Revegetation Guidance Document For Erosion Control Projects in the Tahoe Basin

Prepared for:

CALIFORNIA TAHOE CONSERVANCY

Prepared by:

AECOM

870 Emerald Bay Road, Suite 400
South Lake Tahoe, CA 96150

2020 L Street, Suite 400
Sacramento, CA 95811

June 30, 2010

AECOM

Revegetation Guidance Document
For Erosion Control Projects in the Tahoe Basin

Prepared for:

California Tahoe Conservancy
1061 Third Street
South Lake Tahoe, CA 96150

Contact: Scott Cecchi
530/543-6015

Prepared by:

AECOM

870 Emerald Bay Road, Suite 400
South Lake Tahoe, CA 96150

2020 L Street, Suite 400
Sacramento, CA 95811

Contact: John Zanzi
Sr. Landscape Architect/Project Manager
916/414-5800

June 30, 2010

P 04110017.02

Acknowledgment

This document has been prepared based on Steve Goldman's (formerly of the California Tahoe Conservancy) idea of advancing the science and practice of revegetation implementation for erosion control projects in the Tahoe Basin. The document reflects collaboration with Steve Goldman, Scott Cecchi of the California Tahoe Conservancy, Shay Navarro of the Tahoe Regional Planning Agency, Brendan Ferry of El Dorado Department of Transportation, Julie Etra of Western Botanical Services, Michael Hogan and Kevin Drake of Integrated Environmental Restoration Services, and Curtis Alling of Ascent Environmental.

Table of Contents

Section	Page
1. INTRODUCTION	**1-1**
1.1 Context, Scope, and Goals	1-1
1.1.1 Context	1-1
1.1.2 Scope	1-1
1.1.3 Goals	1-2
1.2 Approach	1-3
1.2.1 Literature Review	1-3
1.2.2 Reconnaissance Assessment of Projects	1-4
1.2.3 Detailed Roadside Cut Slope Survey	1-5
1.2.4 Agency Input	1-6
1.2.5 Peer Review	1-6
1.3 Organization of This Document	1-6
2. EROSION, PLANT GROWTH, AND REVEGETATION	**2-1**
2.1 The Process of Erosion	2-1
2.1.1 Erosion by Raindrops	2-2
2.1.2 Erosion by Flowing Water	2-2
2.1.3 Erosion by Wind	2-5
2.1.4 Mass Wasting	2-5
2.2 Plant Establishment and Growth	2-5
2.2.1 Plant Establishment	2-6
2.2.2 Plant Growth	2-7
2.3 Disturbance	2-10
3. DESIGN IMPLEMENTATION	**3-1**
3.1 Implementation Approach	3-1
3.1.1 Project Delivery Methods	3-2
3.1.2 California Conservation Corps Crews	3-8
3.2 Construction Documents	3-10
3.2.1 Construction Drawings	3-13
3.2.2 Construction Specifications	3-13
3.3 Contracting	3-18
3.3.1 Turnkey vs. Separate Revegetation Contracts	3-18
3.3.2 Contractor Minimum Qualifications	3-19
3.3.3 Bidding	3-21
3.3.4 Preconstruction Activities	3-21
3.3.5 Preconstruction Meeting	3-22
3.3.6 Submittals, RFI's, and Approvals	3-23
3.3.7 Construction Oversight	3-24
3.3.8 Regular Construction Meetings	3-25
3.3.9 Record Drawings	3-26

Table of Contents

Section	Page
4. REVEGETATION APPROACHES AND COMPONENTS	**4-1**
4.1 Site Evaluation Practices	4-2
4.1.1 Relationship to Revegetation	4-2
4.1.2 Recent Practices	4-3
4.1.3 Observed Outcomes of Revegetation Projects	4-4
4.2 Site and Soil Preparation	4-4
4.2.1 Relationship to Revegetation	4-4
4.2.2 Recent Practices	4-10
4.2.3 Observed Outcomes of Revegetation Projects	4-15
4.3 Plant Materials	4-18
4.3.1 Relationship to Revegetation	4-18
4.3.2 Recent Practices	4-23
4.3.3 Observed Outcomes of Revegetation Projects	4-35
4.4 Planting and Seeding Techniques	4-37
4.4.1 Relationship to Revegetation	4-37
4.4.2 Recent Practices	4-40
4.4.3 Observed Outcomes of Revegetation Projects	4-42
4.5 Mulch	4-45
4.5.1Relationship to Revegetation	4-45
4.5.2 Recent Practices	4-46
4.5.3 Observed Outcomes of Revegetation Projects	4-48
4.6 Biotechnical and Other Treatments	4-48
4.6.1 Relationship to Revegetation	4-49
4.6.2 Recent Practices	4-50
4.6.3 Observed Outcomes of Revegetation Projects	4-52
4.7 Maintenance	4-53
4.7.1 Relationship to Revegetation	4-53
4.7.2 Recent Practices	4-56
4.7.3 Observed Outcomes of Revegetation Projects	4-58
4.8 Monitoring	4-60
4.8.1 Relationship to Revegetation	4-60
4.8.2 Recent Practices	4-62
4.8.3 Observed Outcomes of Revegetation Projects	4-65
4.9 Performance and Success Criteria	4-66
4.9.1 Relationship to Revegetation	4-66
4.9.2 Recent Practices	4-67
4.9.3 Observed Outcomes of Revegetation Projects	4-71

Table of Contents

Section	Page
5. RECOMMENDATIONS	**5-1**
5.1 Basis and Scope of Recommendations	5-1
5.2 Recommendations Regarding Revegetation Components	5-6
5.2.1 Site Evaluation Practices	5-6
5.2.2 Engineering Design	5-7
5.2.3 Site and Soil Preparation	5-10
5.2.4 Plant Materials	5-12
5.2.5 Planting and Seeding Techniques	5-15
5.2.6 Mulch Recommendations	5-16
5.2.7 Biotechnical and Other Treatments	5-17
5.2.8 Maintenance	5-18
5.2.9 Monitoring	5-20
5.2.10 Performance and Success Criteria	5-22
6. PEER REVIEW	**6-1**
6.1 Peer Review Group	6-1
6.2 Science-Design Series Workshop	6-2
7. REFERENCES	**7-1**
8 LIST OF PREPARERS	**8-1**

Appendices

Appendix A. Field Study of Revegetation Projects in the Tahoe Basin
- A.1 Methods
- A.2 Results and Discussion

Appendix B. Tahoe Basin Solar Path and Climate Summaries

Appendix C. Summary of Tahoe Basin Soil Attributes

Appendix D. Attributes of Plant Species Included in Reviewed Tahoe Basin Revegetation Projects

Appendix E. Specifications Templates
- E.1 Section 00 41 02 Bid Form Example
- E.2 Section 31 35 19.16 Geotextile Slope Protection
- E.3 Section 32 01 90 Plant Establishment
- E.4 Section 32 84 00 Planting Irrigation
- E.5 Section 32 91 00 Planting Preparation
- E.6 Section 32 92 19 Seeding
- E.7 Section 32 93 00 Plants

Appendix F. Minimum Qualifications Examples
- F.1 Minimum Qualifications Example–Short Version
- F.2 Minimum Qualifications Example–Long Version

Appendix G. Assessment Protocols from Field Surveys

Table of Contents

Section **Page**

Exhibits

2-1 Soil Erosion Control Process 2-3
2-2 Site Properties 2-4
2-3 Plant Growth—Water and Nutrient Cycles 2-8
3-1 The Design Process 3-2
4-1 Example of Application of Site Assessment to Design 4-5

Tables

3-1 A Comparison of Design-Bid-Build and Design-Build 3-7
3-2 Key Entities with Specific Roles during Project Construction 3-12
3-3 Specification Types 3-14
3-4 Specification Section Organization: Seeding Specification vs. Cake Recipe 3-15
4-1 Site and Soil Preparation 4-11
4-2 Soil Properties of Roadside Cut Slopes 4-16
4-3 Cover of Vegetation, Mulch/Litter, Rock-Wood, and Exposed Soil at Roadside Cut Slopes 4-17
4-4 Noxious Weeds and Problematic Invasive Plants of the Lake Tahoe Basin 4-21
4-5 Herbaceous Plant Species of Reviewed Revegetation project 4-25
4-6 Woody Plant Species of Reviewed Revegetation Project 4-31
4-7 Planting and Seeding Techniques 4-41
4-8 Pure Live Seed per Square Foot in Recent Tahoe Basin Revegetation Specifications 4-43
4-9 Total Plant Cover and Maximum Cover of Plant Growth Forms 4-44
4-10 Mulch Treatments 4-47
4-11 Biotechnical Treatments 4-51
4-12 Maintenance Practices 4-57
4-13 Monitoring 4-63
4-14 Performance and Success Criteria 4-68
5-1 Summary of Recommendations 5-2

1. Introduction

AECOM, as part of its Soil Erosion Control Program contract with the Department of General Services, Real Estate Services Division, and in direct coordination with the California Tahoe Conservancy (Conservancy), has conducted an examination of past revegetation projects completed as part of soil erosion control/water quality improvement projects that integrate native plant and seed revegetation and/or other biotechnical treatments in the Tahoe Basin, with a focus on California projects. This study has assessed design, implementation, and performance specifications of the revegetation projects with the goal of improving revegetation success and cost effectiveness. In addition, the study has assessed the successes, lessons learned, and effectiveness of revegetation approaches related to soil erosion control projects in terms of their prescribed specifications and success criteria for postconstruction monitoring.

1.1 Context, Scope, and Goals

1.1.1 Context

Around 2005, implementing agencies within the Tahoe Basin and the California Tahoe Conservancy (Conservancy) had significant needs related to revegetation of sites affected by erosion control projects. These needs included consistent information about revegetation techniques, resources that increase efficiency and success, guidance parameters for technical consultants, revegetation specifications that minimize mediation during design and construction, and consensus on examples of successful projects. With the goal of meeting these needs, the Conservancy's solution was to fund a neutral third party with knowledge and experience within and outside the Tahoe Basin to conduct an objective assessment of existing revegetation projects (primarily in uplands), broaden the revegetation knowledge base with new perspectives and techniques, and offer the revegetation community a Revegetation Guidance Document to facilitate consistent revegetation results.

1.1.2 Scope

This guidance document for revegetation construction and monitoring for erosion (and sediment) control projects serves as a practical and technical ("how-to") resource for implementing agencies and other project implementers in the Tahoe Basin. This document provides recommended standards, guidelines, specifications, and performance measures for implementing the revegetation elements for erosion control projects, often referred to as water quality improvement projects. The document is intended for use by designers and implementers for preparing construction documents (i.e., plans and specifications) including success criteria, and implementation of revegetation elements of projects. The document is intended to serve as a guide, adding to the current state of understanding about revegetation issues in the Tahoe Basin and beyond, although it is not intended to be interpreted as a "cookbook" with "one-size-fits-all" detailed prescriptions. This document is not a

comprehensive guide to all the techniques available related to revegetation implementation. In addition, this document is based on observations conducted as part of this study coupled with AECOM staff's professional experience and expertise with revegetation, as well as on a review of other relevant research, studies, and implementation efforts related to revegetation conducted to date in the Tahoe Basin. Although much of the content is more broadly applicable, this study focused on revegetation of upland habitats. By promoting an enhanced understanding of revegetation, it is anticipated that implementers will make design decisions that will result in more successful projects. Therefore, this guidance document explains the purposes and approaches of revegetation and the advantages and disadvantages of different possible approaches and techniques as they pertain to erosion control projects.

Since this study is funded by the Conservancy, the focus of the efforts and resulting recommendations have been directed to the California side of the Tahoe Basin. However, some revegetation projects in Nevada were reviewed during reconnaissance-level field visits of potential study projects conducted during the initial efforts of this study; the information collected during the reconnaissance-level observations were considered in preparation of this document.

1.1.3 Goals

The goals of this document are as follows:

- to advance the science of revegetation as a tool for soil erosion control in the Tahoe Basin, and beyond, based on effective and ineffective techniques practiced to date;
- to help identify the aspects of erosion control projects that present challenges to the project implementers (public agencies, design consultants, and revegetation contractors);
- to provide tools for the use and benefit of the erosion control project implementers;
- to educate project implementers, regulators, and funders about the factors that affect the success of revegetation for erosion control projects;
- to develop revegetation-related erosion control guidelines, specifications, and performance measures;
- to identify revegetation design elements that have worked well relative to their prescribed construction specifications for erosion control projects;
- to summarize evaluation criteria for revegetation postconstruction monitoring for performance assessment for erosion control projects; and
- to improve revegetation success and cost effectiveness for erosion control projects.

1.2 Approach

This study was conducted over a 3-½ year period beginning in fall 2006 and with completion in summer 2010. The approach included review of revegetation practices that have been applied in the Tahoe Basin and related scientific literature and to assess the outcomes of those practices. A variety of completed revegetation projects were assessed by reviewing project documentation and a reconnaissance survey of site conditions. Subsequently, a more detailed study of roadside cut slopes (i.e., road cuts) was conducted to more rigorously evaluate the relationships among revegetation practices and outcomes. Practitioners and agency representatives provided input and review throughout this process. Please refer to Appendix A for maps indicating site locations.

Detailed Study of Roadside Cut Slope Projects

To begin the study, a start-up meeting was conducted with Conservancy staff and key representatives from implementation agencies to identify constructed erosion control projects that integrate native plant and seed revegetation and/or other biotechnical treatments. Revegetation construction documents (i.e., plans and specifications) and monitoring reports were obtained and reviewed for the study projects that were identified. Reconnaissance-level field visits of potential study projects were conducted throughout the Tahoe Basin in fall 2006. The purpose of the visits was to meet with designers and representatives of implementing agencies at project sites to gain a full understanding of the variety and types of revegetation approaches and implementation techniques used historically and currently for erosion control projects. Project-specific input was solicited on what treatments and specifications were successful and most cost effective and on performance measures used for the study projects. The results of these field efforts are summarized in this document and served as a basis for identifying and developing evaluation criteria for the detailed analysis of 10 roadside cut slope projects. This detailed analysis is also summarized in this document. The following sections describe the literature review, reconnaissance survey, detailed study of roadside cut slopes, peer review, and agency input in greater detail.

1.2.1 Literature Review

A search for relevant technical literature was conducted using electronic databases and online resources. Internet sites for the California Department of Transportation (Caltrans), Federal Highway Administration, Nevada Department of Transportation, Natural Resources Conservation Service, and U.S. Forest Service (USFS) were searched for relevant information and publications. A list of keywords was developed from this preliminary search, and Google Scholar and ISI Web of Science (which includes the Science Citation Index) were searched initially for publications associated with these keywords. Subsequently, the Science Citation Index was used to identify relevant publications that cited other relevant publications identified through the initial search of web sites and electronic databases.

In addition, other key documents were reviewed, including the following:

- *Erosion and Sediment Control Handbook* (Goldman, Jackson, and Bursztynsky 1986),
- *Water Quality Management Plan for the Lake Tahoe Region Volume II. Handbook of Best Management Practices* (TRPA 1988),
- *Rehabilitation of Disturbed Lands in California: A Manual for Decision Making* (Newton and Claassen 2003), and
- *Sediment Source Control Handbook: an Adaptive Approach to Restoration of Disturbed Areas* (Hogan and Drake 2009).

This document also reflects information gained at two International Erosion Control Association revegetation workshops (Woodland, CA, 2008; Kings Beach, CA, 2009).

1.2.2 Reconnaissance Assessment of Projects

Reconnaissance Project Assessment

Based on input received during the start-up meeting, nearly 30 potential study projects were observed during the reconnaissance-level field visits (Appendix A). The projects are located throughout the Tahoe Basin and represent a variety of types (e.g., cut slopes and roadsides) and a range of ages (e.g., some were recently installed, while others were constructed 20 years ago).

For these projects, available plans, specifications, and monitoring reports were compiled and reviewed. The prescriptions in these documents that were reviewed included site evaluation, site and soil preparation, plant materials, planting and seeding techniques, maintenance (including irrigation), monitoring, and performance standards.

During preliminary site visits, observations of topographic, soil surface, vegetation, and disturbance attributes were recorded. Observations were also made regarding implementation of revegetation components, such as the condition of biotechnical treatments and irrigation systems. At each project site, a standardized set of observations was recorded on a field data form. The methods and results of the preliminary sites visits (including the field data form) are provided in Appendix A.

1.2.3 Detailed Roadside Cut Slope Survey

To better evaluate the relationships among revegetation practices and outcomes, a more detailed assessment was conducted of revegetation projects on roadside cut slopes. By limiting the assessed projects to a set of several more similar sites, differences among alternative practices would be more discernable in the data than if several very different types of sites were evaluated. Roadside cut slopes were selected because these are among the more problematic sites to revegetate, and thus, differences among alternative techniques might be more discernable; results of the study also might be more beneficial to the practice of revegetation than if projects were assessed at a type of site that is more readily revegetated.

Detailed Assessment of Soil Profile

During summer and fall 2007, the sites of eight roadside cut slope projects were visited for the purpose of a detailed site analysis. These projects are:

- Apalache—Glen Eagles Drive
- Big Springs and Overlook Place
- Brockway Summit
- Marshall Court
- Marshall Trail at Columbine
- Pioneer Trail Erosion Control
- State Route 267 Repair
- Truckee Bypass State Route 267

In addition, two El Dorado County erosion control projects with revegetation that was installed by California Conservation Corps (CCC) crews were visited and analyzed in summer 2008:

- Apalache—Muskawaki Drive
- Christmas Valley

At the 10 roadside cut slope projects, the revegetation efforts varied in age from 1 year to more than 20 years from time of planting. The reconnaissance-level site work conducted in 2006 was reviewed to select site, plant, and soil attributes to analyze in the detailed survey analysis of the revegetation efforts at the 10 roadside cut slope projects. The site, plant, and soil attributes were either measures of revegetation outcomes (e.g., plant cover), factors influencing revegetation outcomes (e.g., shade), or both (e.g., soil density, which is both modified by site preparation and influences subsequent plant growth).
The complete methods and a summary of the results of this detailed site study are summarized in Chapter 4 and Appendix A of this document.

1.2.4 Agency Input

Agency staff from the California side of the Tahoe Basin were invited to participate in the project, and the following attended and provided input during the start-up meeting on September 20, 2006: Steve Goldman, Russ Wigart, Penny Stewart, Scott Cecchi, Mark Sedlock, and Jacqui Grandfield from the Conservancy; David Vacarello from Placer County; Greg Balzer, Monica Finn, and David Moffatt from Caltrans; and Douglas Cushman and Bob Larsen from the Lahontan Regional Water Quality Control Board.

During fall 2006, reconnaissance-level field visits were conducted independently with the following agency staff: David Vacarello, Placer County; Stan Hill, City of South Lake Tahoe; Troy Alexander and Brendan Ferry, El Dorado County Department of Transportation; and Monica Finn and David Moffatt, Caltrans. In addition, independent site visits were conducted with Julie Etra, Western Botanical Services, and Michael Hogan, Integrated Environmental Restoration Services.

Plans, specifications, and/or monitoring reports were provided by the aforementioned agency staff for most of the study projects. The information gained through efforts with these agencies is reflected in this document.

Detailed Assessment with Agency Staff

In August 2008, the site of an El Dorado County erosion control project was visited with Scott Cecchi and Erik Larson of the Tahoe Regional Planning Agency (TRPA) to evaluate revegetation implementation that was conducted by CCC crews.

In fall 2009 and winter 2010, Shay (Boutillier) Navarro of TRPA collaborated with Scott Cecchi and John Zanzi to coordinate work on this document with revisions to TRPA's best management practices (BMP) handbook.

1.2.5 Peer Review

A peer review group with knowledge and experience in revegetation for erosion control design, specifications preparation, construction, and performance monitoring in the Tahoe Basin was established and was solicited to provide constructive feedback on a Draft iteration of the Revegetation Guidance Document. The comments were evaluated, and where appropriate, were addressed in this document. In addition, a one day Science-Design Series workshop was conducted in June 2010, and presented, discussed, and solicited feedback on the Draft-Final iteration of the document from implementers and agencies. As appropriate, this document reflects the feedback received from the workshop. Please refer to Chapter 6, Peer Review, for more information.

1.3 Organization of This Document

This document begins with an overview of erosion, plant growth, and revegetation (Chapter 2). The overview includes a discussion on the process of erosion, plant establishment and growth, and disturbance. A discussion of

design implementation approaches applicable to revegetation projects in the Tahoe Basin follows (Chapter 3). The discussion includes a comparison of Design-Bid-Build and Design-Build project delivery methods, followed by a discussion on the use of CCC crews. In addition, Chapter 3 provides an overview of construction documents, contracting, contractor minimum qualifications, bidding, preconstruction activities, and construction administration activities.

Observations of existing revegetation and erosion control approaches and components are presented in Chapter 4. The text reviews the practices and techniques of revegetation, their use in the Tahoe Basin, and their relationship to the outcomes of Tahoe Basin revegetation projects observed during field surveys. The relationship to revegetation, recent practices, and observed outcomes of revegetation projects are described for the following: site evaluation practices, site and soil preparation, plant materials, planting and seeding techniques, mulch, biotechnical and other treatments, maintenance, monitoring, and performance and success criteria. This review and these observations provide the basis for the recommendations summarized in Chapter 5.

Site Assessment for Revegetation

Chapter 5 discusses the basis and scope of the recommendations and provides specific recommendations regarding revegetation components organized parallel to Chapter 4 and addressing site evaluation practices, engineering design, site and soil preparation, plant materials, planting and seeding techniques, mulch, biotechnical and other treatments, maintenance, monitoring, and performance and success criteria. These recommendations are intended to improve the success and cost effectiveness of revegetation in the Tahoe Basin.

Chapter 6 summarizes the peer review efforts to enhance the overall quality of this document. References (Chapter 7) and a list of preparers (Chapter 8) are acknowledged at the end of the document.

Seven appendices are included at the end of this document:

- Appendix A, “A Field Study of Revegetation Projects in the Tahoe Basin,”
- Appendix B, “Tahoe Basin Solar Path and Climate Summaries;”
- Appendix C, “Summary of Tahoe Basin Soil Attributes;”
- Appendix D, “Attributes of Plant Species Prescribed for Tahoe Basin Revegetation Projects;”
- Appendix E, “Specifications Templates;”
- Appendix F, “Minimum Qualifications Examples;”and
- Appendix G, “Assessment Protocols from Field Surveys.”

This page has been intentionally left blank.

2. Erosion, Plant Growth, and Revegetation

The following sections of text describe the processes of erosion and plant growth and the approaches to and components of revegetation projects. Their purpose is to support explanations in subsequent sections of this document of how revegetation techniques work and of the basis for the recommended practices.

The descriptions of erosion, plant growth, and revegetation have been derived in large part from texts and handbooks on these subjects, which may be consulted for additional information. These texts and handbooks are:

- *Introduction to Soil Physics* (Hillel 1982),
- *Erosion and Sediment Control Handbook* (Goldman, Jackson, and Bursztynsky 1986),
- *Terrestrial Plant Ecology* (Barbour et al. 1999),
- *Principles of Terrestrial Ecosystem Ecology* (Chapin, Matson, and Mooney 2002),
- *Soil Erosion and Conservation* (Morgan 2005), and
- *The Sediment Source Control Handbook* (Hogan and Drake 2009).

2.1 The Process of Erosion

The primary purpose of revegetation projects is to reduce soil erosion. Soil erosion is the displacement of soil and involves the detachment of soil particles from the mass of soil followed by their transport. When sufficient energy is no longer available to transport the particles, they are deposited.

Soil particles are dislodged by energy transferred from:

- falling raindrops (rainsplash),
- flowing water (overland flow and flow in rills and gullies),
- wind,
- freeze/thaw cycles, and
- in some instances, animals or machinery.

Deposit of Dislodged Soil Particles on Cut Slope

Also, under the influence of gravity, soil particles may move downslope individually (colluvation), or in some instances, an entire mass of soil particles may move downslope more or less simultaneously. The movement of soil particles and masses of soil is resisted by the cohesion of soil particles and the adhesion of soil to plant roots. Both the forces potentially moving and those resisting movement of soil are affected by the properties of a site's topography, soil, hydrology, and vegetation (Exhibits 2-1 and 2-2). The primary mechanisms of erosion (i.e., rainsplash, flowing water, wind, and mass failure) and the effects of site attributes on these mechanisms are briefly described below.

2.1.1 Erosion by Raindrops

When raindrops strike exposed soil, particles are detached. On level surfaces, these detached particles are displaced evenly in all directions, but on sloping ground raindrops displace more particles downslope than upslope.

Crusted Soil Surface

The repeated impact of raindrops also consolidates exposed soil. Soil crusts consist of tightly packed soil particles and lack larger pore spaces. Thus, water passes through a crusted soil surface more slowly than through a noncrusted surface, and soil crusts are said to seal off the soil surface from precipitation.

The vulnerability to crust formation decreases with increasing content of clay and organic matter because these provide greater strength to the soil. (The strength of a soil is a measure of its cohesiveness and resistance to forces exerted by gravity, moving water and wind, and mechanical loads.)

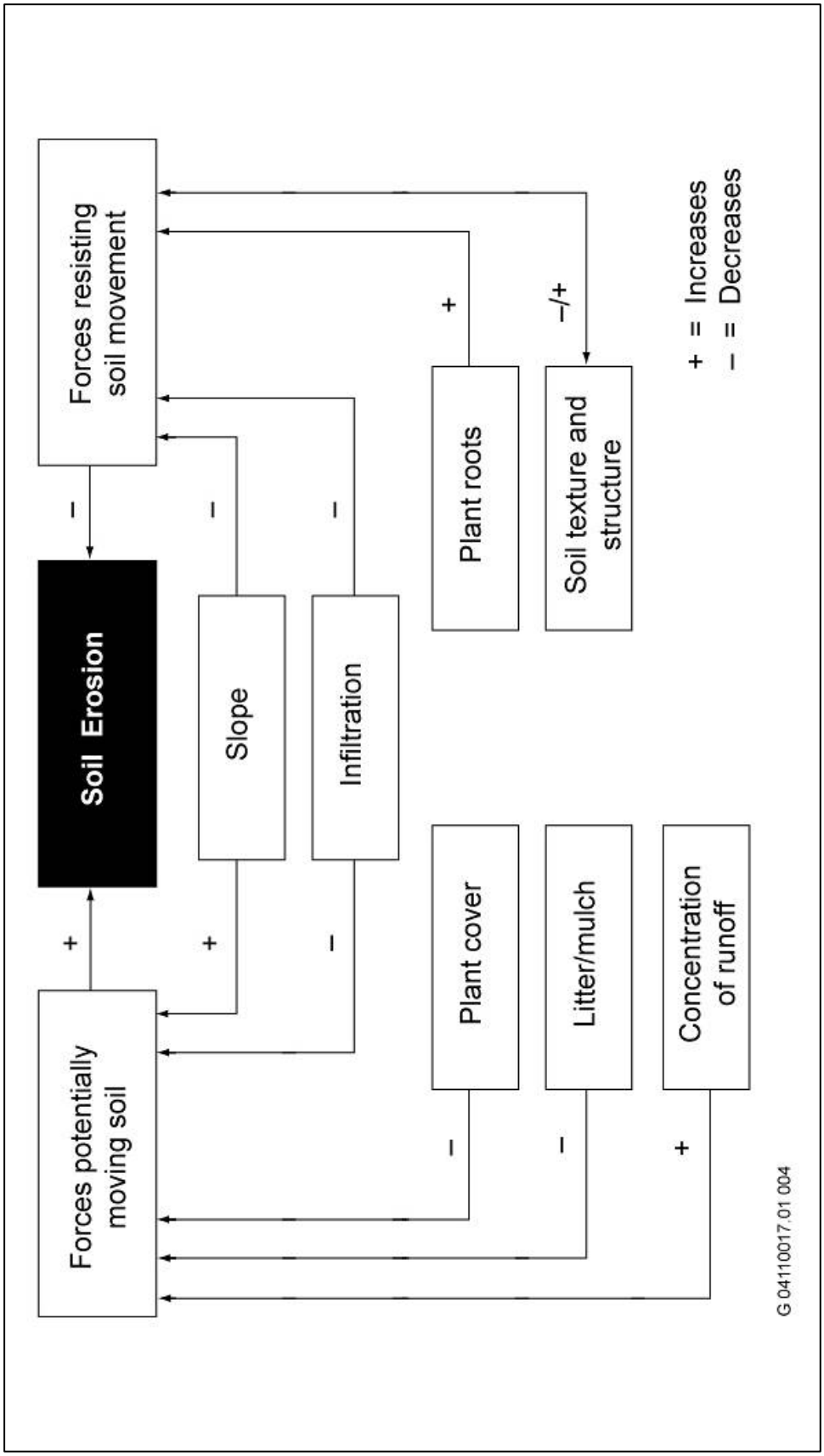
Vegetation and litter intercept raindrops, and thus protect the soil surface from their impact. Vegetation also contributes organic matter that reduces the vulnerability of soil to crust formation.

2.1.2 Erosion by Flowing Water

Together with the intensity and amount of precipitation or irrigation, the rate at which water can enter a soil (i.e., the infiltration rate) determines the amount of water that will flow over the soil surface and erode soil. This rate is affected by soil structure and the moisture content of soil.

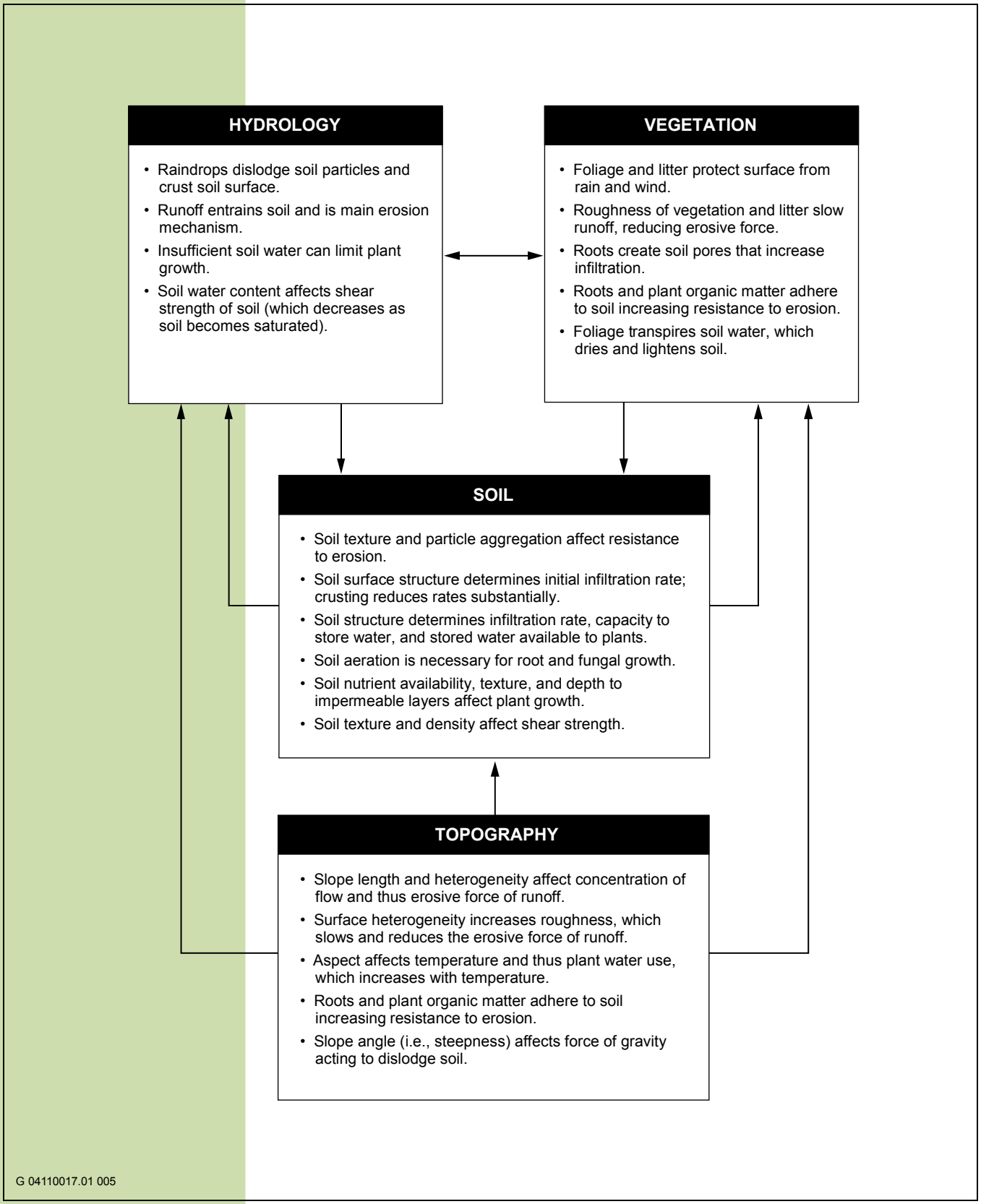
Infiltration rate is related to soil texture and structure because water moves much more rapidly through larger pores than through smaller ones. Coarser-textured soils, such as sands, have much faster infiltration rates than finer-textured soils such as clays. The aggregation of soil particles and the displacement of soil by roots form large pores and cracks that greatly increase the rate of infiltration. Conversely, the sealing of pores during the formation of a soil crust greatly reduces the rate of infiltration.

As air spaces in the soil fill with water during a storm, the rate of infiltration decreases; eventually all spaces in the soil fill with water, and water can only enter the soil at the rate water moves from surface layers to deeper layers in the soil.



Source: Data provided by AECOM in 2007

Soil Erosion Control Process **Exhibit 2-1**



Source: Data provided by AECOM in 2007

Site Properties **Exhibit 2-2**

When rainfall, snowmelt, or irrigation water arrives at the soil surface at a rate exceeding the infiltration rate, water ponds in small depressions on the soil surface, and once these depressions have filled, begins to flow over the surface. This flowing water exerts a force parallel to the soil surface (i.e., a shear force) that can displace soil. This erosive force increases with the velocity of flowing water, which in turn increases with:

- slope angle (i.e., steepness),
- smoothness of the surface, and
- cross-sectional area to perimeter ratio of the flowing water.

Rills on Roadside Cut Slope

Consequently, the potential for flowing water to erode soil is greater on steep slopes and where flow becomes concentrated into rills and larger channels (which occurs as water moves downslope). Conversely, vegetation and litter add roughness to the soil surface, which reduces the velocity and erosive force of water.

The cohesion of soil particles, and adhesion of soil to roots (and to organic matter), increases the shear force required for water to displace soil particles. (The cohesion and adhesion of soil particles is the basis for most aspects of soil structure including the formation of aggregates, which strongly influences both erosion and plant growth.)

2.1.3 Erosion by Wind

As with flowing water, the erosive force of wind is related to its velocity. Roughness lowers wind speed near the soil surface. Vegetation increases roughness and substantially reduces wind speed near the soil surface. The cohesion of soil particles and adhesion of soil to roots (and to organic matter), increases the shear force required for wind to displace soil particles.

2.1.4 Mass Wasting

Mass wasting occurs when a mass of soil moves downslope along a plane below the soil surface. Along this plane, if the strength of the soil is exceeded by downslope forces, the soil above the plane moved downslope. The downslope force is caused by gravity. Consequently, steeper slopes are more prone to mass wasting, and mass wasting typically occurs when soil is wet because this increases the weight of soil and also can reduce strength. The tensile strength of roots (of woody plants in particular) can contribute significantly to soil's resistance to downslope forces.

2.2 Plant Establishment and Growth

A successful revegetation project creates conditions and provides resources that facilitate plant establishment and sustain plant growth. Temperature is the primary condition affecting plant establishment and growth, and light, water, and nutrient availability are the resources affecting plant establishment and

growth. In some instances the goals and objectives of revegetation are to control erosion and facilitate water quality; at other times aesthetics plays an important role.

2.2.1 Plant Establishment

Plant establishment depends on the dispersal of seed to a site, its germination, and survival until its root and shoot (i.e., leaves and stems) systems are able to obtain sufficient nutrients, water, and energy from the soil and atmosphere to sustain the plant.

Dispersal of desired, seeded and planted species does not limit their establishment. However, dispersal of undesired nonnative species as contaminants in soil amendments or seed and from adjacent vegetation affects revegetation projects. Dispersal in time through persistence in the soil seedbank from preproject vegetation also affects revegetation projects. The establishment of desired, but unplanted, native species depends on dispersal from adjacent vegetation (or establishment from the soil seedbank).

However, the establishment of planted species can be limited by conditions being unsuitable for germination and initial growth. For each species, specific conditions and resources are required to break seed dormancy, stimulate germination, and support growth. A setting that provides those conditions and resources and which lacks the hazards of predators, pathogens, and competitors is a “safe site” for seed of that species. A revegetation site cannot provide safe sites for all species that could potentially grow there. For example, fire stimulates germination of the seed of some species, such as Ceanothus and Manzanita (*Arctostaphylos*) species, but would kill the seed of some other species. But several conditions are requirements for establishment of most seeded species, including:

- continual availability of sufficient moisture to avoid desiccation,
- access to sufficient oxygen to support growth,
- sufficient light to stimulate germination (if needed) and to support growth,
- access to sufficient nutrients from soil to support growth,
- protection from temperature extremes, and
- protection from predation by animals.

These requirements are satisfied in covered, moist sites, where there is sufficient contact between seed and soil (for dissipation of heat and absorption of moisture). However, the soil and litter covering a seed have to be penetrable by the growing seedling; if the soil and litter are too thick or otherwise impenetrable, they constitute a barrier.

Following germination and initial growth, competitors can limit establishment by substantially reducing the availability of light, water, and nutrients. This competition occurs not only between planted species and weeds (undesired species), but also among planted individuals of the same and different species. Which species are successful competitors depends in part on site conditions and resources. For example, nutrient-rich sites tend to be dominated by fewer,

faster-growing species than nutrient-poor sites. The sensitivity of competitive relationships to changes in conditions and resource availability has been well documented in agricultural research, in particular research on weed-crop interactions and management of multispecies pastures (Radosevich, Holt, and Ghersa 1997; Barnes, Miller, and Nelson 1995).

Survival to the second growing season is a useful indicator of successful establishment. Even then, however, a plant's root and shoot systems may have access to limited volumes of space, and thus the plant may remain vulnerable to environmental fluctuations (such as drought) and have limited growth. This is generally the case for small trees and shrubs, for example.

2.2.2 Plant Growth

Plant growth is simply an increase in plant size; however, that increase in size depends on energy and materials provided by photosynthesis. Photosynthesis, in turn, depends on:

- sunlight, from which energy is bound into carbohydrates;
- carbon dioxide (CO_2) from the atmosphere, which is incorporated (fixed) into carbohydrates;
- nutrients from the soil (e.g., nitrogen, phosphorus), which are incorporated into a variety of plant molecules, including photosynthetic pigments and enzymes; and
- temperatures suitable for photosynthetic reactions to proceed efficiently.

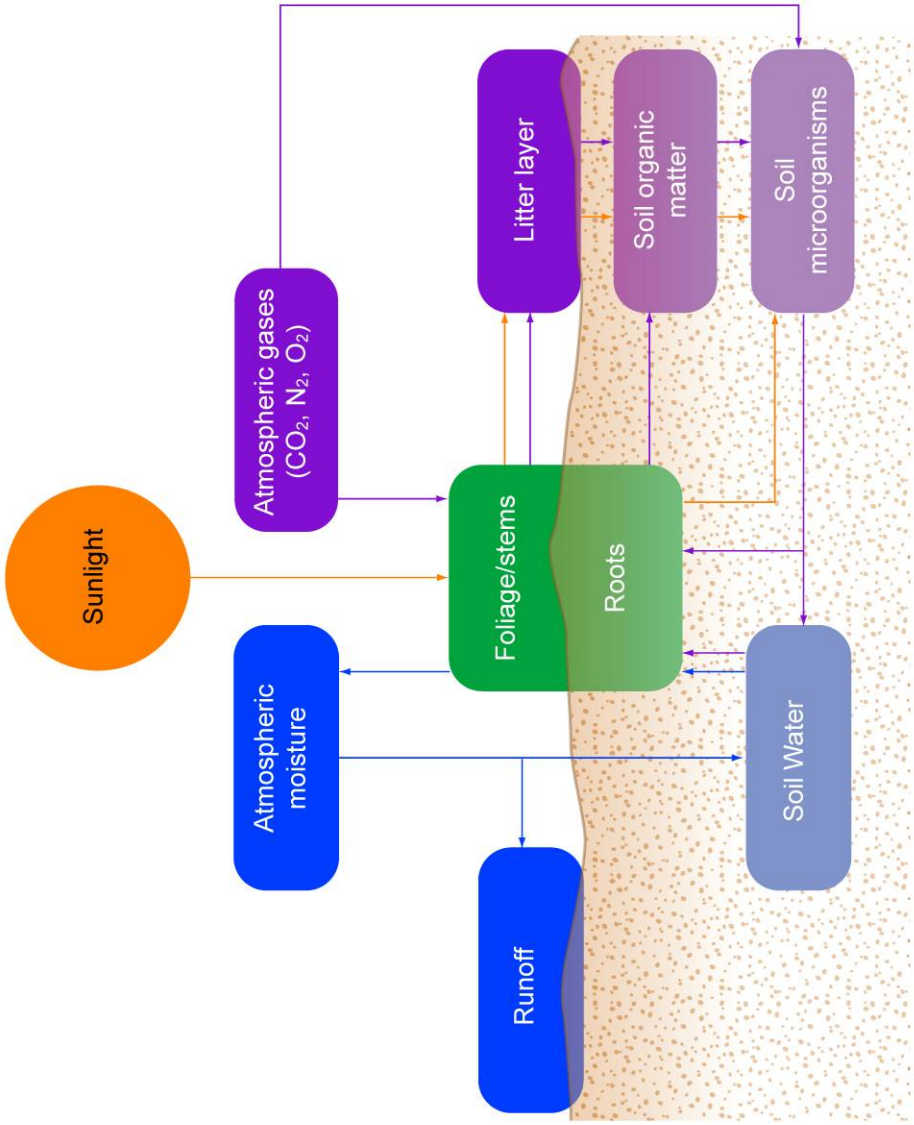
For plants to acquire these materials and to maintain these conditions, all of the following must occur:

- Considerable quantities of water must move from the soil through the plant to atmosphere.
- Sufficient oxygen must be available in soil for roots to survive.
- Roots must be able to grow through soil.

Thus, plant growth is connected to water and nutrient cycles (Exhibit 2-3) and affected by soil structure. Although shade limits plant growth, for revegetation projects in the Tahoe Basin (which at are semiarid sites with disturbed soils), the availability of water and nutrients is the main factor determining plant growth and associated inputs of organic matter to the soil. Therefore, the relationships between plant growth and the water and nutrient cycles are described further below.

2.2.2.1 Plant Growth and the Water Cycle

When plants take up CO_2 from the atmosphere, they simultaneously and unavoidably lose water vapor to the atmosphere. Plants replace this lost water with water from the soil when soil water is available. The loss of water from leaves creates a tension within the water-filled tubes of the water-conducting tissues of plant leaves and stems, and this tension pulls water out of soil pores and into the plant, replacing the water lost to the atmosphere.



G 04110017.01 006

Note: CO_2 = carbon dioxide; N_2 = nitrogen; O_2 = oxygen.

Plant Growth—Water and Nutrient Cycles **Exhibit 2-3**

However, only a portion of the water stored in soil can be extracted by plants. As soil dries, much of the remaining water is in the smallest soil pores and strongly held (by electrostatic attraction) to the surface of soil particles; thus, it is not available to plants.

As soil water becomes less available, plants reduce their rate of water loss (i.e., transpiration). Transpiration is reduced by closing stomata, which are the pores in the wax-coated surfaces of leaves. Closing stomata also reduces the movement of CO_2 into leaves, which reduces photosynthesis and growth.

The quantity of soil water available to plants is a product of the quantity of available water stored in a unit volume of soil and the total volume of soil that can be accessed by a plant. Although the timing and amount of precipitation (or irrigation) determines the amount of water that is available to enter the soil, soil structure (the size of soil particles and the pores between them) and depth influences the infiltration rate, the maximum quantity of available water, and the ability of roots to access soil water. For example, in soils that are shallow or that have been heavily compacted (and thus are dense), plant roots may only be able to exploit a relatively small volume of soil compared to deeper or less dense soils.

The amount of water required to support plant growth is largely a product of temperature and humidity. Plant species, however, do differ in the efficiency with which they use water and in their ability to avoid damage from desiccation or high temperatures when little water is available.

2.2.2.2 Plant Growth and Nutrient Cycling

Plants acquire nutrients by passive or active uptake from soil water or direct transfer to plants by mycorrhizal fungi or nitrogen-fixing bacteria. In the absence of fertilizers, these nutrients are derived primarily from physical weathering of rocks, and the physical and chemical breakdown (decomposition) of dead microbial, plant, or animal material (detritus). In the case of nitrogen, these nutrients also become available by fixation or deposition from the atmosphere. In the Tahoe Basin, weathering of granitic rocks results in very different levels of rock-derived nutrients and ability to retain nutrients than does weathering of volcanic rocks, and this is difference exerts a major effect on the vegetation of the Tahoe Basin.

Over time, through leaching, chemical alteration, and fragmentation, plant, animal, and microbial material (i.e., detritus) is eventually converted to CO_2 and inorganic nutrients, and a remnant pool of complex organic compounds that are resistant to further microbial breakdown (e.g., humus or recalcitrant organic matter) (Chapin, Matson, and Mooney 2002). Water leaches soluble materials away from detritus. Microbes exude enzymes that convert the large, insoluble molecules in detritus into small, soluble molecules that can be absorbed by microbes (and subsequently are broken down into CO_2 and inorganic nutrient-containing molecules, or are incorporated into microbial biomass). Fragmentation (primarily by soil animals) exposes surfaces to leaching and microbial action. Some organic matter, however, is resistant to chemical alteration by microbes and remains as soil organic matter for a prolonged period of time.

From soil water, plants absorb some of the molecules produced by microbial enzymes. For most plants, this nutrient source is supplemented by nutrients transferred to plants by mycorrhizal fungi; plants in turn transfer carbohydrates to these fungi. This symbiosis increases the efficiency of nutrient acquisition by plants. The body of a fungus is composed of branched filaments of cells called hyphae, through which materials can be transported. Hyphae are much narrower than are plant roots, and consequently much greater lengths of hyphae can be constructed with a given amount of carbohydrate. Therefore, it is much less costly (in terms of carbon and nutrients) to exploit soil with hyphae than with roots.

In addition to symbioses with mycorrhizal fungi, some plant species have symbioses with nitrogen-fixing bacteria. These bacteria convert atmospheric nitrogen (N_2) into ammonium (NH_4+), which can be incorporated into organic molecules. This conversion requires considerable energy and is sensitive to oxygen concentrations. The plant provides an energy source to these bacteria and in its roots provides suitable conditions for the conversion (of N_2 to NH_4+); the bacteria in turn provide the plant with ammonium. Legumes (members of the pea family), bitterbrush (*Purshia tridentata*), *Ceanothus* species, alders (*Alnus* species), and mountain mahogany (*Cercocarpus* species) can all form symbioses with nitrogen-fixing bacteria (Chapin, Matson, and Mooney 2002; Paschke, Redente, and Brown 2003).

At most revegetation sites, nutrient availability is probably in a state of flux because of the loss of organic matter resulting from topsoil removal or mixing with lower soil layers, temporary addition of fertilizers, temporary inputs of organic matter as mulch, changes in plant community composition, and changes in microbial communities in response to these changes in soil and vegetation. These changes strongly influence the vegetation that develops from plantings.

2.3 Disturbance

A disturbance is any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes the physical environment or the availability of resources or substrate.

Revegetation is only necessary at disturbed sites—typically sites that were drastically disturbed by construction activities. This disturbance may have entailed the partial or complete removal of not only the vegetation, but also the upper layers of soil. These upper soil layers may or may not have been replaced after construction, and the soil's properties (e.g., bulk density) may have been altered by the process of removal, storage, and replacement.

Disturbance continues after construction is completed. Revegetation sites are continually affected by several different types of disturbance that are caused by different mechanisms and result in different effects. The most significant type of ongoing disturbance is soil erosion, which not only removes soil but also removes detritus, plant propagules, and plants. Disturbances are also caused by:

- trampling;
- mowing and clearing of vegetation during infrastructure maintenance;

- crushing of vegetation, disturbance of the soil surface, and placement of mechanical loads on soil by vehicles, machinery, and stockpiled materials;
- herbivory;
- disease;
- burrowing rodents;
- drought;
- fire; and
- rock and tree falls.

Because these disturbances damage or remove plants, plant propagules, litter, and soil, they also contribute to subsequent erosion. However, the consequences of disturbances are not all adverse. Disturbances generally provide opportunities for plants to establish from seed by making resources available, and some forms of disturbance are part of the natural dynamics of every ecosystem.

