards have been developed to measure the relative success or failure of the erosion control and/or restoration.

- Standards for percent cover, density, and species richness and survival rates for native plant communities.
- Standards for the control of non-native species.
- Standards for planting by seed and shrub plantings.
- Standards for slope stability (no evidence of significant erosion).
- Standards for self-perpetuating native plant cover, seedlings evident.

Baseline Vegetation Analyses - Standards for Monitoring Success Criteria

Monitoring of permanent restoration plots will determine if the standards for erosion control and restoration activities are being met. The percent absolute cover, density of trees and shrubs, and the efficacy of erosion control will be determined. Monitoring of both permanent restoration plots and permanent reference plots (intact vegetation) will occur so that comparisons can be made in "real time" rather than based on historic baseline conditions. Monitoring shall continue until all success criteria have been met.

In order to determine the amount of acreage annually restored and achieving success criteria, the restoration and erosion control areas shall be mapped and quantitatively analyzed with a GIS mapping program.

Environmental Factors

The condition of a vegetation restoration effort can be quantified by the criteria in this section. The complexity of environmental factors (slope, aspect, soil type, macro/micro climate, moisture availability, plant competition, etc.) can determine the status of a restoration at a point in time. The climate of the Big Sur coast region is dependent on global weather patterns, with annual rainfall varying greatly. The coastal plant communities respond to the environmental factors, with each species having its specific response. A wet year may be beneficial to one species and harmful to another, causing shifts in species diversity and plant density for example.

The environmental factors discussed above, when combined with coastal erosion, periodic landslides and highway maintenance activities creates a variable environment for plant establishment. On any given section of the highway a patchwork of vegetative covering represents the plant community response to time and the environment. The definition of restoration success can be analyzed by the criteria in this section and reflected by how the site supports native vegetation consistent with the site conditions when compared to similar sites and/or the adjacent plant community.

Qualitative Standards

Qualitative standards for the restoration plan will focus on the establishment of representative species selected from the pre-existing and adjacent plant communities. Qualitative standards will be measured by aesthetic quality of the recreated vegetation or "community types". The landscape will eventually simulate natural contours, color, and texture of forest, grass, and shrub lands to the extent possible given the post erosion terrain and soil conditions.

Photo Reference Points

Photo monitoring can be done simply and inexpensively and can provide illuminating observations on a time scale that we don't naturally appreciate. Permanent monitoring plots will be established at key locations throughout restoration sites of the eroded area. At each monitoring plot, a permanent marker is installed. For each monitoring point corrected GPS location data are taken and recorded. A permanent datum will be installed at the ground level consisting of t-bar stakes.

Quantitative Standards

Plant establishment will be measured by field survey. Mortality of selected native plant species of over 10% of planted individuals will indicate corrective actions are required. Vegetative cover of herbaceous species is a good index to the amount of light and soil nutrients being captured by a member of the community. Thus, canopy cover of herbaceous weed species will be used to determine when weedy species require corrective actions. Absolute canopy cover of more than 10% of an exotic weed species will require corrective action. Plant community dominance values of larger woody species, including French broom, pines, and redwoods (for example) can be influenced by both how many individuals are in a given area and the size of each individual measured. The number of individuals can be measured as density of stems (number/unit area). The size of individuals can be indexed by

measuring the total area of trunks measured at a standard height above ground (eg., 1.4 meters above the ground is Diameter at Breast Height (DBH)). Diameter at a standard height is measured and recorded to allow calculation of areas of each stem. Corrective action for mortality of individually planted species will include an analysis to determine the cause of mortality. If a cause can be established, that information will be used to select and re-install replacement individuals. Corrective action for abundant, non-native weeds will vary with the species, but in all cases will require appropriate weed control. Methods of exotic plant control are discussed in this chapter. Corrective action for loss of large woody species will include an analysis of the cause of mortality or lack of growth. Poorly performing species will be replaced.

Canopy Cover, Density, and Species Richness Standards

Canopy Cover

Canopy cover, density, and species richness standards are determined from the baseline vegetation analyses. Some example relative cover values for some habitat types are: 1) Mixed Evergreen Forest is 82.5%, 2) Redwood Forest is 100%, 3) Oak Woodland is 83%. The ultimate canopy cover standard for each habitat type shall be no less than 80%.