Disturbances that cause soil compaction (e.g., vehicles placing mechanical loads on soil), however, have particularly significant, adverse effects on both infiltration and plant growth. Soil compaction rearranges soil particles to decrease spaces between them and bring them into closer contact (i.e., compaction increases bulk density). It affects infiltration and gas exchange with the atmosphere, and consequently, root growth and distribution, and decomposition.

Plant growth and survival can be substantially affected by compaction of topsoil or subsoil. The inability of plant roots to penetrate compacted soil is well documented (Hamza and Anderson 2005). For crop plants, root growth is reduced as soil penetration resistance is increased from 1 to 2 Megapascals (145 to 290 pounds per square inch [psi]) under wet conditions; soils with a penetration resistance above 290 psi are generally considered to substantially reduce root growth (see *Penetration Resistance* in National Soil Survey Center 1993; Sinnett, Poole, and Hutchings 2006 and references cited therein). Crop plants rooting into soils with greater strength (and thus greater penetration resistance) generally are species that possess a deep tap root (Hamza and Anderson 2005).

Because soils remain compacted for several to many years, revegetation projects are often affected by soil compaction that occurred before the installation and maintenance of plantings. In particular, soil compaction to increase soil density and strength, which is a common construction practice, affects subsequent revegetation projects.

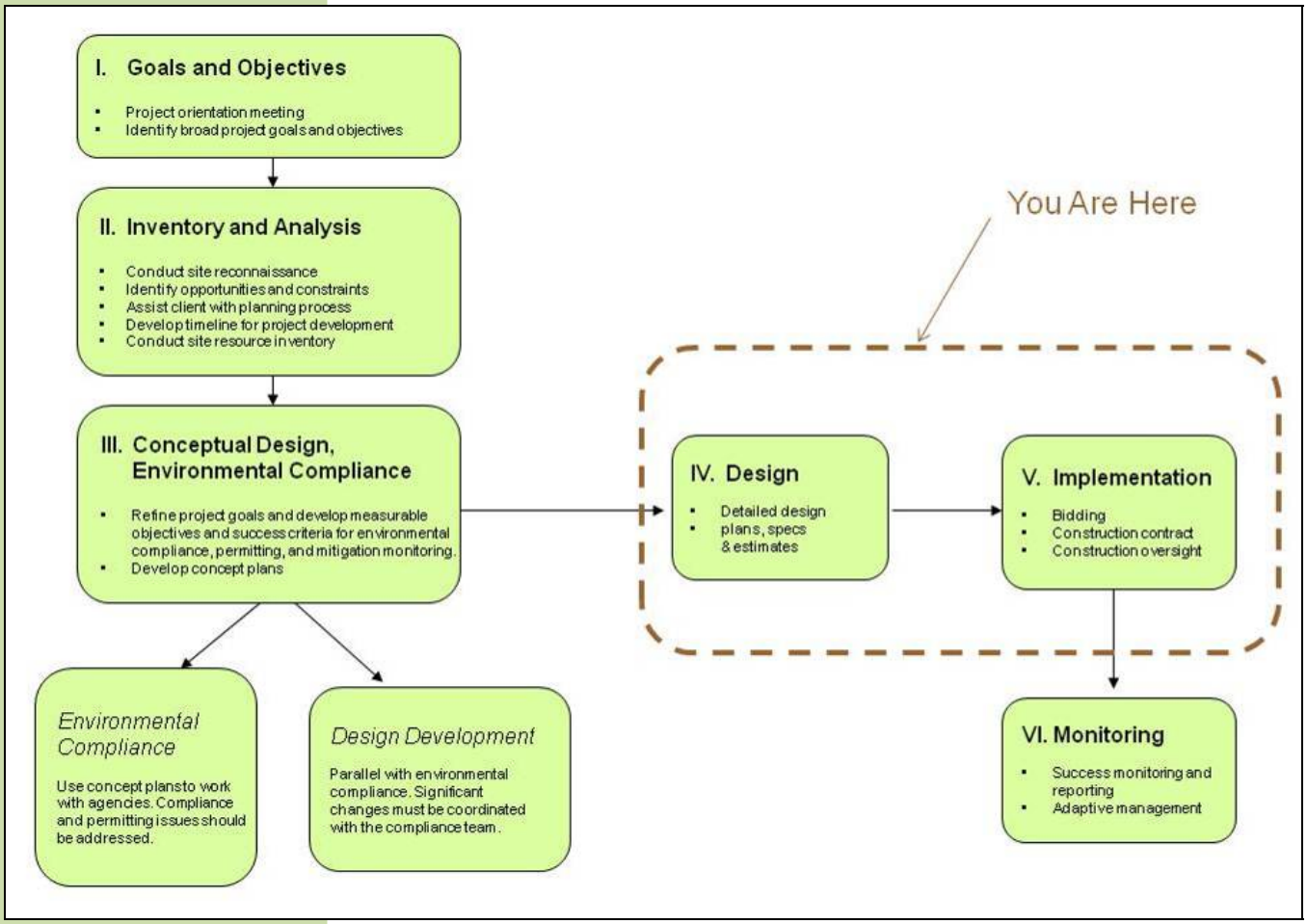
This page has been intentionally left blank.

3. Design Implementation

This document addresses specific design implementation approaches applicable to revegetation projects in the Tahoe Basin (and beyond), including a comparison of Design-Bid-Build and Design-Build project delivery methods followed by a discussion on the use of California Conservation Corps (CCC) crews. In addition, this chapter provides an overview of what construction documents are and their role in project implementation. Templates for technical revegetation specifications are included in Appendix E and address bid forms, geotextile slope protection, site and soil preparation, temporary irrigation, planting and seeding, and plant establishment maintenance. A discussion on contracting is included and briefly covers topics such as turn-key vs. separate revegetation contracts, contractor minimum qualifications, bidding, preconstruction and construction administration activities, and record drawings.

3.1 Implementation Approach

To get projects in the ground, a systematic approach is often used and is referred to as the "design process" (see Exhibit 3-1). A brief overview of this process follows, as it relates to revegetation projects. Step I involves establishing goals and objectives with the owner and any regulating agencies. Step II involves conducting a thorough inventory and analysis of site conditions, including opportunities and constraints. This step will guide the development of conceptual design solutions and alternatives. These concept designs will be evaluated in Step III of the process through regulation of the environmental review processes. During Step IV, design, the preferred design concepts are further studied for constructability and site specific application. The design is further refined and plans, specifications, and cost estimates are prepared for project construction. In Step V, implementation, the project is often put out to bid so that multiple contractors can submit proposals to conduct the physical construction. The project owner will select the best value in terms of cost and contractor experience, though often there is a low bid mandate that drives the award of contract. In addition, often the designer or a representative designated by the project owner oversees the project to ensure quality installation. Lastly, once the project is in the ground, postconstruction monitoring may be conducted to evaluate project performance. In any approach, the owner needs to maintain a hands-on connection with their projects during implementation.



The Design Process **Exhibit 3-1**

This section is focused on the design and implementation steps of the design process. Revegetation implementation approaches are addressed including a comparison of Design-Bid-Build and Design-Build project delivery methods followed by a discussion on the use of California Conservation Corps (CCC) crews.

3.1.1 Project Delivery Methods

Once there is stakeholder buy-in on the goals, objectives, and conceptual design, it is time to get the project in-the-ground. Revegetation projects require many technical disciplines to formulate innovative project solutions. It takes teamwork: scientists, designers, materials suppliers, and contractors working together on a common goal in planning, designing, implementing, and establishing quality functional revegetation for erosion control to meet and support owner and agency needs. Implementation keeps these efforts from becoming academic. Time and money often influence the design and construction approach. Additional factors, including the level of design detail provided before actual construction, availability of materials, regulatory issues, public health, safety, and welfare, and comfort level of the owner, can influence the design and construction project delivery method. For successful revegetation projects, it is important to establish collaboration between the

designers, inspectors, and construction contractor, and coordinate the anticipated grading and revegetation work before the start of any earthwork operations.

Issues of public safety, precision, and other technical and legal factors influence the appropriateness of a "back of the napkin" sketch or full construction documents for implementing solutions. Two common ways of facilitating design implementation are Design-Bid-Build and Design-Build. Depending on budget, schedule, risk management, and owner need, both project delivery methods have advantages and disadvantages. Risk management factors may include budget (value), schedule, regulatory requirements, public healthy safety and welfare, project success or failure and remediation, ability to address uncertainties, and long-term operations and maintenance. In addition, risk management factors for erosion control projects often include increased erosion and sediment loading, plant survivorship, short-term plant establishment, and adaptive management.

Design-Bid-Build is considered the traditional approach and involves conducting design and preparing detailed design bid/construction documents (i.e., plans and specifications), soliciting comparative construction bids from contractors and awarding a construction contract to the selected contractor, and carrying out the physical construction for a project. This approach incorporates checks and balances throughout construction and establishes legal precedence for ensuring quality control. Traditionally, insurance and bonding issues are well defined. However, the relationship between owner, designer, and contractor is often not well defined and the owner may bear the responsibility for an adequate design. Additionally, cost and schedule inefficiencies may result.

A second approach, Design-Build, reflects a collaborative effort between designer and contractor. This approach results in a single point of responsibility (the owner is free from coordinating designers and contractors) and may result in innovative solutions and schedule and cost efficiencies. Unfortunately, this approach is somewhat new territory and may present risks while confronting institutional barriers such as procurement and licensing. A limited availability of insurance and bonding products can affect the feasibility of designer-contractor teaming arrangements.

Below is a summary discussion of both project delivery methods followed by the advantages and disadvantages of each approach for transforming projects from ideas into on-the-ground reality.

3.1.1.1 Design-Bid-Build

The traditional approach for project implementation, Design-Bid-Build, reflects systematic process for design, contractor selection, and physical construction. In this project delivery method the agency or owner contracts with separate entities for each the design and construction of a project.

Owners and agencies want to know exactly what will be built before actual project construction to ensure that the results will achieve the project's overall goals and objectives and satisfy any regulatory requirements. To facilitate this understanding, the design phase is

Project Design

conducted. During the design phase the owner often retains a design consultant (e.g., landscape architect, engineer, ecologist) or works with their own in-house professional to conduct project design and produce technical construction documents (i.e., plans and specifications) on which contractors will in turn bid and ultimately use to construct the project. Please see Section 3.2, "Construction Documents," for an overview related to revegetation plans and specifications. The design phase may take several years before construction and is often conducted independent of any construction contractors. Plans and specifications facilitate comparative design interpretation during agency ("plan check") review, comparable ("apples to apples") contractor bidding, and physical construction.

Detailed design is a critical step in the design phase and is required to bring concepts into realities. This step, conducted just before preparing plans and specifications, verifies (at the project site) and develops details to fit each element of the project design to specific site conditions; further, specific materials and construction techniques are determined for each design element. Site factors (such as hydrology and soils), regulatory factors, and owner factors can influence revegetation design for erosion control projects.

Bidding is the next step toward project implementation. Bids can be conducted as "public," in which multiple qualified bidders may participate, or by way of a "short list," in which a limited number of preselected contractors are invited to bid. The various contractors bidding on the project obtain copies of the construction documents, gain an instantaneous understanding of the project, and propose costs to the project design elements by way of bid items. Questions may arise during the bid period, which usually lasts about 2 weeks, and, if appropriate, clarifications may be issued by way of addenda. From these elements, the contractor compiles their complete "bid price" for sealed submission by a predetermined closing date and time. Bid prices can be based on the quantities of materials and the level of effort required by construction documents, and any addenda, for project implementation.

Once bids are received, the owner and its design professionals typically review the bids, seek any clarifications required of the bidders, ensure all documentation is in order (including bonding if required), and establish the ranking of the bids. If the bids fall in a range acceptable to the owner, the qualifications of various bidders and their proposals may also be evaluated. While the owner is not always obligated to accept the lowest bid, often there is a low bid mandate. Whenever possible, a better method of contractor selection is based on best value to the owner in terms of contractor price, quality, and past performance experience on projects with similar scope and magnitude. In the event that all of the bids are in excess of the goals of the owner, the owner may elect to reject all bids. The following options become available:

- Abandon the project.
- Revise the design and construction documents, making the project smaller or more efficient, or reducing project features, elements, or limits to decrease the cost; the project would then be rebid.
- Elect to select the lowest qualified bid's contractor to join the design team to assist with cost reduction, often referred to as "value engineering."

Upon construction, contractor selection, and award of contract, the “build” phase, or construction phase, begins. After the project has been awarded to the contractor, the construction documents may be updated by the designer to incorporate addenda or changes before they are issued for construction. The necessary approvals must be also achieved from all jurisdictional authorities before beginning the construction process. The project is then built based on the construction documents.

A general contractor may conduct the work with its own forces, but it is not uncommon for a general contractor to limit its role to management of the construction process using specialized subcontractors and overseeing daily activity on a construction site. An owner’s representative and/or governing agency inspector usually reviews the progress of the work and issues site instructions, change orders, or other documentation necessary to the construction process. Contractually, the project designer is not often involved with the construction phase, unless serving as the owner’s representative to administer construction or oversight services to ensure quality implementation.

Some benefits of Design-Bid-Build are:

- translating science and design into in-the-ground solutions;
- enabling projects to come to life rather than dying on a shelf;
- fully understanding what will be built before construction by way of clear, precise plans and specifications and accurate, itemized cost estimates;
- providing an instantly understandable presentation of the project design and regulatory and construction requirements;
- ensuring public health, safety, and welfare;
- providing a fair and efficient process for receipt of comparative/competitive bids for contractor selection; and
- ensuring quality implementation conforming to environmental permits and agreements.

3.1.1.2 Design-Build

A second approach for project implementation, Design-Build, reflects a collaborative effort between designer and contractor. Design-Build combines design and construction interests, and integrates responsibility and teaming within the owner’s team (Design-Build Institute of America, Design-Build Conference 1998). It involves many of the traditional players with new responsibilities: designers, construction managers, contractors, subcontractors, and material suppliers; while responding to performance requirements of owners. In this way, firms can provide a custom package of comprehensive (full-spectrum) service to meet the owners’ ultimate goals as part of the owner's team, and can be helpful for those owners not familiar with construction. Some of the benefits of Design-Build are:

- facilitating innovative project delivery by providing efficiencies for owners resulting in projects delivered on cost, schedule, and quality;
- providing value analyses through direct designer-contractor collaboration on estimating cost and schedules to meet owner needs as a project is designed;
- providing direct contractor input to design regarding cost, schedule, methods of construction, materials, quality assurance and safety, and records and monitoring;
- providing direct contractor input on life cycle cost projections, including determining postconstruction operations and maintenance costs;
- transferring risk to the entity best suited to take the risk; and
- creating opportunities for strategic alliances and market focused business units, while opening up business opportunities by exploring cutting edge design, preparing innovative solutions, and staying ahead of the competition.

Design Implementation

Trends indicate that some public sector agencies, especially for engineering facilities such as water treatment plants, are using a Design-Build approach. In addition, the private sector has been using a Design-Build approach for many years, including for custom homes. Design-Build seems to be a trend for fast-track projects, requiring “turnkey” service; the trends are nationwide, predominately in the central and western States. For such projects, affiliate or subsidiary businesses seem to be the best way to conduct Design-Build operations: two separate and self-sustainable companies get together and create a third entity (firm) to be operated, when appropriate, for Design-Build projects; staff can jump between their parent company and the "third entity" as needed.

To facilitate firm selection, a Design Criteria Consultant may assist the owner, acting as a jury in evaluating Design-Build firm qualifications, proposals, and operations. Firms are usually required to submit their qualifications, plus both design and cost proposals. As a result, firm or contractor selection is based on qualifications rather than solely on a hard bid (i.e., dollars) only. Due to the need for detailed proposals, stipends may sometimes be offered to firms for unsuccessful proposals.

Design-Build projects need to be conducted under one contract in order to provide seamless, “one-stop shopping.” For Design-Build contracts, “one size does not fit all”; instead, contracts should be created on a project specific basis. It is important that a teaming agreement be established between the designer and construction contractor (e.g., roles, responsibilities scope, ownership of design) as there will be overlap of traditional roles. For Design-Build contracts a construction contractor usually holds prime contract due to bondability.

With Design-Build, a single source delivers comprehensive services and has absolute accountability for both design and construction, bearing full responsibility for integrating conceptual design with functional performance (Design-Build Institute of America 2009). This often results in valued assurance that can only be provided by a singular source. By pursuing design quality, and

by effectively controlling costs and schedule, a Design-Build can deliver concept-to-completion projects to meet owner needs. Table 3-1 summarizes a comparison of Design-Bid-Build (traditional approach) and Design-Build.

Table 3-1
A Comparison of Design-Bid-Build and Design-Build

	Design-Bid-Build	**Design-Build**
Owner	• more control over process • better operational features • lower costs • schedule can be drawn • less risk • less hassle (i.e., no accidents, no changes, no cost increases, no delays)	• must be more sophisticated • less control over process • better operational features out • higher initial costs • turnkey projects • more risk, all one contract • potential for increased hassle
Contractor	• more work • more profit • 100% perfect plans • less risk • less hassle	• can team with designers to gain more work • may result in less profit on individual projects • not 100% plans • more risk • increased hassle
Designer	• more work • more profit • design in a vacuum • no interference • no risk • less hassle	• can team with contractors to gain more work, full service opportunities • design with input from others • can lead to innovation • increased coordination • more risk • increased hassle
Advantages	• traditional approach • suitable for competitive bidding • system of checks and balances • established legal precedent • no legal barriers in procurement and licensing • insurance and bonding are defined	• single point of responsibility • owner free from coordination of designer and contractor • savings: schedule and cost • improve risk management • early knowledge of firm costs • rewards innovation
Disadvantages	• all parties have different agendas • owner mediates designers and contractors • owner bears design adequacy risk • too much case precedent • delivery can be slow • not always cost efficient	• new territory, new risks • institutional barriers: procurement and licensing • owner relinquishes some control • limited availability of insurance and bonding products • complexity/learning curve

Source: Design-Build Institute of America, Design-Build Conference 1998

3.1.2 California Conservation Corps Crews

An alternative to the Design-Bid-Build and Design-Build approaches is for agencies to contract with CCC crews to implement revegetation projects. Both El Dorado County and Placer County have had success using CCC crews for their projects. These crews are based in South Lake Tahoe and can be contracted using purchase orders for small-scale revegetation projects. Often cost, project size, and the complexity of the revegetation specifications and construction determines whether or not to use CCC crews; CCC crews are most effective on simpler projects. Generally, CCC crews focus their efforts on plant installation only, and construction contractors may be needed to provide civil work, such as earthwork, for revegetation projects. In such cases, the work of the CCC crews complements that of the contractors who perform many of the large operations of projects, typically requiring machinery. A summary of advantages and disadvantages of using CCC crews is below. A discussion on the process for contracting and conducting coordination with CCC crews follows.

As part of the research for this document, detailed site evaluations were conducted for two El Dorado County erosion control projects that had revegetation installed by CCC crews: Apalache—Muskawaki Drive and Christmas Valley. Please refer to the discussions in subsequent chapters for the results of these evaluations.

Some advantages of using CCC crews for revegetation projects include the following.

Roadside Revegetation Using CCC Crews

- With construction oversight and direction, CCC crews provide field flexibility in customizing work for sensitive areas as they are able to revegetate areas inaccessible by machinery or that require intensive manual labor.
- CCC crews are efficient, accommodating, and act as an extension of agency staff, resulting in significant cost savings.
- CCC crews experience rigorous in-house training and are eager to learn.
- CCC crews are normally responsive and motivated to do a good job.
- CCC crews are contracted directly with the implementing agency, separately from contractors.
- CCC crews can be used to conduct maintenance of source control areas, removing sediment before it enters infrastructure and cleaning out swales and rock-lined channels.

Some disadvantages of using CCC crews for revegetation projects include the following.

- CCC crews have some variability in terms of productivity and work limited hours (generally 8:00 a.m. to 4:00 p.m. with no overtime); also, in 2009, they were furloughed on Fridays.

- CCC crews have limited availability due to fire fighting responsibilities and are generally available in early spring and late fall.
- CCC crews occasionally have training days and cannot perform revegetation work during those weeks resulting in scheduling problems.
- CCC crews can have large turnover and shifting of employees due to workload; this turnover can occur during the middle of a project and may not be well communicated with the owner.
- The qualifications and experience of CCC crews varies and depends on crew availability.
- Generally, CCC crews do not perform large tasks, and very large projects can be difficult; if they do take on a larger effort, it takes a long time to get to completion.
- CCC crews have limited access to equipment.
- There is no warranty on the work conducted by CCC crews, and direct construction oversight is needed by the implementing agency.
- There is no recourse should CCC crews conduct a poor installation, compared to the competitive bid process that requires a performance bond to keep contactors accountable for their work.
- CCC crews generally do not provide plant establishment maintenance, including irrigation; if needed, CCC crews can provide minor adjustments for revegetation projects during subsequent years under a separate contract.
- CCC crews are often contracted under a purchase order which can be limited to a fixed dollar amount per project (depending on the contracting agency).
- CCC crews generally do not procure their own revegetation materials because of state budget issues; this requires increased paperwork and management by implementing agency project managers to supply the materials to CCC crews.

To contract with CCC crews to execute revegetation construction, implementing agencies must take the following steps.

1. Contact the CCC and request a CCC standard contract form (minor paper work); the form is available from and can be prepared by the CCC.
2. Solicit and receive signatures on the form.
3. Provide an estimate cost per project per season.
4. Receive authorization for the cost.
5. Prepare a project-specific purchase order for an agreed dollar amount.
6. Coordinate with the CCC on project timing.
7. Oversee the project work.
8. Coordinate billing invoices and facilitate payment.

Implementation by CCC Crews

When using CCC crews on revegetation projects, coordination is often needed with construction contractors also working at a revegetation site (responsible for items such as grading and curb and gutters). As an example, for clarity on the public bid/construction documents (i.e., plans and specifications), the planting portion of the work is usually indicated to be conducted "by others"; the "others" would then be the CCC crews. At the site, the construction contractor and CCC crews work independently, with the contractor completing their work before the CCC crews begin their planting efforts. Often, the contractor will conduct site preparation using heavy equipment and the CCC crews follow with the planting work, including seeding, mulching, and compost (Cecchi, pers. comm., 2007). However, the implementing agency usually conducts oversight of both the contractor and the CCC crews to ensure seamless coordination, efficiency, and quality.

Often, implementing agencies meet California Tahoe Conservancy grant requirements by using CCC crews when possible on projects to meet the grant program objective of cost-effectiveness. The grant guidelines advise that using CCC crews is desired for projects and require the implementing agencies (project proponent) to illustrate how the CCC crews can be used as a cost savings measure to supplement Conservancy funds. To ensure success, critical preproject planning, design, materials specifications, and ordering are performed by the agencies. For projects to be implemented by CCC crews, revegetation design is usually conducted by implementing agency staff or their consultants, working closely with construction contractors whenever possible, to ensure the constructability of the revegetation design. The monitoring of past projects and trainings on current revegetation techniques influence designs; the lessons learned are incorporated into the construction specifications for current projects. In addition implementing agencies train and continually manage CCC crews on-site to promote project success. To be cost-effective, implementing agencies can use CCC crews for tasks that may not be directly related to revegetation such as fence building to protect revegetated areas (Cecchi, pers. comm., 2007).

In addition, to CCC crews, implementing agencies can use other staff to support revegetation efforts. As an example, El Dorado County uses snow removal staff from their road crews from April through October to maintain, irrigate, and monitor revegetation projects (Cecchi, pers. comm., 2007). For irrigation, a solid irrigation plan for at least the first two years after planting facilitates success.

Construction Documents

3.2 Construction Documents

This section provides a brief overview of construction documents as they relate to implementing revegetation projects. "Construction documents" is the legal term for plans, specifications, and cost estimates, and consist of the drawings and text required to bring a construction contract to satisfactory completion. Plans are drawings that depict the physical relationships of the project design elements, while specifications prescribe the level of quality that is required for materials and installation techniques during construction (and for revegetation projects, plant establishment). Together, plans and specifications (i.e., construction documents) serve as an integral part

of legally binding contract documents between an owner and construction contractor. The construction documents translate the science of revegetation in concert with any site engineering solutions into contract language and set a legal precedence resulting in a means for quality control during construction.

Construction documents can be thought of as a “recipe for success” for owners as they detail instructions, the work to be conducted, and the materials needed and how to combine everything to successfully complete a construction project. Construction documents serve as an important tool for interpreting the science of revegetation and serve as a bridge to construction while communicating defensibility and professional liability. The documents are used for agency approvals (plan check review), competitive bidding, and project construction, enabling projects to become a reality.

Revegetation construction documents involve several players. While the revegetation design is greatly influenced by resource specialists (e.g., ecologists, soil scientists, botanists, biologists, engineers, landscape architects), the preparation of revegetation construction documents is usually overseen and endorsed (“stamped”) by a licensed landscape architect, registered engineer, or both. Revegetation construction documents are used by contractors, inspectors, and review agencies, as well as the project owner and possibly special interest groups. Revegetation construction documents should provide appropriate detail for agency approval and construction permitting, complete technical information for construction, a standard or measure of quality expected during construction, and be consistent with design and construction industry standards.

Inspectors-Owners at Erosion Control Project Site

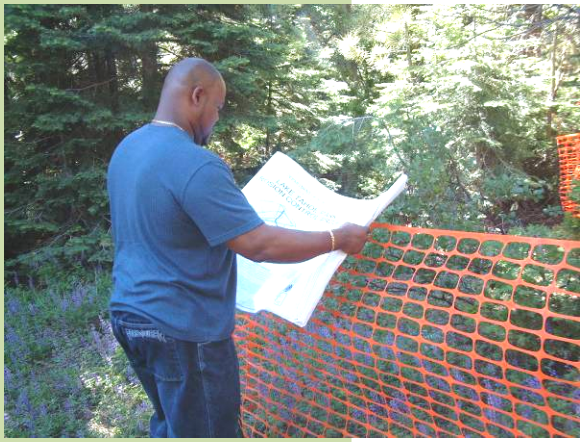
While several players are involved in revegetation design, for clarity construction documents limit terms to three key entities with specific roles during project construction: “Owner,” “Inspector,” and “Contractor.” Several alternatives are often used for these entities, but only one should be selected per entity; please see Table 3-2.

Table 3-2
Key Entities with Specific Roles during Project Construction

Entity	Description	Alternative Terms[1]
Owner	The project proponent and funding entity with whom a contractor contracts the work; the entity that conducts construction contract administration; if public land, may be the governing agency	• County • City • Government • Client
Inspector	The person or group of people conducting oversight and approvals for quality control and conformance to the construction documents during physical project construction; may or may not be contracted with the owner and may include a representative from a governing agency and/or the project designer	• Owner's authorized representative • Restoration specialist • Landscape architect • Engineer
Contractor	A company or person with proper licensure and a formal contract to supply labor, materials, and equipment to conduct physical project construction	• Contractor • Subcontractor • Revegetation contractor

Note: [1] These terms do not comprise a comprehensive list, but are commonly used for revegetation projects.

Revegetation construction documents facilitate project implementation by securing a competent contractor for the construction work; prescribing requirements for quality construction conforming to project goals and objectives, permits, and other compliance documents; providing a simplified interpretation of (without compromising) the project design; and promoting greater success in the field, minimizing the chances of finger pointing.



Oversight Using Construction Drawings

Preparation of revegetation construction documents does not include planning, alternatives development, conceptual design, regulatory permitting processes, or construction administration. These tasks are conducted separately; please refer to Exhibit 3-1, "The Design Process."

Revegetation construction documents are based on site inventory and analysis and concept design plans, using detailed survey information and rectified aerial photos. They can be prepared as independent documents or incorporated into a larger set of engineering documents. Revegetation construction documents address design details, installation techniques, site preparation, quality and quantities of material, and ensure that the design protects the health, safety, and welfare of any users.

Construction documents are prepared after detailed design (the tailoring the preferred alternative concepts to exact conditions at specific locations within the project site, in concert with other design decisions for the project), at the 65%, 95%, and 100% design stages, and before bidding and construction. Please refer to Exhibit 3-1, "The Design Process."

Revegetation construction documents should be clear, precise, and user-friendly; consist of clearly dimensioned, measurable information; provide specific detail for accurate, itemized cost estimates and competitive bids; and provide an instantly understandable presentation of the project design and regulatory and construction requirements. Whenever possible, prescriptions should be written in layperson's terms, avoiding jargon, and with comparable interpretation by all. It is critical that the plans and specifications complement each other without any redundant, conflicting, or superfluous prescriptions or information. The following is a brief overview of the instruments of service for construction documents: construction drawings and specifications.

3.2.1 Construction Drawings

Construction drawings are the precise graphic representation of the design elements of a project. The drawings include the sizes, shapes, and spatial relationships of the design elements; should reflect the existing and proposed topography at the project site, and are commonly prepared using AutoCAD. The drawing set typically includes the following sheets:

- Cover sheet
- General notes
- Site/Key plan
- Staking/Layout plans
- Grading plans
- Weed abatement plan
- Planting plans
- Irrigation plans
- Construction details and cross-sections
- Other drawings for specific construction for a given project

Construction drawings require quality graphic communication. Graphic considerations include drawing format and title blocks, line types and line weights, labels (annotations) and leader lines, dimensions, symbols, and level of base plan information (e.g., contours). A graphic hierarchy should be established so that the relevant subject of a given sheet (e.g., revegetation elements on a planting plan) is primary in the foreground, with supplemental, subordinate information (e.g., base plan topography) placed in the background.

3.2.2 Construction Specifications

Construction specifications are the verbal component of construction documents and indicate the level of quality of materials and techniques required during construction. Specifications complement the construction drawings and vary extensively from nothing but notes on drawings to fully developed multidivision specification book form project manuals prepared by the design team. A project manual typically includes bidding requirements, general contract conditions, the owner-contractor agreement, the schedule of drawings, and technical specifications (e.g., materials type, quality, and installation techniques). Technical specifications for revegetation can be prepared as descriptive, performance, and proprietary types, and these types usually are not mixed; refer to Table3-3.

Table 3-3
Specification Types

Specification Type	Description	Example: Coir Logs
Descriptive	Prescribes the pertinent features of a selected material, without naming proprietary names, but actually limiting acceptable products to the one described	Coir logs shall be 20-foot long rolls, 12-inch diameter (plus or minus one inch), and have a minimum weight of 5.0 lb per linear foot; made from 100% mattress grade coconut fiber and bound by high-strength coir fiber netting that is 100% biodegradable. At no time shall "Photodegradable" or "UV stabilized" material be used. The minimum tensile strength of the fabric shall be 55 lb per yarn dry or 40 lb when wet.
Performance	Prescribes the attributes and duties of the materials, but the bidders are left free to find their own materials complying to the those functioning requirements	Coir logs shall be 12-inch diameter, biodegradable, and used as sediment source control for erosion at locations shown on the Drawings.
Proprietary	Prescribes actual trade names and model numbers for the required materials	Coir logs shall be biologs, manufactured by Eco Fabriks 1-877-COIR MAT (264-7628), or approved equal.

Source: Meier 1983; example created by AECOM in 2010.

The format for specifications is usually dictated by the owner, or for public works projects, the governing agency that practice their own individual standards and protocols. A commonly-used format, which is considered the industry standard, for specifications is the Construction Specifications Institute (CSI) format which uses an indexing system for organizing construction specifications. The latest version, referred to the CSI 2004 format, consists of 50 Divisions of construction (similar to a chapter in a book) and includes work for all construction trades such as civil, landscape, masonry, electrical, finishes, or mechanical. For revegetation projects, specifications are usually found under the "Site and Infrastructure Subgroup" and specifically in Division 31, Earthwork, and Division 32, Exterior Improvements. Within each Division, Sections are prepared for specific subject prescriptions. For revegetation projects, below is a list of commonly used Sections:

Division 31, Earthwork

- 31 11 00 Clearing and Grubbing
- 31 23 16 Excavation
- 31 23 23 Fill
- 31 35 19.16 Geotextile Slope Protection

Division 32, Exterior Improvements

- 32 01 90 Plant Establishment
- 32 31 26 Wire Fences and Gates
- 32 84 00 Planting Irrigation
- 32 91 00 Planting Preparation
- 32 92 19 Seeding
- 32 93 00 Planting
- 32 94 00 Planting Accessories

Within each section, prescriptions are presented in three parts: Part 1—General, Part 2—Materials, and Part 3—Execution. This is similar to a recipe that one might use in the kitchen. Table 3-4 compares how specifications are set-up similar to a recipe. Part 1 is a general overview of what is to be built or made, Part 2 describes and defines the materials or ingredients to be used, and Part 3 prescribes how to put the materials together. It is best to keep each section 8–10 pages long, though some projects require much more information.

Table 3-4
Specification Section Organization: Seeding Specification vs. Cake Recipe

Parts	Seeding Specification (abbreviated example) (1)	Cake Recipe (example)
General	• Furnish all labor, materials, tools, and equipment required to drill seed where indicated on the drawings, and otherwise complete drill seeding as specified. • Drill seeding shall not occur during weather conditions which will adversely affect materials or installation or when soil is excessively moist for proper operation of the drill or in a muddy condition.	• Prepare a mocha decadence, chocolate lover's delight, cake that provides 14 servings • Calories per Serving: 221
Materials	• Seed mixes shall be as shown on the drawings. Seed source shall be within a 100-mile radius of the project site. • Mychorrhizal Innoculant: An endomychorrizal innoculant shall be applied during soil preparation. Either a granular form or similar or micronized powder shall be used. Application rate: 10 pounds (lb) per acre. • Straw Mulch shall be mold-free, air-dry uncut straw, certified weed free. Application rate: 4,000 lb per acre. • Tackifier shall consist of an organic substance in powder form and shall be psyllium-based and packed in clearly marked bags stating the contents of each package. The tackifier will require no curing time, shall remain soft and rewettable, and shall not inhibit seed germination. All ingredients shall be	• 1/2 cup butter • 6 (1 ounce) squares semi-sweet chocolate • 3/4 cup white sugar • 1 1/4 cups finely ground walnuts • 2 tablespoons all-purpose flour • 3 tablespoons coffee-flavored liqueur • 1 teaspoon vanilla extract • 3 eggs • 2 (1 ounce) squares semisweet chocolate, melted

Table 3-4
Specification Section Organization: Seeding Specification vs. Cake Recipe

Parts	Seeding Specification (abbreviated example) (1)	Cake Recipe (example)
	biodegradable. Application rate: Follow manufacturer's directions.	• 2 tablespoons coffee-flavored liqueur • 1 tablespoon confectioners' sugar for dusting
Execution	• The Contractor shall handle all materials to ensure that the seed mixes and supplies are not damaged at any time. • Before any drill seeding, all finish grading in areas to be seeded shall have been completed. • Seeding equipment shall be a range land drill seeder. The seeder shall be equipped with a fluffy seed box with agitators to prevent bridging and clogging. The seed box shall have metal row dividers and individual box adjustment to meter seed flow. • Seed shall be applied by way of drill seeding methods to the prepared soil surface. Drill seed work shall consist of drilling seed into seeding areas as shown on the drawings. • Fertilizer shall not be applied. • Mychorrizal innoculant shall be mixed with the seed and applied during the seeding operation. • Seed shall be drilled in rows at a maximum distance of 8 inches apart. Seed shall be drilled to a depth of 1 inch. A minimum of three passes in different directions with seeding equipment shall be required to distribute the seed and reduce the uniform row appearance. • Mulch shall be placed on the seeded areas and spread by hand or blown to achieve a maximum depth of one-quarter inch. Mulch shall be distributed evenly without clumping or piling. • Immediately following application, mulch shall be tractor-walked or tucked in with a mulching roller or mulch crimper that punches the mulch in the ground to a depth of 2 inches. • Tackifier: Once mulch work is started in an area, stabilizing emulsion applications shall be completed according to manufacturer's specifications in that area on the same working day.	• Preheat oven to 325°F (165°C). • In a saucepan over medium heat, melt butter and 6 ounces semi-sweet chocolate, stirring until blended. Remove from heat and let cool. • In a large bowl, beat eggs and sugar on high speed of electric mixer for about 3 minutes until thick and lemon colored. Stir together ground walnuts and flour; gradually stir into egg mixture. • Stir 3 tablespoons coffee liqueur and the vanilla extract into the chocolate mixture, then stir into the batter until well blended. Pour batter into a 9 inch springform pan. • Bake for 35 to 45 minutes in the preheated oven or until top is set. Cool cake in pan. Remove metal ring and place cake on a serving plate. Dust the top with confectioners' sugar. Stir together 2 ounces melted chocolate and 2 tablespoons coffee liqueur. Drizzle over cake.

Note: [1] Significantly more information is provided in seeding specifications, and this is an abbreviated version for use in comparison to a recipe. Refer to Appendix E for specifications templates.

Source: Data created by AECOM in 2010.

Several resources are available for preparing specifications. Appendix E provides templates for revegetation specifications sections based on CSI 2004 format and have been prepared as an annotated outline for each section. The templates should not be interpreted as ready to use, and in turn need to be tailored to site-specific conditions and designs for each project. The template sections include plant materials procurement, site preparation/soil preparation, temporary irrigation, planting and seeding, and plant establishment maintenance. In addition, there are public resources available for use as a starting point for preparation of revegetation specifications; as with the templates, the specifications available at these resources should not be interpreted as ready-to-use specifications, and in turn need to be tailored to site-specific conditions and designs for each project. The resources include:

- standard specifications from the local agency,
- California Department of Transportation standard specifications,
- the U.S. Army Corps of Engineers,
- materials suppliers, and
- internet searches.

Bad specifications can be a deterrent to the contractor to do a good job. It is considered the contractor's role to exploit construction specifications to their competitive advantage. As such, successful implementation requires clear, precise, and "ironclad" (i.e., strong, firm, or unyielding; not capable of being attacked or refuted) specifications. At all times specifications must be specific, detailing all requirements and prescriptions to decrease any uncertainty and allow for comparable interpretation by all users. When writing revegetation specifications, it is important to:

- conduct one or more visits to the project to conduct a thorough site analysis to fully understand site conditions, opportunities, and constraints;
- analyze soil, biologic, and hydrologic conditions;
- consider existing vegetation patterns, including dominant vegetation, seed sources, and invasive and noxious species;
- consult a plant specialist;
- consult plant and other material suppliers on species sizes, availability, and pricing (no "lazy" specifications);
- know seeds per pound of each species to correctly evaluate and prescribe an appropriate mix; and
- ensure that prescribed construction methods are contemporary.

In the specifications, "success" should be defined and tied to project goals and objectives, performance standards, and any regulatory requirements. For revegetation projects, success should be not measured solely as plant performance, but should assess if the project site is stable against erosion during the first year after planting, and is measurable and repeatable over time.

3.3 Contracting

Below is a summary discussion of issues related to select contracting issues that relate to revegetation project implementation, and is not to be interpreted as a comprehensive discussion of contracting.

The discussion briefly addresses turnkey vs. separate revegetation contracts, contractor minimum qualifications, bidding, preconstruction activities, construction oversight, and record drawings. Please refer to Sections 3.1, "Implementation Approach," and 3.2, "Construction Documents," for additional information related to contracting.

3.3.1 Turnkey vs. Separate Revegetation Contracts

3.3.1.1 Turnkey Contracts

The traditional "turnkey" approach for award of construction contract for an erosion control project is to have the revegetation work be a subset of the civil work, such as grading and curb and gutter improvements. To do this, a general (civil) contractor often subcontracts the planting-related and plant establishment maintenance work to a licensed landscape contractor. Often, the result is increased cost for the revegetation efforts, as the general contractor will add a fee to the contract to manage its subcontractor. Further, since the plant establishment maintenance work to be conducted by the landscape contractor may last over a period lasting 1- to 3-years, the general contractor also becomes responsible contractually for this period. In this traditional approach the owner's contract and communication is directly with the general (civil) contractor, and not necessarily with the landscape contractor. Instead, the general (civil) contractor is responsible for all communication with its landscape contractor. Further, the general (civil) contractor chooses its landscape contractor. With a low-bid mandate that faces many public agencies, general (civil) contractors are often choosing revegetation bidders using the lowest landscape bid that they receive without consideration of the bidder's qualifications, which ensures a lower overall bid. However, no law requires that planting and establishment be conducted by a landscape contractor. A general contractor can, though may not be adequately qualified to, conduct the planting and establishment work; this results in increased risk for the owner.

Revegetation Contractors During Construction

3.3.1.2 Separate Revegetation Contracts

To reduce cost and increase efficiency, qualifications, and communication, a modified contract approach is being tested for erosion control projects that allows for a separate revegetation contract from the contract for civil work. In this approach, the civil contract often covers earthwork operations including hydromodifcation and infiltration, while the landscape contract addresses planting and establishment. In this approach the owner has contracts and communicates directly with both the general (civil) contractor and the

landscape contractor; the two contracts operate independently and are administered and coordinated by the owner. In addition, environmental and regulatory clearances should be acquired by the owner with the "parent" contract (often the civil contract). The benefit of separate contracts to the owner is more quality control of the revegetation installation and, depending on the project specifications, increased recourse during the (postinstallation) plant establishment period. A cost savings may occur because no general contractor mark-up (fee) for managing its subcontractor through the (postinstallation) plant establishment period will be imposed. However, separate contracts involve more paperwork, which can result in increased management time and expense to the owner. In addition, any disputes and issues of accountability and scheduling between contractors will need to be managed and resolved by the owner.

3.3.1.3 Plant Procurement Contracts

Depending on the quantity of plants and species needed, plant procurement can also be contracted separately (from the civil and planting contracts) with a reputable nursery that specializes in native plants. Usually plant species for native revegetation are to be grown from genetic stock that is local to the project site or region. As such, plant materials take several months lead time for propagule (a structure [e.g., seed, spore] that propagates a plant) collection, growing, and storage, before delivery to the project site. It can be to the project's advantage to contract the plant procurement work separately as insufficient lead time may result by the time the general-landscape contractor team is under contact with the owner. In addition, with this scenario, the owner has full control over the quality of the plant materials, providing them to the ultimate landscape contractor for installation. Upon delivery to the project site, the contractor does have the right to accept or deny the plant materials based on health and vigor before they become its responsibility during installation and plant establishment. With advance plant procurement, a cost savings is usually had as the contractor's price does not include the cost of plant materials and limited to supplying labor and equipment for installation of the materials.

Plant Materials Delivered to Site

With any contracting approach, the responsibility for coordinating contracts and enforcing the design specifications during construction toward ultimate project performance and success remains with the owner.

3.3.2 Contractor Minimum Qualifications

To ensure best value when selecting a revegetation contractor in terms of bid price and proven experience, often proof of minimum qualifications will be required as part of a contractor's bid submittal. Depending on the contract type (turnkey vs. separate revegetation contracts), it is important to receive information on the experience of all contractors on a given team (e.g., general [civil] contractor and any of its subcontractors, including the landscape contractor). For turnkey contracts, it is very important to educate general contractors on the importance of revegetation or landscape contractor

minimum qualifications so that low-price is not their only consideration when selecting a subcontractor. The contractor is required to submit verification of qualifications for approval before award of the construction contract. During the bid submittal evaluation each contractor's bid price and their proven experience is evaluated to ensure best value for the project toward increasing the chances for success of the revegetation efforts and ultimate plant establishment. Minimum qualifications should isolate key requirements for a given project, be straightforward, and legally defensible. Key requirements should at a minimum include:

- holding the correct and current contactor and business licenses in good standing;
- having experience in the installation and establishment of California native plant materials for revegetation projects, including temporary irrigation systems for a proven amount of time (e.g., 5 years, minimum);
- having successfully completed a minimum number of native planting and seeding revegetation projects with a plant establishment, maintenance period of similar scope and scale within the montane (coniferous to alpine) zone of California or western Nevada, with at least one project within the last 5 years including planting of an area that is ecologically similar to the project in question;
- providing at least three references for successful past revegetation projects; and
- identifying key staff and providing a field supervisor with proven revegetation experience who will be on site for the duration of the construction and plant establishment maintenance periods.

It is critical that in this process the owner be strict in enforcing any prescribed minimum qualifications requirements and in verifying all submitted qualifications from potential contractors to eliminate any fabricated bid proposals. This verification includes contacting all references submitted as part of potential contractor qualifications. By verifying contractor qualifications (e.g., resumes, references, project experience) and evaluating the bid (cost) form, the owner can assess whether a contractor is adequately capable of conducting the work required for successful revegetation and plant establishment for erosion control projects.

Revegetation Plant Establishment Maintenance

For some owners, requiring minimum qualifications beyond licensing may be a legal challenge. It is critical that any minimum qualifications requirements be reviewed by the owner's legal counsel to ensure that they are defensible. For efficiency, with respect to cost and project schedules, it is very important that the bid and contractor selection process be clean and free of any subjectivity and challenges. For examples of text describing minimum qualifications, please refer to Appendix F.

A word of caution: while minimum qualifications can facilitate the chances for successful revegetation projects, they can also effectively eliminate the possibility of any new contractors from learning how to conduct revegetation implementation. Solid construction documents (i.e., plans and specifications)

coupled with careful construction oversight can train new contractors in the techniques and requirements for successful revegetation. Minimum qualifications should be used at the owner's discretion with respect to their risk management for a given project.

3.3.3 Bidding

Bidding provides a fair and efficient process for contractor selection for construction projects. The bidding process is conducted by the project owner or an owner's authorized representative and usually includes the following steps.

1. advertising for perspective contractor bids (open to the public or a short list of preselected contractors);
2. making bid documents (request for bid-proposal letter, project specifications, bid quantities, and improvement plans) available for contractor purchase;
3. conducting a prebid meeting with prospective contractors;
4. answering bidders' questions and clarifying the final construction documents;
5. issuing any required addenda;
6. receiving and opening sealed bid proposals;
7. evaluating submitted bids; and
8. awarding the construction contract to the selected contractor.

Due to a low-bid mandate that often drives contractor selection and to increase the chances for receipt of comparable bids, it is recommended that the prebid meeting be a mandatory requirement for all contractors that wish to submit bid proposals. At the meeting, the project owner or an owner's authorized representative should provide a thorough overview of the project, discuss any minimum qualifications criteria, advise on the selection criteria and contract award process, address the necessary construction sequencing and expected schedule milestones, and summarize any innovative project details. Whenever possible, it is helpful to conduct a site walk as part of the prebid meeting. The meeting should also address adequate information to decrease protests, identify key bid period dates (e.g., when to submit questions, bid submittal date and time), and be specific about the level of information required from contractors in their submitted bid proposal.

At all times, it is critical that the bid evaluation criteria are objective in order to conduct a comparable assessment of the bid proposals. In addition, for revegetation projects, it is in the owner's best interest to get revegetation bid bonds up-front from the contractor.

3.3.4 Preconstruction Activities

Once the contractor is selected and contract award is given, several activities need to occur before the start of the physical, on-the-ground construction, including conducting a preconstruction meeting, reviewing contractor submittals and requests for information (RFI's), and providing approvals. As with

the bid process, these activities are conducted by the project owner or an owner's authorized representative.

3.3.5 Preconstruction Meeting

Preconstruction Direction at Site

A preconstruction meeting is conducted to ensure that all parties involved with the project construction understand their roles and communication protocols. The meeting should include the owner, designer, construction manager, inspectors, contractor (including any subcontractors and project foremen), and others as the owner deems necessary (e.g., regulating agency and funding representatives). The meeting should be held at the project site and review and discuss the overall implementation of the project including: design objectives, environmental permit limitations, endangered species issues, emergency contact information and protocol, contract management and chain of command, media protocol, project construction documents, implementation schedule (including key milestones), discussion of key project issues (e.g., noxious/invasive weed management), and any addenda. An example agenda for a preconstruction meeting is as follows; the agenda should be tailored for project specific issues.

- Project management organization/roles and responsibilities
- Procedures for
  - Routine correspondence
  - Meetings
  - Submittals
  - RFI's
  - Emergencies
  - Progress payments
- Contract management
- Completion dates
- Liquidated damages
- Labor regulation requirements
- Construction documents (plans, specifications, and any addenda)
- Submittals
- Inspections
- Safety program
- Use of premises by contractor
- Permits
- Environmental controls
- Procedures for security and housekeeping

- Record drawings
- Work hours
- Schedule
- Contractor's work plan
- Other contractors
- Questions and answers

The preconstruction meeting should be well documented in writing to record the project name; meeting date, time, and location; and attendees (name, company, contact information, and project role); and any specific information or decisions that are made during the meeting based on the agenda items. To ensure thorough communication and coordination, a copy of the meeting minutes should be provided to all attendees and parties involved with the project construction.

3.3.6 Submittals, RFI's, and Approvals

As prescribed in the project specifications, submittals are often required for quality construction to ensure that the appropriate project materials and implementation techniques will be used during project construction. In addition, submittals can consist of contractor initiated RFI's that may occur throughout the construction contract period to gain further clarity on the construction documents, and requests for a product, material, and/or approach substitution. In all cases, submittals require planning to account for any lead time needed (from subcontractors to general contractors to owner) to communicate and process the information clearly and efficiently to keep the project on track with the overall schedule. All submittals should be tracked by the project owner or owner's authorized representative by way of multiple copies recording the project contract number, submittal number, project name and location, contractor's name, submittal description and application, reference to the construction documents, date, and response or action related to the submittal or request.

When requesting consideration of a product, material, and/or approach substitution, the burden of proving the equality of an alternate material should be the contractor's responsibility. The determination of suitability and compatibility of a proposed substitution should be at the sole discretion of the owner or owner's authorized representative. Further, the owner or owner's authorized representative should verify all proposed substitutions with venders and at the project construction site to minimize the chance of a "bait and switch" tactic where the paperwork is good, but in the field it is not. All substitutions submitted for approval should be fully supported by documented proof of equivalent to the product, material, and/or approach prescribed in the construction documents. It is best to have the documentation in the form of test results obtained by independent peer-reviewed research efforts on similar landforms, soil types, aspect, climate, elevation, and other specific site conditions as the specific products, materials, and/or approaches prescribed for the

Plant Material Approval at Nursery

project.

At times, the contractor may request field clarification or design changes based on specific site conditions that may not have been accounted for on or have changed from that shown in the construction documents. Any field direction provided by the owner or owner's authorized representative should be fully documented as noted above for adequate record keeping. Please refer to the construction oversight discussion below for additional information.

3.3.7 Construction Oversight

Observation of Recently Installed Plants

Construction oversight can be conducted during physical project construction for quality control and to ensure efficient implementation conforming to the final construction documents and environmental permits and agreements. Construction oversight conducted by the project designer, or a third party with expertise in revegetation, can greatly increase the chances for success for revegetation projects. It is suggested that the owner hire a designer or a third party expert to serve as the owner's authorized representative and be on site to oversee plant implementation and establishment, and to make adaptive management decisions in the field. The designer can inspect and enforce the construction documents, and make field adjustments as needed to improve the chances for revegetation success. In addition, construction oversight can facilitate construction within the project budget and schedule. For revegetation projects, construction oversight can include some or all of the following activities.

- conducting a preconstruction meeting;
- conducting weekly meetings at the project site with contactor, owner, and others as appropriate;
- clarifying the construction documents; evaluating any contract change order requests;
- reviewing contractor submittals, shop drawings, and Requests for Information (RFIs);
- reviewing any materials and samples submittals or request for substitutions;
- conducting preconstruction staking and field-marking for design element location;
- observing plant materials at nurseries before delivery to a project site;
- conducting observations of site preparation, irrigation system, and planting construction;
- conducting any tests on equipment (e.g., temporary irrigation system); and
- facilitating Final Acceptance (i.e., approval) of phases of construction and plant establishment maintenance.

Construction oversight should provide detailed and specific field review and observation of the contractor's operations, materials, and implementation methods and techniques for conformance to the project construction documents. As examples for revegetation projects, construction oversight

actions might include checking tilling method and depth, verifying amendment application rates, and observing seeding methods and application rates. Construction oversight also includes extensive record keeping of the construction operations by way of field reports and memorandums to fully document the construction activities, any field design direction or adjustments, and "punch lists" (i.e., organized "to-do" items) of tasks that need to be addressed for completion and before Final Acceptance of the project installation.

In addition close implementation oversight by qualified personnel is critical for project success. To do this, the owner should enlist its designer (including a revegetation ecologist) with the institutional knowledge of the project design and specific details and prescriptions required for the revegetation work. The designer's hands-on start-to-finish "ownership" of the project process, including design and implementation oversight can contribute to revegetation success for erosion control projects.

3.3.8 Regular Construction Meetings

As part of the construction oversight activities and to ensure thorough communication and coordination between all parties involved with the project construction, regular construction meetings should be held throughout the construction contract period at an agreed upon interval (e.g., weekly, bi-weekly) by the owner, owner's authorized representative, and the contractor. An example agenda for a typical construction meeting is as follows; the agenda should be tailored for project specific issues.

- Safety
- Environmental issues
- Contract time
- Work progress
- Discussion of key project issues (e.g., noxious/invasive weed management)
- Milestone schedules/critical path schedule (updated weekly)
- On-site or other issues
- In-field changes and documentation
- Submittals
- RFIs
- Extra work items
- Record drawings

The construction meeting should be well documented in writing to record the project name; meeting date, time, and location; and attendees (name, company, contact information, and project role); and any specific information or decisions that are made during the meeting based on the agenda items. To ensure thorough communication and coordination, a copy of the meeting minutes should be provided to all attendees and parties involved with the project construction.

3.3.9 Record Drawings

After the completion of a revegetation for erosion control construction project, it is helpful to prepare record drawings to document the actual constructed conditions. The record drawings indicate any construction deviations and show all features of the project as actually built. Record drawings reflect changes made during the construction process, recording differences between the original design and the completed project. The record drawings should document every change from the final construction drawings to the installed locations, sizes, and materials used in the revegetation treatment areas. These drawings provide a permanent record of as-built conditions and can aid as key references for future maintenance processes.

Record drawings serve several important functions. They can inform the owner of locations for any infrastructure, and other hidden components to make repairs and maintenance easier. They are also helpful for any future renovations at a project site, and can be used as a base when creating any future plans at a later date. In addition, record drawings should clearly document the implementation details for specific revegetation treatments, allowing for implementers to repeat successful treatments and learn from unsuccessful efforts.

The record drawings are typically prepared by hand as red-lined mark-ups of the original construction plans. They are often based on input provided by or are prepared directly by the Contractor. The record drawings should be full size drawings, drawn to scale, and based on the final construction drawings for the project. They include all the changes that have been made from the original design reflected on the construction drawings, and include notes, modifications, and any other pertinent information realized during project construction. The record drawings often contain handwritten notes and sketches to denote any field changes. Record drawings are usually delivered to the owner on or before the project final acceptance observation. For additional information on documenting revegetation treatments, please refer to Tool 14 from the Sediment Source Control Handbook (Hogan and Drake 2009).

4. Revegetation Approaches and Components

The following text reviews the practices and techniques of revegetation, their use in the Tahoe Basin, and their relationship to the outcomes of Tahoe Basin revegetation projects observed during field surveys. This review and these observations provide the basis for recommended practices.

Several approaches are taken to control erosion as part of revegetation projects. These include:

- minimizing disturbance to existing vegetation;
- avoiding erosion and stabilizing soil surfaces through the use of temporary measures;
- installing and maintaining permanent structures to reduce erosion or retain sediment on-site;
- restoring soil properties to increase infiltration and facilitate plant growth; and
- establishing seeds, cuttings, and container-grown plants to restore the layers of vegetation and detritus that protect the soil surface and sustain infiltration and other soil properties.

Some combination of these approaches is usually applied at a site. Revegetation and erosion control projects also involve preliminary site assessments, maintenance, and adaptive management (which also entails monitoring and measurable success criteria). The practices and techniques that are components of these approaches to erosion control and revegetation are discussed in this section:

- site evaluation practices,
- site and soil preparation,
- plant materials,
- planting and seeding techniques,
- mulch,
- biotechnical and other treatments,
- maintenance,
- monitoring, and
- performance and success criteria.

In the sections that follow, this chapter describes and discusses these components based on the results of project assessments, including field observations, review of project specifications and monitoring reports, and input from the project implementers. In addition, this section applies information learned from literature reviews to the assessment of the revegetation projects.

4.1 Site Evaluation Practices

A preliminary assessment of a project site's characteristics is necessary for designing an effective revegetation project, in part, because no two sites are the same. Such assessments typically consider the site's setting, and physical, biological, and cultural factors. The discussion of these factors below includes a brief description of their significance for revegetation and of site evaluation practices in the Tahoe Basin.

4.1.1 Relationship to Revegetation

At any site, there are a number of site-specific influences on revegetation efforts, and these influences can differ dramatically among sites. These factors include the site's setting, and physical, biological, and cultural factors; and these influences on revegetation are discussed briefly below. (This section is based on Goldman et. al. 2005.)

4.1.1.1 Setting

Surrounding land uses (both existing and future) affect the value of some vegetation attributes. For example, the appearance of the vegetation will be more important for sites adjacent to residential or other developed areas than for sites adjacent to wildlands. Also, surrounding land uses can affect a site's hydrology, microclimate, and disturbance regime.

4.1.1.2 Physical Factors

Temperature and wind affect evapotranspiration (the loss of water vapor from plants and soil), and are related to the aspect/exposure of a site. For example, south- and west-facing slopes are usually hotter than north- and east-facing slopes. Exposed areas (such as many sites along roadsides) are prone to wind, which increases evapotranspiration.

Seasonal patterns in temperature and precipitation exert a major influence on plant growth and can be used to determine planting times and irrigation needs. (For additional information on irrigation needs, see University of California Cooperative Extension and California Department of Water Resources 2000). In the Tahoe Basin, there is a substantial range of elevation that influences seasonal patterns of temperature and precipitation. Also, the Tahoe Basin is in a transition zone between Mediterranean and continental climates, and in this transition zone precipitation declines from west to east across the Tahoe Basin.

Slope length and angle (steepness) affect the volume of flowing water that can be concentrated in rills and other channels on the slope, and affect the erosive force of this flowing water. Slope angle (together with aspect) also affects temperature because it affects the angle of the soil surface relative to the sun.

A site's soil is a key factor in any revegetation project. Soil attributes affect nutrient and water availability and the potential for erosion. Important attributes include texture, bulk density, strength, nutrient and organic matter content, and pH (which affects availability of nutrients to plants). For example,

rocky soils will make the installation of container plants more laborious, and sandy soils will require different applications of fertilizers and irrigation water. Besides observations and measurements of specific soil attributes, it is important to understand previous disturbance to the site's soil and alterations to topography that may have affected soil attributes and hydrology. Modeling also may be applied to interpret the consequences of a site's physical attributes for revegetation or soil erosion (e.g., Revised Soil Loss Equation [RUSLE], version 2).

The hydrology of a site affects both erosion and plant growth. In particular, sources of concentrated flow upslope from a revegetation site, the area and duration of inundation, and depth to groundwater are important aspects of hydrology to consider during the design of a revegetation project.

4.1.1.3 Biological Factors

The species composition of adjacent vegetation should be considered even if the goals of a revegetation project do not include restoration of native vegetation. Adjacent vegetation can indicate what species would be likely to establish and grow on a site. Also, seed from adjacent vegetation will disperse onto the revegetation site, supplementing planted seed, and litter from adjacent trees and shrubs may fall onto the revegetation site and supplement the litter produced on-site.

The presence of invasive plant species at the revegetation site or adjacent land can adversely affect revegetation projects. (Donaldson 2004 and Cal-IPC 2006 provide descriptions of invasive plant species in the Tahoe Basin.) These species may benefit from the site preparation and maintenance associated with revegetation and interfere with the establishment of desired species.

Animals browse and prey on plants and may complicate revegetation efforts. Rodents dig up and consume seeds and seedlings, beavers girdle trees and shrubs, and deer browse on plantings. In developed areas, dogs and human influences also may cause problems.

4.1.1.4 Cultural Factors

Motor vehicle and foot traffic affects many roadside revegetation sites. Without barriers that block access, trampling of vegetation and soil can be a chronic disturbance affecting such sites and greatly complicating revegetation.

Also, in the Tahoe Basin, snow removal affects conditions at portions of most roadside revegetation sites. Snow removal can cause effects similar to motor vehicle traffic (trampling, soil compaction), can scrape and redistribute soil material, and can increase salinity.

4.1.2 Recent Practices

Although documented preproject site assessments were not available for the reviewed revegetation projects, recent guidance from agencies and implementers in the Tahoe Basin (Cobourn et al. 2006, California Tahoe Conservancy 2008, Hogan and Drake 2009, USFS 2010) indicate recent practices. These recommendations encompass the general practices described above.

They also include consideration of infrastructure, defensible space, vectors for movement of invasive plant, and propagules, and they recommend that soil samples be collected and analyzed to document soil conditions. (Soil samples composited from several locations on a site will provide a more reliable indication of overall conditions than will soil collected from a single site.)
In some instances, recommendations for applying the site assessment to design of the revegetation project are also provided (California Tahoe Conservancy 2008, Exhibit 4-1). Furthermore, this local guidance recommends documenting the initial site assessment.

4.1.3 Observed Outcomes of Revegetation Projects

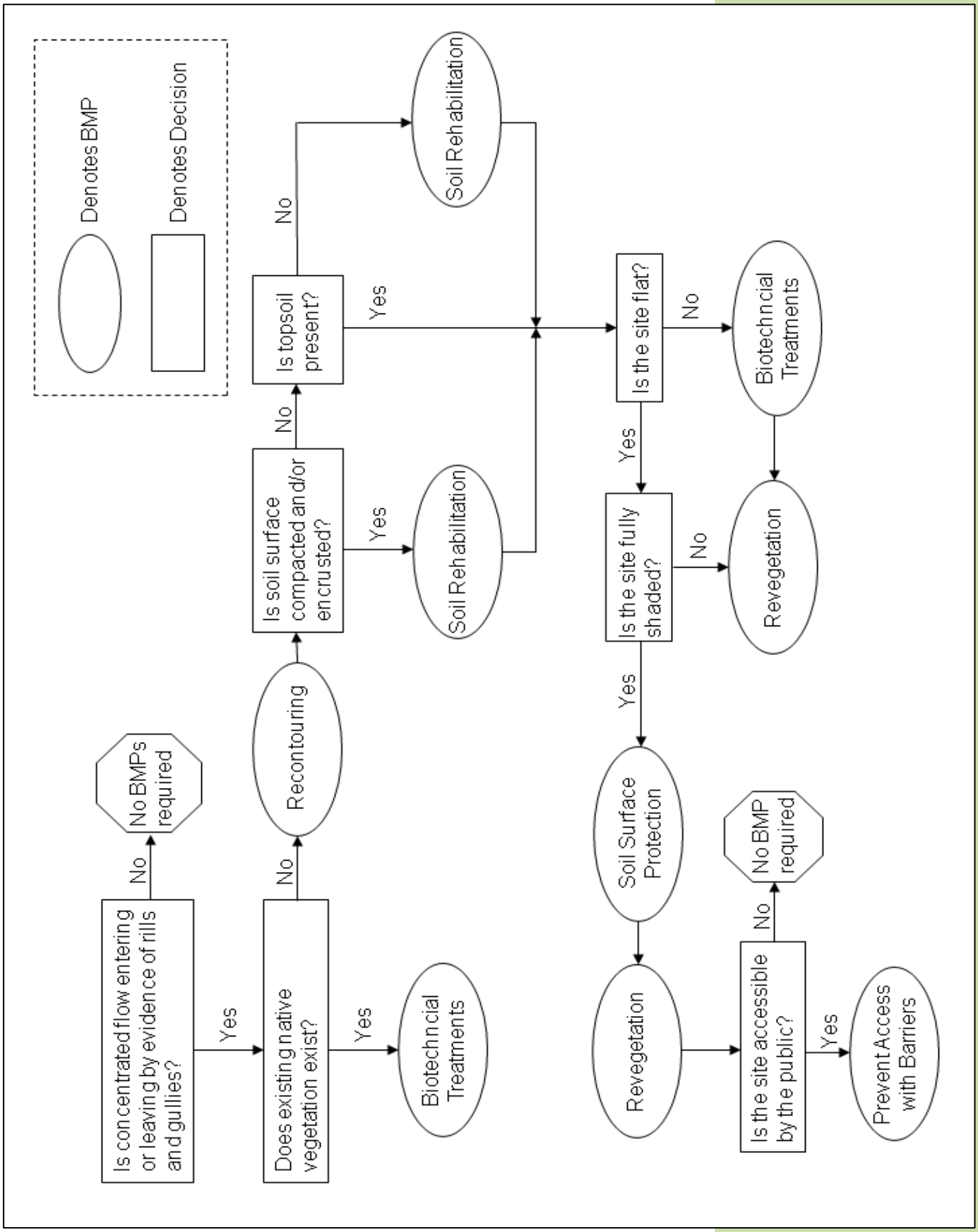
Because preproject site evaluations generally were not documented and available, the relationship of site evaluations to project outcomes cannot be evaluated in any detail. Nonetheless, project designs and outcomes indicated that site evaluations had been conducted and their results applied to designing projects, but that the site evaluations and/or the designs did not address all site conditions potentially affecting revegetation. Projects observed during the field surveys differed in their revegetation components, and these differences frequently corresponded to differences in site conditions. This indicates that a site evaluation was conducted and its results applied to designing the project. However, the design of some projects did not address water flowing onto the site from upslope or chronic disturbance of the site from pedestrians and vehicles. Most of these conditions could have been identified during the site evaluation and addressed by the design. In summary, the preproject site evaluation process appears to be an area where substantial improvements in practices could be made in the Tahoe Basin, and these changes would benefit revegetation.

4.2 Site and Soil Preparation

Site and soil preparation includes conserving topsoil, loosening compacted soil, adding soil amendments as appropriate, and controlling nonnative, invasive plant species. Site and soil preparation prepares the site to ensure that plantings have the best survival chances. This section discusses key aspects of site and soil preparation, recent practices, and observed outcomes of revegetation projects.

4.2.1 Relationship to Revegetation

The goal of site and soil preparation is to not disturb existing vegetation and soil unnecessarily, but prepare the site enough to ensure that plantings have the best survival chances (Goldman et al. 2005). In addition to minimizing soil disturbance, a goal is to conserve topsoil. A rough, nonuniform surface is best for planting, and soil is often loosened or ripped to a depth of 6 to 12 inches (Leiser 2004a).



Example of Application of Site Assessment to Design **Exhibit 4-1**

In general, accepted site and soil preparation practices for revegetation projects currently include the following techniques:

- collecting native plant cuttings and propagation materials from source plants;
- clearing vegetation and removing or eradicating nonnative plants;
- removing litter and duff, stockpiling, and reapplication;
- transplanting native plants that tolerate this practice (e.g., willows, roses, alder, and currants);
- removing, stockpiling, and reapplying topsoil;
- avoiding the use of manufactured soils unless for containers;
- grading sites;
- minimizing soil compaction by conducting soil loosening (e.g., ripping and tilling); and
- incorporating topsoil, compost, and other soil amendments and inoculants.

Site and soil preparation occur after mobilization of equipment to the project site and before any planting and seeding operations. Site and soil preparation activities often occur in the following sequence of events as applicable to a given project:

(1) Collect native plant cuttings and propagation materials from source plants.

(2) Transplant native plants.

(3) Clear vegetation and remove or eradicate exotic plant material.

(4) Remove litter and duff, and conduct stockpiling and reapplication.

(5) Remove topsoil removal and conduct stockpiling and reapplication.

(6) Grade the site.

(7) Minimize soil compaction by conducting soil loosening (e.g., ripping and tilling).

(8) Incorporate imported topsoil, compost, and soil amendments and inoculants.

Site preparation includes control of undesired nonnative species (weeds) that compete with desired native species. Site preparation can reduce weed problems if problematic species are removed from the site prior to ground disturbance; soil disturbance is minimized throughout the project; and topsoil and soil amendments (e.g., compost) are free of weed seeds.

Materials used during site and soil preparation include litter and duff, imported topsoil, compost, and fertilizers. Litter and duff consist of a combination of new and decomposing leaf litter from existing trees and shrubs, including pine and fir needle litter, shrub leaf litter, and grass leaf litter. (CalTrans includes duff in the definition for the term “local topsoil.”). Litter and duff are often removed to a 4- to 6-inch depth throughout the revegetation area before site grading and other improvements, stockpiled on-site in a designated area, and reapplied after grading operations are complete. (On linear projects [e.g., roadsides],

stockpiling litter, duff, or soil may be logistically challenging because of the narrow width of the right-of-way.) Although stockpiling and reapplying topsoil is preferable, topsoil may be imported and added to supplement native soil to meet a desired grade (elevation) and or to add organic nutrients to existing soil. Topsoil mixes are tailored to meet specific site conditions, and may be tilled in with existing soil. Compost usually consists of material resulting from a combination of chipped, shredded, or ground vegetation, wood products, and horse or cattle manure, and is integrated into the top 6 to 12 inches of the soil to make it more fertile (Beaulieu 2007). Organic slow-release organic fertilizers, such as Kiwi Power and Biosol or Kiwi Power and Fertil Fibers, are often added to the soil to supplement the soils' nitrogen, phosphorus, and potassium percentages. Soil inoculants such as mycorrhizal inoculants consisting of spores, mycelium, and mycorrhizal root fragments may be hand broadcasted as dry application to increase nutrient and water intake, by way of the roots, for plant growth (Amaranthus 2004).

Fertilizers and soil amendments are not always necessary for successful revegetation. Local native plants, especially shrubs and trees, are adapted to local soil conditions and do well in native soil without fertilizer or amendments. Furthermore, research has shown that while roots proliferate well in amended backfill, they do not penetrate the native soil as well as they will when no amendment is used (Leiser 2004b). In addition, amendments increase planting costs substantially.

However, many soils or revegetation sites have been dramatically altered by disturbance, and as a result not only are poor in nutrients (especially nitrogen) but also have a reduced nutrient holding capacity. Therefore, adding fertilizer alone may not be useful; instead, the soil should be improved by adding other amendments, mulches, or plants that are nitrogen fixers. Some nitrogen-fixing plants can be inoculated (the process of attaching the proper nitrogen-fixing bacteria to the seed) to enhance their growth and the nitrogen fixation process. (Goldman et al. 2005.)

The treatment of soil during site and soil preparation has a substantial effect on subsequent revegetation. There are several reasons for this substantial effect, including the following:

- **Alteration of soil physical properties.** The handling of soil during removal, stockpiling, and spreading alters soil properties, and in general makes it less favorable for the establishment and growth of plants, particularly through compaction (McQueen and Ross 1982; Langer, Davis, and Ross 1999; Stahl et al. 2002).
- **Loss of soil nutrients.** Topsoil (i.e., the upper soil layer) contains much of the nutrients stored in the soil. Thus, if topsoil is lost from the site, the supply of nutrients is reduced, which can reduce plant growth.
- **Reduced infectivity of mycorrhizal hyphae and spores.** Any mechanical disturbance or stockpiling of soil is likely to reduce the ability of mycorrhizal associations to form between roots and fungi (Allen, Jasper, and Zak 2002). This occurs because death, fragmentation, and dilution (of upper topsoil with deeper soil layers) reduce the concentration of viable hyphae and spores.

- **Dilution of seed stored in the soil.** Most seed is concentrated at the soil surface and in the upper few inches of the soil, and few species have seed that can emerge from more than an inch below the soil surface (Parker, Simpson, and Leck 1989; Young 1992; Grant et al. 1996; Koch et al. 1996). Thus, the mixing of the upper few inches of soil with deeper layers of soil will reduce the concentration of seedlings emerging from the soil (Koch et al. 1996, Rokich et al. 2000).
- **Mortality of seed.** The handling of soil also contributes to the mortality of seed (Koch et al. 1996).

Compaction occurs when vehicles and heavy equipment pass over soil, particularly under wet conditions (Hillel 1982, Hamza and Anderson 2005). It can substantially reduce the volume of soil accessible to plant roots, reducing water and nutrient availability, and consequently reducing plant growth. Compaction also reduces infiltration rate, and thus, increases runoff.

The most widespread technique for alleviating compaction is ripping the soil with a tractor or bulldozer pulling an attachment through the compacted soil (Switalski et al. 2004, Hamza and Anderson 2005). “Cross ripping” entails two passes of the attachment pulled at a 45° angle to each other. This breaks apart compacted layers and creates air spaces, which increases infiltration of water and facilitates deeper growth of roots. This ripping generally enhances plant growth on sites with compacted soils. Several other techniques include the use of infiltration tines, hand tilling, augering/drilling, and especially, the use of the bucket of an excavator or backhoe (Hogan and Drake 2009).

However, without the incorporation of organic matter (or another binding agent), the benefits of soil loosening are often only temporary. Recompaction may occur in 1–4 years (Luce 1997, Moffat and Boswell 1997, several studies cited in Hamza and Anderson 2005).

Three adverse consequences of mixing compost, wood chips, and/or tub grindings (tub grindings are wood chips that vary in size with some long pieces, promote natural airflow, and serve as a source of carbon in the soil) into soil are the possible introduction of invasive plants, reduction in soil strength, and altered nitrogen availability. Compost can contain weed seeds and be a vector for introducing weed species to a revegetation site.

Alleviating soil compaction reduces soil strength. To an extent, this is necessary for increasing infiltration and enhancing root growth; however, further reductions in soil strength may provide little benefit. In addition, on steeper slopes, reductions in soil strength increase the likelihood of mass failure, especially at the boundary between tilled soil (through which water moves rapidly) and underlying, unloosened soil (through which water moves slowly). Although root growth should reduce the risk of mass failure over time, it will not reduce this risk much during the first year, and if plants do not root into the underlying (unloosened) soil, then the risk of mass failure could persist for years.

Adding compost and wood chips can alter the availability of nitrogen to plants for several years. These organic materials contain both carbon compounds that provide energy for microbial growth, and nitrogen-containing compounds that

are required by microbes (and plants). If an organic material contains relatively little nitrogen, such as wood chips, it provides energy for microbial growth, but microbes must still obtain additional nitrogen from other sources. Thus, adding organic materials with high carbon-to-nitrogen ratios can reduce nitrogen availability to plants for several years (Marrs 2002). In contrast, organic material with a relatively low carbon-to-nitrogen ratio will provide additional nitrogen for plant growth. More so than wood chips, composts vary in their composition and in the amount and timing of nitrogen they provide. (See Hogan and Drake 2009 for a more detailed discussion of this topic.)

Change in the availability of nitrogen and other nutrients, however, is the combined result of handling litter, duff, and soil; adding compost, other organic matter, and fertilizer; and establishing nitrogen-fixing plants. Together, these practices affect soil physical properties, total amounts of nutrients stored in soil, and composition of the soil ecosystems. The significance of any effects of incorporating compost and wood chips into soil on nutrient availability and plant growth depend on these other influences.

The availability of nitrogen often limits plant growth; plants require more nitrogen than other nutrients, and most soil nitrogen is associated with organic matter, so disturbances can reduce nitrogen availability. (In general, disturbances that cause loss of topsoil reduce plant growth [Tormo, Bochet, and Garcia-Fayos 2007], in large part because of loss of nitrogen.) Reduced availability of nitrogen may be limiting plant growth on many disturbed sites in the Tahoe Basin. Levels of nitrogen stored in the soil at disturbed sites in the Tahoe Basin range from less than 90 to more than 1,000 pounds per acre of nitrogen (Claassen and Hogan 2002). The higher values in this range are comparable to those of many undisturbed sites. The lower values in this range represent either sites that support little plant growth or sites that have lost plants, soil, and organic matter by disturbance. Soil microorganisms make only a small portion of soil nitrogen available each year. Therefore, availability of nitrogen may limit total plant growth on sites with lesser amounts of soil nitrogen (Marrs 2002).

Fertilizers can provide additional nitrogen and strongly affect establishment and growth (Paschke, DeLeo, and Redente 2000). The effect on growth is often temporary, however (Petersen, Roundy, and Bryant 2004; Ewing 2002). Also, fertilizers enhance the growth of some species more than others, and this differential effect can reduce establishment and growth of some desired species (Carpenter et al. 1990; Petersen, Roundy, and Bryant 2004 and studies cited therein). Often, the growth of annual species is increased, to the detriment of perennial plant species (Carpenter et al. 1990; Petersen, Roundy, and Bryant 2004). Bacteria and fungi are also affected by rapid nitrogen additions. For example, addition of fertilizer can reduce fungal diversity (Wardle 2002). Furthermore, the nutrients in some fertilizers are prone to rapid release and leaching from the site. (Such fertilizers [e.g., ammonium phosphate] should not be used.)

Besides adding fertilizers or organic matter, the only options for increasing nutrient availability to plants are to add plants that have nitrogen-fixing associations with microbes, or to increase the ability of plants to scavenge for nitrogen by providing optimal soil conditions for root growth and for the

formation of mycorrhizal associations. The use of nitrogen-fixing plants is discussed below in Section 4.3, "Plant Materials," and the effects of soil disturbance, removal, and storage on the formation of mycorrhizal associations are also discussed below.

The establishment of mycorrhizal associations is important to nutrient uptake and to the survival and growth of most plants, including most plants used by revegetation projects in the Tahoe Basin. The diversity and abundance of fungal hyphae and spores can be substantially reduced by disturbance (Allen, Jasper, and Zak 2002; Wardle 2002), and in turn, this reduces the formation of mycorrhizal associations (Allen, Jasper, and Zak 2002).

In stockpiled soils, the two main factors reducing infectivity of mycorrhizal hyphae and spores are the absence of growing roots and anaerobic, water-saturated conditions (Allen, Jasper, and Zak 2002). Loss of infectivity will be minimized by minimizing the effects of these two factors. Measures to minimize the effects of anaerobic, water-saturated conditions and the absence of growing roots include:

- removing soil at the end of the growing season when many plants and fungi are already dormant and soils are dry,
- minimizing the time that soil is stockpiled, and
- stockpiling soil in shallow piles with a large ratio of surface area to volume.

The separate removal and stockpiling of litter and duff also may aid the survival and reestablishment of the soil microflora and fauna, including mycorrhizal fungi. These materials are rich in organic matter and soil animals and microorganisms, and these organisms are likely vulnerable to mixing and burial in large piles of soil. Furthermore, when replaced on the revegetation site, this layer contributes mulch that protects the soil surface.

Treatments to enhance mycorrhizal infectivity are discussed further in Section 4.4, "Planting and Seeding Techniques," below.

The loss of seed and potential absence of desired species is addressed by planting and seeding. These practices are also discussed in detail in Section 4.4.

4.2.2 Recent Practices

In the project plans and specifications reviewed for this study, site and soil preparation included the following techniques:

- clearing vegetation;
- removing litter and duff and conducting stockpiling and reapplication;
- transplanting native plants;
- removing topsoil and conducting stockpiling and reapplication;
- grading the site;
- minimizing soil compaction by conducting soil loosening (e.g., ripping and tilling); and
- incorporating imported topsoil, compost, tub grindings, and other soil amendments and inoculants.

Specific treatments by site are summarized in Table 4-1, "Site and Soil Preparation." Most sites included one or more of the treatments, although no one site used them all. The specifications for many sites prescribed vegetation clearing, litter/duff removal, topsoil removal, and grading; and the majority of the sites incorporated compost and other soil amendments. For most sites, the soil was not compacted before planting. Soil loosening operations, when prescribed, were conducted at a range in depth of 2 to 18 inches below grade.

Table 4-1
Site and Soil Preparation

Site Name	Vegetation Cleared	Litter/Duff Removed and Replaced	Topsoil Removed and Replaced (Depth in inches)	Grading	Soil Compacted	Soil Loosened (Depth in inches)	Compost	Other Amendments	Notes
Apalache—Glen Eagles Drive	N	N	6	N	N	2–3	Y	FERT	Fertilizer specified as 1,800 lbs. per acre slow-release 7-2-3.
Apalache—Muskawaki Drive	N	N	6	N	N	2–3	Y	FERT	Fertilizer specified as 1,800 lbs. per acre slow-release 7-2-3.
Apalache—Nattaway Basin	N	N	6	N	N	2–3	Y	FERT	Fertilizer specified as 1,800 lbs. per acre slow-release 7-2-3.
Bay View	N	N	N	Y	N	N	Y	FERT	-
Beaver Street	Y	Y	N	Y	Y	6	N	FERT (KB/KF)	Soil inoculants are applied along with soil amendments. Biosol applied at 1,200 lbs. per acre.
Big Springs and Overlook Place	Y	N	N	Y	C	8–12	N	FERT (Biosol) Other	Composted wood chips 4 inches deep were incorporated into soil. Fertilizer was Biosol at 1,500 lbs. per acre

Table 4-1
Site and Soil Preparation

Site Name	Vegetation Cleared	Litter/Duff Removed and Replaced	Topsoil Removed and Replaced (Depth in inches)	Grading	Soil Compacted	Soil Loosened (Depth in inches)	Compost	Other Amendments	Notes
B-Line Export Pipeline	Y	Y	Y	N	N	6	N	FERT (KF)	2,000 lbs. per acre Fertil-Fibers (6.3-4-1)
Brockway Summit	Y	Y	Y	Y	Y	N	Y	N	None
Brockway Water Quality	Y	Y	Y	Y	Y	0 and 12–18	Y	FERT (Biosol)	Two treatments at this site that differed in soil loosening. Compost applied at 2,235 lbs. per acre. Biosol applied at 535 lbs. per acre.
Burton Creek	–	–	–	–	–	–	–	–	No information provided
Cattleman's Basin	–	Y	Y	–	–	6	–	FERT Other	25% humus/75% native soil mix; 6 inches of ripping was conducted.
Cave Rock	–	–	N	–	N	6	Y	FERT	Fertilizer was Biosol
Glorene and Eighth	N	N	6	Y	N	6	N	FERT (KF) MYCO	Mycorrhizal inoculants did not fulfill specifications.
Highlands Drive	Y	Y	Y	Y	N	12	N	FERT	The fertilizer was Biosol.
State Route 267 Repair	N	N	Y	Y	N	12–18	N	FERT (Biosol)	"Topsoil" of undocumented origin and properties applied. Biosol applied at 2,000 pounds per acre.
Lake Tahoe Park Erosion Control Project	Y	6	Y	Y	N	6	N	FERT	Biosol was applied at .1,200 lbs. per acre
Marshall Court	N	N	N	N	N	2	N	FERT	Type and amount of slow-release fertilizer varied: 225 lbs. per acre 17-7-12, 654 lbs. per acre 10-2-6, 1,200 lbs. per acre Biosol.

Table 4-1
Site and Soil Preparation

Site Name	Vegetation Cleared	Litter/Duff Removed and Replaced	Topsoil Removed and Replaced (Depth in inches)	Grading	Soil Compacted	Soil Loosened (Depth in inches)	Compost	Other Amendments	Notes
Marshall Trail at Columbine	N	N	N	N	N	2	N	FERT	Type and amount of fertilizer varied.
Meyers Bike Trail	N	N	N	N	N	4	N	FERT (Biosol)	Biosol or Ringer (5-10-3) at 800 or 550 lbs. per acre, respectively.
Meyers Erosion Control	Y	Y	N	Y	N	N	Y	FERT	
Park Heights Drive Culvert Repair	N	N	N	Y	Y	6	N	FERT (Biosol)	Fertilizer was Biosol
Pioneer Trail Erosion Control	Y	Y	N	Y	N	2–4	Y	FERT	Depth for litter/duff not mentioned
Ponderosa Ranch	Y	N	N	Y	N	18	N	FERT (Biosol) Other	Biosol applied at 2,000 lbs. per acre. Amendments included wood chips (from cleared trees).
Sierra Tract Phase 2	Y	Y	N	Y	N	6	Y	FERT (KB/KF) MYCO	Topsoil salvage specified but did not occur. Fertilizer was 2,000 lbs. per acre Biosol or equivalent.
Timberland Erosion Control Project	Y	Y	Y	Y	Y	6	Y	FERT (KB/KF)	Biosol at 1,200 lbs. per acre or Fertile-Fibers at 2,000 lbs. per acre
Truckee Bypass State Route 267	Y	N	N	Y	N	2.8	Y	FERT	Slow-release, 100% natural commercial fertilizer
Upper Cutthroat	Y	Y	Y	N	N	12	Y	FERT	446 to 1,338 lbs. per acre of (5.5–7)-(1–2)-3 fertilizer

Key:
N = None; Y = Yes; KB/KF = Kiwi Power and Biosol or Kiwi Power and Fertil Fibers, or product equal; FERT = Fertilizer; MYCO = mycorrhizal inoculant; A 1-2 = Combination of amendments, the second amendment is a nonburning slow release fertilizer.

At many sites in the Tahoe Basin, compost and wood chips or tub grindings are incorporated into the soil in conjunction with soil loosening. This is done by tilling the organic materials into the soil. This process mixes the soil, compost, and wood chips to depths of 3–12 inches. This mixing alters the soil structure and composition to a much greater extent than ripping. The biological and long-term physical effects of this practice have not been documented. However, in the short term (i.e., 1 to several years), this practice substantially increases infiltration (Grismer and Hogan 2005a). For this practice to be effective in the long term as well, growth of plant roots would need to sustain the uncompacted conditions.

Although invasive plant control was not a documented component of site preparation in the reviewed plans and specifications, it is a current practice applied to other projects in the Tahoe Basin. The Lake Tahoe Basin Management Unit of the U.S. Forest Service (USFS) requires noxious weed assessments and implementation of recommended mitigation measures for its projects and projects that USFS funds. Mitigation measures in USFS guidance for these noxious weed assessments include the following types of measures related to site and soil preparation to reduce the spread and establishment of weeds:

- preconstruction (manual) removal or flagging and avoidance of noxious weed infestations;
- cleaning vehicles and construction equipment at wash stations;
- not locating staging areas in infested locations;
- using “weed free” mulches, gravel, fill, and other materials; and
- minimizing vegetation and ground disturbance (USFS 2010).

Fertilizer was applied at most sites (Table 4-1). In conjunction with fall seeding, “slow release” fertilizers were applied (usually Biosol) in amounts that ranged from less than 500 to 2,000 pounds per acre. This range corresponds to approximately 35 to 130 pounds per acre of nitrogen, and is comparable to or greater than fertilizer applications recommended for dryland pasture in eastern California, which is the most comparable agricultural system to Tahoe Basin revegetation sites. For dryland pastures, Wilson et al. (2006) recommend applying 50 pounds per acre of nitrogen. In contrast to revegetation practices in the Tahoe Basin, Wilson et al. (2006) recommend that fertilizer not be applied at seeding time, because small perennial grass seedlings will not utilize applied fertilizer efficiently and growth of annual plants and weeds will be enhanced.

Considerable quantities of compost were also applied at many sites (Table 4-1). At a number of sites, compost was applied at depths that ranged from 0.5 to 4 inches; corresponding to roughly 540–2,200 pounds per acre of nitrogen (assuming a compost density of 800 pounds per cubic yard [CalTrans 2010] and a nitrogen content of 1%).

These inputs, particularly of compost, represent a substantial quantity of nitrogen relative to the amount that is present on disturbed sites, and even relative to natural vegetation in the Tahoe Basin. For example, in a survey of Tahoe Basin sites, Claassen and Hogan (1998) found that much of the variability in plant cover on disturbed sites was related to the total amount of nitrogen stored in the soil, and that sites with less than 1,070 pounds per acre of nitrogen

generally had much less plant cover than sites with more nitrogen. Their results suggest that the quantities of nitrogen being applied in compost are sufficient to replenish soil nitrogen to levels associated with well-vegetated sites. However, in compost, nitrogen is stored in somewhat different materials than in an undisturbed forest soil, and may be released by different assemblages of organisms and more rapidly than would nitrogen stored in an undisturbed forest soil.

4.2.3 Observed Outcomes of Revegetation Projects

The reconnaissance survey did not include observations of below-ground soil conditions, and thus of some outcomes of site and soil preparation. Nonetheless, several observations related to site and soil preparation were made during the reconnaissance survey. First, at most sites, there had either not been previously existing vegetation or this vegetation had not been retained; but at several sites, previously existing vegetation had been present and retained. (Greenleaf manzanita [*Arctostaphylos patula*] and mahala mat [*Ceanothus prostratus*] were abundant species that were represented primarily by retained individuals.) Second, at more drastically disturbed sites, particularly cut slopes, previous disturbance had removed the upper soil layer(s). Thus, there was no opportunity for stockpiling and reapplying litter, duff, and topsoil. Sites where revegetation treatments did not include soil loosening or that loosened soil less than 6 inches did not differ in plant cover, but had substantially more exposed soil than did sites with soil loosened to a depth of 6 inches or more (30% versus 10% of soil surface exposed, respectively). Sites with 0 to 6 inches of soil loosening also were older than sites with deeper soil loosening and frequently had lesser inputs fertilizer and soil amendments than did sites with deeper soil loosening. Although these other factors may have contributed to the difference in exposed soil, some are related to soil loosening, `degraded sites may be less likely to provide long-term protection of the soil surface.

Retained Shrubs at Apalache-Muskawaki Drive

For sites included in the reconnaissance survey, plant cover was not related to the quantity of fertilizer, compost, or the total quantity of nitrogen applied during revegetation. This may reflect not only the influence of other limiting resources (e.g., light, water), but also for many sites, the sufficiency of even small fertilizer applications. In experiments in the Tahoe Basin and in the Truckee area, plant cover often did not differ between treatments with 2,000 and 4,000 pounds per acre of Biosol, and sometimes did not differ between treatments with and without fertilizer (e.g., at the Northstar Highlands Road site) (Grismer et al. 2008, IERS 2009). Furthermore, local experiments have not systematically evaluated smaller fertilizer applications (e.g., 500–1,000 pounds per acre of Biosol).

Invasive plants were present at many sites observed during the reconnaissance survey, and often were absent from adjacent vegetation. Sites treated with compost were associated with invasive species: invasive plants were observed at 70% of sites treated with compost but only 15% of sites that were not.

Compost may contain seed of invasive plants as contaminants, but also may increase the suitability of sites for establishment of invasives. For example, cheatgrass (*Bromus tectorum*) was the most widespread invasive and compost addition may improve conditions for this annual grass. The ability of cheatgrass to compete with perennial grasses increases with nitrogen availability (Vasquez, Sheley, and Svejcar 2008), and addition of compost increased cheatgrass cover in a revegetation experiment at Brockway Summit on SR 267 (Grismer et al. 2008, IERS 2009).

The roadcut survey included measurements of below-ground soil conditions that supported several additional observations regarding soil preparation and revegetation outcomes. These observations indicate that some types of soil preparation facilitate the establishment of a high cover of vegetation.

Sites included in the roadcut survey differed considerably in soil properties, and in the cover of vegetation and exposed soil (Tables 4-2 and 4-3). Differences in soil preparation accounted for much of the variation in soil properties. All of the sites had an upper layer of loose, readily penetrated soil at least 3 inches in depth, and a lower layer of soil that was much more difficult to penetrate. The transition between these layers was very abrupt, and in general, it corresponded to transitions in color and incorporated amendments (e.g., compost). Thus, this layering was the result of soil preparation. Where this upper, prepared layer was deeper and more amended, bulk density of the soil was lighter.

Table 4-2
Soil Properties of Roadside Cut Slopes[1]

Site	Soil Texture[2]	Bulk Density[2]	Rooting Depth[3]	Penetrability Depth[4]	Percent Organic Matter[5]
Apalache – Glen Eagles Drive	Loamy Sand	1.33±0.030	6.6±0.76	6.8±0.79	0.66
Apalache – Muskawaki Drive	Sandy Loam	1.09±0.136	4.8±0.96	5.1±1.10	1.68
Big Springs and Overlook Place	Sandy Loam	0.83±0.090	5.1±0.72	7.2±1.03	5.39
Brockway Summit	Sandy Loam	1.28±0.039	2.9±0.49	4.2±0.55	0.32
Marshall Court	Loamy Sand	1.27±0.101	5.6±0.80	4.5±1.33	0.37
Marshall Trail at Columbine	Loamy Sand	1.55±0.055	4.4±0.63	6.8±0.86	0.31
Pioneer Trail Erosion Control	Sandy Loam	1.28±0.049	4.8±0.34	6.9±0.85	0.52
State Route 267 Repair	Sandy Loam	0.71±0.032	8.0±0.59	10.8±1.18	1.89
Truckee Bypass State Route 267	Sandy Loam	0.81±0.037	5.0±0.84	7.0±1.22	1.04

Notes:

1 Data are from 9 revegetated roadside cut slopes in the Tahoe Basin

2 Based on 6-inch-deep cores of soil collected at 5 random locations per site; mean ± 1 standard error

3 Measured for fine roots at 5 random locations per site; mean ± 1 standard error

4 Measured with a cone penetrometer at each end of 5 randomly located transects; mean ± 1 standard error of depth to >350 psi to penetrate

5 Loss on ignition; based on composite of the 6-inch-deep cores from 5 random locations per site

Table 4-3
Cover of Vegetation, Mulch/Litter, Rock-Wood, and Exposed Soil at Roadside Cut Slopes[1]

Site	Cover[1] (Mean ± 1 Standard Error)			
	Plant	Mulch/ Litter	Rock, Wood	Exposed Soil
Apalache – Glen Eagles Drive	53±5.7	72±5.2	0.3±0.26	14±3.8
Apalache – Muskawaki Drive	57±6.9	61±7.4	0±0	23±4.9
Big Springs and Overlook Place	67±3.8	72±4.2	5±2	9±2
Brockway Summit	46±8.1	46±6.4	10±1.6	30±6.5
Marshall Court	23±5.2	66±5	0.3±0.26	20±2.9
Marshall Trail at Columbine	29±7.8	46±9.8	2±1.4	42±11.6
Pioneer Trail Erosion Control	43±8.8	52±7.8	3±0.5	29±9.5
State Route 267 Repair	67±4	89±1.7	1.3±0.59	4±1.4
Truckee Bypass State Route 267	75±5.6	64±4.3	1.8±0.69	9±3.3

Notes:

[1] Data are from 9 revegetated roadside cut slopes in the Tahoe Basin.

[2] Based on 10 randomly located, 10-m-long transects at each site along which cover was recorded at 25 cm intervals.

There were not strong, general relationships between plant cover and depth of soil loosening, penetrability of soil, or plant rooting depth. However, there was a strong relationship between soil bulk density and herbaceous plant cover. This relationship was largely the result of related differences among sites in age and treatment.

Three sites had a distinct combination of soil conditions and plant cover (Big Springs and Overlook Place, State Route 267 Repair, and Truckee Bypass State Route 267). These were younger sites with a high cover of vegetation that also had extensively prepared soil with lesser bulk density, greater organic matter content, and relatively deep penetrability compared to the other six sites (particularly the four oldest), which had much less herbaceous plant cover and more varied combinations of soil conditions. Interestingly, there was not a relationship between shrub cover and soil bulk density.

Thus, the relationship between soil density and plant cover may indicate that extensive soil treatment is more effective for revegetation or that herbaceous plant cover diminishes on older revegetation sites, or both. Because comparable sites in the Tahoe Basin are generally dominated by trees and shrubs, and because older revegetation sites have less grass cover, the long-term persistence of grass-dominated vegetation is a concern. However, experiments in the Tahoe Basin and the Truckee area have demonstrated that deep soil loosening (i.e., 9–18 inches in depth) combined with extensive incorporation of amendments is more effective at establishing and maintaining perennial grass for at least several years than treatments that do not loosen the soil or incorporate amendments (Grismer et al. 2008, IERS 2009).

4.3 Plant Materials

Plant Materials Delivery at the Lake Tahoe Park Erosion Control Project

Willow Transplant at the Lake Tahoe Park Erosion Control Project

Willow Cutting at the Lake Tahoe Park Erosion Control Project

"Plant materials" refers to procurement of the physical materials used during planting and seeding installation; these can include transplants, cuttings, container plants, and seed. The success or failure of any revegetation project, no matter how well planned, depends on the proper selection, production, care, and handling of the plant materials at each step of the project. (Leiser 2004a.) This section discusses important considerations regarding plant materials, recent practices, and observed outcomes of revegetation projects. This section focuses on the actual plant material sources; plant installation is addressed later in this document.

4.3.1 Relationship to Revegetation

Accepted sources of plant materials for revegetation projects currently include the following:

- transplants,
- cuttings,
- plant procurement,
- propagation materials, and
- seed.

Transplants are usually desired native species that will be affected by site improvements and are relocated within a project site before grading operations. Cuttings are sticks harvested from selected species that are cut from healthy, live branches within a project area; the sticks are then planted at desired locations, resulting in new plant growth for that species. Plant procurement refers to purchasing desired species that have been previously propagated and grown as container plants to a desired size and form. At other times, and as part of a revegetation construction contract, plant propagation materials may be collected as seed or small cuttings harvested on or in the region of a project site, taken off-site and contract grown as container plants to the size and form desired for later delivery back to and ultimately planted at the project site. Seed refers to both seed by themselves and to seed with attached coverings, such as a fruit or the papery bracts that cover grass seed.

Transplanting usually occurs at the time of site/soil preparation and before grading operations. It is best to directly install transplants at their new location immediately after excavation from the original location. When timing with other site activities precludes immediate installation, the transplants need to be stored in a cool, shaded location with their root ball intact and maintained moist. The International Society of Arboriculture and the Tree Care Industry Association provide detailed guidance

and standards for tree and shrub transplanting including the benefits of pruning roots prior to transplanting, the size and preparation of root balls scaled to the size of plants, planting hole preparation, and watering requirements after transplanting (ISA 2001, ANSI 2005).

Cuttings are usually harvested at the time of plant installation, after site/soil preparation and grading are complete. Cuttings need to be installed within 24–48 hours of harvesting, and they should be maintained moist at all times after harvest.

Procurement of plants and seed mix often requires several months of lead time to ensure the quantity and quality of the plants needed; therefore, procurement generally needs to be conducted immediately after the construction contract is awarded. Similarly, if propagation materials are to be collected as part of the construction contract, their collection generally needs to begin as soon as possible after the construction contract is awarded. As an alternative, the implementing agency may conduct plant/seed mix procurement as separate contract, ahead of the construction contract, and provide the required plant materials to the contractor.