Density

Planting densities shall conform to those species and rates as stated in The Planting and Seeding Specifications which will ultimately meet or exceed tree and shrub densities of existing vegetation of each habitat type.

Species Richness Standard

The species richness standard is based on achieving a level of plant diversity within each of the habitats to be revegetated. The primary or dominant species shall be established per stated mortality standards. The species richness standard shall include 80% cover of 75% of the additional diversity species present within Redwood Forest, Mixed Evergreen Forest, Riparian, and Maritime Chaparral habitats. The species richness standards for Needle grass grassland and diverse grassland shall include 75% of the forb component at a 35% cover standard.

Monitoring Methods

Restoration will proceed in stages over many years. At each stage, the success of the planting will be monitored with a statistically valid sampling method, and changes can be made in the selection of species to be planted in

new restoration areas, and species which need to be added to previously restored areas. Species, which are not suited to a particular area, will suffer significant mortality. This mortality will be documented during monitoring, and will prompt closer study of the sites. For instance, if one species dies out and it is found that the soils are relatively acid, a more acid-tolerant species will be added to the next restoration and to previous sites where less acid-tolerant species did not thrive. By this kind of adaptive management, new patches of diverse, native plants will be assisted on restoration sites that will then contribute to the natural vegetation mosaic of the Central Coast of California.

Observation of previously eroded sites where only natural colonization has occurred provides a list of native plant species that are known to thrive. Experience with collection and propagation of native plants provides a further filter for native plants that are known to be successful at natural colonization.

Description of Monitoring Methods

Herbaceous Vegetation, Grassland, and Erosion Control

A sampling regime will be established so that at least 2% of the total restoration area, or at least 20 sampling plots, will be included. A total of 25 sampling points must be selected. The sampling design will be stratified to include all restoration sites. Dividing the entire restoration area into 25 sub-units of roughly equal area can do this. On a map of each sub-unit, a grid overlay will be placed showing at least 100 roughly equal area subdivisions. Subdivisions will be assigned a number from 1-100. At least one sampling location will be chosen from each sub-unit by selecting a random number (from 1-100) from a random numbers table. That random number will identify the subdivision in each sub-unit. The map will then provide the rough location of each starting point, one per subdivision. This point will be determined in the field, and from this point, a 50-meter measuring tape along the contour will be laid out. This line represents the centerline of a 50 x 20-meter sampling plot. The heading of the line will be noted for future monitoring reference. At every 2.5 meters along the line, a steel quadrat (0.1 square meter) will be placed. The quadrat is painted along the edges to show 6 cover classes (0-5%, 6-25%, 26-50%, 51-75%, 75%-95%, 95-100%). Percent cover for each species will be determined by averaging estimated crown cover of each species within a quadrat. Midpoints of cover classes will be assigned to each observation and averaged twenty quadrats at each sampling location. This method is commonly used in vegetation sampling (Bonham, 1989).

A sample of 25 individual plants of each herbaceous perennial species planted will be marked with a plastic flag on a steel wire and individually

numbered. For relocation purposes, these will be located near the centerline of the sampling plots. Four times a year, each plant will be visited and scored as:

- alive and showing new growth
- alive
- alive but with dead leaves, or
- dead.

Shrub Vegetation

Along the centerline of the sampling plot, a tape will be laid out and line intercept values will be recorded for each species encountered. Canopy coverage is projected down on the tape for each individual plant encountered. The number of centimeters of tape covered by the shrub is recorded. Percent cover for each species is expressed as a sum of all intercepted distances divided by 50 meter.

Tree Vegetation

Abundance of trees can be determined by using a so-called "Point-Centered Quarter Method" (Mueller-Dombois and Ellenberg, 1974). This requires that one establish a point (starting point, described above). For each species, the nearest four "trees" (diameter at 1.4 meter greater than 1inch) are identified in each of the four principal directions. For each species, distances to each tree from the starting point are recorded, as are diameters of each tree at 1.4 meter height. From these data, density and total basal diameter can be calculated (Bonham, 1989). Density of trees are expressed as number of trees per acre, and diameter at standard height can be read with "diameter tapes" which are wrapped around the tree and read diameters directly. At least 25 center points for each species to be monitored must be sampled.