As a rule, plant materials that are native to and grown in the region of the revegetation project site and are acclimated to local site conditions before actual plant installation will establish and grow better than plants that are not native to, produced in the region, and acclimated to local site conditions (e.g., Petersen, Roundy, and Bryant 2004). Consequently, a frequent specification for Tahoe Basin revegetation projects is that, where feasible, plant materials should originate within 50 miles of the Tahoe Basin and from an elevation within 1,000 feet of the project site's elevation. However, even at comparable elevations, environmental conditions differ substantially to the east and west of the Tahoe Basin. These differences likely influence the suitability of plant materials for use in the Tahoe Basin. For example, the Tahoe Basin is in California Tree Seed Zone 772, and the boundaries of this zone extend nearly 30 miles to the north of Lake Tahoe but only 2–3 miles to the west (CAL FIRE 1987). East-west environmental gradients are also important for regional genetic differences in grass populations (Kitzmiller 2009). In a common-garden experiment conducted in the Plumas National Forest, native grass populations from east of the crest of the Sierra Nevada differed from western populations in germination timing, shoot growth, and other attributes, indicating the significance of east-west environmental gradients for suitability of plant materials.

Seed materials for a species may be commercially available from a number of sources. There can be substantial differences in the quality of these sources, including in the genetic identity of the seed. Within a plant species there can be ecologically important genetic differences across its geographic range. During the collection, handling, and subsequent production of seed, these genetic distinctions can be maintained or not. Certified seed has been produced in a manner that maintains its genetic identity and has been approved by a certifying agency. Not all seed that is offered for sale is certified.

Seed of a particular species also varies substantially among sources in their purity, germination, and weed seed content. Consequently, federal and state law requires that this information be provided for any seed (certified or

noncertified) offered for sale. This information will be on a label or tag affixed to the packaging of the seed.

Information regarding purity and germination is used in calculating seeding rates (i.e., the amount of seed applied to an area), and information on weed species can be used to identify seed materials containing invasive plant seed. Seeding rates are often given in units of pounds of pure live seed (PLS) per acre. The purity and germination percentages of a seed lot are multiplied to determine the pounds of PLS per pound of packaged seed (i.e., bulk seed). For example, a seed lot with 50% purity and 50% germination would have a quarter-pound of PLS per pound of bulk seed (because purity X germination = 0.5 X 0.5 = 0.25). This information is used to determine the quantity of bulk seed from a particular source that must be applied to conform to specifications based on PLS. In developing specifications for PLS applied per acre, the size of a species' seed is particularly important because together with the pounds of PLS applied, it determines the density of germinating seed, of which a fraction will successfully emerge above the soil surface, survive physical conditions, herbivory, and competition with other plants to become established.

Information regarding weed seed content can provide information regarding the inclusion of invasive plant seed as contaminants. Invasive plants may be classified as noxious or common weeds. The inclusion in seed materials (offered for sale) of the seed of a noxious weed is restricted to very small amounts or completely prohibited, depending on the species. Some invasive plants that are problematic in the Tahoe Basin are listed noxious weeds (e.g., musk thistle [*Carduus nutans*] and perennial pepperweed [*Lepidium latifolium*] [USDA 2009]). Table 4-4 provides a list of invasive plant species that are considered problematic in the Tahoe Basin by the U.S. Forest Service, and Donaldson (2004) and the Lake Tahoe Basin Weed Coordinating Group (LTBWCG 2010) provide additional information regarding these species.

"Common" weeds are species that are not on the prohibited or restricted federal or state noxious weed lists. The percentage (by weight) of weed seeds in a seed mix is limited by federal and state law and is provided on the label. (In California and Nevada, this percentage is 1.5% [USDA 2009]).

The species of common weeds present in the seed mix are not identified on the label. A number of invasive plants that infest revegetation sites in the Tahoe Basin, including cheatgrass (*Bromus tectorum*), are not federal- or state-listed noxious weeds (Table 4-4); and thus, their inclusion in seed mixes is not identified on the label. However, these species are identified in the seed analysis report, and a copy of this report can be requested. Seed analysis reports are prepared for each certified seed lot by an authorized seed laboratory.

Table 4-4
Noxious Weeds and Problematic Invasive Plants of the Lake Tahoe Basin[1]

Common Name	Scientific Name	LTBWCG[2]	CDFA[3]	NDA[4]	SNFPA[5]	Cal-IPC[6]
Russian knapweed	*Acroptilon repens*	Group 1	B	B	NW	Moderate
Tree of heaven	*Ailanthus altissima*				NW	Moderate
Cheat grass	*Bromus tectorum*				NW	High
Heart-prodded hoarycress/whitetop	*Cardaria draba*	Group 1	B	C	NW	Moderate
Globe-prodded hoarycress/ hairy whitetop	*Cardaria pubescens*	Group 1	B		NW	Limited
Musk thistle	*Carduus nutans*	Group 1	A	B	NW	Moderate
Purple starthistle/red starthistle	*Centaurea calcitrapa*		B	A	NW	Moderate
Diffuse knapweed	*Centaurea diffusa*	Group 1	A	B	NW	Moderate
Spotted knapweed	*Centaurea maculosa*	Group 2	A	A	NW	High
Yellow starthistle	*Centaurea solstitialis*	Group 1	C	A	NW	High
Squarrose knapweed	*Centaurea virgata* ssp. *squarrosa*	Group 1	A	A	NW	Moderate
Rush skeletonweed	*Chondrilla juncea*	Group 1	A	A	NW	Moderate
Canada thistle	*Cirsium arvense*	Group 1	B	C	NW	Moderate
Bull thistle	*Cirsium vulgare*	Group 2			NW	Moderate
Poison hemlock	*Conium maculatum*			C		Moderate
Scotchbroom	*Cytisus scoparius*	Group 2	C		NW	High
Teasel/Fuller's teasel	*Dipsacus fullonum*	Group 1				Moderate
Stinkwort	*Dittrichia graveolens*					Moderate Alert
Quackgrass	*Elytrigia repense*		B		NW	
Hydrilla/Waterthyme	*Hydrilla verticillata*		A	A	NW	High Alert
St. John's wort / Klamath weed	*Hypericum perforatum*	Group 2	C	A	NW	Moderate
Tall whitetop / Perennial pepperweed/ broadleaved pepperweed	*Lepidium latifolium*	Group 2	B	C	NW	High
Oxeye daisy	*Leucanthemum vulgare*	Group 2			NW	Moderate
Dalmatian toadflax	*Linaria genistifolia* spp. *dalmatica*	Group 2	A	A	NW	Moderate
Yellow toadflax/butter & eggs	*Linaria vulgaris*	Group 2		A		Moderate
Purple loosestrife	*Lythrum salicaria*		B	A	NW	High
Eurasian watermilfoil	*Myriophyllum spicatum*	Group 2		A	NW	High
Scotch thistle	*Onorpordum acanthium* ssp. *acanthium*	Group 1	A	B	NW	High

Table 4-4
Noxious Weeds and Problematic Invasive Plants of the Lake Tahoe Basin[1]

Common Name	Scientific Name	LTBWCG[2]	CDFA[3]	NDA[4]	SNFPA[5]	Cal-IPC[6]
Reed canarygrass	*Phalaris arundinacea*					
Curlyleaf pondweed/ curly pondweed	*Potamogeton crispus*	Group 2				Moderate
Sulfur cinquefoil	*Potentilla recta*	Group 1		A		
Russian thistle	*Salsola tragus*		C		NW	Limited
Medusahead	*Taeniatherum caput-medusae*		C	B	NW	High
Tamarisk/saltcedar	*Tamarix chinensis, T. ramosissima, & T. Parvifolia*			C	NW	High
Woolly mullein/common mullein	*Verbascum thapsus*				NW	Limited

Notes:

[1] Table is from USFS 2010.

[2] Lake Tahoe Basin Weed Coordinating Group (LTBWCG) prioritizes invasive weeds of concern by management group. Group 1: watch for, report, and eradicate immediately. Group 2: manage infestations with the goal of eradication.

[3] The California Department of Food and Agriculture's (CDFA) noxious weed list (http://www.cdfa.ca.gov/phpps/ipc/) divides noxious weeds into categories A, B, and C. A-listed weeds are those for which eradication or containment is required at the state or county level. With B-listed weeds, eradication or containment is at the discretion of the County Agricultural Commissioner. C-listed weeds require eradication or containment only when found in a nursery or at the discretion of the County Agricultural Commissioner. Q-listed weeds require temporary "A" action pending determination of a permanent rating.

[4] Nevada Department of Agriculture (NDA) noxious weed list (http://agri.nv.gov/nwac/PLANT_NoxWeedList.htm divides) divides noxious weeds into categories A, B, and C. Category "A": Weeds not found or limited in distribution throughout the state; actively excluded from the state and actively eradicated wherever found; actively eradicated from nursery stock dealer premises; control required by the state in all infestations. Category "B": Weeds established in scattered populations in some counties of the state; actively excluded where possible, actively eradicated from nursery stock dealer premises; control required by the state in areas where populations are not well established or previously unknown to occur. Category "C": Weeds currently established and generally widespread in many counties of the state; actively eradicated from nursery stock dealer premises; abatement at the discretion of the state quarantine officer.

[5] Sierra Nevada Forest Plan Amendment (SNFPA) part 3.6 defines noxious weeds as: those plant species designated as noxious weeds by Federal or State law. Noxious weeds generally possess one or more of the following characteristics: aggressive and difficult to manage, poisonous, toxic, parasitic, a carrier or host of serious insects or disease, and generally non-native.

[6] California Invasive Plant Council (Cal-IPC) invasive plant inventory (http://www.cal-ipc.org/ip/inventory/weedlist.php) categorizes non-native invasive plants by the ecological impacts of each plant on wildlands into three categories high, moderate, & limited as well as an alert. An "alert" is assigned for species with significant potential for invading new ecosystems. High: these species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Moderate: these species have substantial and apparent—but generally not severe—ecological impacts on physical processes, plant and animal communities, and vegetation structure. Limited: these species are invasive but their ecological impacts are minor on a statewide level or there was not enough information to justify a higher score.

4.3.2 Recent Practices

In the project plans and specifications reviewed for this study, specific plant species by site are summarized in Table 4-5, "Herbaceous Plant Species," and Table 4-6, "Woody Plant Species." Table 4-5 includes forbs, grasses, rushes, and sedges, while Table 4-6 includes trees and shrubs. Plants were procured as container plants of sizes such as treepots (4 inches square by 14 inches long), deepots (2-1/2 inches in diameter by 10 inches long), and plugs (approximately 2-1/4 inches square by 5 inches long). Additionally, herbaceous species (and at some sites some woody species) were planted by way of seed. For the Lake Tahoe Park project, three willows were transplanted and several willow cuttings were harvested and installed.

Reviewed specifications differed in the growth form, life span, nitrogen-fixing ability, invasiveness, and potential for dominance of selected plant species. These attributes of the plant materials are described below.

4.3.2.1 Growth Form

Shrubs, and to a lesser extent forbs, not grasses, dominate most natural vegetation adjacent to revegetation sites or in similar settings in the Tahoe Basin. Shrubs and forbs also differ from grasses in potentially important ecological attributes (e.g., root system architecture). For these and aesthetic reasons, most revegetation projects included in the reconnaissance survey incorporated shrubs and forbs into their plantings, often as relatively expensive container plantings (Table 4-6) and many establish well from seed. (Many shrub species also can be established readily from seed [e.g., bitterbrush (*Purshia tridentata*)].)

4.3.2.2 Life Span

Most species in the reviewed specifications have moderate to long life spans (Appendix D). Several short-lived perennials are exceptions: short-awn foxtail (*Alopecurus aequalis*), pearly everlasting (*Anaphalis margaritacea*), California brome (*Bromus carinatus*), slender hairgrass (*Deschampsia elongata*), California poppy (*Eschscholzia californica*), silver lupine (*Lupinus argenteus*), and Pacific lupine (*Lupinus lepidus*); and the annual species Purshing's lotus (*Lotus purshianus*). To persist on a site, short-lived species require periodic regeneration from seed.

4.3.2.3 Nitrogen-Fixing Ability

In revegetation projects in the Tahoe Basin, nitrogen-fixing plants have not been a primary component of seed mixes and container plantings. For example, lupines are frequently included in seed mixes, but at dramatically lower densities than grasses. Typical application rates for lupines correspond to only one seed every 2–5 square feet. Assuming that 10% of seed results in a lupine plant (which is an optimistic assumption), then there would be one lupine plant every 20–50 square feet versus hundreds of grasses in the same space. Similarly, although bitterbrush has been included in many revegetation projects in the Tahoe Basin, the density of seed applied has been small, the density of grass seed applied has been much greater, and the resulting density of bitterbrush has generally been very low.

Also, several nitrogen-fixing species that may be well suited for use in revegetation are rarely used in the Tahoe Basin (e.g., mountain mahoganies [*Cercocarpus* species]). For example, curl-leaf mountain mahogany (*Cercocarpus ledifolius*) occurs on dry slopes in the Tahoe Basin, and the closely related mountain mahogany *Cercocarpus montanus* is one of the most widely used shrub species in mine reclamation in the intermontane west (Paschke, Redente, and Brown 2003).

4.3.2.4 Invasiveness

Several nonnative species that can grow well in the Tahoe Basin were included in the reviewed specifications, (such nonnative species are often referred to as "adapted" nonnatives [TRPA 1988]). In general, native species have been used for revegetation in recent projects. Native species are used for both aesthetic and ecological reasons. However, nonnative plants are able to grow, establish, and survive better than native species in some settings. Some nonnative species have been used for revegetation in the Tahoe Basin: birdsfoot trefoil (*Lotus corniculatus*), pubescent wheatgrass (*Elytrigia intermedia*), and hard fescue (*Festuca brevipila* including *F. ovina* and *F. trachyphylla*) (Table 4-5), and also *Astragalus cicer* (Etra, pers. comm., 2010). These nonnatives have probably been used because of their availability and known effectiveness for (at least temporary) erosion control. None of these species has been recognized as a problematic invasive species in the Tahoe Basin (Table 4-4). Nonetheless, there is usually some uncertainty regarding the ability of a nonnative to spread into adjacent natural vegetation.

4.3.2.5 Potential for Dominance

Most plant species are rarely dominant in natural vegetation. Selected plant materials include a number of species that are abundant in natural vegetation at settings similar to many revegetation sites (e.g., steep, exposed slopes) including Jeffrey pine (*Pinus jeffreyi*), bitterbrush, mountain sagebrush (*Artemisia tridentata* var. *vaseyana*), manzanita species (*Arctostaphylos* species), and lupines (*Lupinus* species), among others. However, several species that are abundant in natural vegetation at settings similar to many revegetation sites are used rarely or not at all in Tahoe Basin revegetation projects. These species include:

- spreading dogbane (*Apocynum andrasaemifolium*),
- curl-leaf mountain mahogany,
- California fuschia (*Epilobium canum* ssp. *latifolium*),
- mountain pennyroyal (*Monardella odoratissima* ssp. *pallida*), and
- mountain mule ears (*Wyethia mollis*).

Although plant material of these species may need to be collected specifically for projects, each of these species has been in horticultural use or for used for revegetation projects elsewhere.

Table 4-5
Herbaceous Plant Species of Reviewed Revegetation Projects

Botanical Name	Common Name	Apalache—Eagle Drive	Apalache—Muskawaki Street	Apalache—Nattaway Basin	Bay View	Beaver Street	Big Springs + Overlook Place	B-Line Export Pipe Line	Brockway Summit	Brockway Water Quality	Burton Creek	Cattlemans Basin	Cave Rock	Glorene and Eighth	Highlands Drive	State Route 267 Repair	Lake Tahoe Park Erosion Control Project	Marshall Court	Marshall Trail at Columbine	Meyers Bike Trail	Meyers Erosion Control	Park Heights Drive Culvert Repair	Pioneer Trail Erosion Control	Ponderosa Ranch	Sierra Tract Phase 2	Timberland Erosion Control Project	Truckee Bypass, State Route 267	Upper Cutthroat	Notes
Forbs																													
Achillea millefolium	Yarrow			S			S		S					S			S				S		S		S	S	S		
Anaphalis margaritacea	Pearly everlasting																						S						
Eriogonum nudum	Nude buckbrush								S												S						S		
Eriogonum umbellatum	Sulfur buckwheat					S								S						S									
Eschscholzia californica	California poppy							S						S			S						S					S	
Gilia capitata	Globe gilia																						S						
Ipomopsis aggregata	Scarlet trumpet flower			S																									
Linum lewisii	Lewis flax			S		S		S						S									S		S	S			
***Lotus corniculatus* 'Empire' or 'Viking'**	**Birdsfoot trefoil**																						**S**						**Nonnative**
Lotus purshianus	Purshing's lotus								S												S						S		
Lupinus argenteus	Silver lupine			S		S		S						S			S								S	S			
Lupinus breweri	Brewer's lupine								S												S		C				S		
Lupinus grayi	Sierra lupine								S												S						S		
Lupinus lepidus	Lupine																								S				
Lupinus polyphyllus	Tahoe lupine			S				S						S			S												
Penstemon rydbergii	Rydberg's penstemon							S	S					S							S				S		S		
***Penstemon speciosus* 'Bandera'**	**Rocky Mountain penstemon**																								**S**				**Nonnative**
Penstemon strictus	**Rocky Mountain penstemon**			**S**													**S**						**S**						**Nonnative**
Phlox drummondii	**Drummond phlox**																						S						**Nonnative**
Potentilla fruticosa 'Sutter's Gold'	Sutter's Gold potentilla																						C						
Potentilla gracilis	Cinquefoil			S				S						S			S								S			S	
Wyethia mollis	Mountain mule ears								C																		S		

Table 4-5
Herbaceous Plant Species of Reviewed Revegetation Projects
Continued

Botanical Name	Common Name	Apalache—Eagle Drive	Apalache—Muskawaki Street	Apalache—Nattaway Basin	Bay View	Beaver Street	Big Springs + Overlook Place	B-Line Export Pipe Line	Brockway Summit	Brockway Water Quality	Burton Creek	Cattlemans Basin	Cave Rock	Glorene and Eighth	Highlands Drive	Highway 267 Repair	Lake Tahoe Park Erosion Control Project	Marshall Court	Marshall Trail at Columbine	Meyers Bike Trail	Meyers Erosion Control	Park Heights Drive Culvert Repair	Pioneer Trail Erosion Control	Ponderosa Ranch	Sierra Tract Phase 2	Timberland Erosion Control Project	Truckee Bypass, State Route 267	Upper Cutthroat	Notes
Grasses																													
Achnatherum occidentalis	Western needlegrass								S												S				S		S		
Agropyron trichophorum 'Luna'	Pubescent wheatgrass																						S						
Agrostis exerata	Bentgrass													S															
Agrostis scabra	Ticklegrass													S											S				
Alopecurus aequalis	Short awn foxtail													S															
Alopercurus pratensis	Meadow foxtail																						S						
Bromus carinatus	California brome			S		S	S	S	S					S	S		S				S		S		S	S	S	S	
***Bromus inermis* 'Bromar'**	**Smooth brome**																						**S**						**Nonnative**
Calamogrostis canadensis	Bluejoint reedgrass													S															
***Dactylis glomerata* 'Paiute'**	**Orchardgrass**																						S						**Nonnative**
Deschampsia cespitosa	Hairgrass			S		S		S	S/P					S			S				S		S		S	S	S		
Deschampsia elongata	Slender hairgrass								S/P												S						S		
Elymus elymoides	Squirreltail			S		S	S	S	S/P					S	S		S				S				S	S	S		
Elymus elymoides ssp. *elymoides*	Sierra squirreltail																											S	
Elymus glaucus 'Stanislaus'	Blue wildrye			S		S	S	S						S	S		S								S	S		S	
Elymus trachycaulus	Slender wheatgrass			S		S		S						S									S		S	S			
***Elytrigia intermedia* ssp. *Trichophorum* 'Luna'**	**Pubescent wheatgrass**			**S**																									**Nonnative**
Festuca brevipila	**Hard fescue**																**S**												**Nonnative**
***Festuca ovina* 'Covar'**	**Sheep fescue**			S																			S						**Nonnative**
Festuca ovina* ssp. *Duriuscula	**Hard fescue**																						S						**Nonnative**
Festuca rubra	Red fescue			S				S						S			S						S		S				

Table 4-5
Herbaceous Plant Species of Reviewed Revegetation Projects
Continued

Botanical Name	Common Name	Apalache—Eagle Drive	Apalache—Muskawaki Street	Apalache—Nattaway Basin	Bay View	Beaver Street	Big Springs + Overlook Place	B-Line Export Pipe Line	Brockway Summit	Brockway Water Quality	Burton Creek	Cattlemans Basin	Cave Rock	Glorene and Eighth	Highlands Drive	Highway 267 Repair	Lake Tahoe Park Erosion Control Project	Marshall Court	Marshall Trail at Columbine	Meyers Bike Trail	Meyers Erosion Control	Park Heights Drive Culvert Repair	Pioneer Trail Erosion Control	Ponderosa Ranch	Sierra Tract Phase 2	Timberland Erosion Control Project	Truckee Bypass, State Route 267	Upper Cutthroat	Notes
Grasses—Continued																													
***Festuca trachyphylla* 'Aurora Gold'**	**Hard fescue**			**S**																									**Nonnative**
Glyceria grandis	Manna grass													S															
Hordeum brachyantherum	Meadow barley								S/P								S				S						S		
Hordeum brachyantherum	Meadow barley, from 6,000 feet and higher			S				S						S											S				
Leymus triticoides 'Shoshone'	Creeping wildrye			S		S		S						S			S								S				
Phalaris arundinacea	Reed canary grass													S															
Phleum pratense	**Timothy**																						**S**						**Nonnative**
Poa ampla (= *Poa secunda*)	Big bluegrass					S											S						S		S				
Poa pratensis	**Bluegrass**			**S**		**S**		**S**						**S**									**S**		**S**	**S**			**Nonnative**
Poa secunda 'Juncifolia'	Sandberg bluegrass			S				S						S												S			
Rushes																													
Juncus balticus	Baltic rush			S/P				S						S											S				
Juncus ensifolius	Equitant rush			P																									
Sedges																													
Carex athrostachya	Sedge			P																									
Carex nebrascensis	Nebraska sedge			S/P																									
Carex praegracilis	Sedge			P				S						S											S				
Carex utriculata	Beaked sedge			P																									
Eleocharis macrostachya	Spikerush													S															

Key:
C = planted from containers; P = planted from plugs; S = planted from seed
Bold font indicates nonnative species.

Table 4-6
Woody Plant Species of Reviewed Revegetation Projects

Botanical Name	Common Name	Apalache—Eagle Drive	Apalache—Muskawaki Street	Apalache—Nattaway Basin	Bay View	Beaver Street	Big Springs + Overlook Place	B-Line Export Pipe Line	Brockway Summit	Brockway Water Quality	Burton Creek	Cattlemans Basin	Cave Rock	Glorene and Eighth	Highlands Drive	Highway 267 Repair	Lake Tahoe Park Erosion Control Project	Marshall Court	Marshall Trail at Columbine	Meyers Bike Trail	Meyers Erosion Control	Park Heights Drive Culvert Repair	Pioneer Trail Erosion Control	Ponderosa Ranch	Sierra Tract Phase 2	Timberland Erosion Control Project	Truckee Bypass, State Route 267	Upper Cutthroat	Notes
Trees																													
Abies concolor	White fir																						C						
Acer ginnala	**Amur maple**																						**C**						**Nonnative**
Acer glabrum	**Rocky Mountain maple**														**C**														**Nonnative**
Calocedrus decurrens	Incense cedar							C																		C		C	
Pinus jeffreyi	Jeffrey pine				C	C	C	C							C								C					C	
Pinus lambertiana	Sugar pine							C																					
Populus tremuloides	Quaking aspen			C											C														
Shrubs																													
Amelanchier alnifolia	Serviceberry					C		C							C								C			C			
Amelanchier alnifolia var. *pumila*	Western serviceberry																											C	
Arctostaphylos nevadensis	Pinemat manzanita							C																				C	
Arctostaphylos patula	Greenleaf Manzanita				C	C	P	C							C	S										C		C	
Arctostaphylos uva-ursi	Bearberry																						C						
Artemisia tridentata ssp. *vaseyana*	Mountain sagebrush			S		S/C	S/P	C/S					S	S	S	S		S					C		S			S	
Ceanothus cordulatus	Whitethorn					C	P	C															C			C			
Ceanothus prostratus	Squaw carpet or Mahala mat							C															C					C	
Ceanothus velutinus	Tobaccobrush							C																		C			
Cercocarpus ledifolius	Mountain mahogany														C														
Chrysothamnus nauseosus	Rabbitbrush			S		S/C	S/P	C/S							S/C			S					C		S				
Eriogonum umbellatum ssp. *polyanthum*	Buckwheat/Sulfur-flower						C																					S/C	
Eriogonum umbellatum	Sulphur buckwheat			S	C	S	S						S		S	S							C/S		S	S			
Lonicera involucrata	Twinberry														C														
Penstemon newberryi	Mountain pride penstemon				C			C															C					C	

Table 4-6
Woody Plant Species of Reviewed Revegetation Projects
Continued

Botanical Name	Common Name	Apalache—Eagle Drive	Apalache—Muskawaki Street	Apalache—Nattaway Basin	Bay View	Beaver Street	Big Springs + Overlook Place	B-Line Export Pipe Line	Brockway Summit	Brockway Water Quality	Burton Creek	Cattlemans Basin	Cave Rock	Glorene and Eighth	Highlands Drive	Highway 267 Repair	Lake Tahoe Park Erosion Control Project	Marshall Court	Marshall Trail at Columbine	Meyers Bike Trail	Meyers Erosion Control	Park Heights Drive Culvert Repair	Pioneer Trail Erosion Control	Ponderosa Ranch	Sierra Tract Phase 2	Timberland Erosion Control Project	Truckee Bypass, State Route 267	Upper Cutthroat	Notes
Shrubs—Continued																													
Pinus mugo* var. *mugo	**Dwarf mugo pine**																						**C**						**Nonnative**
Prunus emarginata	Bittercherry							C							C												S	C	
Prunus virginiana	Choke cherry																						C						
Purshia tridentata	Bitterbrush			S		S/C	S/C/P	C/S					S		S/C	S		S					C		S	S	S	S/C	
Quercus vaccinifolia	Huckleberry oak				C	C	P	C																				C	
Rhus trilobata	Skunkbush sumac														C								C						
Ribes aureum[1]	Golden currant																						C						Host of white pine blister rust
Ribes cereum[1]	Wax currant															S											S	C	Host of white pine blister rust
Ribes nevadense[1]	Sierra currant							C							C											C			Host of white pine blister rust
Ribes roezlii[1]	Sierra gooseberry				C			C															C					C	Host of white pine blister rust
Rosa woodsii var. *ultramontana*	Wood's rose			C		C		C							C								C					C	
Rubus parviflorus	Thimbleberry														C													C	
Salix ssp. (*lemmonii, lucida* var. *lasiandra, geyeriana*)	Willows			C																									
Salix lemmonii, Salix scouleriana	Willows																CT												
Sambucus cerulea	Blue elderberry														C														
Sambucus racemosa	Common red elderberry														C														
Spiraea densiflora	Mountain spiraea																											C	
Symphoricarpos albus	Mountain snowberry														C														
Symphoricarpos mollis	Creeping snowberry					C	C/P	C							C								C			C		C	
Symphoricarpus albus	Snowberry																						C						

Key:
C = planted from containers; P = planted from plugs; S = planted from seed; CT = planted from cuttings
Bold font indicates nonnative species.
Note:
[1] *Ribes* species should not be planted within several hundred feet of white pines (including sugar pines) because they are an alternate host of white pine blister rust (Kliejunas and Adams 2003).

4.3.3 Observed Outcomes of Revegetation Projects

At revegetation sites in the Tahoe Basin, a wide variety of species mixtures has been used to successfully revegetate disturbed sites, many of which have stressful conditions for plant growth. This indicates that in general the species selected for revegetation projects have been well-suited for establishment and growth on stressful sites in the Tahoe Basin.

However, the species selected by different projects differed in their growth form, life span, nitrogen-fixing ability, invasiveness, and potential for dominance. The inclusion (or exclusion) of plants with these particular traits can strongly influence the outcome of revegetation projects. Therefore, the potential effects of each of these plant traits on observed outcomes are discussed below.

4.3.3.1 Growth Form

At sites observed during the field surveys, shrubs and forbs were frequently a minor component of the vegetation. Selection of plant materials may be contributing to the limited success in establishing shrubs on revegetation sites because shrubs and forbs were frequently represented by just a few species at any one site, and additional variety and greater abundance of forbs and shrubs may have resulted from including additional species in the selected planting materials at some sites. However, the primary factors affecting the abundance of shrubs and forbs appear to be the retention of existing vegetation, proportions of seed mixes and the effectiveness of establishing container plants on some sites. The retention of existing vegetation is addressed in Section 4.2, “Site and Soil Preparation,” and seed mix proportions and establishment of container plants in Section 4.4, “Planting and Seeding Techniques.”

4.3.3.2 Life Span

Of short-lived species planted at revegetation sites, only the perennial California brome and the annual Purshing’s lotus were abundant at the sites observed during the field surveys. These species depend on regeneration from seed for their long-term persistence at a site.

California brome was among the most abundant species at multiple sites, including many of the more recent projects included in the field surveys. At observed sites, seed production, but no evidence of regeneration of California brome was observed. But, limited regeneration of California brome is unlikely to have been noticeable near the end of the growing season when both field surveys were conducted, because newly established plants would be similar in appearance to plants directly established by the initial seeding.

Purshing’s lotus was abundant at the Truckee Bypass State Route 267 site in 2006b and 2007. Purshing’s lotus had regenerated at this site, but irrigation was still being applied and regeneration may not be as successful in the absence of irrigation. Resurveying these sites in several years would be very informative regarding the long-term persistence of California brome and Purshing’s lotus.

In addition to planted species, a number of annual species have naturally regenerated at most roadside revegetation sites. In general, annuals are widely distributed and abundant along the region's roadsides (Frenkel 1970). The most widely distributed of these species were willowweed (*Epilobium brachycarpum*) and the invasive nonnative cheatgrass. These species provide less protection of the soil surface, for less of the year, than perennial species.

4.3.3.3 Nitrogen-Fixing Ability

Although nitrogen-fixing species were abundant at some revegetation sites observed during the field surveys, at many sites, nitrogen-fixing species were only minor components of the vegetation or absent altogether. There is little evidence that the selection of plant materials is a major factor contributing to the abundance of nitrogen-fixing species. For example, five of the nine sites included in the roadcut survey had less than 10% cover of nitrogen-fixing species (Appendix A), but the specifications were available for only one of these sites, and it had included several nitrogen-fixing species in its planting materials. Furthermore, available specifications contain multiple nitrogen-fixing species, and thus, multiple practitioners are incorporating nitrogen-fixing species in their revegetation projects in the Tahoe Basin. Rather than inclusion in the planting materials, the primary factors affecting the abundance of nitrogen-fixing species (other than unaided dispersal) appear to be the proportions of seed mixes and the effectiveness of establishing container plants on some sites. These topics are discussed in Section 4.4, "Planting and Seeding Techniques."

4.3.3.4 Invasiveness

Although problematic nonnative species were not included in reviewed specifications, plant materials may be introducing invasive nonnative species to revegetation sites in the Tahoe Basin. As described in Appendix A, invasive species were frequently present at revegetation sites (particularly cheatgrass at roadside sites), and revegetation projects may be facilitating their spread. These species can arrive as contaminants in potting material or seed lots. In samples of revegetation seed materials evaluated by CalTrans, invasive species are frequently present (Moffatt, pers. Comm. 2010).

Of the adapted nonnative species included in specifications, only hard fescue, big blue grass, and wheatgrasses (*Elytrigia* species, primarily pubescent wheatgrass) were abundant at any surveyed sites. In fact, adapted nonnative species accounted for most of the grass that had persisted on older sites. (Wheatgrass plants that appeared to be the persistent remnants of previous revegetation projects were also observed at several sites.) At no sites was there evidence of wheatgrasses or hard fescue having spread into adjacent disturbed or undisturbed vegetation.

4.3.3.5 Potential for Dominance

Although a wide variety of species have been used at revegetation sites in the Tahoe Basin, at sites visited during the reconnaissance and roadside cut slope surveys, very few species were among the most abundant species on more than one site (as documented by the roadcut survey [Appendix A]). Planted species

that were among the most abundant species at multiple sites observed during the field surveys included the following:

- Mountain sagebrush,
- California brome,
- Rabbitbrush (*Chrysothamnus nauseosus*),
- Sheep/hard fescue (*Festuca ovina*),
- Red fescue (*Festuca rubra*),
- Bluegrass (*Poa secunda*),
- Squirreltail (*Elymus elymoides*),
- Blue wildrye (*Elymus glaucus*), and
- Bitterbrush.

4.4 Planting and Seeding Techniques

Planting and seeding techniques are methods for physically installing plant and seed materials. Successful planting and seeding will result in establishing healthy, persistent plants that can assist in inhibiting erosion. This section discusses important considerations regarding planting and seeding techniques, recent practices, and observed outcomes of revegetation projects. (Planting and seeding materials are described above in Section 4.3, “Plant Materials.”)

4.4.1 Relationship to Revegetation

The addition of plants, seed, or both is generally necessary for successful revegetation of disturbed sites. There are several reasons why this is the case:

- Soil removal, storage, and replacement may have substantially reduced the density of seed near the soil surface.
- Species germinating from the soil seedbank, or dispersing from adjacent vegetation, may not be well suited for conditions on the disturbed site, or may not be desired.
- Perennial plants may establish from seed infrequently. Thus, the removal of vegetation may eliminate perennial species from the site or greatly reduce their abundance.

In the absence of planting and seeding, disturbed sites typically have less cover of plants than undisturbed sites or than disturbed sites that have been planted and/or seeded. At semiarid or higher elevation sites, this has been documented by experiments regarding revegetation of pipeline corridors (Holmstead and Anderson 1998), campsites (Urbanska and Chambers 2002), and roadsides (Tyser et al. 1998; Bochet and Garcia-Fayos 2004). Planting and seeding treatments can fail, of course, in which case, plant cover remains sparse. (For example, in the roadside experiment, forb cover was not increased by seeding [Tyser et al. 1998].)

Revegetation planting practices include installation of container stock, such as treepots, deepots, and plugs, and seeding practices conducted by broadcast seeding, drill seeding, or hydroseeding methods. The success of both planting of container stock and seeding are strongly influenced by their timing during the growing season. Planting in late-summer or fall exposes transplanted materials to less stressful conditions than late-spring or mid-summer, and allows growth throughout the following growing season. Similarly, late-summer or fall seeding results in spring germination during more favorable conditions than would result from spring or early summer seeding.

Container planting generally involves the following steps:

(1) Individual plant locations are field marked (e.g., painted, staked, or flagged) by plant species before the start of installation.

(2) Planting holes are excavated approximately three times the width and 1.5 times the depth of the container. The sides of the planting hole are scarified before backfilling and plant placement.

(3) The planting hole is backfilled to approximately half the depth of the hole. The backfill is then tamped and watered to remove air pockets and reduce settling.

(4) If prescribed, fertilizer and other amendments are then added to the planting holes.

(5) The plant is placed in the hole and the backfill is completed, tamped, and watered. The plant is positioned so that the root crown is set one-half inch above finished grade at the time of planting. The plant is placed in the hole and the hole is backfilled with excavated soil.

(6) The plants are watered before, during, and after the installation to ensure a healthy and vigorous condition before the start of maintenance.

Although most herbaceous and woody species can be established through container plantings, only a portion of the plantings, often just a small portion, will establish and persist (Paschke, DeLeo, and Redente 2000). For shrubs, competition from herbaceous plants often reduces establishment, and transplants often have little response to fertilizers (Paschke, DeLeo, and Redente 2000; Paschke, Redente, and Brown 2003; Petersen, Roundy, and Bryant 2004). Death of container plantings is frequent. Furthermore, plants transplanted from containers may languish for years with little or no growth.

Broadcast seeding generally involves the following steps:

(1) A seed mixture is spread evenly by hand or by mechanical spreader onto a prepared seedbed. (e.g., a surface that has been tilled and then firmed).

(2) Following seed broadcasting, the seed is worked into the soil surface by hand raking or by lightly harrowing. The seed should be covered with adjacent soil to a depth of one-quarter to one-half inch.

(3) Mulch may then be spread after the seed has been worked into the soil (typically as a thin layer about a quarter-inch in depth). The mulch may be

tractor-walked or tucked in with a mulching roller or crimper that punches the mulch in the ground to a depth of approximately 2 inches. As an alternative, tackifier may be applied to secure the mulch.

Drill seeding uses a tractor-pulled machine to sow seeds in rows of drilled holes.

Hydroseeding consists of a water/slurry mix that can include seed, amendments, fiber mulch, and tackifier; the mix is applied using a high-pressure spray technique. Inoculated seeds can be planted by hydroseeding, but hydroseeding of inoculated seed should be avoided because the acidity of some water/slurry mixes can damage bacterial inoculants (Brown et al. 1983). Hydroseeding is generally performed in conjunction with hydromulching, which is similar to hydroseeding except that it is a water/slurry mix of just wood mulch and tackifier. If hydroseeding and hydromulching are not performed separately as a two-step process, seed may be exposed to air or in contact with mulch rather than soil (Newton and Claassen 2003).

Successfully establishing multiple species on a site from seed is a difficult process (Young 1992; Schuman, Booth, and Cockrell 1998; Langer, Davis, and Ross 1999; Paschke, Redente, and Brown 2003). First, seed from local populations of the necessary species may not be available, and collecting the seed can be expensive. Second, the mechanical process of planting seed of multiple species can be problematic because species differ substantially in seed size and some have awns. Additionally, species differ in their optimal planting depth for germination and establishment. Third, competition among seedlings strongly affects their establishment and the species composition of the resulting vegetation.

Seedbeds need to be firmed so that seed will be in close contact with soil and remain close to its planted depth and so that seedlings will not be buried or uprooted by shifting soil. (As a rule of thumb, in a firmed seedbed, a footprint would not be deeper than a quarter inch.) CalTrans generally prepares a firm, uneven seedbed by track walking prior to application of seed (Moffatt, pers. comm., 2010).

However, a uniform soil surface is not necessarily ideal. On arid sites, seeded plants often establish better near stones or woody debris, or in depressions. These microsites provide some shelter and collect some additional moisture. Consequently, imprinting or pitting treatments have been used to create such microsites and to establish a variety of plants in arid landscapes (Whisenant 1999, 2002).

However, roughened or pitted surfaces do not always improve seedling establishment. For example, in an experimental evaluation of revegetation treatments on road cuts in Mesa Verde National Park, deliberately pitted surfaces did not have greater seedling establishment (Paschke, DeLeo, and Redente 2000). Slumping soil filled many pits, burying seed deeply and preventing any benefit from the pitting treatment. On roadcuts in the Tahoe Basin, slumping soil also would likely fill deliberately produced pits or depressions, because slumping soil and mounds of coarse material were frequently observed at revegetation sites on cut and fill slopes along roads in the Tahoe Basin.

During preparation of the seedbed, a variety of amendments may be incorporated, including mycorrhizal inoculum, compost, and fertilizer. In addition, some type of mulch is generally applied to the soil surface.

Commercial mycorrhizal inoculum has also been used to aid inoculation of plantings at many revegetation sites in the western United States, including some in the Tahoe Basin (Table 4-1). (The quality of mycorhizal inoculum is not regulated and varies; however, testing services are available to determine its quality.) The use of mycorrhizal inoculum is a controversial practice (Allen, Jasper, and Zak 2002). On the one hand, mycorrhizal fungi may be slow to reestablish on drastically disturbed sites, and inoculation with mycorrhizal fungi has been successful in mine reclamation and in forestry, in particular when planting nonnative species. On the other hand, less drastically disturbed sites may not require inoculum, and commercial inoculum may not be as effective or long-lived as local fungi. A recent study using plants and soil from Rocky Mountain National Park found that the two sources of commercial inoculum evaluated were much less effective than inoculum from local soil (Rowe, Brown, and Claassen 2007). (This study included plant species used in Tahoe Basin revegetation projects, related species, and cheatgrass, an invasive plant infesting revegetation sites in the Tahoe Basin.) The local inoculum was obtained simply by adding some local soil.

4.4.2 Recent Practices

In the project plans and specifications reviewed for this study, planting and seeding included the following issues and techniques:

- container planting, including planting hole preparation and amendments and
- seeding, tackifier, and amendments.

Specific installation approaches are summarized in Table 4-7, “Planting and Seeding Techniques.” Container planting operations were consistent with those described above. Most plantings occurred in the fall and plants were set at on-center spacing ranging from 3 to 10 feet. Seeding methods included broadcast seeding (hand-held seeders and belly grinder types) and hydroseeding methods; tackifier was used in most cases, along with fertilizer, compost, or other amendments. In addition, for the Lake Tahoe Park Erosion Control Project, willow transplants and cuttings were prescribed as discussed in Section 4.3, “Plant Materials.”

In the project plans and specifications reviewed for this study, the density of PLS applied to project sites varied considerably in density, and included a dense application of PLS at some sites (Table 4-8). Grass seed was applied at much greater densities than shrub and legume seed were applied. General recommendations for the total density of broadcast PLS are typically less 100 PLS per square foot, and often less than 50 PLS per square foot (Munshower 1994; Stromberg et al. 2007; Cornforth, St. John, and Ogle 2001; also see studies cited in Whisenant 1999:202–203); and this range is exceeded by a number of revegetation projects in the Tahoe Basin. Greater densities are desirable in the Tahoe Basin because of relatively harsh conditions, the typical use of broadcast seeding, and thick mulch layers. However, substantially greater densities also

Table 4-7
Planting and Seeding Techniques

Site Name	Timing	Planting Hole Preparation	Container Planting Amendments	Plant Spacing (Feet On-Center)			Seeding Technique	Tackifier	Seeding Amendments	Notes
				Woody	Forbs	Grass				
Apalache—Glen Eagles Drive	F	Y	N	5	–	–	HH	Y	N	
Apalache—Muskawaki Drive	F	Y	N	5	–	–	HH	Y	N	
Apalache—Nattaway Basin	F	Y	N	5	–	–	HH	Y	N	
Bay View	–	Y	Y	–	–	–	–	–	–	
Beaver Street	F	Y	N	3 to 4	–	–	HH	Y	–	
Big Springs and Overlook Place	–	–	–	–	–	–	–	–	–	Specifications were not provided.
B-Line Export Pipeline	–	Y	N	5 to 10	–	–	HH	Y	–	
Brockway Summit	F	N	N	3 to 10	–	1	H	Y	OF	
Brockway Water Quality	F	N	N	3 to 10	–	1	H	Y	C	
Burton Creek	–	–	–	–	–	–	–	–	–	
Cattleman's Basin	–	–	–	–	–	–	–	–	–	Specifications were not provided.
Cave Rock	–	–	–	–	–	–	HH	Y	C	
Glorene and Eighth	F	Y	Y	–	–	–	HH	Y	N	
Highlands Drive	–	–	–	–	–	–	–	–	–	Specifications were not provided.
State Route 267 Repair	–	–	–	–	–	–	–	–	–	Specifications were not provided.
Lake Tahoe Park Erosion Control Project	F	Y	N	3 to 4	–	–	H	–	–	Willow cuttings were harvested and installed.
Marshall Court	–	–	–	3	–	–	–	–	FERT	
Marshall Trail at Columbine	–	–	–	3	–	–	–	–	FERT	
Meyers Bike Trail	–	–	–	–	–	–	–	–	–	Specifications were not provided.
Meyers Erosion Control	–	–	–	–	–	–	H	Y	FERT /C	
Park Heights Drive Culvert Repair	F	–	–	–	–	–	H	Y	FERT	Fertilizer was Biosol.
Pioneer Trail Erosion Control	F	Y	Y	–	–	–	HH	N	Y	
Ponderosa Ranch	–	–	–	–	–	–	–	–	–	Specifications were not provided.
Sierra Tract Phase 2	Su/ Sp	Y	Y	–	–	–	HH	Y	–	
Timberland Erosion Control Project	F	Y	Y	4	–	–	HH/ B	Y	Y	
Truckee Bypass, State Route 267	–	–	–	–	–	–	–	–	FERT /C	
Upper Cutthroat	–	Y	Y	See notes	–	–	HH/ B	Y	Y	25–100 plants placed within 200 square feet

Key
B = Belly grinder type
C = Compost
F = Fall
FERT = Fertilizer
H = Hydroseeder
HH = Hand-held seeders
N = None
OF = Organic fertilizer
Su = Summer
Sp = Spring
Y = Yes

may be favoring the establishment of more rapidly germinating and growing species, and may be reducing the health and growth of most individuals of all species in the short term.

Two experiments in the Tahoe Basin and Truckee area have compared pairs of treatments differing in planted seed density by about 300% and spanning the range of densities in Table 4-8. In one experiment (Brockway Summit), the two treatments resulted in comparable cover of seeded species; and in the other, the treatment with lesser seed density resulted in less cover of seeded species when fertilizer was also applied and comparable cover without fertilizer (Northstar Highlands View Road) (IERS 2009).

4.4.3 Observed Outcomes of Revegetation Projects

Shrub and herbaceous plant cover was provided by planting and seeding, in some cases by retained vegetation, and on older sites, by plants recruited from adjacent vegetation. Planting and seeding practices supported the generally successful establishment of grass species, but may have contributed to the inconsistent and often limited establishment of shrubs and forbs.

Herbaceous cover varied among sites, was frequently sparse, and at almost all sites was dominated by grasses. At sites included in the reconnaissance survey, the herbaceous layer covered from less than 5% to greater than 90% of a site. This cover was often sparse, however: five sites (16%) had less than 10% herbaceous cover; about two-thirds of the sites had less than 30% cover, and only two sites had greater than 50% cover. (However, these cover values are based on visual estimates made in September, after many plants had begun to senesce; thus, actual cover values for much of the growing season may be somewhat greater.)

The transect data collected during the roadcut survey indicated that visual estimates made during the reconnaissance survey tended to underestimate total plant cover. Nonetheless, in this data set, herbaceous cover still consisted primarily of grasses (at all but one site), varied considerably among sites, and was generally less than 50% (Table 4-9). The low density of forb seed, and the large difference in the density of forb and grass seed applied (based on reviewed specifications [Table 4-8]) could be contributing to this limited establishment.

Table 4-8
Pure Live Seed per Square Foot in Recent Tahoe Basin Revegetation Specifications[1]

Species	Site[2]										
	CalTrans Mix	8th & Glorene	LTP Upland	LTP Wetland	UTC Dry	UTC Mesic	Beaver Street	B-Line Upland	B-Line Mesic	BS & OP	SR 267 Repair
Grasses											
Achnatherum occidentalis[3]	13	-	-	-	-	-	-	-	-	-	-
Agrostis exarata	-	197	-	-	-	-	-	-	-	-	-
Agrostis scabra[3]	-	165	-	-	-	-	-	-	-	-	-
Aleopecurus aequalis[3]	-	48	-	-	-	-	-	-	-	-	-
Bromus carinatus	14	-	8	-	63	49	6	6	6	72	57
Calamogrostis canadensis[3]	-	64	-	-	-	-	-	-	-	-	-
Deschampsia caespitosa	112	-	-	12	-	-	50	-	74	-	-
Deschampsia elongata[3]	55	-	-	-	-	-	-	-	-	-	-
Eleocharis macrostachya	-	12	-	-	-	-	-	-	-	-	-
Elymus elymoides	21	-	9	-	93	52	9	9	-	121	135
Elymus glaucus	-	7	11	-	40	89	9	-	7	108	91
Elymus trachycaulus	-	5	-	-	-	-	11	11	11	-	-
Festuca ovina = F. brevipila	-	-	12	-	-	-	-	-	-	-	-
Festuca rubra	-	-	-	39	-	-	-	-	19	-	-
Hordeum Brachyantherum	18	-	-	10	-	-	-	-	4	-	-
Leymus triticoides	-	6	-	57	-	-	8	-	8	-	-
Poa pratensis[3]	-	-	-	-	-	-	23	-	46	-	-
Poa secunda	-	-	41	-	-	-	33	33	-	-	-
Grass Total	**232**	**504**	**81**	**118**	**196**	**190**	**148**	**59**	**175**	**301**	**282**
Forbs											
Achillea millefolium	86	-	-	-	-	-	-	-	-	34	-
Eschscholzia californica[3]	-	-	13	-	4	4	-	-	2	-	-
Linum lewisii[3]	-	-	-	-	-	-	2	2	-	-	-
Lotus purshianus	4	-	-	-	-	-	-	-	-	-	-
Lupinus alpestris[4]	-	-	<1	-	-	-	-	-	-	-	-
Lupinus argenteus[4]	-	-	-	-	-	-	1	1	-	-	-
Lupinus breweri[4,5]	1	-	-	-	-	-	-	-	-	-	-
Lupinus greyi[4,5]	1	-	-	-	-	-	-	-	-	-	-
Lupinus polyphyllus	-	-	-	5	-	-	-	-	<1	-	-
Lupinus species[4,5]	-	-	<1	-	2	2	-	-	-	-	-
Penstemon strictus[3]	-	-	8	-	-	-	-	-	-	-	-
Penstemon rydbergii[3]	4	-	-	-	-	-	-	-	1	-	-
Potentilla gracillis[3]	-	-	-	14	50	50	-	-	14	-	-
Wyethia mollis[3]	1	-	-	-	-	-	-	-	-	-	-
Forb Total	**97**	**-**	**22**	**19**	**56**	**56**	**3**	**3**	**17**	**34**	**-**
Shrubs											
Arctostaphylos patula	-	-	-	-	-	-	-	-	-	-	1
Artemesia tridentata	-	-	1	-	5	5	-	3	-	-	-15
Cercocarpus ledifolius	-	-	-	-	-	-	<1	-	-	-	-
Chrysothamnus nauseosus	-	-	<1	-	-	-	<1	<1	-	-	-
Eriogonum umbellatum	-	-	<1	-	<1	<1	<1	<1	-	-	10
Prunus emarginata[3]	<1	-	-	-	-	-	-	-	-	-	-
Purshia tridentata	<1	-	3	-	1	1	<1	<1	-	-	6
Ribes cereum[3]	4	-	-	-	-	-	-	-	-	-	8
Shrub total	**4**	**-**	**4**	**-**	**7**	**7**	**1**	**4**	**-**	**-**	**40**
Total	**334**	**504**	**107**	**137**	**260**	**254**	**152**	**66**	**192**	**335**	**332**

Notes:
1 Calculated by multiplying pounds per acre by percentage purity and percentage germination, and then dividing by 43,560 square feet per acre
2 Site Names abbreviated as follows: LTP = Lake Tahoe Park, and UTC = Upper Trout Creek, BS & OP = Big Springs and Overlook Place, SR 267 Repair = State Route 267 Repair
3 Representative purity and germination values not in PLANTS data base; purity value of 90% and germination value of 80% assumed in calculations.
4 Representative purity and germination values not in PLANTS data base; purity value of 90% and germination value of 50% assumed in calculations.
5 Seeds per pound not in PLANTS data base; 50,000 seeds per pound assumed in calculations.

Table 4-9
Total Plant Cover and Maximum Cover of Plant Growth Forms[1,2]

Site	Shrub	Perennial Forb	Perennial Graminoid	Annual	Total[3]
Apalache – Glen Eagles Drive	25±7.4	6±2.7	21±5.5	3±2.6	53±5.7
Apalache – Muskawaki Drive	36±13.8	1±0.4	29±8.5	–	57±6.9
Big Springs and Overlook Place	–	2±1.8	54±6.1	27±5.3	67±3.8
Brockway Summit	14±6.3	1±1.1	6±3.2	33±9.2	46±8.1
Marshall Court	6±3.7	4±1.4	18±5.0	1±0.6	23±5.2
Marshall Trail at Columbine	19±5.5	4±3.8	8±4.6	1±0.8	29±7.8
Pioneer Trail Erosion Control	14.3±4.8	0.3±0.26	28±5.7	9.5±6.0	43±8.8
State Route 267 Repair	–	–	72±5.2	1±0.8	67±4.0
Truckee Bypass State Route 267	2±0.6	35±25	7±1.5	55±8.1	75±5.6

Notes:
1 Mean ± 1 Standard Error
2 Based on 10 randomly located, 10-m-long transects at each site along which cover was recorded at 25 cm intervals.
3 Maximum cover of growth forms does not sum to total plant cover because of overlapping plants (i.e., more than one plant covering a location).

Top-killed Wood's Rose (*Rosa woodsii*) Sprouting From Base

Die-back of Planted Skunkbush Sumac (*Rhus trilobata*)

At sites included in the reconnaissance survey, shrubs generally covered only a small portion of the site: nearly three-quarters of sites had less than 10% cover of shrubs; only one site had greater than 30% shrub cover. Although indicating that the visual estimates from the reconnaissance survey underestimated cover, transect data from the roadcut survey was consistent with this general pattern: shrub cover varied substantially, but roughly three-fourths of the sites had less than 20% shrub cover (Table 4-9).

Observations made during the field surveys indicate that the long-term survival of shrubs planted from containers is low: only a small number of apparently planted shrubs were present at most older sites, most container plantings had produced relatively little new growth during the previous year, and many shrubs had died-back or not increased in size measurably since planting.

Establishment of shrubs from seed was also limited. The low density of shrub seed, and the large difference in the density of shrub and grass seed applied (based on reviewed specifications [Table 4-8]) could be contributing to this limited establishment.

Significantly, much of the woody plant cover at revegetation sites was from retained vegetation or naturally recruited individuals (e.g., greenleaf manzanita, mahala mat,

whitethorn, Jeffrey pine). This suggests that some shrub species for which container plantings have been used, or that have not been widely planted, might be effectively established from seed. Pretreatment of these seeds to break dormancy, or careful handling of seed to maintain viability, may be necessary for some species, but the cost of such seed treatments probably would not exceed the cost of container plantings.

Extensive Area of Exposed Soil at Pioneer Trail Erosion Control Project

Despite retention of existing vegetation on some sites, and use of both plantings and dense seeding of a variety of species, and some natural recruitment, most sites still had a moderate to extensive amount of exposed soil after revegetation. For example, in both the reconnaissance survey and the more detailed roadcut survey, more than 20% of the soil surface was exposed at half of revegetation sites on roadcuts (Appendix A and Table 4-3). Areas of exposed soil were often more than 2 feet in width. Areas this large may persist indefinitely unless covered by adjacent shrub growth because continual erosion and harsher physical conditions at the soil surface make seedling establishment more difficult (e.g., see Ellison 1949).

4.5 Mulch

Mulch is a protective covering of organic material laid over the soil; materials include pine needles, wood chips, tub grindings, wood fiber products, straw, or even rock. Mulch is a key component to revegetation projects, as it conserves soil moisture and enriches the soil, while inhibiting weed growth (Goldman et al. 2005). Mulch also protects a disturbed site from erosion until plants grow large enough to provide protection, and holds seed and soil amendments in place in the presence of wind, rain, and runoff. This section discusses the relationship of mulch to revegetation and important considerations regarding mulch, recent practices, and observed outcomes of revegetation projects in the Tahoe Basin.

4.5.1 Relationship to Revegetation

Mulch protects the soil surface from the impact of raindrops, and thus reduces soil crusting; mulch also can slow overland flow (Morgan 2005). For these reasons, mulch reduces erosion. Substantially reduced runoff and sediment yield have been documented for revegetation sites covered by mulch (straw, pine needles, or wood chips) in the Tahoe Basin (Grismer and Hogan 2005b).

The protection provided by mulch is important where plants and the detritus they produce (litter) do not cover the ground surface. This is the case on disturbed sites before revegetation, and for this reason, mulch is applied as part of most revegetation projects.

Pine Needle Mulch at Glorene Avenue and Eighth Street

Mulch is typically spread by hand or blown on a site, or applied during hydroseeding operations. Mulch materials include pine needles (collected in the vicinity of the project site), wood chips, tub grindings, wood fiber products, and straw. Straw mulch is effective, although wood fiber is preferable for steep cut slopes (2:1 or steeper), where vehicle access is not possible within 50 feet, where weed growth or fire hazard is a problem, and where mulch is to be applied during windy conditions (Goldman et al. 2005). Mulch is placed after container plants have been installed and concurrent with seeding operations.

In addition to reducing erosion, mulch can also aid seedling establishment. Mulch moderates soil temperatures and reduces evaporation from the soil surface. The moister, more moderated conditions can facilitate the germination, survival, and growth of seedlings (Blanco-Garcia and Lindig-Cisneros 2005). For this reason, under semiarid and arid conditions, a thin layer of mulch is often applied as part of seeding treatments (Whisenant 1999).

Mulch treatments, however, can impede seedling germination and establishment; for example, in hydroseeding treatments the mulch may reduce infiltration of water, or suspend seeds above the soil surface if seed is applied with the hydromulch (Sheldon and Bradshaw 1977, Roberts and Bradshaw 1985). Also, mulch can cause spring temperatures at the soil surface to remain cooler and thus reduce germination and establishment of seeds (Cotts, Redente, and Schiller 1991, cited in Petersen, Roundy, and Bryant 2004).

Thick mulches can be a barrier to seedling emergence. Mulches 2–6 inches thick are often recommended to reduce or prevent establishment of weed seedlings (Harris and Leiser 1979; Harris, Clark, and Matheny 2004) and similar effects can be expected on seeded species.

4.5.2 Recent Practices

In the project plans and specifications reviewed for this study, mulch installation included the application of pine needles, tub grindings, wood chips, wood fiber products, and straw. Rock has not been used as mulch by the reviewed projects. Specific installation approaches are summarized in Table 4-10, “Mulch Treatments.” Pine needles (collected in the vicinity of the project site), wood chips, and straw (wheat, oat, or barley) were either placed by hand or applied using a blower after seed was worked into the soil and/or container planting was completed. Straw mulch was tractor-walked or tucked in with a mulching roller or straw crimper that punched the straw mulch into the ground. Wood fiber products were applied as part of a hydroseeding mix. Mulch depth varied from one-half inch to 4 inches depending on materials used. At most sites, tackifier was used to secure the straw or wood fiber products in place.

Table 4-10
Mulch Treatments

Site Name	Mulch Type	Mulch Depth (inches)	Notes
Apalache—Glen Eagles Drive	Humus/W	1	Wood Cellulose Fiber Mulch—500 lb/acre
Apalache—Muskawaki Drive	Humus/W	1	Wood Cellulose Fiber Mulch—500 lb/acre
Apalache—Nattaway Basin	Humus/W	1	Wood Cellulose Fiber Mulch—500 lb/acre
Bay View	P	1	
Beaver Street	P/W	0.5/1	
Big Springs and Overlook Place	P	1.25	
B-Line Export Pipeline	W/O	–	Wood chips, and paper mulch at 500 lb/acre
Brockway Summit	P	1	
Brockway Water Quality	P	1	
Burton Creek	–	–	
Cattleman's Basin	–	–	Specifications were not provided.
Cave Rock	P	–	
Glorene and Eighth	P/W/WF	1/2	100% recycled long-fiber pulp
Highlands Drive	T	1–2	
State Route 267 Repair	P	2	
Lake Tahoe Park Erosion Control Project	W	1	
Marshall Court	S	1.5–2.25	Wheat, oat, or barley straw at 1.5 tons per acre
Marshall Trail at Columbine	S	1.5–2.25	Wheat, oat, or barley straw at 1.5 tons per acre
Meyers Bike Trail	S	1.5–2.25	Straw at 1.5 tons per acre
Meyers Erosion Control	P	1	
Park Heights Drive Culvert Repair	None	–	Hydroseeded only.
Pioneer Trail Erosion Control	S	1.5–2.25	Wheat, oat, or barley straw at 1.5 tons per acre
Ponderosa Ranch	T	1–2	
Sierra Tract Phase 2	P/W/WF	1/2	
Timberland Erosion Control Project	P/W	1 inch if applied by blower—2 inches otherwise	
Truckee Bypass, State Route 267	W/O	4	Wood chips or tree bark or combination of both; mixed with compost and spread uniformly
Upper Cutthroat	P/W	1 inch if applied by blower—2 inches otherwise	

Key
O = Other
P = Pine Needles
S = Straw
T = Tub grindings/tub-ground wood chips
W = Wood Chips
WF = Wood Cellulose Fiber
Note: lb/acre = pounds per acre

4.5.3 Observed Outcomes of Revegetation Projects

Significantly, in the Tahoe Basin, applied mulch remains important for protection of the soil surface for several years. On many revegetation sites, combined herb and shrub cover is less than 50%, even a number of years after plant materials were installed. The intervening soil surface is either covered by litter and applied mulch or exposed.

For sites included in the reconnaissance survey, the cover of the litter layer (i.e., applied mulch plus plant litter) varied considerably among sites of any age (Appendix A). The cover of the litter layer ranged from 15% to 90% and most sites had a litter layer that covered 35–85% of the soil surface. On most sites, applied mulch (particularly wood chips and grindings) accounted for most of this cover, particularly in areas not below a plant; on some sites, however, pine needles from adjacent trees (as opposed to needles applied as mulch) were an important component of mulch. On few sites were herbaceous plants producing sufficient litter to cover a substantial portion of the soil surface. Interestingly, at some sites where wood chips accounted for a noticeable (and often substantial) portion of litter/mulch, wood chips had been incorporated into the soil as an amendment, but not applied to the surface as mulch.

Data from sites included in the roadcut survey were consistent with data from the reconnaissance survey (Appendix A). The cover of the litter layer, which still consisted primarily of applied mulch at most sites, varied from 44% to 89%, but only one site (which was 2 years old) had greater than 75% cover of the litter layer; and at five of these 9 sites, more than 20% of the site had exposed soil.

Over time, for the soil surface to remain covered, the production of plant litter must be sufficient to form and maintain a more or less continuous layer. For most revegetation sites in the Tahoe Basin, this often may not be the case. At older revegetation sites (i.e., >2 years old), the combined cover of herbs and shrubs was not greater than at younger revegetation sites, and the cover of mulch was reduced. As a result, the cover of bare soil tended to be greater on older revegetation sites (Appendix A). This suggests that more persistent mulch materials (e.g., wood chips or grindings as opposed to straw) may result in greater protection of the soil surface during the period from installation to greater litter production by vegetation.

Despite the absence of a thick, continuous litter layer on older sites, thick layers of mulch are being applied during revegetation. At several recently revegetated sites visited during the reconnaissance survey, mulch layers were 2–4 inches thick. Such a thick mulch layer can reduce emergence of plant seedlings from the soil.

4.6 Biotechnical and Other Treatments

Biotechnical erosion control treatments use live native vegetation or a combination of vegetative and structural materials to protect slopes and reduce erosion. Biotechnical treatments are now emerging as a more cost-effective, aesthetically pleasing, and environmentally acceptable solution to hard-armor

solutions such as concrete and riprap (McCullah 1999–2001). This section discusses recent practices, observed relationships to outcomes of revegetation projects, and conclusions on the effectiveness of and uncertainties about this component of revegetation, as well as key challenges regarding biotechnical and other erosion control treatments.

4.6.1 Relationship to Revegetation

Commonly used biotechnical erosion control treatments include vegetated gabions, vegetated rock riprap, fabrics/blankets, cellular confinement systems, coir logs, willow wattles, and brush layering. These treatments can provide temporary (during ground-disturbance), short-term (for one to several growing seasons), and/or long-term protection of the soil surface.

Erosion control fabrics/ blankets (e.g., jute fabric), cellular confinement systems, straw wattles, and coir logs provide temporary to short-term erosion control. Fabrics and blankets intercept raindrops and other forces and are best when they are made of organic biodegradable materials such as coconut fiber. Cellular confinement systems are polypropylene cells filled with aggregate or soil and vegetation; these systems are integrated on and anchored to a slope during finish grading operations. Coir logs or straw wattles, when set on contour, can be used as erosion-source and intermediate controls on slopes, trapping sediment while slowing and spreading runoff. Coir logs may consist entirely of organic, biodegradable materials, or may contain some nonorganic, nonbiodegradable components.

Temporary erosion control measures such as erosion fabrics/blankets can substantially reduce erosion from unvegetated surfaces (Grace et al. 1998; Sutherland 1998a, 1998b). They protect the soil surface from rainfall and they slow overland flow. However, these treatments often fail because they require contact with the soil surface, and this contact is difficult to maintain (Morgan 2005). Furthermore, erosion control fabrics/blankets can impede plant establishment.

Vegetated gabions, vegetated rock riprap, willow wattles, and brush layering can provide long-term erosion control benefits. Vegetated gabions are rock, contained in baskets, with live branch cuttings (such as willows or cottonwoods) used for slope or embankment stabilization. Use of vegetated rock riprap includes placing container plantings, cuttings, and/or seed within voids between angular-rock slope protection; the plantings are integrated and conducted concurrent with rock placement.

Straw Wattles at the Timberland Erosion Control Project

Tub Grindings in Understory for Thinned Jeffrey Pine (*Pinus jeffreyi*)-White Fir (*Abies Concolor*) Forest

Erosion Control Blankets at the Lake Tahoe Park Erosion Control Project

Jute Fabric at Apalache—Glen Eagles Drive

Similar in use to coir logs, willow wattles are constructed from bundled live branch cuttings and, once sprouted, can create a vegetated barrier to erosion. Brush layers are also constructed from interlaced live branch cuttings that are placed in layers against a slope. Both willow wattles and brush layering use harvested cuttings of local willow species. The willow cuttings form adventitious roots from the portion of the stem that is in contact with soil and water, while branches sprout above. The roots eventually spread out and stabilize the soil. These biotechnical systems are strong initially and grow stronger with time as the vegetation becomes established (Salix Applied Earthcare 2000). The willow wattles and brush layers are held in place with twine, live stakes, and/or wood stakes.

Biotechnical erosion control treatments should be placed at the time of site grading operations. Cuttings for willow wattles and brush layers need to be installed within 24–48 hours of harvesting and establishment depends on maintaining cuttings moist at all times after harvest.

4.6.2 Recent Practices

Logs and Boulders at the B-Line Export Pipeline

In the project plans and specifications reviewed for this study, the prescribed biotechnical and other techniques included the following treatments:

- fabrics/blankets;
- straw wattles and coir logs;
- willow wattles, mattresses, and fences;
- logs and green logs;
- brush layers; and
- boulders.

Specific treatments by site are summarized in Table 4-11, “Biotechnical and Other Treatments.” Many sites included one or more of the treatments, although no one site used them all collectively. Fabrics and blankets were used at many of the sites observed, in concert with revegetation plantings and seeding. Often these were sites with either steep slopes and/or detention basins. Similarly, but to a lesser extent, coir logs were used at some sites. Willow wattles were prescribed for three sites, while brush layers were prescribed at the Burton Creek site only. Logs (felled timber) and boulders were used to control vehicular access to the revegetation areas at a few sites. Besides reducing access, boulders and logs increase heterogeneity of establishment sites for plants, add roughness that may slow runoff and increase infiltration, and can concentrate runoff, which may increase erosion. Fencing, such as split rails, was not prescribed to control access to the revegetation areas.

Table 4-11
Biotechnical Treatments

Site Name	Fabrics/Blankets	Coir Logs	Willow Wattles	Logs	Brush Layer	Boulders	Fencing	Notes
Apalache—Glen Eagles Drive	Y	Y	N	N	N	N	N	CF-4 erosion control blanket. 6-inch diameter straw wattle halfway up slope.
Apalache—Muskawaki Drive	N	N	N	N	N	N	N	
Apalache—Nattaway Basin	Y	N	N	N	N	N	N	CF-7 erosion control blanket with 6-inch wood stakes. North American Green SC150 blanket with metal staples.
Bay View	N	N	N	Y	N	Y	N	Placed in terraces; looks natural.
Beaver Street	N	N	N	N	N	N	N	Rock-lined channel. BMPs including sediment roll and filter fabric. Rock slope protection.
Big Springs and Overlook Place	N	N	N	N	N	N	N	
B-Line Export Pipeline	Y	N	N	Y	N	Y	N	Rough soil texture. Sediment logs.
Brockway Summit	N	N	N	N	N	N	N	
Brockway Water Quality	N	N	N	N	N	N	N	
Burton Creek	Y	N	Y	N	Y	Y	N	Coir fiber netting with metal staples.
Cattlemans Basin	N	Y	N	N	N	N	N	
Cave Rock	N	N	N	N	N	Y	N	Concrete retaining wall at base.
Glorene and Eighth	Y	N	N	N	N	N	N	Blankets in Tahoe Basin. Propagated wetland mat. North American Green SC150 blanket with Eco-stakes. CF-7 erosion control blanket.
Highlands Drive	N	N	N	N	N	N	N	
State Route 267 Repair	N	N	N	N	N	N	N	Pine needle wattle BMP at base of slope/road edge.
Lake Tahoe Park Erosion Control Project	Y	Y	N	N	N	N	N	North American Green C125BN blanket with Eco-stakes.
Marshall Court	Y	N	N	N	N	N	N	North American Green SC150 blanket with metal staples.

Table 4-11
Biotechnical Treatments

Site Name	Fabrics/Blankets	Coir Logs	Willow Wattles	Logs	Brush Layer	Boulders	Fencing	Notes
Marshall Trail at Columbine	Y	N	N	N	N	N	N	North American Green SC150 blanket with metal staples.
Meyers Bike Trail	N	N	N	N	N	Y	N	Rock slope.
Meyers Erosion Control	N	N	N	N	N	Y	N	
Park Heights Drive Culvert Repair	N	Y	N	N	N	N	N	Straw wattles with rebar anchors.
Pioneer Trail Erosion Control	Y	N	Y	N	N	Y	N	Stone placement, base of south slope.
Ponderosa Ranch	N	N	N	Y	N	Y	N	Pine needle wattle BMP at base of slope.
Sierra Tract Phase 2	N	N	Y	N	N	Y	N	North American Green SC150 blanket with Eco-stakes.
Timberland Erosion Control Project	Y	Y	N	Y	N	N	N	North American Green C125BN blanket. Roadside vegetated swale. Sediment logs. Willow wattles were prescribed, though not installed.
Truckee Bypass, State Route 267	N	N	N	N	N	N	N	
Upper Cutthroat	N	N	N	Y	N	Y	N	Rock-lined channel. BMPs including sediment roll and filter fabric. Rock slope protection.

4.6.3 Observed Outcomes of Revegetation Projects

At several of the revegetation sites visited in 2006, coir logs, rolls of pine needles, and even erosion control blankets were no longer firmly in contact with the soil surface, and thus were no longer effective.

Willow wattles can rapidly establish dense woody vegetation; however, they can only be used where wet conditions support the growth and survival of willows. Also, Scouler willow (*Salix scouleriana*), a common willow in the Tahoe Basin, is difficult to establish from dormant unrooted cuttings (Ogle, Hoag, and Scianna 2000).

At two of the three visited sites with willow wattles, wattles had failed to survive on a large portion of the site. In both cases, the dead wattles were on a slope, and farther from wet soil than the wattles that survived. This pattern

suggests that willow wattles may be reliable only on the immediate banks of streams and of some stormwater detention basins.

The placement of boulders was a component of revegetation at most decommissioned road, ROW, and several roadside sites. The decommissioned road and ROW sites with boulders (five sites) had little or no disturbance from vehicles, or even trampling. (Gates also limited access at some of these sites.) The roadside sites with boulders (four sites) still experienced some vehicle disturbance between boulders, and extensive trampling. Fencing may reduce this trampling, but it was not a component of any revegetation project.

4.7 Maintenance

Maintenance is a period of time (usually 1–5 years in duration) immediately after plant and seed installation where plant establishment actions including irrigation/watering, fertilization, weed control, and replacement planting and seeding are conducted to meet the performance criteria for a revegetation project. At the end of the maintenance period, healthy, persistent plants should be established, with the ability to survive without irrigation or other maintenance actions.

Healthy plants are those that are free of disease and insect infestation, are robust, and have vigorous foliage and wood. Plant foliage should not have symptoms of disease, size, color, wilting, defoliation, browsing by wildlife, insect damage, or vandalism. In addition, the wood and root crown of each plant should not have symptoms of disease, browsing by wildlife, insect damage, girdling, structural deformities, dieback, and sunburn.

This section discusses the relationship of maintenance to successful revegetation, recent practices in the Tahoe Basin, and maintenance-related observations of Tahoe Basin revegetation projects.

4.7.1 Relationship to Revegetation

4.7.1.1 Irrigation

Water availability is a major factor affecting seedling establishment and plant growth on revegetation sites in areas with drier climates, including the Tahoe Basin (e.g., see Garcia-Fayos, Garcia-Ventoso, and Cerda 2000; Bochet and Garcia-Fayos 2004). Consequently, revegetation sites are frequently irrigated temporarily to aid the establishment and initial growth of plants. However, irrigation is not necessary on all sites.

Watering may be conducted by truck, hand (e.g., with buckets or a backpack sprayer), or a temporary irrigation system with overhead spray-sprinklers, drip emitters, or bubblers. Temporary irrigation systems can be supplied with water under pressure by way of a watering truck, a connection to a city water main, a well, or drafting water from a water body (e.g., a creek). The various approaches to temporary irrigation are described in greater detail in the Sediment Source Control Handbook (Hogan and Drake 2009).

Each of these irrigation methods has advantages and disadvantages. Truck and hand watering require no infrastructure, and allow for quick applications. Hand watering also can be applied to focused locations at a site (discouraging weed growth) and at relatively inaccessible sites. Both truck and hand watering, however, can be inconsistent, and are prone to either apply water too rapidly, resulting in runoff and erosion, or apply too little water resulting in only shallow wetting of the soil profile and poor root development.

Sprinkler irrigation System at the Timberland Erosion Control Project

Temporary irrigation systems using drip emitters, overhead spray-sprinklers, and bubblers are more costly, require more maintenance, and are feasible at fewer sites than truck or hand irrigation. These systems allow more consistent application of water. Overhead sprayers, however, distribute this water widely on a site, promoting weed growth, whereas drip systems concentrate water applications so much that they also concentrate development of the root system to a small volume of soil (Hanson, Schwankl, and Fulton 2004).

Local soil and site conditions, amount of vegetation, and weather affect the infiltration and storage of irrigation water, and the rate at which it is depleted from the soil. Coarse soils, like most soils in the Tahoe Basin, store less water than finer textured soils: in general, sands store about 0.7 inches of “available” water per foot of soil, loamy sands store about 1.0 inches per foot, and sandy loams store about 1.3 inches per foot (Hanson, Schwankl, and Fulton 2004). The available water capacity of most soils in the Tahoe Basin is provided in Appendix C.

During the first year after seeding, and to a lesser extent in subsequent years, the rate of water depletion from the soil changes during the growing season. On a newly seeded revegetation site, water is primarily depleted from the soil by evaporation from the soil surface. Plants are still very small and therefore do not transpire much water. Less water is depleted from the soil each day than later in the growing season, or in subsequent years. As the growing season progresses, plants become larger and the weather becomes warmer and drier, and as a result, water is depleted from the soil more rapidly. Later in the growing season, as growth slows, leaves senesce, and days shorten and weather cools, water is depleted more slowly from the soil.

Roughly half to two-thirds of available water can be depleted without damaging or substantially reducing the growth or crop plants, including a number of grasses (Hanson, Schwankl, and Fulton 2004). Thus, such depletion is unlikely to hinder the growth or damage the more drought-tolerant native plants used in revegetation projects. However, germinating seeds and newly planted container plants have relatively limited root systems, and thus need to be kept moister initially than after the establishment of plants on site.

Because the depth of watering by an application and the relative rate of water use at a site are difficult to precisely estimate initially, and weather and plant growth continually change evapotranspiration, frequent monitoring of plant condition and soil moisture may be necessary. Stunted growth, wilting, and

premature loss of leaves all can indicate that plants are experiencing water stress.

Soil moisture can be measured be various techniques. The simplest technique is to estimate soil water content by appearance and feel (Hanson, Schwankl, and Fulton 2004; Page 113). For example, many Tahoe Basin soils are sandy loams or loamy sands, and the appearance and feel of these categories of soils changes as their water deficit increases. (Water deficit is a measure of the amount of additional water that could be stored in a soil layer: a water deficit of 1 inch/foot means that applying water to a depth of 1inch would bring the upper foot of soil to field capacity.) Both of these categories of soils will leave a wet outline on a hand when at field capacity and squeezed. However, their appearance and feel changes differently as they dry out:

- Loamy sand appears moist and can be pressed into a weak ball at water deficits of 0.2–0.4 inches/foot; at water deficits of 0.4–0.6 inches/foot, loamy sand can no longer be pressed into a ball, but still appears slightly moist and will stick together slightly; and at a water deficit of 0.8 inches/foot, it is at wilting point and is dry and loose.
- Sandy loam will appear dark and can be pressed into a hard ball at water deficits of 0.2–0.4 inches/foot; at water deficits of 0.4–0.8 inches/foot loamy sand still has a dark color and can be pressed into a ball; at water deficits of 0.8–1.0 inches/foot, its color lightens and the ball it is pressed into becomes more fragile; at a water deficit of 1.0 inches/foot, sandy loam is only lightly colored by moisture and will not ball; and at water deficits of 1.2–1.4 inches/foot, its color lightens until only slightly colored by moisture at the wilting point (which is at approximately 1.4 inches/foot).

4.7.1.2 Fertilization

The relationship of fertilization to revegetation is described above in Section 4.2, “Site and Soil Preparation.”

4.7.1.3 Weed Control

In general, weeds are a major obstacle to successful revegetation. Also, invasive plants that establish at disturbed sites can subsequently spread to adjacent land. Weed control consists of maintaining the individual planting sites and areas between individual planting sites free of weeds. Weed control can consist of chemical or mechanical treatments, or a combination of both. Spot applications of herbicide can be used as needed to control weeds and other undesired vegetation. Undesirable consequences of weed control treatments include damage to installed or desirable native volunteer plants. Effective weed control may require more than one treatment per growing season for up to several years.

4.7.1.4 Replacement Plantings and Reseedings

Replacement plantings and reseedings offset loss of plants because of treatment failure (e.g., a faulty irrigation system) and disturbances. They also provide an opportunity to adjust the species composition of plantings in response to the success of different species in the initial planting.

Plant material without easily observable viable aboveground living matter, as determined by plant establishment monitoring, can be considered dead. Replacement plantings, required because of losses from inundation, mortality, or poor health and vigor, are often conducted at a rate of one replacement plant for each plant lost. Replacement plantings may be of the same species as the original plantings or of a different species (if the death of the original plantings indicates that other species would be better suited for growth and survival at the site). After each replacement, written documentation recording the time, species, and location of all replacements is typically prepared.

Reseeding is often conducted for large areas with less than 15% cover by target species. Reseeding may be conducted with a similar seed mix, or with a modified native seed mix (if the failure of the initial seeding indicates that different species or relative amounts of seed would be more likely to establish at the site).

4.7.2 Recent Practices

Approaches to revegetation maintenance have been dictated by site accessibility, number of plants or project complexity, water availability, and soil condition (e.g., erodability, relative imperviousness, steepness). Additionally, project budgets and funding often have limited the amount of maintenance that can be conducted at a revegetation site.

In the project plans and specifications reviewed for this study, maintenance prescriptions have been varied. Specific plant establishment approaches are summarized in Table 4-12, “Maintenance Practices,” and address the following:

- maintenance period duration,
- irrigation type,
- water application rate,
- fertilizer,
- weed control,
- replacement planting, and
- reseeding.

Maintenance was specified for about half of the study sites and ranged in duration from 1 to 5 years. Temporary irrigation was prescribed for most sites, using drip and sprinkler systems or truck watering. Water application rates and amounts were only documented in part, but varied among projects. Wetting the soil to a depth of 3 inches was a common specification. (Except during initial establishment, this depth of wetting would not be sufficient to encourage development of deep systems of roots.) In some instances, irrigation continued for more than 1 year. Fertilizer was not prescribed for use during maintenance operations. Weed control, replacement planting, and reseeding were prescribed for only a few sites.

Table 4-12
Maintenance Practices

Site Name	Maintenance Period Duration (years)	Irrigation Type	Water Application Rate	Fertilizer	Weed Control	Replacement Planting	Reseeding	Other	Notes
Apalache—Glen Eagles Drive	N	N	N	N	N	N	N	N	EDOT does not monitor; CCC crews were used, so no contractor warranty.
Apalache—Muskawaki Drive	N	N	N	N	N	N	N	N	EDOT does not monitor; CCC crews were used, so no contractor warranty.
Apalache—Nattaway Basin	N	N	N	N	N	N	N	N	EDOT does not monitor; CCC crews were used, so no contractor warranty.
Bay View	N	N	N	N	N	N	N	N	Seedlings were irrigated twice at the time of planting.
Beaver Street	2	Sprinkler	Soil penetration to 3 inches min.	N	N	Y	Y	N	Treatment to ensure no significant rilling or erosion.
Big Springs and Overlook Place	–	–	–	–	–	–	–	–	Specifications were not provided.
B-Line Export Pipeline	5	Hand	As needed	N	Y	Y	Y	N	Treatment to ensure no evidence of erosion, such as rills or gullies.
Brockway Summit	5	Temporary	N	N	N	N	N	N	Irrigation approach not provided.
Brockway Water Quality	5	Drip/truck	N	N	N	N	N	N	Noxious weed problem.
Burton Creek	N	N	N	N	N	N	N	N	
Cattlemans Basin	2	Spray via truck	1x/week (Year 1); 2x/month (Year 2)	N	N	N	N	N	Mustard on berm; cheatgrass in undisturbed areas.
Cave Rock	DN	Sprinkler	N	N	N	N	N	N	A lot of rodent activity.
Glorene and Eighth	2	N	N	N	N	N	N	N	Specs called for irrigation design by contractor, but none was installed outside of basins; and second year of irrigation may not have occurred.
Highlands Drive	–	–	–	–	–	–	–	–	Specifications were not provided.
State Route 267 Repair	1	Temporary	4 events only	N	N	N	N	N	
Lake Tahoe Park Erosion Control Project	2	Sprinkler/ truck	Soil penetration to 3 inches min.	N	Y	Y	Y	N	Treatment to ensure no significant rilling or erosion. Remove weeds from revegetated areas: cheatgrass, sweet blossom clover (Melilotus ssp.), and alfalfa.
Marshall Court	2	Truck	1x/week (year 1); 2x/month (year 2)	N	N	N	N	N	Irrigation by way of plant collar.

Table 4-12
Maintenance Practices

Site Name	Maintenance Period Duration (years)	Irrigation Type	Water Application Rate	Fertilizer	Weed Control	Replacement Planting	Reseeding	Other	Notes
Marshall Trail at Columbine	2	Truck	1x/week (year 1); 2x/month (year 2)	N	N	N	N	N	
Meyers Bike Trail	N	N	N	N	N	N	N	N	
Meyers Erosion Control	DN	Sprinkler/ truck	2x/month	N	N	N	N	N	
Park Heights Drive Culvert Repair	DN	Sprinkler	Per engineer	N	N	N	N	N	
Pioneer Trail Erosion Control	1	Truck	N	N	N	N	N	N	1 year of irrigation: truck by way of water wand.
Ponderosa Ranch	N	N	N	N	N	N	N	N	
Sierra Tract Phase 2	2	Truck	Per engineer	N	N	Y	Y	N	Treatment to ensure no evidence of erosion, such as rills or gullies; irrigation systems in basins, but operation may have been inconsistent.
Timberland Erosion Control Project	2	Sprinkler/ truck	Soil penetration to 3 inches min.	N	Y	Y	Y	N	Treatment to ensure no erosion. Maintenance did not occur in years 1 and 2.
Truckee Bypass, State Route 267	2	Sprinkler	Per engineer	N	N	N	N	N	Topical treatments for failed areas. Watering is bringing up a lot of undesired plants.
Upper Cutthroat	2	Sprinkler/ drip/ soaker hose	Soil penetration to 3 inches min.	N	N	Y	Y	N	Irrigation applied to revegetation at settling ponds, grassed waterways, and designated roadside areas.

Key:
DN = don't know, N = none, Y = yes; Notes: CCC = California Conservation Corps;
EDOT = El Dorado County Department of Transportation

4.7.3 Observed Outcomes of Revegetation Projects

4.7.3.1 Irrigation

Of the revegetation sites visited in 2006, eight were not irrigated. Nonirrigated sites had established a cover of vegetation that was comparable to that of irrigated sites. However, the nonirrigated sites tended to be partially shaded and on gentler slopes (and on these sites, plants may require less water or soil may store more water than on more exposed, steeper slopes). For example, only one was on a road cut, and this site was partially shaded by adjacent trees.

Erosion caused by irrigation was observed at several sites during the field surveys. These included truck watered sites and sites with overhead sprinklers.

During the reconnaissance survey, the temporary irrigation systems at several sites were damaged and partially or fully nonfunctional. This indicated both that these systems are prone to damage and that maintenance of these systems was not occurring on a regular basis.

4.7.3.2 Fertilization

In general, maintenance of revegetation sites in the Tahoe Basin has not included fertilization. For a discussion of the need for and effects of fertilization, see Section 4.2, "Site and Soil Preparation."

4.7.3.3 Weed Control

Because invasive plants have frequently established on revegetation sites in the Tahoe Basin, and in some cases, extensive growth of weeds or invasive species has occurred, there is a need for weed control. However, weed control has not been widely implemented. Weed control was a component of only three erosion control projects included in the reconnaissance survey, and in 2006, at two of these three sites, invasive plants were growing. In 2006, the presence of invasive plants at 44% of revegetation sites, and the frequent absence of those same plants from nearby roadside vegetation, suggests that revegetation projects are facilitating the spread of invasive species. Additional weed control could prevent revegetation projects from aiding the spread of invasive plants.

Weed control by hand or mechanical removal is recommended in the Tahoe Basin by the USFS (2010), and is generally recommended when weed control is conducted near surface water or by untrained, volunteer labor. Important considerations for hand or mechanical control of weeds are that cutting or removal of weeds does not allow the plant to survive and regrow, and that it occurs before (and precludes) seed production. For most invasive plants that are problematic in the Tahoe Basin (Table 4-4), small infestations can be controlled by repeated hand pulling, digging and removal of the taproot, and/or mowing. Control of larger infestations may not be feasible without the use of herbicides.

Mechanical and chemical treatments for many of the Tahoe Basin's invasive plants are provided by the Lake Tahoe Basin Weed Coordinating Group in *Invasive Weeds: Controlling Your Noxious Neighbors* (LTBWCG No Date). Mechanical treatments for most species consist of pulling out the plant or cutting the tap root two inches below the soil surface. This pulling or cutting is recommended before flowering, and needs to be repeated during the year and subsequent years. For some species, mowing before flowering is also recommended to reduce growth and seed production. For all herbaceous species, application of the herbicide glyphosate to actively growing plants is recommended.

The Lake Tahoe Basin Weed Coordinating Group has not published recommendations for control of cheatgrass, a very problematic and widespread invasive grass in the Tahoe Basin. Very small infestations can be pulled, and repeated mowing or disking has been used to reduce abundance, but also damages desired species. Mechanical treatments need to be applied repeatedly for several years, and may not be effective (Carpenter and Murray 1999). Because cheatgrass begins to grow earlier in the year than most native

perennials, herbicide (such as glyphosate) can often be applied to small actively growing cheatgrass plants in early spring with minimal damage to desired native species (Carpenter and Murray 1999, Wilson et al. 2006).

4.7.3.4 Replacement Plantings and Reseedings

Replacement plantings and reseedings were a requirement at only five sites. At least two of these five sites have needed replacement plantings (which were installed in late summer/early fall). This suggests that replacement plantings would be beneficial at many other revegetation sites as well.

4.8 Monitoring

In general, to monitor an ecosystem is to observe the state of an ecosystem. The observations range from rapid assessments that involve little or no equipment to labor-intensive measurements that can involve complex techniques and equipment. Typically, monitoring is done to inform decisions, such as the decision to implement remedial actions or the decision that the project was successful. (In fact, the English word “monitor” is derived from the Latin word “monere,” that means warn or advise.) Thus, monitoring actions should be closely related to a project’s objectives or to managing project implementation. (Project objectives are addressed further in Section 4.9, “Performance and Success Criteria.”) Although observations are also part of experiments, revegetation experiments differ from most revegetation projects in that experiments are carefully designed to test very specific claims (hypotheses or predictions) derived from more general explanations or theories.

Although monitoring does not directly affect plant growth or erosion, it is integral to successful implementation of revegetation projects. This section discusses important considerations for monitoring revegetation projects, recent practices in the Tahoe Basin, and observations regarding the monitoring of Tahoe Basin revegetation projects.

4.8.1 Relationship to Revegetation

The purpose of monitoring can be to document existing or as-built conditions, guide project implementation (including both observations during construction and post-construction), document regulatory compliance, determine project success, and/or inform the design of future projects. Each of these purposes is often considered a different type of monitoring. For example, Newton and Claassen (2003) list four types of monitoring:

(1) baseline monitoring (for determining baseline conditions or conditions of a reference site),

(2) implementation monitoring (for determining if project was constructed as designed),

(3) effectiveness monitoring (for determining if project had the desired effect), and

(4) validation monitoring (for determining if assumptions behind project were valid).

Monitoring is important for successful revegetation, and in general, the lack of monitoring has been associated with the frequent failure of restoration and revegetation efforts (National Research Council 2001, Holl and Cairns 2002). Consequently, foregoing monitoring is often more costly than conducting monitoring.

Well thought out monitoring plans result in more effective monitoring, In general, monitoring plans include the purpose of the monitoring, and to fulfill that purpose, the variables that will be monitored, the protocols for measuring these variables, and the timing, location, and number of measurements. Monitoring plans can be simple (e.g., several statements incorporated into a project's plans and specifications) or complex (e.g., a document describing a complex experimental design).

Monitoring plans may include qualitative observations and/or quantitative measurements. In revegetation monitoring, qualitative observations may include photo monitoring and observations of several factors potentially affecting planting and seeding success and the effectiveness of erosion control: plant vigor, presence of invasive plants, browsing by herbivores, vandalism, and condition of biotechnical treatments and irrigation systems, and evidence of ongoing erosion. Although qualitative observations are important for guiding project implementation and may be necessary for other purposes, quantitative measurements are generally necessary, particularly for evaluating project outcomes.

In revegetation monitoring, quantitative measurements typically consist of counts of plant survival and/or point intercept sampling of plant cover along permanently marked transects. However, a variety of other measurements could be informative including dates of seedling emergence, soil sampling to determine nutrient content and mycorrhizal spore count, and measurements of soil physical conditions (e.g., penetrability). Useful descriptions of protocols for quantitative monitoring of relevant vegetation and soil variables are provided by Elzinga, Salzer, and Willoughby 1998, Newton and Claassen (2003), Drake and Hogan 2009, and NRCS 2010.

The number of measurements of a variable (the number of replicates) is an important consideration because of its relationship to costs and to precision of monitoring results. For revegetation projects, most quantitative measurements involve measuring a variable at one or several locations at a site and using those measurements to characterize the entire site. For example, plant cover along several transects may be used to estimate plant cover of an entire site. The precision of such an estimate is a product of variability across the site and the number of replicates: estimates are less precise with greater heterogeneity, and more precise with more replicates.

Unfortunately, ecosystems have considerable amounts of heterogeneity, and thus, regardless of the rigor of the measurement technique, estimates based on a few replicates may be very imprecise. For example, it would not be unusual for three transects to yield an estimate of plant cover such as 30 ± 20% at a 90% confidence level (in essence, 90% probability of the actual cover being between 10% and 50% cover).

Monitoring should be planned to include enough replicates for sufficient precision, but not an excessive number of replicates that unnecessarily increases costs. Most introductory statistics textbooks provide techniques for determining sufficient numbers of replicates (e.g., Zar 2009, Sokal and Rohlf 1995).

Following monitoring of the revegetation site, a report describing the monitoring results may be prepared (particularly for more complex monitoring plans). The report often includes a list of all participants in the monitoring activities, prints of monitoring photographs, summaries of quantitative data, and recommendations for remedial actions, if necessary.

4.8.2 Recent Practices

For revegetation projects in the Tahoe Basin, monitoring practices have varied widely. For many projects, no formal monitoring was performed (Table 4-13). Other projects have been monitored for 1–5 years following plant and seed installation, including detailed inspections of planting and seeding. This monitoring has mostly been conducted on an annual basis, although in some cases qualitative site assessments were conducted more frequently or monitoring of different variables required multiple site visits in a single year. Recent monitoring practices for revegetation projects include evaluations of the following:

- plant survivorship (individual plant counts);
- plant, mulch, and bare soil cover (percent coverage);
- soil organic matter, total nitrogen, and penetrability;
- infiltration and sediment yield; and
- evidence of runoff and erosion.

For this study, it was observed that some projects were not monitored, and of monitored projects, some were only monitored for conformance to plans and specifications. In contrast, a number of projects received post-installation monitoring of revegetation success criteria. Specific monitoring approaches are summarized in Table 4-13, “Monitoring,” and Table 4-14, “Performance and Success Criteria.”

Monitoring also has been performed to reduce uncertainties regarding revegetation methods. This has been done by incorporating experimental designs into the revegetation project and then monitoring outcomes. Most of these studies have compared, at severely degraded sites, a “full treatment” of soil rehabilitation (loosening soil and incorporating amendments) to representative “surface treatments” that do not loosen soil or incorporate amendments (e.g., Grismer and Hogan 2005, IERS 2009, Grismer et al. 2008). The results of these studies have demonstrated that a “full treatment” of soil rehabilitation results in greater plant cover and infiltration rate, and a smaller runoff rate than representative “surface treatments” for several years after

Table 4-13
Monitoring

Site Name	Period (years)	Frequency (years)	Remedial Measures	Notes
Apalache—Glen Eagles Drive	N	N	None.	EDOT does not monitor; CCC crews wer used, so no contractor warranty.
Apalache—Muskawaki Drive	N	N	None.	EDOT does not monitor; CCC crews wer used, so no contractor warranty.
Apalache—Nattaway Basin	N	N	None.	EDOT does not monitor; CCC crews wer used, so no contractor warranty.
Bay View	1	1	None.	Only 1 year of monitoring; occurred at year 1.
Beaver Street	2	1	Revegetate to the original specified numbers and densities	
Big Springs and Overloo Place	6	1	None	Monitoring was conducted for 5 years of a 6-year-long period. Monitoring included plant, mulch, and bare soil cover; soil organic matter, total nitrogen, and penetrability; and infiltration and sediment yield. Monitoring was not required for compliance.
B-Line Export Pipeline	5	1	Reseed, reamend soil, and/or remulch.	Qualitative ocular surveys; cover sampling (transects); plant survival; photo monitoring. Seeded species are outgrowing the container species.
Brockway Summit	N	N	Soil data, planting techniques, species, etc., will be evaluated before initiating any actions.	
Brockway Water Quality	3	1	Repair of localized failure because of runon from SR 267	Monitoring included plant, mulch, and bare soil cover; soil organic matter, total nitrogen, and penetrability; and infiltration and sediment yield. Monitoring was not required for compliance.
Burton Creek	N	N	None.	
Cattlemans Basin	N	N	None.	
Cave Rock	–	–	–	Specifications were not provided.
Glorene and Eighth	<1	N	Some CCC work in the Tahoe Basin.	Monitoring did occur during initial construction.

Key: N = none
Notes: CCC = California Conservation Corps; EDOT = El Dorado County Department of Transportation

Table 4-13
Monitoring

Site Name	Period (years)	Frequency (years)	Remedial Measures	Notes
Highlands Drive	1	1	None	Monitoring included plant, mulch, and bare soil cover; and soil organic matter, total nitrogen, and penetrability. Monitoring was not required for compliance.
State Route 267 Repair	1	1	None	Monitoring included plant, mulch, and bare soil cover; soil organic matter, total nitrogen, and penetrability; and infiltration and sediment yield. Monitoring was not required for compliance.
Lake Tahoe Park Erosion Control Project	2	1	Revegetate to the original specified numbers and densities.	
Marshall Court	1	1	None.	Observation: after 10 years, plant growth has been very slow.
Marshall Trail at Columbine	1	1	None.	Observation: after 10 years, plant growth has been very slow.
Meyers Bike Trail	1	1	–	
Meyers Erosion Control	N	N	None.	
Park Heights Drive Culvert Repair	N	N	None.	
Pioneer Trail Erosion Control	1	1	None.	
Ponderosa Ranch	2	1	None	Monitoring was conducted pre- and post-treatment.
Sierra Tract Phase 2	2	1	Reseed, reamend soil, and/ or remulch.	
Timberland Erosion Control Project	2	1	Revegetate to the original specified numbers and densities.	
Truckee Bypass, State Route 267	N	N	Topical treatments for failed areas.	
Upper Cutthroat	2	1	Revegetate to the original specified numbers and densities.	

Key: N = none
Notes: CCC = California Conservation Corps; EDOT = El Dorado County Department of Transportation

treatment of severely degraded sites. These experiments have also evaluated the relative performance of several variants of the soil rehabilitation techniques.

Monitoring reports included graphical and tabular summaries of observations and measurements. Several also included statistical analyses of the precision of estimates and/or the significance of differences observed among treatments or species. For the project monitoring reports reviewed, monitoring was conducted on an annual basis for 1–6 years depending on the project. Remedial measures, when conducted, included replacement planting (to the originally planted quantities) and reseeding, and in at least two cases reamending the soil and reapplying mulch.