Methods for Analyzing Monitoring Results

For each of the herbaceous species, total canopy cover must be calculated at each transect, using the smaller (20 centimeter x 50 centimeter) quadrats as sampling units. Individual cover values for each species in each of the 20 quadrats at each sampling plot must be recorded. Means and standard deviations are calculated and standard, parametric "t" tests will be used to compare cover between sampling periods, or between a sampling period and a given threshold (eg. 40%). The absolute numbers of surviving plants installed on the site will be taken directly from the numbers of flagged, plants still alive. Average number alive can be calculated. No comparative

statistics should be needed, but these data shall be used in 2x2 Chi-Square analyses.

Similarly, for each of the sampling plots (at least 20), the mean cover of each species will be calculated from the observed individual cover values. That is, at each 20 meter x 50 meter plot, individual cover values, as they are read along the 50 meter tape, are recorded. These are then averaged and will allow comparisons (Means, variances, parametric "t" tests) for the same sampling plots between years (for each species of concern) or for a given species at one plot against some pre-determined threshold (eg. 40%). For tree species, the density of stems will be calculated. Again, comparative standard parametric statistics (means, variances, "t" tests) will be calculated to make comparisons between plots or between the same plot over time (Bonham, 1989).

Site Maintenance

Maintenance

Erosion control, revegetation, restoration maintenance, and protection of planting and seeding shall begin immediately upon initial project completion and continue until the end of a maintenance period of sufficient length to ensure successful attainment of project objectives and specifications. A maintenance schedule is a necessary requirement for every project. A maintenance period provides and assures:

- plants are being cared for,
- exotic plants are controlled,
- plastic, debris and non-bio-degradable materials are removed,
- sites will be inspected more frequently, and site elements will be corrected,
- a project will have a better success long-term.

Minimum length of maintenance should cover two growing seasons, and optimal duration should be five growing seasons. Defective work shall be corrected as soon as possible after it becomes apparent that weather and season permit. Once a landslide occurs or site instability is detected, no site restoration work should occur on the site until the end of the rains and/or after site review for safety by an appropriate safety officer.

Maintenance during this period includes, but is not limited to:

- **Correcting the grade in areas of settlement or erosion:** correcting the grade and repair of erosion features should be incorporated into all revegetation specifications.
- **Fertilization:** Post-establishment fertilization should occur to enhance plant growth, increase soil coverage, and promote seed production of targeted species. Care should be taken to not enhance weed species by over fertilization or misapplication.
- **Mowing and or vegetation control:** Mowing and/or other forms of vegetation control may be necessary to repress or reduce biomass for safety reasons, and limit the spread of invasive plant species.
- **Re-seeding:** If the stated success criteria for coverage of targeted species are not met, reseeding or replanting may be required.

- **Re-planting:** If plants die or are not healthy, then replanting may be required.
- **Watering:** Supplemental watering may be required to establish plant materials during the dry season.
- **Weeding:** Reduction and/or elimination of invasive pest weeds may be required to reach stated ecological outcomes.
- **Litter and clean-up:** Follow up maintenance shall include pick up of litter and debris. Cleanup shall include eventual removal of wooden and steel stakes, containers, plant protection, straw bale twine, and other non-organic revegetation materials.

Timing of application of erosion control

- Temporary erosion control should be in place by October 15
- Permanent erosion control should be in place November 15- January 15
- The timing of weed control is dependent on weed species and the method of control. Physical removal of weeds by uprooting should occur during the wet season for ease of plant extraction. Chemical control is best during the fast growth period of target species, and mowing or cutting should occur close to seed maturation of target species.

Weed Control

Weed control has been identified as one of the most important primary processes for the success of future revegetation plantings, as well as for the successful reestablishment of existing native plant populations. Specific goals for weed control are as follows:

- Limit the spread of invasive, exotic plant species.
- Support the reestablishment of existing native plant species and their future progeny by limiting unnatural competition by exotic species.
- Provide a competition-free planting zone for future revegetation planting endeavors during restoration.
- To utilize mowing and selective spot spraying of approved post-emergent herbicides as the primary weed controls.
- To physically protect native plant species growing in the midst of exotic weeds during spray operations.