Collection of Cover Data at Points along a Transect

Penetrometer at Highlands Drive

Soil Pit Exposing Thin Amended Layer at Apalache-Glen Eagles Drive

4.8.3 Observed Outcomes of Revegetation Projects

Site visits and review of monitoring reports did not reveal substantial differences between monitored and nonmonitored projects in vegetation or soil surface conditions, but provided evidence that monitoring contributed to project success. For three of the seven projects for which monitoring reports were available, monitoring identified remedial actions, and these actions were presumably implemented. These remedial measures would not have been implemented without project monitoring (and associated maintenance). Similarly, during 2006 site visits, failure of some component of the revegetation project was observed at 30% of sites. Many of these failures could have been identified by qualitative observations and most could have been corrected, contributing to successful revegetation.

Observations recorded during the reconnaissance survey and measurements made during the roadcut study provide some insight into the value of these techniques for future monitoring:

- Visual estimates of cover and transect-based measurements both had disadvantages: visual estimates of cover were often inaccurate, but even 10 transects provided somewhat imprecise estimates of cover after several hours of labor, while disturbing several hundred square feet of a revegetated slope. This inaccuracy, imprecision, cost, and damage limits the information provided by plant cover estimates.
- Soil density was inversely related to herbaceous plant cover and the cover of exposed soil, and thus, may be useful for effectiveness monitoring.
- The combination of cone penetrometer readings and a small soil pit was very informative regarding the depth and effects of soil treatments for relatively little cost.

(However, cone penetrometer readings will vary with soil moisture, and this relationship must be considered when interpreting penetrometer readings.) The combination of these techniques could be useful for implementation and effectiveness monitoring.

In addition, project monitoring reports document that herbaceous plant cover fluctuates between years in response to climate (e.g., Overlook East monitoring data in IERS 2009), and that evidence of excessive erosion is often only temporarily visible because of the sandy texture of Tahoe Basin soils, removal of dislodged soil, and repair of treatment failures (Hogan, pers. comm., 2010; Drake pers. comm., 2010; Etra, pers. comm. 2010).

4.9 Performance and Success Criteria

Performance and success criteria are logically related to and used to evaluate project outcomes; and thus, are standards for attainment of project goals and objectives, and for fulfillment of regulatory and contractual obligations. These criteria must be based on variables that are feasible to monitor. This section discusses key aspects of performance and success criteria, recent criteria applied in the Tahoe Basin, and observations regarding the criteria of Tahoe Basin revegetation projects.

4.9.1 Relationship to Revegetation

Performance standards or success criteria are related to the goals and objectives of revegetation projects (i.e., revegetation treatments for erosion control projects). Goals are the overall, ideal states that a project is intended to contribute to or achieve. The main goals of revegetation projects are:

- short-term protection of the soil surface from erosion following soil disturbance,
- creation of sustainable soil conditions that retain water and nutrients on-site,
- establishment of self-sustaining vegetation, and
- development of self-sustaining protection of the soil surface by litter and vegetation.

Objectives are the end result of specific actions undertaken to achieve goals (SERI Science & Policy Working Group 2004). Because objectives describe specific conditions, their attainment is verifiable or measureable, and performance standards/success criteria are the specific conditions that indicate that an objective has been attained (e.g., a specific percentage of mulch cover). To support adaptive management of revegetation projects, performance and success criteria should include both standards for a successful outcome and interim standards that determine the need for remedial actions in order to achieve a successful outcome.

Techniques for establishing objectives and performance standards include the use of reference sites, engineering approaches, outcomes of previous projects, and professional judgment.

A common practice in ecological restoration has been to base performance standards on the attributes of natural "reference sites" (SERI Science & Policy Working Group 2004, Holl and Cairns 2002). This approach is particularly useful where natural ecosystems that exist at comparable sites are known to fulfill a project's goals. However, some substantially modified settings may not have natural analogs (e.g., road shoulders in developed settings) or the vegetation of reference sites may not provide desired ecosystem services, or otherwise not meet societal needs; and thus, not meet a project's goals.

Where the use of reference sites is problematic, an engineered approach, such as ecological engineering, may be applied. Ecological engineering focuses on designing sustainable ecosystems to provide valued services to humans (Mitsch and Jorgensen 2004). Engineered ecosystems may differ substantially from natural counterparts to better meet societal needs. Through an engineered approach the objectives and performance criteria are calculated from empirical and mechanistic relationships, which are the basis of the formulas and models of applied science, and then ecosystems are designed to attain the criteria. For example, desired soil strength may be determined and a revegetation treatment designed to meet that objective (among others).

In contrast to both the reference site and engineered approaches, performance standards may be based on the outcomes of previous projects or on professional judgment regarding technical literature and other available information. Compared to reference site or engineered approaches, such performance standards may be more readily developed and related to existing revegetation practices, particularly if they are based on the outcomes of previous projects. However, the relationship to project goals may be more uncertain for performance standards based on the results of previous projects or professional judgment than for performance standards based on reference sites or engineered approaches.

Regardless of their basis, performance standards for revegetation must meet practical requirements in addition to indicating fulfillment of project objectives (and thus presumably project goals). Performance standards must be attainable by feasible treatments and readily documented. Also, performance standards for a construction contract must represent the likely outcomes of satisfactory implementation of the project's plans and specifications–implementers cannot be held accountable for results that the project's plans and specifications are unlikely to provide.

4.9.2 Recent Practices

Some revegetation projects in the Tahoe Basin have not had performance standards/success criteria. Those that have performance standards use several different criteria related to soil and vegetation attributes and evidence of ongoing erosion (Table 4-14). Performance and success criteria included percent plant survival (ranging from 50% to 80%) and percent plant cover (ranging from 20% to 95%). Other performance criteria included observations of the following:

- no significant evidence of rills, gullies, or other erosion;
- a minimum of one tree surviving every 15 feet;

Table 4-14
Performance and Success Criteria

Site Name	Plant Survival (%)	Plant Cover (%)	Other Performance Criteria	Notes
Apalache—Glen Eagles Drive	N	N	None	EDOT does not monitor; CCC crews were used, so no contractor warranty. (Rodent problem at this site.)
Apalache—Muskawaki Drive	N	N	None	EDOT does not monitor; CCC crews were used, so no contractor warranty.
Apalache—Nattaway Basin	N	N	None	EDOT does not monitor; CCC crews were used, so no contractor warranty.
Bay View	N	N	65% survival after Year 1.	
Beaver Street	80	30	No significant evidence of rills, gullies, or other erosion. 100% survival after Year 1.	
Big Springs and Overlook Place	N	N	None	Specific performance criteria were not identified for project. However, post-project conditions were compared to conditions at a reference site, and used to develop performance criteria for future projects.
B-Line Export Pipeline	80	70	No significant evidence of rilling or erosion. 70% coverage by seeded species and mulch (including rock) and 80% shrub survival.	
Brockway Summit	N	95	A minimum of one tree surviving every 15 feet. Stable soil surface. No bare areas larger than 8 feet square.	
Brockway Water Quality	N	95		Specific performance criteria were not identified for project. However, post-project conditions were compared to conditions at a reference site, and used to develop performance criteria for future projects.
Burton Creek	–	–	–	

Key: N = none

Notes: CCC = California Conservation Corps; EDOT = El Dorado County Department of Transportation; psi = pounds per square inch

Table 4-14
Performance and Success Criteria

Site Name	Plant Survival (%)	Plant Cover (%)	Other Performance Criteria	Notes
Cattlemans Basin	–	–	–	Specifications were not provided.
Cave Rock	–	–	–	Specifications were not provided.
Glorene and Eighth	N	N	35% coverage by seeded species and 70% mulch such that there is no significant evidence of rills, gullies, or other evidence of erosion.	
Highlands Drive	N	N	None	Specific performance criteria were not identified for project. However, post-project conditions were compared to conditions at a reference site, and used to develop performance criteria for future projects.
State Route 267 Repair	N	N	None	Specific performance criteria were not identified for project. However, post-project conditions were compared to conditions at reference site, and used to develop performance criteria for future projects.
Lake Tahoe Park Erosion Control Project	80	80	No significant evidence of rills, gullies, or other erosion.	
Marshall Court	N	N	None	Plant sampling; soil core sampling; seedling emergent dates; coverage and plant survivorship; evidence of rills, gullies, or other erosion.
Marshall Trail at Columbine	N	N	None	Plant sampling; soil core sampling; seedling emergent dates; coverage and plant survivorship; evidence of rills, gullies, or other erosion.
Meyers Bike Trail	80	30	No evidence of significant erosions (e.g., no rills or gullies)	
Meyers Erosion Control	–	–	–	

Key: N = none

Notes: CCC = California Conservation Corps; EDOT = El Dorado County Department of Transportation; psi = pounds per square inch

Table 4-14
Performance and Success Criteria

Site Name	Plant Survival (%)	Plant Cover (%)	Other Performance Criteria	Notes
Park Heights Drive Culvert Repair	N	N	None	
Pioneer Trail Erosion Control	–	–	–	
Ponderosa Ranch	N	N	Depth to refusal averaging 12", as measured with a cone penetrometer at 350 psi. At least 95% ground cover, including mulch and vegetative cover, as measured with cover point monitoring. Post-treatment soil organic matter levels initially higher than native reference levels.	
Sierra Tract Phase 2	N	35	70% mulch cover; 90% cover of planted roses; no significant evidence of rills, gullies, or other erosion.	
Timberland Erosion Control Project	80	50	None	Below 50% survivorship after 2 years.
Truckee Bypass, State Route 267	N	N	None	
Upper Cutthroat	50	20	95% mulch cover. Soil compaction, measured by penetrometer, resistance to pressure shall not exceed 400 psi to a depth of 8 inches. No visible signs of erosion. Irrigation soil penetration to 3 inches minimum.	

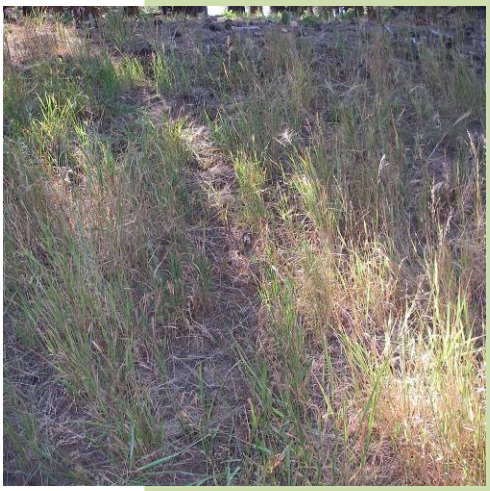
Key: N = none
Notes: CCC = California Conservation Corps; EDOT = El Dorado County Department of Transportation; psi = pounds per square inch

- stable soil surface;
- no bare areas larger than 8 feet square;
- soil compaction, measured by penetrometer; and
- irrigation penetration of soil to 3 inches minimum.

In general, the basis for performance criteria has not been documented in plans and specifications or monitoring reports, but most criteria appear to be based on professional judgment. However, soil conditions at reference sites have been used as a source for performance criteria in some cases.

IERS implemented the projects in Table 4-14 that used reference conditions to develop performance criteria for future projects with similar conditions and designs (IERS 2009). In addition to reference conditions, these performance criteria were based on the monitored results of these restoration projects and experiments conducted in conjunction with them. The criteria represent measureable, outcomes that are likely results of satisfactory implementation of plans and specifications for a "full treatment" of soil rehabilitation and revegetation similar to the treatments evaluated.

Brockway Summit Revegetation Site (Plant Cover 46%)



State Route 267 Repair (Plant Cover 67%)

Marshall Trail at Columbine Revegetation Site (Plant Cover 23%)

4.9.3 Observed Outcomes of Revegetation Projects

Performance and success criteria for revegetation projects in the Tahoe Basin have been related to resistance to erosion, but have generally not been related to the sustainability of vegetation or of protection of the soil surface. For example, in the reconnaissance survey, older sites tended to have less total cover of vegetation and litter, but more cover of shrubs. Because shrubs are important to long-term protection of the soil surface, performance standards for shrub density or cover, and/or of combined cover of woody and perennial plants would better indicate long-term maintenance of vegetation and litter layers than would total plant cover that includes annual, herbaceous perennial, and woody plants. Yet, applied criteria have been based on total plant cover, including annuals that provide less (and more transient) protection of the soil surface.

In addition to not considering the sustainability of vegetation and litter layers, some recently applied performance and success criteria regarding plant cover may not be attainable. Plant cover criteria spanned a wide range, and several were very large percentages—80% to 95%. These percentages exceed the plant cover at all but one of 32 revegetation sites observed during the reconnaissance survey (Appendix A). These sites spanned the range of physical, biological, and cultural conditions and involved multiple implementing agencies, designers, and contractors. Similarly, for sites included in the roadcut survey, estimates of plant cover based on transect data were also less than 80–95% plant cover: four sites had less than 50% total plant cover, and five sites had a total plant cover between 50% and 75% (Table 4-3). Therefore, although some revegetation treatments may transiently attain performance criteria for greater than 70% plant cover, it is unlikely that greater than 70% plant cover can be sustained on most upland sites, and plant cover of 50–70% also may not be sustainable on many upland sites.

This page has been intentionally left blank.

5. Recommendations

Advancing the science and implementation of revegetation in the Tahoe Basin based on observations of recent practices.

5.1 Basis and Scope of Recommendations

This chapter provides recommendations regarding the implementation approach, specific components, performance standards, plans and specifications, and contracting of revegetation projects. These recommendations are based on examination of completed revegetation projects in the Tahoe Basin (and associated plans, specifications, and monitoring reports), insights of local practitioners, and relevant scientific and technical information. Table 5-1 provides a summary of the recommendations, followed by detailed explanations of each recommendation.

These recommendations are intended to improve the success and cost effectiveness of revegetation in the Tahoe Basin. Consequently, recommendations focus on practices that vary or are inconsistently applied, or practices that are typically applied within the Basin and adjacent montane areas, but that may not be as consistently applied in other nearby areas (e.g., the Reno and Sacramento Valley areas). In addition, some recommendations are suggestions for developing, applying, and evaluating different practices. (See Chapter 4, "Revegetation Approaches and Components" for descriptions of necessary or generally successful practices that are consistently applied throughout the greater region.) The emphasis of the recommendations is on upland sites because of the difficulties that the Basin's climate, topography, and soils pose for upland revegetation.

Further, these recommendations reflect extensive peer review efforts conducted during the preparation of this document and summarized in Chapter 6, Peer Review.

Table 5-1
Summary of Recommendations

No.	Recommendation
5.2.1	**Site Evaluation Practices**
1	Funding agencies should require documentation of a site evaluation by qualified environmental professionals, including individuals with CPESC (Certified Professional in Erosion and Sediment Control) certification, of physical, biological, and cultural conditions at the project site and in adjacent areas affecting the project site. The site evaluation should be sufficient for project design and for required environmental reviews.
5.2.2	**Project Design**
1	The Design-Bid-Build approach should be used for implementing revegetation for erosion control projects in the Tahoe Basin.
2	Detailed construction documents (i.e., plans, specifications, and estimates) that incorporate specific measurement and payment/bid form line items should be prepared to preview exactly what will be built for agency approvals to facilitate quality bidding and construction. Appropriate experts should be consulted when preparing construction documents, including but not limited to ecologists, soils scientists, revegetation specialists, CPESC (Certified Professional in Erosion and Sediment Control), and materials suppliers.
3	An independent revegetation contract that includes the plant establishment maintenance period and is separate from any general and/or civil contract for a given project should be used for implementing revegetation for erosion control projects in the Tahoe Basin.
4	The project owner should require, verify, and strictly enforce minimum qualifications for its revegetation contractor and any general and/or civil contractors for the project.
5	The project design team, preferably including an ecologist, should be directly involved during the project implementation, assisting with bidding and overseeing the construction and plant establishment maintenance operations.
6	Specify compaction of upper 6- to 12-inches of soil to a relative density less than 90% or specify no compaction, where public safety would not be compromised and not otherwise necessary.
7	Develop, apply, and evaluate alternative and innovative hard engineering treatments and site design features to create more amenable conditions for revegetation.
5.2.3	**Site and Soil Preparation**
1	Minimize soil disturbance and removal, and maximize stockpiling and reuse topsoil that must be removed, if any.
2	Remove existing invasive plants and other weeds potentially interfering with successful revegetation before preparing the soil.
3	Maximize retention of existing native vegetation, particularly woody plants.
4	Loosen or rip compacted soil to a depth of 6- to 12-inches; and if topsoil is lacking, and nitrogen and organic matter are at less than minimal levels, then incorporate organic matter to a depth of at least 6 inches, where feasible at hydrologically sensitive sites. .

Table 5-1
Summary of Recommendations

No.	Recommendation
5	Remove and store soil in a manner that minimizes the loss of infectivity of mycorrhizal hyphae and spores and the survival and reestablishment of the soil microflora and fauna in general.
6	Minimize use of nonlocal materials and importation of materials from off-site.
7	The use of fertilizers and nutrient-containing amendments should be avoided, or restricted to slow-release fertilizers or compost applied to enhance the establishment of plantings on sites determined to have very little total soil nitrogen.
8	Continue to consider mycorrhizae innocula as an optional amendment.
5.2.4	**Plant Materials**
1	Use plants native to the Tahoe Basin if they will meet project objectives; use plants not native but adapted to the Basin only if native plants will not meet project objectives.
2	Require use of plant materials originating from similar montane vegetation with soils and climate as the project site, and from an elevation within 1,500 feet of the project site elevation; and encourage use of plant materials (including seeds) originating at or near the revegetation site, and/or east of the Sierra Nevada crest.
3	Require seed be free of contamination by seed of invasive species based on the label package and seed analysis report, and that the seed analysis report be provided before seed application.
4	For container-grown plant materials, use small and deep containers.
5	Establish contracts to procure plant materials more than one growing season in advance (whenever feasible) to ensure availability of desired materials.
6	Incorporate a substantial component of nitrogen-fixing plants into revegetation of drastically disturbed sites.
7	Plant materials from containers should not be relied on as the primary or an essential component of revegetation of drastically disturbed sites.
8	Encourage broader use of forb, shrub, and tree species that are abundant in natural vegetation at settings similar to many revegetation sites, but that recently have been used rarely or not at all in revegetation projects.
9	Develop, apply, and evaluate the results of seed mixes with different total densities and/or relatively lesser densities of large-seeded, competitive, grasses.
5.2.5	**Planting and Seeding Techniques**
1	Plant seeds and plants after the site and soil have been prepared and graded, the irrigation system installed, and other site improvements completed; planting should occur in late summer/early fall.
2	Require careful handling and maintenance of plants before planting.
3	Plant seed at densities from 50 to 150 PLS per square foot; and develop, apply, and evaluate the results of seed mixes with smaller proportions of large-seeded, competitive, grasses and applied at a density of 25 to 100 PLS per square foot.

Table 5-1
Summary of Recommendations

No.	Recommendation
4	Develop, apply, and evaluate the results of phased and other alternative approaches to seeding.
5.2.6	**Mulch**
1	Prescribe placing mulch/litter layers 1 inch in depth in seeded areas to balance protection of the soil surface with seed establishment (in locations more than 30 feet from a structure).
2	In the absence of mycorrhizae innocula, place small amounts of soil and litter from relatively undisturbed sites at the base of shrubs planted at drastically disturbed sites.
3	Evaluate the potential value of applying rock-based mulches at problematic revegetation sites.
5.2.7	**Biotechnical and Other Treatments**
1	Minimize use of biotechnical treatments that contain plastic components, particularly non-photodegradable or shorter-lasting components; and at the end of the contract period, remove temporary BMPs that do not rapidly biodegrade.
2	Limit use of willow cuttings and wattles to seeps, stream and channel banks, and other locations with perennially moist soils.
3	Protect treatment areas from disturbance with a combination of signage, designated trails, and shrub, boulder, and structural barriers, particularly along roadsides.
4	Incorporate logs and boulders (where available on-site) into revegetation sites, excluding logs on steep slopes.
5.2.8	**Maintenance**
1	Limit irrigation of planted seed to one season to support reliable, timely establishment of healthy plants that are not dependent on irrigation for their persistence; or do not irrigate planted seed.
2	Water container plants immediately after installation of individual plants, and periodically irrigate (wetting to a depth below the rooting zone) for two growing seasons to facilitate establishment. Irrigation of container plants should be limited to within planting basins.
3	Apply irrigation water at a rate that does not exceed the rate water infiltrates the soil.
4	Irrigate seeded areas to facilitate plant establishment where erosion control depends primarily on rapid revegetation and irrigation is practicable; where erosion control does not depend primarily on rapid revegetation, determine desirability of irrigation on a site-by-site basis. In general, irrigation of seeded areas should be conducted for only 1 growing season following plant installation.
5	Irrigate seeded areas by applying an amount of water sufficient to wet the soil profile to a depth below the rooting zone, wetting to progressively greater depths (from initially 3- to later 10-inches in depth), and allowing progressively greater depletion of soil water (i.e., longer intervals between applications) as plants increase in size.

Table 5-1
Summary of Recommendations

No.	Recommendation
6	During plant establishment, frequently evaluate water application for runoff, soil water depletion, and plant water stress; and adjust location, rate, duration, and frequency as necessary to avoid runoff, desiccation damage, and to wet soil to necessary depths.
7	Winterize irrigation systems during October–March. In the Tahoe Basin, irrigation systems must be winterized, generally in October.
8	Apply and evaluate phased and/or adaptive management approaches to maintaining mulch depth.
9	Eradicate nonnative invasive plants from revegetation sites using chemical or mechanical control methods (e.g., pulling, harrowing, mowing/cutting); restrict chemical control methods to applications by licensed applicators where mechanical methods would be ineffective.
10	Replacement planting and reseeding should occur before the final growing season of a contract.
11	Replacement planting and reseeding should use different plant materials and a modified seed mix, unless failure of a non-plant component of the project is responsible for the mortality of the initial planting and seeding.
12	Implement and evaluate fine-scale vegetation management projects to control invasive plants; and to stabilize, protect, and revegetate patches of eroding or exposed soil at older revegetation sites.
5.2.9	**Monitoring**
1	Funding agencies should require implementation monitoring by qualified environmental professionals, site-specific project objectives, and for some types of objectives quantitative effectiveness monitoring should also be required.
2	Identify in specifications the monitoring results that will trigger specific management actions including the timing of the triggered action.
3	Funding agencies should require, and accessibly archive, documentation of as-built conditions, subsequent monitoring, and related management decisions.
5.2.10	**Performance and Success Criteria**
1	Establish success criteria for all projects, even if not externally funded and no contractor is involved.
2	Use attainable performance standards for woody plants, perennial plant cover, exposed soil surface, and below-ground soil conditions.
3	Establish performance standards for shrub cover greater than 3%, and combined perennial herbaceous and shrub cover of at least 25% to 50% cover on upland sites (and also at least 70% of pre-existing cover), except on sites with substantial tree cover and/or gentler slopes, where less cover could be acceptable because the litter-mulch layer would be sustained primarily by trees.

Table 5-1
Summary of Recommendations

No.	Recommendation
4	Establish performance standards for soil surface conditions as follows: no visible evidence of excessive erosion (i.e., multiple interconnected rills, rocks on pedestals greater than 0.2 inches high, or mounds of soil piled against rocks, large roots, and bases of larger plants), no patches of exposed soil greater than 2 feet in width, and total cover of exposed soil less than 10%.
5	Establish performance standards for below-ground soil conditions that include soil penetrability or bulk density and plant rooting depth as follows: (1) soil must be penetrable (i.e., less than 300 pounds per square inch [psi] required to penetrate) to at least 6 inches deep; or (2) the soil's bulk density at 3- to 6-inches deep must not be greater than comparable native material and not greater than 1.4 grams per cubic centimeter (g cm^{-3})for clay, 1.5 g cm^{-3} for silt loam, 1.65 g cm^{-3} for sandy loam, and 1.75 g cm^{-3} for sand soils; and herbaceous plant rooting depth must be at least 4.5 inches.

5.2 Recommendations Regarding Revegetation Components

5.2.1 Site Evaluation Practices

1. Funding agencies should require documentation of a site evaluation by qualified environmental professionals , including individuals with CPESC (Certified Professional in Erosion and Sediment Control) certification, of physical, biological, and cultural conditions at the project site and in adjacent areas affecting the project site. The site evaluation should be sufficient for project design and for required environmental reviews.

Evaluation of the physical, biological, and cultural conditions at the project site is prerequisite to designing a revegetation project and required for National Environmental Protection Act (NEPA), California Environmental Quality Act (CEQA), and Tahoe Regional Planning Authority (TRPA) environmental review processes. For these reasons, site evaluations in some form are generally conducted. However, historically these evaluations generally have not been documented and archived in a retrievable manner. Loss of this information regarding preproject conditions impedes assessment and improvement of revegetation practices.

Procedures for analyzing existing conditions have been identified by the Storm Water Quality Improvement Committee (Conservancy 2008). These procedures provide a suitable framework for documenting existing site conditions to support project design and required environmental reviews. However, some modifications of the existing procedures would better support site evaluation for revegetation projects. In particular, the "detailed" characterization of vegetation, soil, and soil surface conditions could state the specific conditions that would be documented. For example, it is unclear if shade, or soil penetrability or bulk density would be documented. Also, the qualifications required for personnel conducting the assessments are also not stated (e.g., plant identification skills).

5.2.2 Project Design

1. The Design-Bid-Build approach should be used for implementing revegetation for erosion control projects in the Tahoe Basin.

Owners want to know exactly what will be built before actual project construction and want to receive comparable bids of good value (as discussed in 3.1.1, "Project Delivery Methods"). In addition and in consideration of the low-bid mandate that faces many projects, owners must ensure high quality implementation. The Design-Bid-Build approach facilitates these objectives thereby achieving the project's overall goals and satisfying any regulatory requirements.

One of the biggest challenges to quality revegetation design and implementation is its lesser management status and budgeting compared to the civil work for an erosion control project. This reality can be made more challenging by a Design-Build approach, where the project is often awarded to a large organization whose lead is manager, engineer, or general contractor. With Design-Build, overall budget and schedule efficiency governs work, and for erosion control projects the focus is often on the civil work, which has a greater effect on overall budget and schedule. As a result, revegetation design, installation, and maintenance have a lower priority than with a Design-Bid-Build approach. As a result, the ecological basis of revegetation work is often minimalized. In a Design-Bid-Build approach, revegetation work is often designed by a team led by a landscape architect or ecologist, resulting in the appropriate analysis, evaluation, and design by appropriate experts (e.g., ecologist, soils scientist, botanist). As a result the revegetation work is not treated as an afterthought of the project's engineering design. Although a Design-Build is appropriate for engineering or architectural projects such as bridges and buildings, the Design-Bid-Build is a preferred approach to increase the chances for a successful revegetation implementation for erosion control projects.

2. Detailed construction documents (i.e., plans, specifications, and estimates) that incorporate specific measurement and payment/bid form line items should be prepared to preview exactly what will be built for agency approvals to facilitate quality bidding and construction. Appropriate experts should be consulted when preparing construction documents, including but not limited to ecologists, soils scientists, revegetation specialists, CPESC (Certified Professional in Erosion and Sediment Control), and materials suppliers.

Detailed construction documents facilitate comparative design interpretation during agency review, comparable contractor bidding, and physical construction (as described in 3.3.2, "Construction Documents"). Specific measurement and payment/bid form line items with precise quantities should be prepared to encourage itemized pricing for individual revegetation components that may result in a lower overall bid. When lump sum bids are prescribed, hidden costs may be included, resulting in higher bid and ultimate construction prices. Further, specific measurement and payment/bid form line items allow for flexibility in managing additions or subtractions to the construction efforts during any field design changes or adaptive management efforts.

It is critical that the appropriate experts (e.g., experienced field ecologists, soils scientists, revegetation specialists, CPESC, and materials suppliers) be consulted when preparing the construction documents. These experts play a key role when conducting site evaluations; analyzing soil, biologic, and hydrologic conditions; considering existing vegetation patterns and invasive species; developing plant lists and evaluating plant and seed sources; and determining appropriate revegetation treatments, implementation techniques, and performance standards. For revegetation project success, these efforts are essential for preparing thorough and defendable construction documents.

3. An independent revegetation contract that includes the plant establishment maintenance period and is separate from any general and/or civil contract for a given project should be used for implementing revegetation for erosion control projects in the Tahoe Basin.

For erosion control projects, independent contracts allow for a civil contract addressing earthwork operations (and infiltration) and a landscape contract that addresses planting and maintenance (i.e., revegetation) (as described in 3.3.1, "Turnkey vs. Separate Revegetation Contracts"). In turn, separate bonds are provided for the civil and landscape (revegetation) work and are dependent on the basis of an individual contract duration basis. These independent contracts can increase project efficiency, encourage better landscape (revegetation) contractor qualifications, and improve communication. In this scenario, the owner has full control over contactor selection and management for both the civil and revegetation work. The revegetation contractor communicates directly with the owner and any issue of accountability between contractors is resolved by the owner. With independent contracts, the civil and revegetation work are considered as equal activities, instead of the traditional approach that often places the landscape installation at a lower priority than the civil construction. Additionally, a cost savings can be realized with independent contracts because there are no added fees for managing subcontractors and the general (civil) contractor responsibilities end, and are paid for after, construction is completed; separately, the landscape contractor remains under contract after construction is complete to address plant establishment maintenance. Lastly, with independent contracts, the owner retains increased quality control of revegetation installation and recourse during plant establishment maintenance period.

4. The project owner should require, verify, and strictly enforce minimum qualifications for its revegetation contractor and any general and/or civil contractors for the project.

By requiring minimum qualifications for both general (civil) and revegetation contractor selection the owner can evaluate the best value for contact award based on both bid price and proven experience (as described in 3.3.2, "Contractor Minimum Qualifications"). It is critical that in this process the owner be strict in enforcing any prescribed minimum qualifications requirements and in verifying all submitted qualifications from potential contractors to eliminate any fabricated bid proposals. This verification includes contacting all references submitted as part of potential contractor qualifications and ensuring that the contractor has a field supervisor with proven revegetation experience on site for the duration of the construction and plant establishment maintenance periods. By verifying contractor qualifications (e.g., resumes,

references, project experience) and evaluating the bid (cost) form, the owner can assess whether a contractor is adequately capable of conducting the work required for successful revegetation and plant establishment for erosion control projects.

5. The project design team, preferably including an ecologist, should be directly involved during the project implementation, assisting with bidding and overseeing the construction and plant establishment maintenance operations.

During the project implementation, the owner should take as much control of the revegetation efforts as possible (as described in 3.3.7, "Construction Oversight"). To do this, the owner should enlist assistance from its design team (including a revegetation ecologist) who bring institutional knowledge of the project design and specific details and prescriptions required for the revegetation work. The design team can assist the owner during bidding and construction by facilitating a fair and efficient process for contractor selection and ensuring quality implementation conforming to the final construction documents and environmental permits and agreements. Further, the design team can add value to the owner's efforts by providing review of plant materials, seed mixes, and soil rehabilitation activities, oversight of specific revegetation techniques, and if necessary, providing in-the-field adjustments working with contractor. Even the most seasoned revegetation contractor can benefit from this supervision, as the contractor may not have a senior revegetation specialist on their team. The owner should empower the design team to enforce implementation in direct conformance to the specifications, accept or reject materials, provide detailed field direction, and stop the contractor's work if needed during construction and plant establishment maintenance period. For revegetation projects, field adjustments may be needed to adapt the project design solutions to peculiar site conditions. The design team's institutional and technical project knowledge can facilitate adaptations in the field needed during construction. The design team's hands-on start-to-finish "ownership" of the project process, including design and implementation oversight can contribute to revegetation success for erosion control projects.

6. Specify compaction of upper 6- to 12-inches of soil to a relative density less than 90% or specify no compaction, where public safety would not be compromised and not otherwise necessary.

Soil compaction is regularly specified in engineering designs. This compaction is typically to 90% relative density. However, in practice in the Tahoe Basin, soils appear to be frequently compacted to much greater densities than native topsoil. This reduces infiltration of water and impedes root growth. Specifying lesser compaction of the upper foot of soil could reduce the frequency of this practice.

7. Develop, apply, and evaluate alternative and innovative hard engineering treatments and site design features to create more amenable conditions for revegetation.

On steep, exposed sites, and on road shoulders and other sites experiencing disturbance by pedestrians and vehicles, revegetation has been problematic. Hard engineering treatments and site design features may substantially improve the effectiveness of revegetation by reducing disturbance, increasing retention

of soil, or locally increasing resource availability or decreasing stress. For example, engineering designs and treatments affect slope lengths and angles, drainage, and vehicle access. Therefore, alternative and novel treatments, such as shallow terracing (to increase retention of water, soil, and organic matter), merit application, and evaluation.

5.2.3 Site and Soil Preparation

1. Minimize soil disturbance and removal, and maximize stockpiling and reuse topsoil that must be removed, if any.

Loss of the plant seed, soil biota, organic matter, and nutrients contained in topsoil, and damage to the physical structure of topsoil has greatly complicated revegetation in the Tahoe Basin, reducing success and increasing costs. Therefore, minimize the area disturbed by machinery during construction and revegetation projects and flag and/or fence areas to be avoided. Also, unless deliberately compacting soil, minimize the weight and number of passes of equipment on soil. In loosening compacted topsoil, disturb only to the depth necessary to decompact soil for plant growth. Where excavating and grading will occur, maximize the amount of topsoil stockpiled and reapplied. On linear projects (e.g., road shoulders), space for stockpiling soil is limited, and sufficient space may not be available. Nonetheless, unless prohibitively expensive or otherwise not feasible, soil should be stockpiled and reapplied.

2. Remove existing invasive plants and other weeds potentially interfering with successful revegetation before preparing the soil.

Revegetation projects create excellent conditions (i.e., disturbed, amended, and irrigated soils) for the establishment of invasive plants. Invasive plants are present at many revegetation sites in the Basin, and the spread of invasive species during revegetation is more likely if these species are on-site. In addition, controlling these plants is more difficult when they are more abundant. For these reasons, invasive plants should be removed before soil preparation.

3. Maximize retention of existing native vegetation, particularly woody plants.

Existing vegetation not only already protects the soil surface, but casts shade and produces debris that benefits adjacent areas during revegetation. Retention of woody plants is particularly valuable because woody plants have greater effects on adjacent areas than herbaceous plants, and woody plants have been difficult to establish through revegetation projects in the Tahoe Basin. Revegetation sites varied substantially in amount of retained vegetation; primarily this may be because of differences in the amount of initial vegetation, but documentation of preproject conditions was generally lacking.

4. Loosen or rip compacted soil to a depth of 6- to 12-inches; and if topsoil is lacking, and nitrogen and organic matter are at less than minimal levels, then incorporate organic matter to a depth of at least 6 inches, where feasible at hydrologically sensitive sites.

On sites with compacted and severely degraded soils, loosening soil to a depth of 6- to 12-inches and incorporating organic matter (to maintain loosened conditions) has substantially increased infiltration and supported revegetation

with a high cover of grass on compacted and severely degraded sites. Shallower soil loosening (often without incorporation of coarse organic matter) has been less effective.

However, extensive soil preparation is costly, and itself disturbs the soil. In addition, on steeper slopes, the "fluffy," lesser strength, lighter soil that temporarily results from soil loosening may locally slump. Therefore, on steeper slopes, soil either should not be loosened or should be loosened to an irregular and perhaps shallower depth (e.g., 6 inches rather than 12 inches) to reduce the risk of mass wasting. Also, on sites that hydrologically are not immediately connected to surface water or stormwater systems (e.g., some segments of decommissioned trails or roads), substantially reducing runoff may not be necessary, and revegetation may be successful with less soil disturbance (e.g., shallower or only localized loosening of compacted soils) and/or without incorporating substantial amendments, particularly on less exposed, more mesic sites.

5. Remove and store soil in a manner that minimizes the loss of infectivity of mycorrhizal hyphae and spores and the survival and reestablishment of the soil microflora and fauna in general.

Mycorrhizae and the soil microflora and fauna are important to plant uptake of nutrients, and their abundance can be dramatically reduced by removal of soil or major disturbance of soil. Measures to minimize impacts on the soil microflora and fauna include the following:

- minimizing the time that soil is stockpiled,
- revegetate soil if stockpiled for more than 2 months,
- stockpiling soil in shallow piles with a large ratio of surface area to volume, and
- separate removal and stockpiling of litter and duff.

6. Minimize use of nonlocal materials and importation of materials from off-site.

Importing materials, particularly from outside of the Tahoe Basin, has been increasing impacts to non-soil resources (e.g., increasing impacts to air quality and spreading invasive species) and increasing costs. Therefore, nonlocal inputs to revegetation sites should be minimized by reducing inputs or substituting local sources. The use of pine needles, tub grindings, or wood chips as mulch is an example of using local rather than imported materials.

7. The use of fertilizers and nutrient-containing amendments should be avoided, or restricted to slow-release fertilizers or compost applied to enhance the establishment of plantings on sites determined to have very little total soil nitrogen.

If increasing the total amount of nitrogen in the soil, use organic matter that contains nitrogen but releases it slowly during decomposition because it is more effective over the long term and has fewer adverse effects. In general, current practices in the Tahoe Basin are consistent with this recommendation, except that nutrient inputs from slow-release fertilizer and compost have been large and may not have been based on testing of preexisting nutrient levels.

8. Continue to consider mycorrhizae innocula as an optional amendment.

No strong evidence exists for the need to apply mycorrhizae innocula to small revegetation sites. Also, no strong evidence shows that the application of mycorrhizae innocula results in any lasting harm to plants or soil flora and fauna. Therefore, application of mycorrhizae innocula should continue to be an optional amendment. Because its cost is small relative to the total cost of a revegetation project, some implementers and funders consider it to be a relatively inexpensive insurance policy.

5.2.4 Plant Materials

1. Use plants native to the Tahoe Basin if they will meet project objectives; use plants not native but adapted to the Basin only if native plants will not meet project objectives.

Do not select plants for revegetation projects in the Tahoe Basin simply because they can grow in the region. Rather, select plant materials based on project goals and site characteristics. In general, use native species for both aesthetic and ecological reasons. Typically, local sources of native species establish, grow, and continue to survive better than nonnatives (Petersen, Roundy, and Bryant 2004); however, there are exceptions. For example, invasive nonnative plants are able to grow, establish, and survive better than native species in many settings.

Some adapted nonnative species have been used for revegetation in the Tahoe Basin: birdsfoot trefoil (*Lotus corniculatus*), pubescent wheatgrass (*Thinopyrum intermedium* [formerly *Elytrigia intermedia*]), and hard fescue (*Festuca trachyphylla*) (Table 4-5). These nonnatives have probably been used because of their availability and known effectiveness for (at least temporary) erosion control. Nonetheless, there is usually some uncertainty regarding the ability of a nonnative to invade adjacent natural vegetation, and thus, nonnative plants should be avoided unless native species will not meet project objectives. An instance where native species may not meet project objectives is the revegetation of dry, exposed, roadside sites, which have been problematic to revegetate, and adapted nonnative grasses have been among the most persistent species. Also, the compact growth form of some adapted nonnative grasses may be more aesthetically pleasing in developed areas, because of the closer resemblance to lawn and ornamental grasses than most native grasses.

2. Require use of plant materials originating from similar montane vegetation with soils and climate to the project site, and from an elevation within 1,500 feet of the project site elevation; and encourage use of plant materials (including seeds) originating at or near the revegetation site and/or east of the Sierra Nevada crest.

Natural vegetation growing under conditions comparable to a site is more likely to provide plant materials suitable for sustained revegetation. Therefore, plant materials originating from sites in the Tahoe Basin, or outside of the Basin but from sites with similar montane vegetation and soil, east of the Sierra's crest at comparable elevations (e.g., within 1,500 feet in elevation), and within the general region, are likely to be more suitable for sustained revegetation in the Basin.

3. Require seed be free of contamination by seed of invasive species based on the label package and seed analysis report, and that the seed analysis report be provided before seed application.

At observed sites, invasive species were more frequent and abundant than in adjacent vegetation. Plant materials may be an important vector for introducing or spreading invasive species. Requiring that seed materials be free of invasive species that are problematic in the Tahoe Basin (based on the label package and seed analysis report) is feasible and would substantially reduce this vector for introduction and spread. As described in Section 4.3, "Plant Materials," demonstrating that seed materials are free of invasive plant seed requires information from the seed analysis report(s). Application of contaminated seed can be avoided if the report is obtained before acceptance and application of seed materials. A list of the nonnative, invasive plant species of concern in the Tahoe Basin is maintained by the Lake Tahoe Basin Weeds Coordinating Group (LTWCG 2007). (See Section 4.7, "Maintenance.") The failure to detect invasive species during seed analysis does not ensure that analyzed seed materials are entirely free of invasive species, but does ensure that the materials contain no more than very minute amounts of invasive species seed.

4. For container-grown plant materials, use small and deep containers.

Plants grown in relatively small and deep containers (e.g., Deepot [2-inch diameter X 7-inch deep], Treepot4 [4-inch square X 14-inch deep]) have proven very useful on difficult sites. However, relatively few species are grown in deep tubes, which are often most suitable for plantings under difficult conditions. Plants in larger containers substantially increase purchase and planting costs. Survival is frequently reduced because of limited root systems in relation to size of the tops of the plants.

5. Establish contracts to procure plant materials more than one growing season in advance (whenever feasible) to ensure availability of desired materials.

Substitutions for unavailable plant materials have frequently occurred, and less frequent substitutions would be beneficial. To obtain desired plant materials, procurement contracts may have to be made for as long as 18- to 24-months before planned planting dates, because many species do not set a reliable seed crop every year, may not have been grown in desired container types, or otherwise may not be available.

6. Incorporate a substantial component of nitrogen-fixing plants into revegetation of drastically disturbed sites.

Nitrogen-fixing plants could be used to a greater extent in revegetation projects in the Tahoe Basin. Plant growth on many revegetation sites in the Tahoe Basin is probably limited by nitrogen availability (Claassen and Hogan 2002; Appendix A). If they are abundant, nitrogen-fixing plants can add substantial amounts of nitrogen to the vegetation and soil of a site (Marrs 2002). Yet, in revegetation projects in the Basin, nitrogen-fixing plants have not been a primary component of seed mixes and container plantings. Therefore, additional use should be made of seeding mixes and/or plantings that supports greater establishment of lupines and other nitrogen-fixing forbs, and nitrogen-fixing shrubs. For example, instead of using seed mixes that lack lupines or apply lupines at a rate that correspond to one PLS every 2–5 square feet, seed mixes could consistently

include lupine species applied at a rate of 2–3 PLS per square foot (which would roughly correspond to application of 1–9 pounds bulk seed per acre, depending largely on species).

7. Plant materials from containers should not be relied on as the primary or an essential component of revegetation of drastically disturbed sites.

Many container plantings at revegetation sites in the Tahoe Basin have died soon after the maintenance period, or have produced relatively little new growth and apparently did not measurably increase in size since planting. This has been most pronounced on exposed drier sites. More careful handling, and refinements to transplanting and maintenance practices may increase the establishment and growth of transplants. Nonetheless, until growth and survival of transplants is more successful, plant materials from containers should not be relied on as the primary or essential component of revegetation of drastically disturbed sites.

8. Encourage broader use of forb, shrub, and tree species that are abundant in natural vegetation at settings similar to many revegetation sites, but recently have been used rarely or not at all in revegetation projects.

Several species that are abundant in natural vegetation at settings similar to many revegetation sites (e.g., steep, exposed slopes) are used rarely or not at all by revegetation projects in the Tahoe Basin. These species include:

- spreading dogbane (*Apocynum andrasaemifolium*),
- California fuschia (*Epilobium canum* ssp. *latifolium*),
- mountain pennyroyal (*Monardella odoratissima* ssp. *pallida*),
- curl-leaf mountain mahogany (*Cercocarpus ledifolius*), and
- mountain mule ears (*Wyethia mollis*).

Each of these species grows in the Tahoe Basin and has been grown horticulturally. For example, curl-leaf mountain mahogany (*Cercocarpus ledifolius*) occurs on dry slopes in the Tahoe Basin, and the closely related mountain mahogany *Cercocarpus montanus* is one of the most widely used shrub species in mine reclamation in the intermontane west (Paschke, Redente, and Brown 2003). Thus, curl-leaf mountain mahogany may be a particularly useful species for revegetation projects. Species that are abundant in settings similar to revegetation sites may be valuable for sustained revegetation, and greater use of more of these species would allow their value to be determined.

9. Develop, apply, and evaluate the results of seed mixes with different total densities and/or relatively lesser densities of large-seeded, competitive, grasses.

At most observed revegetation sites, despite seed mixes having contained multiple species of grasses, forbs, and shrubs, the resulting herbaceous vegetation has been dominated by grasses, and relatively few shrubs established from seed. This might be a consequence of the high density of applied grass seed, because competition from grasses is a major impediment to the establishment of many shrubs (Paschke, Redente, and Brown 2003), and interspecific competition is a major factor affecting plant establishment in general. However, other factors (e.g., mulch thickness) also could be affecting

the establishment of shrubs and forbs, and of grass species with smaller seeds. Therefore, developing and applying seed mixes at different densities and with different proportions of grass seed could determine if the density of grass seed is substantially affecting shrub and forb establishment and would refine seed mixes and application rates for revegetation in the Tahoe Basin.

5.2.5 Planting and Seeding Techniques

1. Plant seeds and plants after the site and soil have been prepared and graded, the irrigation system installed, and other site improvements completed; planting should occur in late summer/early fall.

In some instances, disturbance after seeding and planting or undesirable timing of planting and seeding may result in reduced revegetation success. Planting and seeding before all site preparation and improvements are completed (including system installation) would result in undesirable disturbance of installed plants. Although plants can establish well from planting or seeding in spring, the risk of water stress causing reduced establishment is greater, particularly if revegetation is delayed until late spring/early summer. Therefore, late summer/early fall planting is recommended.

2. Require careful handling and maintenance of plants before planting.

Improper handling during shipping, storage, or the holding period on the planting site may be contributing to the frequently unsuccessful establishment and growth of container plants. Plants should be adequately “hardened off” and acclimatized to site conditions; this is particularly critical if the growing nursery is different from the planting site. Procured plants should be acclimated to local site conditions for 2 weeks before actual plant installation. During the holding period and after being moved on-site, plants must be carefully watered and refertilized if necessary. Plants must be thoroughly watered immediately before planting.

3. Plant seed at densities from 50 to 150 PLS per square foot; and develop, apply, and evaluate the results of seed mixes with smaller proportions of large-seeded, competitive, grasses and applied at a density of 25 to 100 PLS per square foot.

In the Tahoe Basin, revegetation projects have applied seed at a wide range of densities (see Table 4-8). The greater densities (greater than 150 PLS) substantially exceed general recommendations (even for small-seeded species), and at these densities are likely reducing the growth and vigor of all plants, the establishment of shrubs and forbs from seed, and the resulting vegetation’s diversity. The intermediate densities of seed previously applied (100 to 150 PLS per square foot) are also greater than generally recommended densities, and also may be resulting in reduced plant vigor and diversity than less dense applications, but these adverse effects should be less than at greater densities. The less dense applications of seed (50 to 100 PLS per square foot) are within the range of general recommendations. Seed has not been as widely applied in the Basin at these lesser densities, but they may result in establishment of more vigorous plants and more diverse vegetation. Thus, they merit greater application, and their composition and effectiveness merits further evaluation.

4. Develop, apply, and evaluate the results of phased and other alternative approaches to seeding.

At many sites observed during the reconnaissance survey and the more detailed survey of roadcuts, herbaceous plants and shrubs covered less than two-thirds of the site several years after seeding and planting. Furthermore, at most sites, forb and shrub establishment from seed was very limited. Therefore, a more complete cover of plants might be established by applying seeds in two phases (initially and in a subsequent year) or using multiple seed mixes or multiple planting techniques on a site. Furthermore, a number of species for which container plantings have been used might be more effectively established from seed. (Pretreatment of these seeds to break dormancy, or careful handling of seed to maintain viability, may be necessary, but the cost of such seed treatments probably would not exceed the cost of container plantings.)

5.2.6 Mulch Recommendations

1. Prescribe placing mulch/litter layers 1 inch in depth in seeded areas to balance protection of the soil surface with seed establishment (in locations more than 30 feet from a structure).

The depth of applied mulch affects both the establishment of plants from seed and the duration of the protection of the soil surface provided by the applied mulch. With increasing mulch thickness, the establishment of seed is increasingly impeded. At several revegetation sites visited in 2006, mulch layers were 2–4 inches thick and probably had reduced emergence of plant seedlings through the mulch layer. Such thick mulch applications should be avoided if revegetation depends on plants establishing from seed.

In contrast, thin layers of applied mulch (i.e., less than 1 inch) protect the soil surface for fewer years. As mulch redistributes, fragments, and decomposes; progressively more of the soil surface is exposed, unless inputs of plant litter are sufficient to sustain the mulch/litter layer. For thicker layers, and for larger, woodier materials, exposure of the soil surface progresses more slowly. At sites visited in 2006, mulch layers were frequently thin (i.e., less than 0.5 inch) and discontinuous (i.e., less than 50% cover). These observations were supported by the roadcut data collected in 2007 and 2008. Thus, applying thicker layers of mulch (particularly of larger, woody material) would slow exposure of the soil surface; and as a consequence, reduce erosion for several years.

Because the 1- to 2-inch-deep range in mulch thickness corresponds to a substantial range of effects on seedling establishment and protection of the soil surface, the prescribed depth within this range should be based on site-specific conditions (e.g., thinner on mesic sites with gentler slopes). However, for seeded areas, mulch depth generally should not exceed 1 inch in depth initially. Phased or adaptive management applications of mulch and/or of plant seed could be beneficial in providing additional protection of the soil surface without impeding plant establishment. (See Recommendation 3 in Section 5.2.5, “Planting and Seeding Techniques,” and Recommendation 8 in Section 5.2.8, “Maintenance.”)

2. In the absence of mycorrhizae innocula, place small amounts of soil and litter from relatively undisturbed sites at the base of shrubs planted at drastically disturbed sites.

The placement of small amounts of "live" (as opposed to stockpiled) topsoil from adjacent sites at the base of planted shrubs has been suggested as a means of inoculating shrubs with mycorrhizal fungi and nitrogen-fixing bacteria (Paschke, Redente, and Brown 2003). Recently removed topsoil is an effective source of inoculum (Rowe, Brown, and Claassen 2007), and it is generally available from adjacent or nearby sites. Therefore, the collection and placement of small amounts of topsoil in conjunction with planting and seeding probably would increase mycorrhizal infectivity. This practice merits implementation on a trial basis.

3. Evaluate the potential value of applying rock-based mulches at problematic revegetation sites.

On some sites, it may only be feasible to maintain a sparse cover of plants, and a large portion of the soil surface may remain exposed. At such sites, rock-based mulches (as applied in mine reclamation) may provide additional protection of the soil surface. The potential use of rock mulches for controlling erosion should be evaluated for Tahoe Basin sites that are difficult to revegetate.

5.2.7 Biotechnical and Other Treatments

1. Minimize use of biotechnical treatments that contain plastic components, particularly non-photodegradable or shorter-lasting components; and at the end of the contract period, remove temporary BMPs that do not rapidly biodegrade.

Biotechnical treatments are intended to provide temporary to short-term erosion control, or to be sustainable features of the site. In contrast, plastic components are persistent and non-sustainable. Thus, temporary BMPs (both biotechnical and others) that have persistent components should be removed at the end of the contract period.

2. Limit use of willow cuttings and wattles to seeps, stream and channel banks, and other locations with perennially moist soils.

Some failures of willow wattles were observed at revegetation sites; these failures were at locations that did not have perennially moist soil. Willow cuttings and wattles are damaged or killed by desiccation, and thus, should only be used at sites with soils that are moist year-round.

3. Protect treatment areas from disturbance with a combination of signage, designated trails, and shrub, boulder, and structural barriers, particularly along roadsides.

Vehicle and pedestrian damage to plants and soil is widespread at roadside revegetation sites and is an impediment to successful revegetation. Barriers (e.g., boulders, fences, shrub "hedges") can eliminate vehicle disturbance and reduce pedestrian disturbance. Signage and provision of relocated access are also important considerations for protecting revegetation areas from disturbance. Tool 15 of the *Sediment Source Control Handbook* (Hogan and Drake 2009) discusses this topic in detail.

4. Incorporate logs and boulders (where available on-site) into revegetation sites, excluding logs on steep slopes.

Logs and boulders incorporated into revegetation projects have increased diversity of physical conditions affecting plant establishment, disconnected paths of overland flow, and reduced the visual contrast between revegetation sites and surrounding natural vegetation. However, on steep slopes logs can move downslope, and on many sites (e.g., roadsides) this can be a safety hazard.

5.2.8 Maintenance

1. Limit irrigation of planted seed to one season to support reliable, timely establishment of healthy plants that are not dependent on irrigation for their persistence; or do not irrigate planted seed.

Irrigation and watering applications should be conducted to rapidly and reliably establish healthy, persistent plants that are not irrigation dependent. Therefore, water should be applied in a way that facilitates seedling establishment, and initial survival and establishment of plantings, and then prompts plants to develop root and shoot systems that can be sustained solely on precipitation and groundwater. Most irrigated revegetation projects follow this general approach in the Tahoe Basin, but irrigation practices may be contributing to the difficulty of establishing container plants and some seeded plants, and so this approach should be required.

2. Water container plants immediately after installation of individual plants, and periodically irrigate (wetting to a depth below the rooting zone) for two growing seasons to facilitate establishment. Irrigation of container plants should be limited to within planting basins.

Initially, container plants are entirely dependent on irrigation and are prone to desiccation immediately following planting. To develop root systems that will sustain the plant, irrigation that wets soil beyond and deeper than the planting hole is required more than once during the growing season. Because irrigation practices may be contributing to the difficulty of establishing container plants in the Tahoe Basin, this practice should be required.

3. Apply irrigation water at a rate that does not exceed the rate water infiltrates the soil.

Irrigation water that is applied more rapidly than it infiltrates the soil can runoff, and erode soil. Irrigation caused erosion was observed at several revegetation sites, and hand and truck irrigation can easily be applied too rapidly. Irrigation practices should avoid such rapid application of water.

4. Irrigate seeded areas to facilitate plant establishment where erosion control depends primarily on rapid revegetation and irrigation is practicable; where erosion control does not depend primarily on rapid revegetation, determine desirability of irrigation on a site-by-site basis. In general, irrigation of seeded areas should be conducted for only 1 growing season following plant installation.

In the Tahoe Basin, irrigation supports rapid and reliable revegetation from seed. Therefore, although irrigation is not always necessary, seeded areas

should be irrigated where erosion control depends on rapid revegetation from applied seed and irrigation is practicable (e.g., in basins where storm water would scour exposed soil).

5. Irrigate seeded areas by applying an amount of water sufficient to wet the soil profile to a depth below the rooting zone, wetting to progressively greater depths (from initially 3- to later 10-inches in depth), and allowing progressively greater depletion of soil water (i.e., longer intervals between applications) as plants increase in size.

Initially, maintaining a moist soil surface facilitates seedling establishment. Subsequently, the depth of soil wetting strongly influences root system development. This practice will prompt plants to develop root and shoot systems that can be sustained solely on precipitation and groundwater.

6. During plant establishment, frequently evaluate water applications for runoff, soil water depletion, and plant water stress; and adjust location, rate, duration, and frequency as necessary to avoid runoff, desiccation damage, and to wet soil to necessary depths.

Weather and local site conditions affect water infiltration, storage, and use. During plant establishment, plants are relying on a smaller volume of soil for water and are more prone to desiccation damage. This vulnerability diminishes with growth. Therefore, during plant establishment, frequent evaluation of water distribution and storage of water in the soil is necessary to adjust water applications to appropriate amounts at appropriate intervals. Section 4.7.1.1, "Irrigation," provides general guidance regarding a simple assessment of water stored in soil. Additional guidance is provided in the *Sediment Source Control Handbook* (Hogan and Drake 2009).

7. Winterize irrigation systems during October–March. In the Tahoe Basin, irrigation systems must be winterized, generally in October.

Winterization eliminates water from pipes and other equipment to minimize damage from subfreezing temperatures. (An air compressor is used to force water out of the system.)

8. Apply and evaluate phased and/or adaptive management approaches to maintaining mulch depth.

At Tahoe Basin revegetation sites, thick layers of applied mulch may be reducing establishment of plants from seed, but at most sites, the mulch layer also becomes thin and discontinuous within several years (see Section 4.5, "Mulch," and the discussion of Northstar and Heavenly plots on Page 9 of Grismer et al. 2008). Multiple applications of mulch, through either a phased or an adaptive management approach, might provide more sustained protection of the soil surface without impairing plant establishment from seed.

9. Eradicate nonnative invasive plants from revegetation sites using chemical or mechanical control methods (e.g., pulling, harrowing, mowing/cutting); restrict chemical control methods to applications by licensed applicators where mechanical methods would be ineffective.

Invasive plants are frequently present at Tahoe Basin revegetation sites, and these plants can impede successful revegetation and spread to nearby sites.

These plants are not consistently being controlled, but should be to enhance restoration success and to support funding agency mandates related to invasive species. Manual removal avoids damaging desired plants more so than most chemical control methods, and can be effective. Therefore, mechanical methods should be applied unless known to be ineffective.

10. Replacement planting and reseeding should occur before the final growing season of a contract.

Replacement planting and reseeding that occurs before the final growing season of a contract could be maintained and its survival determined before completion of the contract. Thus, the success of replacement planting and reseeding that occurs at completion of a contract is less likely to be successful.

11. Replacement planting and reseeding should use different plant materials and a modified seed mix, unless failure of a non-plant component of the project is responsible for the mortality of the initial planting and seeding.

If the selection of planted materials or composition of seed mixes contributed to failure of initial plantings or seedings, then the previously selected plants should not be replanted or reseeded. Rather, plants more likely to establish under the site's conditions should be substituted. This has not been consistently done in the Tahoe Basin.

12. Implement and evaluate fine-scale vegetation management projects to control invasive plants; and to stabilize, protect, and revegetate patches of eroding or exposed soil at older revegetation sites.

Older revegetation sites have extensive areas of exposed soil that are unlikely to become vegetated through natural processes in the near future. Stabilizing these areas (by applying mulch, for example) would reduce erosion and might facilitate colonization by adjacent vegetation, and revegetating these areas would also reduce erosion. Because of their dispersed nature, fine-scale projects would likely cost more per unit of stabilized or revegetated area than projects revegetating larger, contiguous areas. But, fine-scale projects could focus on localized problem spots to provide greater benefits per unit area stabilized or revegetated.

5.2.9 Monitoring

1. Funding agencies should require implementation monitoring by qualified environmental professionals, site-specific project objectives, and for some types of objectives quantitative effectiveness monitoring should also be required.

Monitoring is necessary to document conformance to plans and specifications, to identify the need for remedial actions, and determine attainment of performance/success criteria. Remedial actions may be necessary or desirable for several years, but most necessary actions would be identified within the first 3 years following planting/seeding or replanting/reseeding. When conducted in the Tahoe Basin, monitoring frequently identifies the need for remedial actions. Nonetheless, if not required, monitoring is not always conducted during implementation because of its perceived cost. Even rapid, primarily qualitative monitoring during implementation would identify most types of remedial

actions that might be necessary. However, rapid, qualitative monitoring may not be sufficiently accurate or precise to determine attainment of some success criteria, or for projects with a goal to evaluate and improve practices. In these situations, more costly, quantitative monitoring may be necessary.

Monitoring costs can be minimized by not monitoring every year during the monitoring period or using performance criteria whose attainment does not require the use of costly monitoring techniques to document. For example, soil penetrability could be used to indicate attainment of objectives related to water infiltration rather than rainfall simulation. Also, the cover of plant, mulch, and exposed soil could be estimated visually in most situations during implementation. (Also, estimating cover in quadrat frames would likely improve the reliability of visual cover estimates.) Transect data for more accurate estimates might only be collected to document attainment of success criteria in the final year or in situations where there was disagreement regarding the need for remedial actions. (Appendix G provides protocols both for visually estimating cover and for collecting transect data.)

Funding agencies should require monitoring by qualified environmental professionals (e.g., CPESC-certified individuals) necessary to support and document efficient attainment of the objectives of their programs. However, regulatory and environmental review processes also may identify specific monitoring requirements for compliance with permits and approvals. To avoid essentially redundant monitoring, monitoring requirements developed through environmental review or regulatory processes should substitute for comparable funding agency requirements.

2. Identify in specifications the monitoring results that will trigger specific management actions including the timing of the triggered action.

In many instances, the relationship between monitoring results and the obligation to implement specific actions in response is not explicitly stated, and recommendations based on monitoring results are not always implemented. Explicitly identifying thresholds based on monitoring and the specific actions that would be implemented, will result in more targeted monitoring and increased use of monitoring data.

3. Funding agencies should require, and accessibly archive, documentation of as-built conditions, subsequent monitoring, and related management decisions.

For many revegetation projects in the Tahoe Basin, documentation of as-built conditions, subsequent monitoring, and related management decisions either did not occur or is no longer available. This lack of information impedes evaluations of project success and of revegetation techniques. Unless required by funding agencies, this documentation may not occur in many instances because of efforts to conserve funds.

5.2.10 Performance and Success Criteria

1. Establish success criteria for all projects, even if not externally funded and no contractor is involved.

Success criteria were not established for some revegetation projects in the Tahoe Basin. Success criteria guide project design and implementation, and encourage refinement of techniques for future projects. Thus, they support cost effective and successful revegetation, and should be established for every project.

2. Use attainable performance standards for woody plant abundance, perennial plant cover, exposed soil surface, and below-ground soil conditions.

The abundance of woody plants, extent of plant cover, extent and condition of the exposed soil surface, and below-ground soil conditions (such as rooting depth, penetrability, and bulk density) are a set of site attributes that are cost-effective to measure, indicate if vegetation will be self-sustaining, and are related to the ecological services provided by a revegetation site. These performance standards should be established as follows:

- Performance standards for woody plant abundance (e.g., cover, density, or percent survival) should correspond to woody plants becoming important or dominant components of upland and riparian vegetation with continued growth of established plants; these standards should be project-specific because cover, density, or percent survival corresponding to future importance of woody plants varies considerably with species, type of plant material (i.e., seed, container, cuttings), site conditions, and duration of monitoring.
- Performance standards for plant survival and cover should correspond to successful establishment of vegetation and litter layers that will provide the maximum sustained protection of the soil surface that is feasible at that site.
- Performance standards for the exposed soil surface should correspond to an absence of excessive, on-going erosion, and a limited potential for excessive erosion in the future.
- Performance standards for soil conditions should correspond to water and nutrient availability that will support sustained plant growth and thus maximum sustained protection of the soil surface that is feasible at that site.

The specific performance standards for perennial plant cover, exposed soil surface, and below-ground soil conditions that are incorporated into a construction contract must be attainable. In other words, specific performance standards should represent the likely outcomes of satisfactory implementation of the project's plans and specifications—because implementers cannot be held accountable for results that the project's plans and specifications are unlikely to provide.

3. Establish performance standards for shrub cover greater than 3%, and combined perennial herbaceous and shrub cover of at least 25% to 50% cover on upland sites (and also at least 70% of pre-existing cover), except on sites with substantial tree cover and/or gentler slopes, where less cover could be acceptable because the litter-mulch layer would be sustained primarily by trees.

Plant cover of less than 50% is unlikely to sustain a mulch/litter layer that would protect most of the soil surface from excessive erosion, except on sites with substantial tree cover. Also, the potential for sediment yield from a site decreases substantially with increasing plant cover (e.g., see Figure 3 of Grismer et al. 2008). However, cover much greater than 30–50% may be infeasible, and may be attainable only with less desirable or non-sustainable assemblages of species, and/or be unnecessary to protect the soil surface (e.g., on sites receiving considerable litter input from trees). Therefore, the 30–50% range of values for cover of perennial plants has been recommended for performance standards because it represents the greatest sustainable plant cover currently attainable on most sites within the one to several year duration of a revegetation project.

Visual estimates of plant cover documented by photographs would be the most cost effective approach to estimating cover (and also would not disturb the revegetation site). However, the accuracy of cover estimates based on visual estimates is known to vary considerably among observers and settings (Elzinga et al. 1998). For example, four older road cuts were included in both the reconnaissance and roadcut surveys, and probably did not change substantially in cover during the year intervening between these studies. For two of these four sites, visual estimates of cover from the reconnaissance survey and transect-based estimates from the road cut survey differed substantially, and the visual estimates should be considered inaccurate. However, the cover estimates based on 10 transects had 95% confidence intervals of ± 11–28% for these sites (i.e., for one of these sites the cover estimate was 43±28% cover). These large confidence intervals indicate that attaining a cover estimate sufficiently precise for a performance criterion, would require moderately costly monitoring that would disturb moderate portion of the revegetation site. This example illustrates the limitations of both visual and transect-based cover estimates.

Nonetheless, to document attainment of success criteria for cover, funding agencies and contractors should have recourse to transect-based cover estimates, which although more costly, would be more accurate and precise. Transects should be located randomly on a revegetation site, and the cover of plants, mulch/litter, rock, and exposed soil recorded at regular intervals. In the detailed survey of road cuts (Appendix A), cover data was collected along such transects: at each site, 10 33-foot (10-meter) long transects were randomly located perpendicular to the slope (i.e., along slope contours) by selecting random distances along a baseline and random distances up the slope. A thin metal rod was dropped at approximately 10-inch (25-centimeter) intervals and plants, mulch/litter, rock, and exposed soil touched by the rod was recorded.

Numerous similar protocols have been used in comparable monitoring efforts and could be applied to monitoring revegetation sites (e.g., Elzinga et al. 1998). For monitoring revegetation sites, the most important aspects of a transect-

based protocol are that transects are randomly located, data are recorded separately for two or more transects of the same length, and the protocol is documented.

4. Establish performance standards for soil surface conditions as follows: no visible evidence of excessive erosion (i.e., multiple interconnected rills, rocks on pedestals greater than 0.2 inches high, or mounds of soil piled against rocks, large roots, and bases of larger plants), no patches of exposed soil greater than 2 feet in width, and total cover of exposed soil less than 10%.

Excessive recent or ongoing erosion is evidence that revegetation has not sufficiently increased infiltration and reduced erosion. Wide patches of exposed soil that are wide (and thus unlikely to be covered by plant growth in the near future) or a moderate portion of the site with exposed soil indicates a vulnerability to erosive forces that should have been reduced further by revegetation.

Visible evidence of excessive erosion is often transient, and the occurrence of excessive erosion is more likely under more extreme weather conditions that occur infrequently. Nonetheless, if this evidence is observed, the revegetation treatment has not been successful.

For the reconnaissance survey, a soil erosion rating was developed and applied. It incorporated varied indicators of recent erosion including plant root exposure, rocks on pedestals of soil, mounds of displaced soil, rills, crusted soils, and wash or scour features. It relied extensively, however, on the extent of crusted soils and plant cover. Categories were based on plant cover values that were high for the Tahoe Basin, and some granite-derived soils exhibited little visible crusting of soil, despite considerable erosion evidenced by mounds forming at slope bases. Therefore, this soil erosion rating has been revised, and the revised rating is provided in Appendix G.

5. Establish performance standards for below-ground soil conditions that include soil penetrability or bulk density and plant rooting depth as follows: (1) soil must be penetrable (i.e., less than 300 pounds per square inch [psi] required to penetrate) to at least 6 inches deep; or (2) the soil's bulk density at 3- to 6-inches deep must not be greater than comparable native material and not greater than 1.4 grams per cubic centimeter (g cm^{-3}) for clay, 1.5 g cm^{-3} for silt loam, 1.65 g cm^{-3} for sandy loam, and 1.75 g cm^{-3} for sand soils; and herbaceous plant rooting depth must be at least 4.5 inches.

These criteria are readily measured variables that indicate below-ground conditions that would not impede root growth and infiltration of water in the first 6 inches below the soil surface. Below, these criteria and their measurement are described further:

- Penetrability measures the force required to move an object into soil. It indicates the ability of plant roots to grow through soil and it also provides information regarding infiltration. It is measured with a cone penetrometer, which is not very expensive and requires minimal training to use. The technique for using the penetrometer is standardized and used for a variety of purposes (Lowery and Morrison 2002). In the road cut survey, a penetrometer was oriented vertically and pushed downward into the soil at a rate of about 1.25 inches per second, and the force required to move the

penetrometer through the soil (as psi values) were recorded for the upper 3 inches and then each subsequent 3-inch depth interval to 12 inches.

A limitation of penetrability as an indicator is that penetrability changes substantially with the moisture content of the soil (Lowery and Morrison 2002). (Penetrometers that measure both penetrability and soil moisture content exist but are much more costly.)

- Bulk density is the density of soil (sometimes the mass and volume of coarse fragments is excluded). Bulk density of a given soil texture indicates the ability of plant roots to grow through the soil and also provides information related to infiltration. There are several widely used methods for measuring bulk density. The core method might be most applicable (Grossman and Reinsch 2002). In this method, a cylinder is inserted into the soil and used to remove a known volume of soil; the soil is then dried and weighed. The drying and weighing of the soil requires additional time and equipment that make the measurement of bulk density somewhat more costly and time-consuming than measurements of penetrability, soil shear strength, or plant rooting depth. The variation of bulk density with both soil texture and compaction makes the interpretation of bulk density measurements only somewhat more complicated, because these relationships are well documented.

  In the road cut survey, at each site, bulk density was calculated for soil samples collected at the end of five vegetation transects. A 2-inch-wide by 6-inch-long pipe was hammered into the soil and the soil core extracted from the pipe. After drying the soil, a 2-millimeter sieve was used to extract gravel, and the sieved soil weighed and the volume of the gravel measured by adding it to a graduated cylinder partially filled with water. Bulk density was calculated as the mass of the sieved soil divided by the volume of the soil sample (i.e., pipe volume minus gravel volume).

  Because at most sites in the road cut survey, the upper 1- to 3-inches of soil were more variable and much less compact than lower depths, the density of the soil at 3–6 inches in depth is recommended as a better indicator of the absence of compacted soil in the upper 6 inches of the soil profile. (And, because the less dense upper 3 inches are not included, the recommended density criteria are greater than densities recorded by the roadcut survey.) For calculating the density of the 3- to 6-inch layer, a 3-inch-wide by 3-inch-deep pipe would be more appropriate.

- Rooting depth is the depth to which a minimum density of roots is exceeded; thus, it directly measures the volume of soil accessible to plant roots. A soil auger is used to extract soil samples from progressively greater depths, which is not an expensive or time-consuming procedure, and requires minimal training. A standardized protocol has been used by USFS in the Basin (Weixelman et al. 1997), and the Natural Resources Conservation Service has a standardized terminology for describing root density (Soil Conservation Service 1975).

  In the road cut survey, rooting depth was observed on the surface of the pit created by collecting the soil sample. Rooting depth was the maximum depth where there was at least 1 root (less than 2 millimeters in diameter)

per square centimeter of soil (0.155 square inches) (Soil Conservation Service 1975).

For revegetation projects that include substantial soil rehabilitation, the performance criteria developed by IERS (2009) would be appropriate. These performance criteria are based on reference conditions and the results of revegetation projects based on a “full treatment” of soil rehabilitation. Those criteria differ from those above in not only in some cover percentages and depths to refusal, but also in including total nitrogen and soil organic matter criteria but not bulk density criteria.

6. Peer Review

All disciplines on a revegetation team bring an important expertise to planned, designed, and built projects. Collaboration by biologists, ecologists, and other scientists, as well as erosion and sediment control specialists, landscape architects, engineers, suppliers, and contractors improves project creativity and increases the chances of a quality and functioning sustainable project.

To ensure that this document provides appropriate, applicable, and tangible guidance, peer review was solicited from implementers in the Tahoe Basin. A peer review group provided feedback on the Draft iteration of this document and a Science-Design Series workshop was conducted to gain further input based on the Draft-Final iteration. These peer review efforts are summarized below.

6.1 Peer Review Group

A peer review group with knowledge and experience in revegetation for erosion control design, specifications preparation, construction, and performance monitoring in the Tahoe Basin was established and in February 2010 was solicited to provide constructive feedback on the Draft iteration of the Revegetation Guidance Document.

The peer review group was organized to include organizations as requested by the Conservancy, including the implementing agencies in the Tahoe Basin. Comments were received from the Conservancy, USFS Lake Tahoe Basin Management Unit, Tahoe Regional Planning Agency, State of California Department of Transportation, Placer County Department of Public Works – Tahoe Engineering Division, Western Botanical Services, and Integrated Environmental Restoration Services.

The comments were evaluated, and where appropriate, were addressed in the document. The peer review efforts provided a wide range of feedback on all topics, including minor edits, organizational suggestions, and specific technical input. Where possible the peer review feedback has been synthesized, combining different ideas, perspectives, and experiences into the document. However, this document does not represent consensus among the peer review group. Divergent opinions were further discussed at the Science-Design workshop described below.

6.2 Science-Design Series Workshop

Science – Design Workshop No. 2 – Revegetation Guidance

A one day Science-Design Series workshop was conducted at the Tahoe Regional Planning Agency in June 2010, and presented, discussed, and solicited feedback on the Draft-Final iteration of Revegetation Guidance Document from implementers, agencies, and practitioners. This was the second workshop in The Water Quality Science-Design Series, which began in 2005. The Science-Design Series was developed to promote dialogue between Lake Tahoe's scientific community, project designers, suppliers, contractors, and implementers. There are many water quality issues that both groups are working hard to understand and effectively address to improve Lake Tahoe's water clarity. This second workshop addressed revegetation guidance for erosion control projects based on the Revegetation Guidance Document. The workshop was an interactive working session that shared ideas, questions, and knowledge of design solutions, constraints, and areas for additional research relevant to design needs.

The goals for the workshop included:

- To develop a consistent implementation process to provide cost effective and successful revegetation projects for erosion control; and
- To share the results of the investigation leading to the Draft iteration of the Revegetation Guidance Document and to gain input on ways to identify and fill information gaps to improve the document.

Science – Design Workshop No. 2 – Panel Discussion

Workshop attendees included a full range of individuals who are involved with planning and design implementation for revegetation for erosion control projects including Conservancy staff, representatives from other governing and implementing agencies in the Tahoe Basin, environmental and design consultants, erosion control materials suppliers, and general and revegetation contractors.

The workshop focused on five key topics that affect revegetation for erosion control:

- Regulatory Issues Relating To Revegetation Projects;
- Soil Rehabilitation and Erosion Control Treatments (related to Chapter 2 of this document);
- Revegetation and Erosion Control Treatments (related to Chapter 2 of this document);
- Design Implementation (related to Chapter 3 of this document); and
- Recommendations (related to Chapters 4 and 5 of this document).

Following a brief presentation on the aforementioned topics, each presenter moderated a panel/audience discussion on their topic area with the purpose of soliciting a variety of perspectives and experiences relating to revegetation for erosion control. The discussions for each topic area were documented and brought forward for consideration during preparation of this final iteration of the Revegetation Guidance Document. As appropriate, this document reflects the feedback received from the workshop.

This page has been intentionally left blank.

7. References

Albaladejo Montoro, J., J. Alvarez Rogel, J. Querejta, E. Diaz, and V. Castillo. 2000. Three Hydro-Seeding Revegetation Techniques for Soil Erosion Control on Anthropogenic Steep Slopes. *Land Degradation & Development* 11:315–325.

Allen, M. A., D. A. Jasper, and J. C. Zak. 2002. Micro-organisms. Pages 257–278 in M. R. Perrow and A. J. Davy (eds.), *Handbook of Ecological Restoration, Volume 1: Principles of Restoration*. Cambridge University Press, New York, NY.

Amacher, M. C., and K. P. O'Neill. 2004. Assessing Soil Compaction on Forest Inventory & Analysis Phase 3 Plots Using a Pocket Penetrometer. *Research Paper RMRS-RP-46WWW*. Rocky Mountain Research Station, Forest Service, U.S. Department of Agriculture, Fort Collins, CO.

Amaranthus, M. 2004. Mycorrhizal Applications; Frequently Asked Questions. Available: <http://www.mycorrhizae.com/index.php?cid=2>. Accessed May 2007.

American National Standards Institute, Inc. 2005. Tree, Shrub and Other Woody Plant Maintenance – Standard Practices (Transplanting). *ANSI A300 (Part 6)-2005*. New York, NY.

Andres, P., and J. Monserrat. 2000. Mitigation Strategies in Some Motorway Embankments (Catalonia, Spain). *Restoration Ecology* 8:268–275.

ANSI. *See* American National Standards Institute, Inc.

Barbour, M. G., J. H. Burk, W. D. Pitts, F. S. Gilliam, and M. W. Schwartz. 1999. *Terrestrial Plant Ecology.* Benjamin Cummings, Menlo Park, CA.

Barnes, R. F., D. A. Miller, and C. J. Nelson. 1995. *Forages Volume I: An Introduction to Grassland Agriculture*. Iowa State University Press, Ames, IA.

Beaulieu, D. 2007. What is the Difference between Compost and Mulch? Your Guide to Landscaping. Available: <http://landscaping.about.com/cs/compostandmulch/f/mulch_compost.htm>. Accessed May 2007.

Blanco-Garcia, A., and R. Lindig-Cisneros. 2005. Incorporating Restoration in Sustainable Forestry Management: Using Pine-Bark Mulch to Improve Native Species Establishment on Tephra Deposits. *Restoration Ecology* 13:703–709.

Bochet, E. and P. Garcia-Fayos. 2004. Factors Controlling Vegetation Establishment and Water Erosion on Motorway Slopes in Valencia, Spain. *Restoration Ecology* 12:166–174.

Brandsma, R. T., M. A. Fullen, and T. J. Hocking. 1999. Soil Conditioner Effects on Soil Structure and Erosion. *Journal of Soil and Water Conservation* 54:485–493.

Brofas, G., and C. Varelides. 2000. Hydro-seeding and Mulching for Establishing Vegetation on Mining Spoils in Greece. *Land Degradation & Development* 11:375–382.

Brown, M. R., D. D. Wolf, R. D. Morse, and J. L. Neal. 1983. Viability of *Rhizobium* in Fertilizer Slurries Used in Hydroseeding. *Journal of Environmental Quality* 12:388–390.

Cal Fire. *See* California Department of Forestry and Fire Protection.

California Department of Forestry and Fire Protection. 1987. Tree Seed Zones – Northern California. Available at: http://frap.cdf.ca.gov/ frapgismaps/download.asp. Accessed: May 5, 2010.

California Invasive Plant Council. 2006. *California Invasive Plant Inventory.* California Invasive Plant Council, Berkeley, CA.

California Tahoe Conservancy. 2006*. Lake Tahoe Basin Science Plan: Research Strategies.* Presented at the Tahoe Science Workshop, October 18–20, Tahoe Center for Environmental Sciences, Incline Village, NV.

California Tahoe Conservancy. 2008*. Interim Guidance Paper for Formulating and Evaluating Alternatives, Tahoe Basin Water Quality Improvement Programs*. Prepared by EDAW, Sacramento, CA; Northwest Hydraulic Consultants, Inc., West Sacramento, CA; and Nichols Consulting Engineers, Zephyr Cove, NV. Prepared for California Tahoe Conservancy, South Lake Tahoe, CA.

California Tahoe Conservancy. 2010. Summary Workshop Notes for Science Design Series: Revegetation Guidance for Erosion Control. June 8, 2010, Stateline, NV. Prepared by AECOM, Sacramento, CA. Prepared for Soil Erosion Control Program, California Tahoe Conservancy, South Lake Tahoe, CA.

Cal-IPC. *See* California Invasive Plant Council.

Carpenter, A. T., J. C. Moore, E. F. Redente, and J. C. Stark. 1990. Plant Community Dynamics in a Semi-Arid Ecosystem in Relation to Nutrient Addition Following a Major Disturbance. *Plant and Soil* 126:91–99.

Carpenter, A. T. and T. A. Murray. 1999. *Element Stewardship Abstract:* Bromus Tectorum. The Nature Conservancy. Available at: http://wiki.bugwood.org/Bromus_tectorum. Accessed: May 4, 2010.

Chapin, F. S., P. A. Matson, and H. A. Mooney. 2002. *Principles of Terrestrial Ecosystem Ecology*. Springer-Verlag, New York, NY.

Cecchi, Scott. California Tahoe Conservancy. September 19, 2007—e-mail to John Zanzi of AECOM regarding contractor, CCC crew, and other staff tasks. Scott Cecchi, Project Manager, California Tahoe Conservancy, 1061 Third Street, South Lake Tahoe, California 96150,Phone: (530) 543-6015,Email: scecchi@tahoecons.ca.gov.

Chambers, Claudia J. CSPEC, CISEC, CIT. 2010. Kelley Erosion Control, Reno, NV. June 14, 2010—written comments on draft-final revegetation guidance document provided to John Zanzi, AECOM.

Claassen, V. P., and M. Marler. 1998. Annual and Perennial Grass Growth on Nitrogen-Depleted Decomposed Granite. *Restoration Ecology* 6:175-180.

Claassen, V. P., and M. P. Hogan. 2002. Soil Nitrogen Pools Associated with Revegetation of Disturbed Sites in the Lake Tahoe Area. *Restoration Ecology* 10:195–203.

Cobourn, J., B. Carlos, J. Christopherson, S. Donaldson, W. Johnson, R. Post, J. Skelly and E. Smith. 2006. *Home Landscaping Guide for Lake Tahoe and Vicinity*. Cooperative Extension, University of Nevada, Reno, NV.

Cornforth, B., L. St. John, and D. Ogle. 2001. Seed Production for Conservation Plants in the Intermountain West. *Technical Note Plant Materials No. 14*. USDA-Natural Resources Conservation Service, Boise, ID.

Cotts, N. R., E. F. Redente, and R. Schiller. 1991. Restoration Methods for Abandoned Roads at Lower Elevations in Grand Teton National Park, Wyoming. *Arid Soil Research and Rehabilitation* 5:235–249. Cited in Paschke, Redente, and Brown 2003.

Design-Build Institute of America. 2009. What is Design-Build? Available: <http://www.dbia.org/about/designbuild/>. Accessed December 4, 2009.

Design-Build Institute of America, Design-Build Conference. 1998 (May 20–21). Conference in Tempe, AZ.

Donaldson, S. 2004. *Invasive Weeds of the Lake Tahoe Basin.* Publication EB-04-05, University of Nevada Cooperative Extension, Reno, NV.

Drake, Kevin. 2010. Environmental Scientist. Integrated Environmental Restoration Services, Tahoe City, CA. April 1, 2010—written comments on draft revegetation guidance document provided to John Zanzi, AECOM.

Drake, Kevin. 2010. Environmental Scientist. Integrated Environmental Restoration Services, Tahoe City, CA. June 15, 2010—written comments from revegetation guidance workshop provided to John Zanzi, AECOM.

Ellison, L. 1949. Establishment of Vegetation on Depleted Subalpine Range as Influenced by Microenvironment. *Ecological Monographs* 19:95–121.

Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. 1998. *Measuring & Monitoring Plant Populations.* Technical Reference 1730-1. National Business Center, U.S. Bureau of Land Management, Denver, CO.

Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. 1998. *Measuring and Monitoring Plant Populations*. *BLM Technical Reference 1730-1*. California State Office, Bureau of Land Management, Sacramento, CA.

Etra, Julie. 2010. Proprietor. Western Botanical Services, Reno, NV. March 8, 2010—written comments on draft revegetation guidance document provided to John Zanzi, AECOM.

Etra, Julie. 2010. Proprietor. Western Botanical Services, Reno, NV. June 11, 2010—written comments on draft-final revegetation guidance document provided to John Zanzi, AECOM.

Ewing, K. 2002. Effects of Initial Site Treatment on Early Growth and Three-Year Survival of Idaho Fescue. *Restoration Ecology* 10:282–288.

Ferry, Brendan. Senior Planner. El Dorado County Dept. of Transportation, Tahoe Engineering Division, South Lake Tahoe, CA. January 11, 2010 – email correspondence with John Zanzi at AECOM regarding contracting and use of California Conservation Corps crews for revegetation projects.

Fransen, P. J. B., C. J. Phillips, and B. D. Fahey. 2001. Forest Road Erosion in New Zealand: Overview. *Earth Surface Processes and Landforms* 26:165–174.

Fredlund, D. G., and S. K. Vanapalli. 2002. Shear Strength of Unsaturated Soils. Pages 329–362 in J. H. Dane and G. C. Topp (eds.) *Methods of Soil Analysis, Part 4 Physical Methods*. Number 5 in the Soil Science Society of America Book Series. Soil Science Society of America, Inc., Madison, WI.

Frenkel, R. E. 1970. Ruderal Vegetation along Some California Roadsides. *University of California Publications in Geography*, Volume 20. University of California Press, Berkeley, CA.

Garcia-Fayos, P., B. Garcia-Ventoso, and A. Cerda. 2000. Limitations to Plant Establishment on Eroded Slopes in Southeastern Spain. *Journal of Vegetation Science* 11:77–86.

Gilpin, D. 2004. *California Native Grasses, Erosion Control and Land Restoration*. University of California, Davis University Extension, Davis, CA.

Goldman, S., J. Etra, A. Howald, and A. Leiser. 2005. *Erosion Control and Land Restoration*. University of California, Davis University Extension, Davis, CA.

Goldman, S. J., K. Jackson, and T. A. Bursztynsky. 1986. *Erosion and Sediment Control Handbook*. McGraw-Hill, New York, NY.

Grace, J. M., B. Rummer, B. J. Stokes, and J. Wilhoit. 1998. Evaluation of Erosion Control Techniques on Forest Roads. *Transactions of the American Society of Agricultural Engineers* 41:383–391.

Grant, C. D., D. T. Bell, J. M. Koch, and W. A. Loneragan. 1996. Implications of Seedling Emergence to Site Restoration Following Bauxite Mining in Western Australia. *Restoration Ecology* 4:146–154.

Grismer, M. E., and A. L. Ellis. 2006. Erosion Control Reduces Fine Particles in Runoff to Lake Tahoe. *California Agriculture* 60:72–76.

Grismer, M. E., and M. P. Hogan. 2004. Simulated Rainfall Evaluation of Revegetation/Mulch Erosion Control in the Lake Tahoe Basin—1: Method Assessment. *Land Degradation & Development* 15:573–588.

———. 2005a. Simulated Rainfall Evaluation of Revegetation/Mulch Erosion Control in the Lake Tahoe Basin—3. Soil Treatment Effects. *Land Degradation & Development* 16:498–501.

———. 2005b. Simulated Rainfall Evaluation of Revegetation/Mulch Erosion Control in the Lake Tahoe Basin—2. Bare Soil Assessment. *Land Degradation & Development* 16:397–404.

Grismer, M. E., C. Schnurrenberger, R. Arst, and M. P. Hogan. 2008. Integrated Monitoring and Assessment of Soil Restoration Treatments in the Lake Tahoe Basin. *Environmental Monitoring and Assessment*. DOI 10.1007/s10661-008-0236-3.

———. 2009. *Monitoring and Assessment of the Erosion Control Treatments in and around the Lake Tahoe Basin 2008 Summary Report*. Prepared for CalTrans, Sacramento, CA. Prepared by Integrated Environmental Restoration Services, Tahoe City, CA.

Grossman, R. B., and T. G. Reinsch. 2002. Bulk Density and Extensibility. Pages 201–228 in J. H. Dane and G. C. Topp (eds.) *Methods of Soil Analysis Part 4, Physical Methods*. Number 5 in the Soil Science Society of America Book Series. Soil Science Society of America, Inc., Madison, WI.

Hamza, M. A., and W. K. Anderson. 2005. Soil Compaction in Cropping Systems: A Review of the Nature, Causes and Possible Solutions. *Soil & Tillage Research* 82:121–145.

Hanson, B., L. Schwankl, and A. Fulton. 2004. Scheduling Irrigations: When and How Much Water to Apply. *Division of Agricultural and Natural Resources Publication 3396.* University of California Irrigation Program, University of California, Davis, CA.

Harris, R.W., J. R. Clark, and N. P. Matheny. 2004. *Arboriculture: Integrated Management of Landscape Trees, Shrubs, and Vines*. Prentice Hall, Englewood Cliffs, NJ.

Harris, R. W., and A. T. Leiser. 1979. *Direct Seeding of Woody Plants in the Landscape.* Leaflet 2577e. Division of Agricultural Sciences, University of California, Oakland, CA.

Hillel, D. 1982. *Introduction to Soil Physics*. Academic Press, San Diego, CA.

Hoag, J. C., L. St. John, and D. G. Ogle. 2001. Reading Seed Packaging Labels and Calculating Seed Mixtures. *Technical Note Plant Materials No. 4*. USDA-Natural Resources Conservation Service, Boise, ID.

Hogan, M. P. 2005. *The Sediment Source Control Handbook*. Prepared for Sierra Business Council, Truckee, CA. Prepared by Integrated Environmental Restoration Services, Tahoe City, CA.

Hogan, Michael. 2010. Proprietor. Integrated Environmental Restoration Services, Tahoe City, CA. April 1, 2010—written comments on draft revegetation guidance document provided to John Zanzi, AECOM.

Hogan, M. and K. Drake. 2009. *Sediment Source Control Handbook: an Adaptive Approach to Restoration of Disturbed Areas.* Sierra Business Council, Truckee, CA. Available: <http://www.sbcouncil.org/Publications>. Accessed January 26, 2010.

Holl, K. D., and J. Cairns, Jr. 2002. Monitoring and Appraisal. Pages 411–432 in M. R. Perrow and A. J. Davy (eds.) *Handbook of Ecological Restoration Volume 1: Principles of Restoration*. Cambridge University Press, New York, NY.

Holmstead, G. L., and D. C. Anderson. 1998. Reestablishment of *Eriastrum hooveri* (Polemoniaceae) Following Oil Field Disturbance Activities. *Madrono* 45:295–300.

International Society of Arboriculture. 2001. *Arborists' Certification Study Guide*. International Society of Arboriculture, Champaign, IL.

ISA. *See* International Society of Arboriculture.

Iverson, L. R., and M. K. Wali. 1982. Buried Viable Seeds and Their Relation to Revegetation After Surface Mining. *Journal of Management* 35:648–652.

Juncosa, Adrian. 2010. Proprietor. EcoSynthesis Scientific & Regulatory Services, Truckee, CA. June 15, 2010—written comments on draft-final revegetation guidance document provided to John Zanzi, AECOM.

Kliejunas, J. and D. Adams. 2003. White Pine Blister Rust in California. Tree Notes 27. California Department of Forestry and Fire Protection, Sacramento, CA.

Kitzmiller, K. 2009. Regional Genetic Variation in Three Native Grasses in Northern California. *Native Plants Journal* 10(3):263–280.

Koch, J. M., S. C. Ward, C. D. Grant, and G. L. Ainsworth. 1996. Effects of Bauxite Mine Restoration Operations on Topsoil Seed Reserves in the Jarrah Forest of Western Australia. *Restoration Ecology* 4:368–376.

Krenits, E. C., M. J. Carroll, R. L. Hill, and J. M. Krouse. 1998. Runoff and Sediment Losses from Natural and Man-Made Erosion Control Materials. *Crop Science* 38:1042–1046.

Lake Tahoe Basin Weed Coordinating Group. No Date. *Invasive Weeds: Controlling Your Noxious Neighbors*. Available: http://tahoeinvasieweeds.org/resources/publications.php. Accessed January 31, 2010.

———. 2007. Priority Invasive Weeds of the Lake Tahoe Basin. Available: <http://tahoeinvasiveweeds.org/weeds/pdf/priorityWeedList_12_2007.pdf>. Accessed January 23, 2010.

———. 2010. *Publications*. Available: <http://tahoeinvasiveweeds.org/resources/publications.php>. Accessed January 30, 2010.

Langer, E. R., M. R. Davis, and C. W. Ross. 1999. *Rehabilitation of Lowland Indigenous Forest After Mining in Westland.* Science for Conservation Publication 117, Department of Conservation, Wellington, New Zealand.

Leiser, A. 2004a. *Obtaining Plants and Handling of Plant Materials, Erosion Control and Land Restoration.* University of California, Davis University Extension, Davis, CA.

———. 2004b. Biotechnology for Slope Protection and Erosion Control, *Erosion control and land restoration*. University of California Davis University Extension, Davis, CA.

Lowery, B., and J. E. Morrison. 2002. Soil Penetrometers and Penetrability. Pages 363–385 in J. H. Dane and G. C. Topp (eds.) *Methods of Soil Analysis Part 4, Physical Methods*. Number 5 in the Soil Science Society of America Book Series. Soil Science Society of America, Inc., Madison, WI.

LTWCG. *See* Lake Tahoe Weeds Coordinating Group.

Luce, C. H. 1997. Effectiveness of Road Ripping in Restoring Infiltration Capacity in Forest Roads. *Restoration Ecology* 5:265–275.

MacDonald, L. H., R. W. Sampson, and D. M. Anderson. 2001. Runoff and Road Erosion at the Plot and Road Segment Scales, St. John, U.S. Virgin Islands. *Earth Surface Processes and Landforms* 26:251–272.

Mantesanz, S., F. Valladares, D. Tena, M. Costa-Tenorio, and D. Bote. 2006. Early Dynamics of Plant Communities on Revegetated Motorway Slopes from Southern Spain: Is Hydroseeding Always Needed? *Restoration Ecology* 14:297–307.

Marrs, R. H. 2002. Manipulating the Chemical Environment of the Soil. Pages 155–183 in M. R. Perrow and A. J. Davy (eds.) *Handbook of Ecological Restoration Volume 1: Principles of Restoration*. Cambridge University Press, New York, NY.

McCullah, John. 1999–2001. Biotech Tip, Vegetated Gabions Offer Habitat Complexity for Fishery Streams. Available: <http://www.forester.net/ec_0101_biotech.html>. Accessed May 2007.

McGahan, Kansas. Senior Civil Engineer. Placer County Department of Public Works. Tahoe Design Division, Truckee, CA. January 7, 2010 – telephone conversation with John Zanzi at AECOM regarding contracting and use of California Conservation Corps crews for revegetation projects.

McQueen, D. J., and C. W. Ross. 1982. Effects of Stockpiling Top Soils Associated with Opencast Mining 2. Physical Properties. *New Zealand Journal of Science* 25: 295–302.

Megahan, W. F., M. Wilson, and S. B. Monsen. 2001. Sediment Production from Granitic Cutslopes on Forest Roads in Idaho, USA. *Earth Surface Processes and Landforms* 26:153–163.

Meier, H. W. 1983. *Construction Specifications Handbook.* Third Edition. Prentice-Hall, Inc., Englewood Cliffs, NJ.

Mitsch, W. J. and S. E. Jorgensen. 2004. *Ecological Engineering and Ecosystem Restoration*. John Wiley and Sons, Inc. New York, NY.

Moffat, A. J., and R. C. Boswell. 1997. The Effectiveness of Cultivation Using the Winged Tine on Restored Sand and Gravel Workings. *Soil and Tillage Research* 40:111–124.

Moffatt, David. Landscape Architect. CalTrans, Sacramento, CA. March 17, 2010—written comments on draft revegetation guidance document provided to John Zanzi, AECOM.

Morgan, R. P. C. 2005. *Soil Erosion and Conservation*. Third edition. Blackwell Publishing, Malden, MA.

Munshower, F. F. 1994. *Disturbed Land Revegetation*. CRC Press, Boca Raton, FL.

National Research Council. 2001. *Compensating for Losses under the Clean Water Act*. National Academy of Sciences, Washington, D.C.

National Soil Survey Center. 1993. *Soil Survey Manual*. Natural Resources Conservation Service, Lincoln, NE. Available: <http://soils.usda.gov/technical/manual/>.

Newton, G. A. and V. P. Claassen. 2003. Rehabilitation of Disturbed Lands in California: A Manual for Decision Making. *Special Publication 123*. California Department of Conservation, California Geological Survey, Sacramento, CA.

Nicolau, J. M. 2003. Trends in Relief Design and Construction in Opencast Mining Reclamation. *Land Degradation & Development* 14:215–226.

NRCS. *See* Natural Resources Conservation Service.

Ogle, D. G., J. C. Hoag, and J. D. Scianna. 2000. Users Guide to Description, Propagation and Establishment of Native Shrubs and Trees for Riparian Areas in the Intermountain West. *Technical Note Plant Materials No. 32*. Plant Materials Program, Natural Resources Conservation Service, Boise, ID and Bozeman, MT.

Parker, V. T., R. L. Simpson, and M. A. Leck. 1989. *Ecology of Soil Seedbanks*. Academic Press, San Diego, CA.

Paschke, M. W., C. DeLeo, and E. F. Redente. 2000. Revegetation of Roadcut Slopes in Mesa Verde National Park, U.S.A. *Restoration Ecology* 8:276–282.

Paschke, M. W., E. F. Redente, and S. L. Brown. 2003. Biology and Establishment of Mountain Shrubs on mining disturbances in the Rocky Mountains, USA. *Land Degradation & Development* 14:459–480.

Petersen, S. L., B. A. Roundy, and R. M. Bryant. 2004. Revegetation Methods for High-Elevation Roadsides at Bryce Canyon National Park, Utah. *Restoration Ecology* 12:248–257.

Radosevich, S., J. Holt, and C. Ghersa. 1997. *Weed Ecology: Implications for Management*. John Wiley & Sons, Inc., New York, NY.

Rivenshield, A. and N. L. Bassuk. 2007. Using Organic Amendments to Decrease Bulk Density and Increase Macroporosity in Compacted Soils. *Arboriculture & Urban Forestry* 33:140–146.

Roberts, R. D., and A. D. Bradshaw. 1985. The Development of a Hydrologic Seedling Technique for Unstable Sand Slopes I. Field Evaluation. *Journal of Applied Ecology* 22:979–994.

Rokich, D. P., K. W. Dixon, K. Sivasithamparam, and K. A. Meney. 2000. Topsoil Handling and Storage Effects on Woodland Restoration in Western Australia. *Restoration Ecology* 8:196–208.