- To utilize a surfactant with the herbicide to enhance adhesion and penetration of the plant dermis, and to utilize an organic dye to help applicators see where the mix has been applied. Both ingredients optimize the use of chemicals for control, increase control effectiveness, limit subsequent reapplication, and provide an overall more environmentally safe procedure.
- To closely oversee and effectively manage weed control operations through well-timed, monitoring procedures.

Primary exotic plants to be controlled

Table 3.7 provides a summary list of species, seed bank life, exotic pest plant classification, control methods, and time year of application of these methods. The CalEPPC Exotic Pest Plant Classification includes USDA and California Department of Food and Agriculture Ratings (CalEPPC, 1999).

Jubata Grass (Cortaderia jubata)

This weedy "Pampas grass" is an extremely invasive species. It has become a serious weed in a large part of California. It can be a highly visible nuisance, which is difficult to kill and is quite prolific. Pampas grass has a propensity for establishing itself on bare, steep slopes by means of its myriad's of very small seeds, which may be wind-dispersed over great distances. Since this characteristic makes it particularly likely to infest site areas scheduled for future revegetation planting, its eradication is first priority. Since the seeds are very small, they are not long-lived and seedlings do not compete well with established vegetation. They germinate best on bare soil, particularly in moist areas.

Because of the abundance of its seeds and the distances to which they may be dispersed by the wind, thoroughness is essential in eradicating this pest.

French Broom (Genista monspessulanus)

This leguminous shrub is the most significant non-native invasive species in the highway corridor. French broom is also the most significant invasive exotic in adjacent areas of the Santa Lucia Mountains and is particularly common on road cuts. French broom typically grows in disturbed areas, and along the highway it is generally distributed on banks and pulloffs.

Table 3.8. Exotic species control methods. [1] Seed bank life: Short is less than two years, long is greater than two years, very long is greater than five years. [2] California Exotic Pest Plant Council, 1999.

EXOTIC SPECIES CONTROL METHODS AND TIMING				
Species	**Seed Bank Life[1]**	**CalEPPC Exotic Pest Rating[2]**	**Control Treatment**	**Timing**
Jubata Grass *(Cortaderia jubata)*	Short	A-1	Manual control – Dig mature plants manually or hand pull seedling plants	October to January
			Flower control – Cut flower tops back prior to seed maturation. Dispose of flower tops. Do not disperse or mulch.	May to July
			Herbicide control – Round-Up applied at 2-4% with Blazon blue agricultural dye.	May to August
French Broom *(Genista monspessulanus)*	Very Long	A-1	Manual control – Dig, weed wrench, or hand pull seedling plants.	October to February
			Flower control – Weed eat or machete seed bearing plants. Dispose of seed bearing plant parts. Do not disperse or mulch.	May to July
			Herbicide control during or after flowering– Garlon 4 applied at 4% with Blazon blue agricultural dye. Herbicide control during active growth stage- Round-up applied at 2-4% with Blazon agricultural dye.	May to July January to April
Purple Star Thistle *(Centarea calcitrapa)*	Short	B	Manual control – Dig plants manually or hand pull seedline plants. Graze plants intensively in the rosette stage.	February to March
			Flower control – Weed eat or machete flowering plants prior to seed maturation. Dispose of seed bearing plant parts. Do not disperse.	May to July
			Herbicide control – Spot spray Round-Up applied at 2% with Blazon blue agricultural dye.	March to April
Fennel *(Foeniculum vulgare)*	Long	A-1	Herbicide control- Spot spray Round-Up applied at 2% with Blazon blue agricultural dye.	March to April
Gorse *(Ulex europaeus)*	Very Long	A-1	Manual control – Dig or hand pull seedling plants.	October to February
			Flower control – Weed eat or machete seed bearing plants. Dispose of seed bearing plant parts. Do not disperse.	May to July
			Herbicide control – Garlon 4 applied at 4% with Blazon blue agricultural dye. Spray plants prior to flowering.	April to July

Table 3.8. continued.

EXOTIC SPECIES CONTROL METHODS AND TIMING				
Species	**Seed Bank Life[1]**	**CalEPPC Exotic Pest Rating[2]**	**Control Treatment**	**Timing**
Bull Thistle *(Cirsium vulgare)*	Short	B	Manual control – Dig plants manually or hand pull seedling plants. Graze plants intensively in the rosette stage.	February to March
			Flower control – Weed eat or machete flowering plants prior to seed maturation. Dispose of seed bearing plant parts. Do not disperse.	May to July
			Herbicide control – Spot spray Round-Up applied at 2% with Blazon blue agricultural dye.	March to April
Eucalyptus *(Eucalyptus globosus)*	Long	A-1	Manual control – Hand pull seedlings. Cut down entire tree. Frill cambium on stump.	October to March
			Herbicide control – Garlon 4 applied at 25% with Blazon blue agricultural dye and surfactant.	March to July
English Ivy *(Hedera helix)*	Long	B	Manual control – Machete or handpull green vegetation.	October to March
			Herbicide control – Rodeo* applied at 2% with Blazon blue agricultural dye and surfactant. *Rodeo to be used near freshwater resources.	March to June
Poison Hemlock *(Conium maculatum)*	Short	B	Manual control – Mow or cut plants prior to flowering.	April to May
			Herbicide control – Round-Up applied at 2% with Blazon blue agricultural dye and surfactant. Spray plants prior to flowering.	April to May
Cape Ivy *(Senecio mikanioides)*	Long	A-1	Rodeo at 1.5% with a 1/2% non-ionic surfactant	November-February
			Manual control – Machete or handpull green vegetation.	March - November
Sticky Eupatorium (*Ageratina adenophora*)	Short	B	Herbicide control – Round-Up applied at 2% with Blazon blue agricultural dye and surfactant. Spray plants prior to flowering.	March-April

French broom seeds are hard-coated and viable for many years, as is generally the case with legumes. Their exploding pods mostly disperse the seeds. They are effectively spread by water, as along watercourses. Other modes of dispersal include vehicles and movement of gravel or soil contaminated with them; birds or animals may transport them to remote areas.

French broom seedlings are intolerant of shade, so it spreads slowly in areas of established vegetation and decreases in the increasing shade of taller growing species. The plants are capable of growing over three feet tall in their first year and mature quickly, rarely living more than 10-15 years.

Fennel

Fennel is a long-lived herbaceous and robust plant quite easily controlled by Round-up applications. Wind and moving soils disperse the seeds. Fennel invades most any soil type, and is a prolific seed producer. If left uncontrolled it may increase in area by 7% annually.

Additional species for control

Additional exotic pest plants targeted for removal and control are:
Poison Hemlock (*Conium maculatum*)
Bull Thistle (*Cirsium vulgare*)
English Ivy (*Hedera helix*)
Gorse (*Ulex europaeas*)
Cape Ivy (*Senecio mikanioides*)
Sticky Eupatorium (*Ageratina adenophora*)

Chemical control procedures

Because most weed species for chemical control lie adjacent to roads, an in-bed, or tow-behind, large spray tank with a minimum one hundred foot (100') length hose is the preferable equipment combination. A flat fan nozzle is also preferable for a more accurate application.

The specified spray mix is as follows:

Herbicide: Active ingredient glyphosate (Round-up or equal)
Water: Clean and free of particulate matter (glyphosate adsorbs on clay

particles)
Surfactant: Triton Ag 98 or equal
Dye: Blazon agricultural dye
Ingredient rates as specified by manufacturer.

Personnel providing spray services shall be fully trained in such operations, and shall wear all required protective clothing. The spray contractor shall carry all licenses and insurance required by the State of California and all other governmental agencies having jurisdiction. The spray contractor shall also be responsible for notification of all parties regarding application of chemical herbicide as is required by law.

Protection of native plant species during spray operations
Prior to the application of herbicide, the spray contractor shall become thoroughly familiar with native plant species, growing within exotic weed colonies, which are to be protected. A monitoring biologist is required to provide familiarity training using photographs, on-site identification, marking with flagging tape, and any other techniques necessary to convey specific identification.

The contractor shall thereafter provide any and all appropriate measures necessary to protect identified native plants, such as shielding of plants with rolled plastic sheeting, while adhering to all applicable health and safety codes for worker protection.