Rowe, H. I., C. S. Brown, and V. P. Claassen. 2007. Comparisons of Mycorrhizal Responsiveness with Field Soil and Commercial Inoculum for Six Native Montane Species and *Bromus tectorum*. *Restoration Ecology* 15:44–52.

Salix Applied Earthcare. 2000. Stafford Slide Biotechnical Erosion Control Project, Photo Documentation June 8, 2000. Available: <http://www.salixaec.com/stafford.htm>. Accessed May 2007.

Schuman, G. E., D. T. Booth, and J. R. Cockrell. 1998. Cultural Methods for Establishing Wyoming Big Sagebrush on Mined Lands. *Journal of Range Management* 51:223–230.

Schuster, S. and M. E. Grismer. 2004. Evaluation of Water Quality Projects in the Lake Tahoe Basin. *Environmental Monitoring and Assessment* 90:225–242.

SERI Science & Policy Working Group. *See* Society for Ecological Restoration International Science & Policy Working Group.

Sheldon, J. C., and A. D. Bradshaw. 1977. The Development of a Hydrologic Seedling Technique for Unstable Sand Slopes I. Effects of Fertilizers, Mulches and Stabilizers. *Journal of Applied Ecology* 14:905–918.

Sinnett, D., J. Poole, and T. R. Hutchings. 2006. The Efficacy of Three Techniques to Alleviate Soil Compaction at a Restored Sand and Gravel Quarry. *Soil Use and Management* 22:362–371.

Society for Ecological Restoration International Science & Policy Working Group. 2004. *The SER International Primer on Ecological Restoration*. Version 2. Science & Policy Working Group. Available at: http://www.ser.org/pdf/primer3.pdf. Accessed: April 25, 2010.

Soil Conservation Service. 1975. *Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys.* Agricultural Handbook 436. Soil Conservation Service, U.S. Department of Agriculture, Washington, DC.

Sokal, R. R. and F. J. Rohlf. *Biometry: The Principles and Practice of Statistics in Biological Research*. Third Edition. W. H. Freeman and Company, New York, NY.

Stahl, P. D., B. L. Perryman, S. Sharmarsarkar, and L. C. Munn. 2002. Topsoil Stockpiling Versus Exposure to Traffic: A Case Study on *in situ* Uranium Wellfields. *Restoration Ecology* 10:129–137.

Stromberg, M. R., C. M. D'Antonio, T. P. Young, Jeanne Wirka, and P. R. Kephart. 2007. California Grassland Restoration. Pages 254–280 in M. R. Stromberg, J. D. Corbin, and C. M. D'Antonio. *California Grasslands: Ecology and Management*. University of California Press, Berkeley, CA.

Sutherland, R. A. 1998a. Rolled Erosion Control Systems for Hillslope Surface Protection: A Critical Review, Synthesis and Analysis of Available Data. I. Background and Formative Years. *Land Degradation & Development* 9:465–486.

———. 1998b. Rolled Erosion Control Systems for Hillslope Surface Protection: A Critical Review, Synthesis and Analysis of Available Data. II. The Post-1990 Period. *Land Degradation & Development* 9:487–511.

Switalski, T. A., Bissonette, T. H. DeLuca, C. H. Luce, and M. A. Madej. 2004. Benefits of Road Removal. *Frontiers in Ecology and Environment* 2:21–28.

Tahoe Regional Planning Agency. 1988. *Water Quality Management Plan for the Lake Tahoe Region Volume II. Handbook of Best Management Practices*. Stateline, NV.

Tinsley, M. J., M. T. Simmons, and S. Windhager. 2006. The Establishment Success of Native Versus Non-Native Herbaceous Seed Mixes on a Revegetated Roadside in Central Texas. *Ecological Engineering* 26:231–240.

Tormo, J., E. Bochet, and P. Garcia-Fayos. 2007. Roadfill Revegetation in Semiarid Mediterranean Environments. Part II: Topsoiling, Species Selection, and Hydroseeding. *Restoration Ecology* 15:97–102.

Tyser, R. W., J. M. Asebrook, R. W. Potter, and L. L. Kurth. 1998. Roadside Revegetation in Glacier National Park, U.S.A.: Effects of Herbicide and Seeding Treatments. *Restoration Ecology* 6:197–206.

University of California Cooperative Extension and California Department of Water Resources. 2000. *A Guide To Estimating Irrigation Needs of Landscape Plantings in California: The Landscape Species Coefficient Method and WUCOLS III.* Sacramento, CA.

Urbanska, K. M., and J. C. Chambers. 2002. High-Elevation Ecosystems. Pages 376–400 in M. R. Perrow and A. J. Davy (eds.), *Handbook of Ecological Restoration Volume 2: Restoration in Practice*. Cambridge University Press, New York, NY.

USDA. *See* U.S. Department of Agriculture.

U.S. Department of Agriculture. 2009. State-Noxious-Weed Seed Requirements Recognized in the Administration of the Federal Seed Act. Seed and Regulatory Testing Branch, U.S. Department of Agriculture, Gastonia, NC. Available: <http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRD3317318>. Accessed January 17, 2010.

U.S. Forest Service. Noxious *Weed Risk Assessment Packet 2010*. Lake Tahoe Basin Management Unit, U.S. Forest Service. South Lake Tahoe, CA.

USFS. *See* U.S. Forest Service.

Vasquez, E., R. Sheley, and T. Svejcar. 2008. Nitrogen enhances the Competitive Ability of Cheatgrass (*Bromus tectorum*) Relative to Native Grasses. *Invasive Plant Science and Management* 1(3): 287–295.

Wardle, D. A. 2002. Communities and Ecosystems: Linking the Aboveground and Belowground Components. *Monographs in Population Biology* 34. Princeton University Press, Princeton, NJ.

Weixelman, D. A., D. C. Zamudio, K. A. Zamudio, and R. J. Tausch. 1997. Classifying Ecological Types and Evaluating Site Degradation. *Journal of Range Management* 50:315–321.

Whisenant, S. G. 1999. *Repairing Damaged Wildlands: A Process-Oriented, Landscape-Scale Approach*. Cambridge University Press, New York, NY.

———. 2002. Terrestrial Systems. Pages 83–105 in M. R. Perrow and A. J. Davy (eds.), *Handbook of Ecological Restoration Volume 1: Principles of Restoration*. Cambridge University Press, New York, NY.

Wilson, R., D. Lile, D. Drake, S. Orloff, D. Lancaster, H. George, R. Delmas, and A. Bower. 2006. Dryland Pastures: Establishment and Management in the Intermountain Region of Northern California. *Publication 8163*. Division of Agricultural and Natural Resources, University of California, Oakland, CA.

Young, J. A. 1992. Population-Level Processes: Seed and Seedbed Ecology. In J. C. Chambers and G. L. Wade (eds.), *Evaluating Reclamation Success: The Ecological Consideration—Proceedings of a Symposium*. General Technical Report NE-164, Northeastern Forest Experiment Station, Forest Service, United States Department of Agriculture, Radnor, PA.

Zar, J. H. 2009. *Biostatistical Analysis*. Fifth Edition. Prentice Hall, Upper Saddle River, NJ.

8. List of Preparers

John Zanzi ..... Senior Landscape Architect, Project Manager

John Hunter ..... Senior Ecologist

Karen Appell ..... Senior Ecological Engineer

Alison Zanzi ..... Field Technician

Amber Giffin ..... Publishing Associate

Debby Jew ..... Publishing Associate

Charisse Case ..... Publishing Associate

Christy Seifert ..... Editor

Brian Perry ..... Graphics

Lorrie Jo Williams ..... Graphics

Chris Donohue ..... GIS Mapping

This page has been intentionally left blank.

Appendix A

FIELD STUDY OF REVEGETATION PROJECTS IN THE TAHOE BASIN

A.1 Methods
A.2 Results and Discussion

APPENDIX A. FIELD STUDIES OF REVEGETATION PROJECTS IN THE TAHOE BASIN

This appendix provides the methods, and a summary and discussion of the results of two field studies of implemented revegetation projects that were conducted in the Tahoe Basin: (1) a reconnaissance assessment of a wide range of revegetation projects, and (2) more intensive assessment of just roadside cut slope sites.

A.1 METHODS

A.1.1 PROJECT ASSESSMENT

Based on input received during the start-up meeting, nearly 30 potential study projects were observed during the reconnaissance-level field visits; Table A-1, "Sites Selected for Initial Evaluation," and Exhibits A-1 and A-2 summarize and identify the locations of the study projects. The projects are located throughout the Tahoe Basin and represent a variety of types (e.g., cut slopes, basins, and roadsides) and a range of ages (e.g., some are recently installed, while others were constructed 20 years ago).

During preliminary site visits, observations of topographic, soil surface, vegetation, and disturbance attributes were recorded. At each project site, a standardized set of observations was recorded on a field data form. This field data form and related guidance is provided in Appendix G.

Recorded topographic attributes included aspect, slope angle (i.e., steepness), slope shape (concave, planar, convex), slope length, and position on slope. Aspect was measured with a compass; slope angle was measured with a clinometer; and slope length was visually estimated.

Recorded soil surface attributes included percentage of the soil surface covered by rocks, plant litter and woody debris, bare soil, and soil crusts. These percentages were based on visual estimates. The presence of rills, rocks on pedestals of soil, exposed roots, and evidence of overland flow and of ponding of water was also noted.

Recorded vegetation attributes included the percentage of the soil surface covered by herbaceous, shrub, and tree layers; dominant species in each layer, presence of invasive plant species, and evidence of ongoing recruitment. Percentages were based on visual estimates.

Recorded disturbance attributes included evidence of disturbance of vegetation or soil by humans, vehicles, or other mechanisms. Failure of components of the revegetation project because of disturbance (e.g., vandalism) also was noted.

Field observations related to design and implementation were qualitative and quantitative with respect to the materials used and treatments executed to address site preparation, plant materials, planting and seeding, irrigation, and maintenance (plant establishment). In addition, site preparation, plant materials, planting and seeding, irrigation, and maintenance (plant establishment) prescriptions were reviewed for the plans, specifications, and monitoring reports that were provided for the identified study projects.

Site preparation attributes included vegetation clearing, litter and duff removal and replacement (depth), topsoil removal and replacement (depth), soil compaction/soil loosening (depth), and addition of compost or other amendments. Plant materials observations included herbaceous and woody material sources, sizes, types, and species used, as well as planting and seeding installation techniques. These attributes included timing of planting, planting hole preparation, container planting amendments, plant spacing, seeding techniques, use of tackifier, seeding amendments, and mulch type and depth. Maintenance (plant establishment) attributes included an inventory of maintenance period duration (years), irrigation type (e.g., spray, drip, bubbler, hand, truck), water application rate, fertilizer, weed control, replacement planting, and reseeding.

Table A-1
Sites Selected for Initial Evaluation

Site Name	Geographic Coordinates (Northing)	Geographic Coordinates (Easting)	Vicinity	Location Description	Implementing Agency	Year Constructed	Date Visited
Apalache—Glen Eagles Drive	38.879	-119.989	South Lake Tahoe	On the south side of Glen Eagles Drive (near Pioneer Trail)	EDOT	2004	9/27/2006
Apalache—Muskawaki Drive	38.891	-119.985	South Lake Tahoe	On the south side of Muskawaki Drive (near Pioneer Trail)	EDOT	2006	9/27/2006
Apalache—Nattaway Basin	38.884	-119.994	South Lake Tahoe	At the north end of Nattaway Drive (near Pioneer Trail)	EDOT	2004	9/27/2006
Bay View	38.945	-120.106	West Lake Tahoe	South of California State Route 89, at Inspiration Point Vista, Emerald Bay	Caltrans	2001	10/12/2006
Beaver Street	39.240	-120.015	North Lake Tahoe	Kings Beach, North of California State Route 28	Placer County	2003	9/26/2006
Big Springs and Overlook Place	39.274	-120.128	North Lake Tahoe	Southwest slope of Big Springs Drive and Overlook Place within the Northstar resort	Private	2006	10/26/2006
B-Line Export Pipeline	38.802	-120.012	South Lake Tahoe	In Christmas Valley, at the end of Grass Lake Road and west of California State Route 89	STPUD	2005	9/26/2006
Brockway Summit	39.259	-120.055	North Lake Tahoe	Brockway Summit on California State Route 267 (east side)	Caltrans	1999	9/26/2006
Brockway Water Quality	39.259	-120.071	North Lake Tahoe	Brockway Summit on California State Route 267 (west side)	Caltrans	2004	9/26/2006
Burton Creek	39.218	-120.087	North Lake Tahoe	South of California State Route 28, east of Ridgewood Drive, Carnelian Bay	Caltrans	2002-03	10/12/2006
Cattlemans Basin	38.909	-119.962	South Lake Tahoe	At the end of Cattlemans Trail (near Pioneer Trail)	EDOT	2001-02	9/27/2006
Cave Rock	39.045	-119.946	East Lake Tahoe	On the east side of Cave Rock Drive in a subdivision south of Cave Rock, east of U.S. Highway 50	CRID + SCS	1980s + 2001	9/26/2006
Glorene and Eighth	38.915	-120.015	South Lake Tahoe	At Glorene Avenue and Eighth Street	City of South Lake Tahoe	2004	9/27/2006

Table A-1
Sites Selected for Initial Evaluation

Site Name	Geographic Coordinates (Northing)	Geographic Coordinates (Easting)	Vicinity	Location Description	Implementing Agency	Year Constructed	Date Visited
Highlands Drive	39.283	-120.109	North Lake Tahoe	East slope of Highlands Drive within the Northstar resort	Private	2006	10/26/2006
State Route 267 Repair	39.281	-120.105	North Lake Tahoe	West slope of California State Route 267, south of Northstar Drive	Caltrans	2005/2006	9/29/2006
Lake Tahoe Park Erosion Control Project	39.141	-120.156	West Lake Tahoe	At Fountain Avenue, west of California State Route 89, Tahoe City	Placer County	2006	10/26/2006
Marshall Court	38.905	-119.964	South Lake Tahoe	On the south side of Marshall Court (near Pioneer Trail)	EDOT	1990	9/27/2006
Marshall Trail at Columbine	38.900	-119.965	South Lake Tahoe	On the east side of Columbine Trail (near Pioneer Trail)	EDOT	1990-92	9/27/2006
Meyers Bike Trail	38.851	-120.022	South Lake Tahoe	Southeast corner of U.S. Highway 50 and California State Route 89	EDOT	1992	9/26/2006
Meyers Erosion Control	38.887	-120.001	South Lake Tahoe	West of U.S. Highway 50 (near the airport)	Caltrans	2004	10/12/2006
Park Heights Drive Culvert Repair	39.144	-120.160	West Lake Tahoe	South of Park Heights Drive, west of California State Route 89, Tahoe City	Placer County	2006	10/26/2006
Pioneer Trail Erosion Control	38.917	-119.960	South Lake Tahoe	On Pioneer Trail, west of Al Tahoe Blvd. and east of Cold Creek	Conservancy	1970s + 1988	9/26/2006
Ponderosa Ranch	39.235	-119.924	East Lake Tahoe	Within Ponderosa Ranch, Incline Village	Private	2005	9/29/2006
Sierra Tract Phase 2	38.928	-119.980	South Lake Tahoe	Near O'Malley Drive and William Avenue, south of U.S. Highway 50	City of South Lake Tahoe	2005	9/27/2006
Timberland Erosion Control Project	39.129	-120.171	West Lake Tahoe	At Timberland Lane, west of California State Route 89, Tahoe City	Placer County	2005	10/26/2006
Truckee Bypass, State Route 267	39.336	-120.166	North Lake Tahoe	On California State Route 267, south of Interstate 80	Caltrans	2004	10/12/2006
Upper Cutthroat	39.243	-120.013	North Lake Tahoe	Kings Beach, North of California State Route 28	Placer County	2005	9/15/2006 and 9/26/2006

Note: Caltrans = California Department of Transportation; EDOT = El Dorado County Department of Transportation; STPUD = South Tahoe Public Utility District
Coordinates in NAD83.

In addition to planting treatments, biotechnical and other treatments were inventoried including use of fabrics/blankets, coir logs, willow wattles, logs (felled trees), brush layers, boulders, tub grindings, and fencing.

A.1.2 Roadside Cut Slope Assessment

For additional information regarding conditions affecting the effectiveness of revegetation, a more detailed assessment of physical conditions and vegetation was conducted in 2007 and 2008 at nine of the thirteen roadside cut slope sites included in the reconnaissance study. Site, vegetation and soil surface cover, and soil properties were recorded for each site.

Site attributes were recorded as in the reconnaissance survey with two exceptions. First, the height of each cut slope was measured with a tape measure rather than visually estimated. Second, the measurements of unobscured sky were recorded for estimating the percent shade at each site (i.e., 100% shade represents the sun's path during the growing season is entirely obscured, and 0% shade represents that throughout the growing season, the sun shines directly on the site). At each site, the angle to unobscured sky (i.e., an elevation angle) was recorded for nine bearings from east to west (i.e., nine azimuth angles) at the beginning, middle, and end of the 100-foot-long baseline, at mid-slope of the roadcut. These angles were used to calculate a percentage shade. This information was used to estimate the percentage of the sun's path that was obscured by determining the range of elevation angles between the spring equinox and summer solstice, and the portion of this range that was obscured at each of the nine azimuth angles. The elevation angles in the Tahoe Basin for the equinox and solstice were determined from the NOAA Solar Position Calculator (available at http://www.srrb.noaa.gove/highlights/sunrise/azel.html).

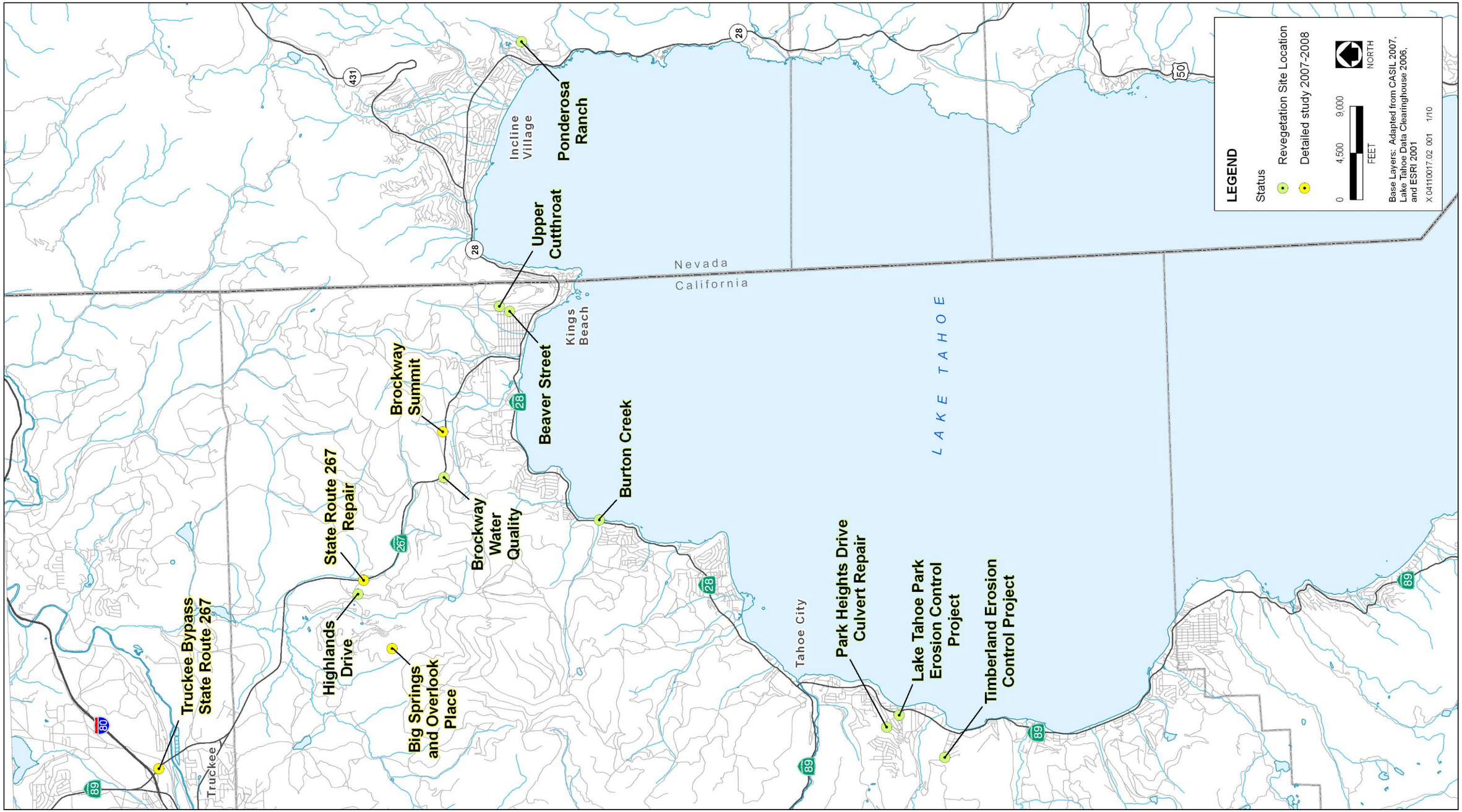
Vegetation and soil surface cover were recorded using transects. Ten 33-foot-long (10-meter-long) transects, perpendicular to the slope were randomly located by selecting starting points at random distances along and up slope from a 100-foot-long baseline. At 10-inch (25-cm) intervals along each transect, a 3/16^{ths}-inch-diameter metal rod was placed on the soil surface, and cover of the soil surface by vegetation, mulch, and/or rock was recorded; or the location was recorded as having exposed soil (which was recorded as crusted or not). Each plant species touching the rod was also recorded.

Soil properties recorded in the field were penetrability and rooting depth. Soil samples were also collected so that bulk density, particle size distribution (i.e., percent sand, silt, and clay), percent organic matter, pH, and total nitrogen could be determined.

Soil samples were collected, and rooting depth and soil penetrability recorded, at one end of alternate transects. Soil samples were collected using a 6-inch-long metal tube with a 2-inch diameter. This tube was hammered into the ground, the surrounding soil excavated, and a thin metal plate inserted below the tube, and all soil within the tube was removed as a sample.

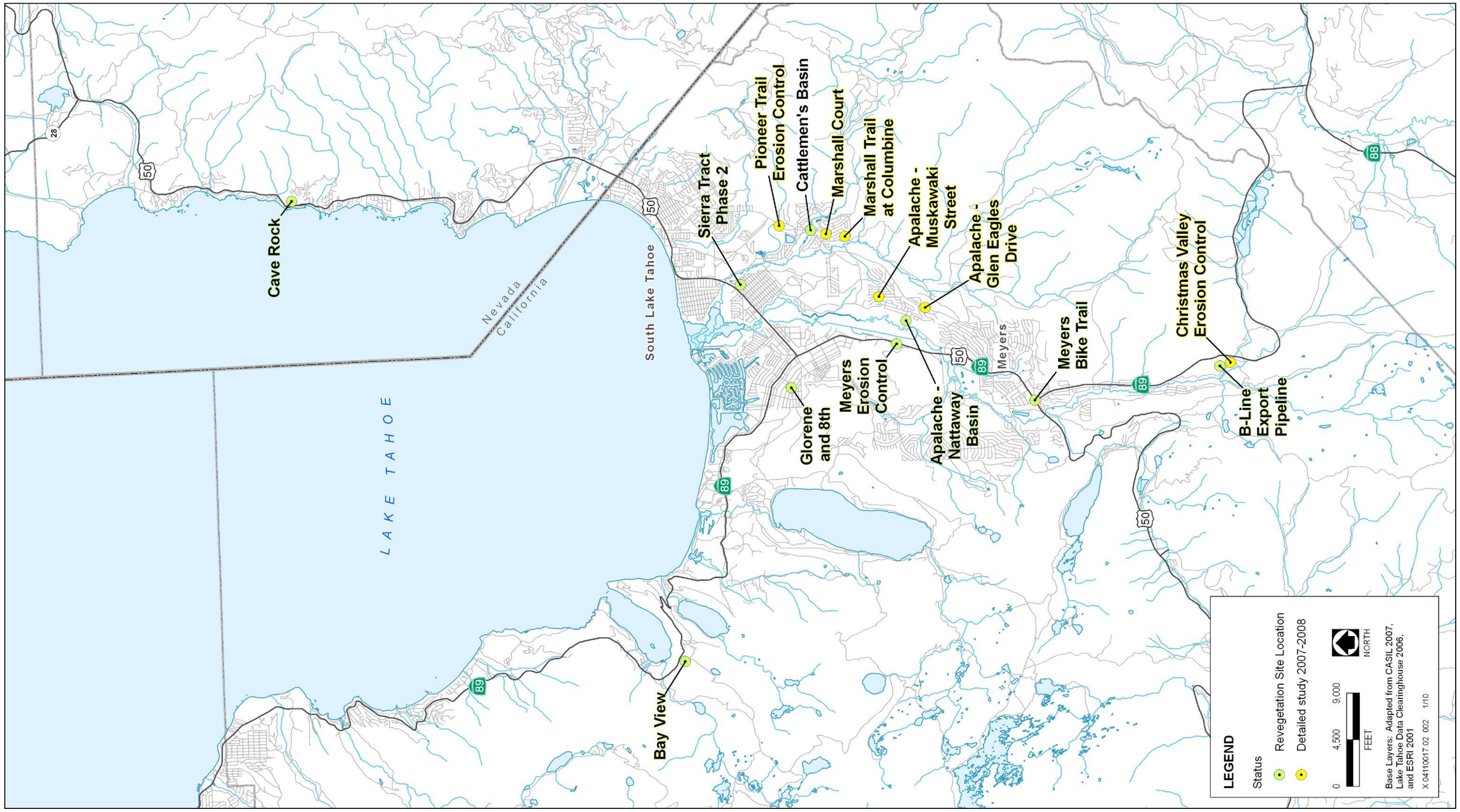
Soil samples were placed in a paper bag, dried in a convection oven, and gravel removed with a 2-mm sieve. The volume of the gravel was measured by submersion in a graduated cylinder of water, and the mass of the sieved soil was determined with a balance. This information was used to calculate the volume and bulk density of the each soil sample. The five soil samples from each site were composited into a single sample that was sent to a soil analysis laboratory (JMLord, Inc., Fresno, CA) for particle size analysis and determination of pH, organic matter content, total nitrogen content, phosphorus, and exchangeable calcium, magnesium, sodium, and potassium.

Rooting depth was observed on the surface of the pit created by collecting the soil sample. Rooting depth was the maximum depth where there were at least 100 roots (< 2 mm in diameter) per square decimeter of soil (SCS [NRCS] 1975). Sharp discontinuities in the density of roots or of soil color or texture also were noted.



Site Locations—North

Exhibit A-1



Site Locations—South

Exhibit A-2

Penetrability was measured with a soil penetrometer oriented vertically and pushed downwards, into the soil, at a rate of about 1.25 inches per second. The force required to move the penetrometer through the soil at that rate was recorded for each 3 inch interval from the surface to 12 inches in depth. The depth to "refusal" was also recorded. For this study, "refusal was defined as the depth requiring more than 400 psi for the penetrometer to continue to move through the soil. It is difficult for field investigators to apply this much force steadily (and to not damage the penetrometer), thus the penetrometer is "refused." (Soils this difficult to penetrate are also associated with reduced plant growth.)

A.2 RESULTS AND DISCUSSION

A.2.1 RECONNAISSANCE SURVEY

A.2.1.1 SUMMARY OF SOIL AND PLANT CONDITIONS

Plant cover varied widely among revegetation sites. Because trees were not included in most plantings, tree cover was primarily from adjacent vegetation and typically covered only a small portion of the site: nearly two-thirds of sites had less than 10% tree cover; only one site had greater then 50% shrub cover.

Shrub and herbaceous plant cover was provided by plantings, in comes cases by retained vegetation, and on older sites, by plants recruited from adjacent vegetation. Shrubs generally covered only a small portion of the site: nearly three-quarters of sites had less than 10% cover of shrubs; only one site had greater than 30% shrub cover. Three species were dominant in the shrub layer at more than one site: bitterbrush (*Purshia tridentata*), mountain sagebrush (*Artemisia tridentata* var. *vaseyana*), rabbitbrush (*Chrysothamnus nauseosus*). Several other species were dominant at a single site: Wood's rose (*Rosa woodsii*), greenleaf manzanita (*Arctostaphylos patula*), mahala mat (*Ceanothus prostratus*), sulfur buckwheat (*Eriogonum umbellatum*), and willow species (*Salix lemmonii* and *S. lucida*). At most sites, however, the shrub layer consisted of just a few plants of different species, so there was no dominant species.

The herbaceous layer covered from less than 5% to greater than 90% of a site. This cover was often sparse, however: five sites (16%) had less than 10% herbaceous cover; about two-thirds of the sites had less than 30% cover, and only two sites had greater than 50% cover. (However, these cover values are based on visual estimates made in September, and actual cover values for much of the growing season may be somewhat greater.) Dominant species were primarily grasses such as California brome (*Bromus carinatus*) fescue species (e.g., *Festuca brevipila, F. rubra*, and *F. trachyphylla*), and blue wildrye (*Elymus glaucus*). California brome was the most abundant species; it was a dominant on half of the sites.

Cheatgrass (*Bromus tectorum*), a nonnative invasive species, was a dominant species at three sites and present at three other sites. Other invasive species also were present at revegetation sites; these included bullthistle (*Cirsium vulgare*), woolly mullin (*Verbascum thapsus*), (*Poa bulbosa*), and white sweetclover (*Melilotus alba*). Overall, one or more invasive species were present on more than half of the sites.

At most sites, a variety of species had been recruited from adjacent vegetation, the soil seedbank, or from contaminants in seed mixes, planting materials, and compost. Besides nonnative invasive species, these recruits included a variety of native species such as Jeffrey pine (*Pinus jeffreyi*) and willowweed (*Epilobium brachycarpum*). In general, these recruits have so far provided relatively little cover, except on a couple of the older sites, and on portions of some sites where small, annual forbs were locally abundant. Recruitment of new plants from seed produced by planted individuals appeared to be rare.

Like vegetation, the cover of the litter layer varied considerably among sites. The cover of the litter layer ranged from 15% to 90% and most sites had a litter layer that covered 35%–85% of the soil surface. On most sites, applied mulch (particularly wood chips and grindings) accounted for most of this cover; on some sites, however, pine needles from adjacent trees (as opposed to needles applied as mulch) were an important component of mulch. On few sites were herbaceous plants producing sufficient litter to cover a substantial portion of the soil surface.

Most sites showed evidence of ongoing erosion, but this erosion was generally slight. Nearly two-thirds of the sites had more than 10% of the soil surface exposed (i.e., not covered by plants, litter, woody debris, or rocks). Typically, a large portion of the exposed surface had a thin, crusted layer of soil, indicating reduced capacity for infiltration. Evidence of overland flow, including wash and scour features, was common, although in some cases this was localized on the site or in isolated patches on the slope. On steeper sites, small mounds of slumped or displaced soil material were also common, as were deposits of soil at the base of slopes. However, evidence of extensive erosion was uncommon. Exposed roots and pedestalled rocks were present at only a few sites. Pronounced, closely spaced, and interconnected rills also were uncommon (occurring at just five sites); and, when present, these features were usually associated with concentrated flow entering the site.

A.2.1.2 RELATIONSHIP OF CONDITIONS TO PROJECT TYPE

Although several very different types of sites were examined, there was a substantial overlap in the vegetation and soil surface conditions among these different types of sites. Types of sites included cut slopes and fill slopes along roads, road sides (i.e., road shoulders) in residential neighborhoods, rights-of-way (ROWs), decommissioned roads, and stormwater retention basins. The primary differences among these types were:

- Road cut sites were steeper than other types of sites, and had much less cover from adjacent trees (Table A-2). Although only four sites were on fill slopes, it is interesting that the median combined cover of herbs and shrubs was greater on those sites than on cut slopes.

- Tree cover was much greater over revegetation sites on roadsides (Table A-2), all of which were in residential neighborhoods. This tree cover not only shaded revegetation sites, but also provided inputs of litter from the tree canopy.

Table A-2
Median Value and Range of Site Attributes by Type of Revegetation Project

Project Type	Number of Sites	Age (yrs)	Slope (%)	Tree Cover (%)	Combined Herb-Shrub Cover (%)	Litter Cover (%)	Bare Soil (%)	Overall Erosion Rating (1–5)
Road Cut—Cut Slope	13	3 (0.5–18)	30 (15–45)	2.5 (0–12.5)	30 (7.5–75)	50 (15–87.5)	20 (5–65)	2 (1–4)
Road Cut—Fill Slope	4	2 (0.5–4)	47.5 (45–100)	0 (0–10)	60 (33–95)	60 (15–90)	8.75 (5–20)	1.75 (1.5–2.5)
Roadside	7	3 (0.5–14)	7.5 (2.5–30)	30 (1–50)	25 (5–45)	75 (30–90)	7.5 (2.5–40)	2 (1–2.5)
Road Decommissioning/ Right-of-Way	6	1 (1–5)	16.25 (10–25)	9 (0–40)	17.75 (15–35)	70 (45–90)	13.75 (2–20)	1.5 (1.5–1.5)
Basin	2	3.25 (2–4)	15 (7.5–22.5)	35 (5–65)	22.5 (1–44)	72.5 (65–80)	16.25 (15–17.5)	1.75 (1.5–2)
All Sites Combined	32	2 (0.5–18)	25 (2.5–100)	5 (0–65)	26.5 (1–95)	65 (15–90)	15 (2–65)	1.75 (1–4)

- Trampling and vehicle disturbance was much more extensive at the seven road shoulder sites in residential neighborhoods. Trampling had disturbed all of these sites, and vehicles had disturbed five of seven. At several of these sites, soil was severely compacted as a result of chronic disturbance by pedestrians and motor vehicles.

Decommissioned road and ROW sites had somewhat less plant cover. Thick layers of mulch, moderate to high shade cast by adjacent trees, and young age (all but one were only 1 year old) all may have contributed to plant cover being somewhat less than at other types of sites.

A.2.1.3 Relationship of Conditions to Project Age

Several soil surface and vegetation attributes tended to differ between younger and older revegetation sites. Three age groups of revegetation sites were compared: 0–2 years, 3–7, and 14–18 years. These groups reflect the early development and ongoing maintenance of sites less than 3 years old, and a gap in site ages with no sites between 7 and 14 years. These age groups differed in cover of shrubs and bare soil, and in overall erosion rating. Shrub cover averaged 3% for sites 0–2 years old, versus 18% and 14% for sites 3–7 and 14–18 years old, respectively (difference significant at $P = 0.0008$; Kruskal-Wallace rank sum test). Bare soil cover averaged 11% for sites 0–2 years old, 23% for sites 3–7 years old, and 40% for sites 14–18 years (difference significant at $P = 0.002$; Kruskal-Wallace rank sum test). Overall erosion rating (which is derived in part from bare soil cover) averaged 1.65 for sites 0–2 years old, versus 2.4 and 2.9 for sites 3–7 and 14–18 years, respectively (difference significant at $P = 0.004$; Kruskal-Wallace rank sum test). The three age groups of sites did not differ in litter cover, herbaceous cover, or combined herb and shrub cover.

These differences may indicate how revegetation sites are changing over time. A major confounding factor, however, is that revegetation techniques have changed considerably during the last 18 years in the Tahoe Basin. Thus, recently implemented revegetation projects may develop differently than projects that were implemented years ago. For example, the shrub cover of 3- to 7-year-old sites in 2006 was greater, already comparable to the shrub cover of 14- to 18-year-old sites, and 10 years from now this cover will likely be much greater, suggesting that revegetation projects have become more effective at establishing shrubs.

A.2.2 Roadside Cut Slope Assessment

A.2.2.1 Summary of Site, Soil, and Plant Conditions

Tables A-3 through A-7 summarize data collected at the roadside cut slope sites. Although all roadside cut slopes, these sites differed in length, aspect and shade. Also, at these revegetation sites, soil and vegetation attributes spanned a wide range: bulk densities of 0.7–1.6 grams per cubic centimeter, organic matter content of 0.3–5.4%, plant cover of 23–75%, mulch cover of 46–89% of the soil surface, and exposed soil at 4–44% of the surface. Plant species composition differed dramatically among sites with few species abundant at more than one site or present at more than half the sites. Among the most abundant and wide spread species were the annual forb *Epilobium brachycarpum*, the perennial grasses *Elymus elymoides* and *Poa secunda*, and the shrub *Purshia tridentata*.

A.2.2.2 Relationships among Site, Soil, and Plant Conditions

Tables A-8 and A-9 summarize the correlations among the topographic and soil attributes of the sites and Table A-9 summarizes the correlations between cover attributes and the physical attributes of the sites (i.e., topographic and soil attributes). The correlations in Table A-8 indicate that there are not only relationships among some soil attributes, but also between the topographic and soil attributes of sites receiving the soil rehabilitation treatments. Most of these relationships are general (aspect and shade) or are a related set of soil attributes in part the result of the soil rehabilitation treatments, which incorporate organic matter into the soil. The data in Table A-9 indicate relationships between site age and exposed soil, as well as bulk density and exposed soil. Because bulk density, age, and the application of soil rehabilitation treatments are all significantly related to each other, the direct interpretation of relationships between any one of these variables with exposed soil or plant cover is complex. It is noteworthy that shrub, perennial (composed primarily of perennial grasses) and annual plants have very different relationships to bulk density (and to soil rehabilitation treatments that are related to the soil loosening and organic matter of these sites).

Table A-3
Topographic Site Attributes

Site	Aspect (Degrees)	Slope Angle (Degrees)	Slope Length (Feet)	Shade (%)[1]
Apalache – Glen Eagles Drive	275	30	16	51
Apalache – Muskawaki Drive	270	41	19	49
Big Springs and Overlook Place	45	35	40	73
Brockway Summit	160	30	72	15
Marshall Court	11	35	15	60
Marshall Trail at Columbine	100	33	26	35
Pioneer Trail Erosion Control	85	35	20	38
State Route 267 Repair	100	35	20	38
Truckee Bypass State Route 267	223	35	34	45

Note:
[1] Percent shade was calculated as percent of the solar path obscured during the growing season at 6 points at the site.

Table A-4
Soil Properties of Roadside Cut Slopes[1]

Site	Soil Texture[2]	Bulk Density[2]	Rooting Depth[3]	Penetrability Depth[4]	Percent Organic Matter[5]
Apalache – Glen Eagles Drive	Loamy Sand	1.33±0.030	6.6±0.76	6.8±0.79	0.66
Apalache – Muskawaki Drive	Sandy Loam	1.09±0.136	4.8±0.96	5.1±1.10	1.68
Big Springs and Overlook Place	Sandy Loam	0.83±0.090	5.1±0.72	7.2±1.03	5.39
Brockway Summit	Sandy Loam	1.28±0.039	2.9±0.49	4.2±0.55	0.32
Marshall Court	Loamy Sand	1.27±0.101	5.6±0.80	4.5±1.33	0.37
Marshall Trail at Columbine	Loamy Sand	1.55±0.055	4.4±0.63	6.8±0.86	0.31
Pioneer Trail Erosion Control	Sandy Loam	1.28±0.049	4.8±0.34	6.9±0.85	0.52
State Route 267 Repair	Sandy Loam	0.71±0.032	8.0±0.59	10.8±1.18	1.89
Truckee Bypass State Route 267	Sandy Loam	0.81±0.037	5.0±0.84	7.0±1.22	1.04

Notes:
[1] Data are from 9 revegetated roadside cut slopes in the Tahoe Basin.
[2] Based on 6-inch-deep cores of soil collected at 5 random locations per site; mean ± 1 standard error
[3] Measured for fine roots at 5 random locations per site; mean ± 1 standard error
[4] Measured with a cone penetrometer at each end of 5 randomly located transects; mean ± 1 standard error of depth to >350 psi to penetrate
[5] Loss on ignition; based on composite of the 6-inch-deep cores from 5 random locations per site

Table A-5
Cover of Vegetation, Mulch/Litter, Rock-Wood, and
Exposed Soil at Roadside Cut Slopes[1]

Site	Cover[2] (Mean ± 1 Standard Error)			
	Plant	Mulch/ Litter	Rock, Wood	Exposed Soil
Apalache – Glen Eagles Drive	53±5.7	72±5.2	0.3±0.26	14±3.8
Apalache – Muskawaki Drive	57±6.9	61±7.4	0±0	23±4.9
Big Springs and Overlook Place	67±3.8	72±4.2	5±2	9±2
Brockway Summit	46±8.1	46±6.4	10±1.6	30±6.5
Marshall Court	23±5.2	66±5	0.3±0.26	20±2.9
Marshall Trail at Columbine	29±7.8	46±9.8	2±1.4	42±11.6
Pioneer Trail Erosion Control	43±8.8	52±7.8	3±0.5	29±9.5
State Route 267 Repair	67±4	89±1.7	1.3±0.59	4±1.4
Truckee Bypass State Route 267	75±5.6	64±4.3	1.8±0.69	9±3.3

Notes:
1 Data are from 9 revegetated roadside cut slopes in the Tahoe Basin.
2 Based on 10 randomly located, 10-m-long transects at each site along which cover was recorded at 25 cm intervals.

Table A-6
Total Plant Cover and Maximum Cover of Plant Growth Forms[1,2]

Site	Shrub	Perennial Forb	Perennial Graminoid	Annual	Total[3]
Apalache – Glen Eagles Drive	25±7.4	6±2.7	21±5.5	3±2.6	53±5.7
Apalache – Muskawaki Drive	36±13.8	1±0.4	29±8.5	–	57±6.9
Big Springs and Overlook Place	–	2±1.8	54±6.1	27±5.3	67±3.8
Brockway Summit	14±6.3	1±1.1	6±3.2	33±9.2	46±8.1
Marshall Court	6±3.7	4±1.4	18±5.0	1±0.6	23±5.2
Marshall Trail at Columbine	19±5.5	4±3.8	8±4.6	1±0.8	29±7.8
Pioneer Trail Erosion Control	14.3±4.8	0.3±0.26	28±5.7	9.5±6.0	43±8.8
State Route 267 Repair	–	–	72±5.2	1±0.8	67±4.0
Truckee Bypass State Route 267	2±0.6	35±25	7±1.5	55±8.1	75±5.6

Notes:
1 Mean ± 1 Standard Error
2 Based on 10 randomly located, 10-m-long transects at each site along which cover was recorded at 25 cm intervals.
3 Maximum cover of growth forms does not sum to total plant cover because of overlapping plants (i.e., more than one plant covering a location).

Table A-7
Percent Cover of Species along Transects at 10 Roadside Cut Slopes

Species	Sites								
	Marsh. Court	Marsh. Trail	Apal at Musk.	Apal. at Eagles	267 Bypass	267 Repair	Big Springs	Brock. Sum.	Pion. Trail
Abies concolor	-	-	-	<1	-	-	-	-	-
Achillea millefolium	-	-	-	1	27	-	2	-	-
Achnatherum occidentalis	-	-	-	<1	<1	-	-	-	-
Amelanchier acuparia	-	-	-	1	-	-	-	-	-
Apocynum androsaemifolium	-	-	-	2	-	-	-	-	-
Arabis holboellii	2	4	-	-	<1	-	-	-	-
Arctostaphylos patula	-	-	14	3	-	-	-	7	5
Artemesia tridentate	-	2	-	<1	-	-	-	3	1
Asteraceae species	<1	1	-	-	-	-	-	-	-
Bromus carinatus	-	-	2	<1	3	57	1	1	<1
Bromus diandrus	-	-	-	-	-	<1	-	-	-
Bromus tectorum	-	-	-	-	-	1	-	30	10
Carex species 1	2	4	-	-	-	-	-	-	-
Carex species 2	-	<1	-	-	-	-	-	-	-
Carex species 3	-	-	-	-	<1	-	-	-	-
Ceanothus cordulatus	3	7	1	<1	-	-	-	-	-
Ceanothus prostratus	-	<1	15	7	-	-	-	1	-
Chrysothamnus nauseous	-	5	<1	<1	-	-	-	-	5
Cirsium arvense	-	-	<1	-	-	-	-	-	-
Cirsium vulgare	-	-	-	-	<1	-	-	-	-
Collinsia torreyi	-	-	-	<1	-	-	-	-	-
Collomia species	-	0.5	-	-	-	-	<1	-	-
Collomia tinctoria	-	-	-	-	<1	-	-	-	-
Cryptantha species	-	-	-	-	-	-	6	-	-
Dactylis glomerata	3	6	<1	-	-	-	-	-	-
Elymus elymoides	1	2	<1	-	1	15	17	<1	-
Elymus glaucus	-	-	-	-	2	-	29	-	-
Elymus trachycaulus	-	-	8	<1	-	-	1	-	-
Elytrigia intermedia	-	-	5	6	-	-	-	-	4
Epilobium brachycarpum	<1	2	-	2	19	-	19	<1	-
Eriogonum nudum	1	3	-	-	-	-	-	-	-
Eriogonum umbellatum	-	-	-	-	-	-	-	-	1

Table A-7
Percent Cover of Species along Transects at 10 Roadside Cut Slopes

Species	Sites								
	Marsh. Court	Marsh. Trail	Apal at Musk.	Apal. at Eagles	267 Bypass	267 Repair	Big Springs	Brock. Sum.	Pion. Trail
Festuca rubra	3	6	-	-	-	-	6	4	2
Festuca trachyphylla	-	-	1	1	-	-	-	-	17
Gnaphalium canescens	-	-	-	-	-	-	-	2	-
Lactuca serriola	-	-	-	-	4	-	-	-	-
Leucanthemum vulgare	-	-	-	-	-	-	-	<1	-
Lotus corniculatus	-	-	-	3	-	-	-	-	-
Lotus purshianus	-	-	-	<1	31	-	<1	<1	-
Lupinus argenteus	-	-	-	<1	-	-	-	-	-
Lupinus grayii	-	-	-	-	8	-	-	-	-
Lupinus lepidus	-	<1	-	-	-	-	-	-	-
Lupinus polyphyllus	-	-	<1	<1	-	-	-	-	-
Melilotus alba	-	-	-	<1	-	-	-	-	-
Melilotus indica	-	-	-	<1	-	-	-	-	-
Phlox gracilis	<1	<1	-	-	-	-	-	-	-
Phlox diffusa	-	<1	-	-	-	-	-	-	-
Pinus jeffreyi	-	<1	2	9	1	-	-	-	-
Poa bulbosa	-	-	-	<1	-	-	-	-	3
Poa secunda	9	26	13	12	-	-	-	-	2
Polygonum arenastrum	-	-	-	-	-	-	1.5	-	-
Polygonum douglassi	-	-	-	-	<1	-	-	-	-
Purshia tridentata	2	23	4	3	<1	-	-	4	<1
Rosa woodsii	-	-	-	-	-	-	-	-	2
Salix lemmonii	2	4	-	5	-	-	-	-	-
Tragopogon dubius	-	-	-	-	-	-	<1	-	-
Wyethia mollis	-	-	<1	-	-	-	-	-	<1

Table A-8
Correlations among Physical Site Attributes1

	Site Age	Slope Aspect	Slope Angle	Slope Length	Shade	Soil Clay	Soil OM	Soil Nitrogen	Soil Loosening Depth	Soil Bulk Density	Penetrability DTR	Rooting Depth
Site Age												
Slope Aspect	-0.34											
Slope Angle	-0.1	-0.3										
Slope Length	-0.12	0.6	-0.39									
Shade	-0.14	**-0.81**	0.39	-0.44								
Soil Clay	-0.51	0.4	-0.05	0.51	-0.1							
Soil OM	-0.53	-0.28	0.41	0.08	0.64	0.6						
Soil Nitrogen	-0.41	-0.4	0.4	0.06	**0.71**	0.41	**0.97**					
Soil Loosening Depth	-0.38	-0.34	0.24	-0.1	0.53	**0.67**	**0.86**	**0.77**				
Soil Bulk Density	**0.67**	-0.04	-0.4	-0.08	-0.32	**-0.77**	**-0.73**	-0.54	**-0.73**			
Penetrability DTR	-0.37	0.05	0.03	-0.28	0.07	0.62	0.4	0.23	**0.74**	-0.56		
Rooting Depth	-0.39	-0.36	0.12	**-0.67**	0.37	0.17	0.28	0.16	0.59	0.45	**0.76**	

Note:

[1] Correlations significant at a critical value of $p = 0.05$ are shown in bold

Table A-9
Correlation of Cover Attributes with Site Physical Attributes[1]

Site Physical Attribute	Cover					
	Plant Cover				Mulch	Exposed Soil
	Woody	Perennial	Annual	Total		
Site Age	0.19	-0.65	-0.23	**-0.86**	-0.59	**0.72**
Slope Aspect	0.16	-0.13	0.47	0.37	-0.31	0.13
Slope Angle	0.03	0.55	-0.28	0.22	0.18	-0.16
Slope Length	-0.19	-0.44	**0.72**	0.21	-0.40	0.14
Shade	-0.31	0.38	-0.10	0.15	0.45	-0.45
Soil Clay	**-0.73**	0.37	0.56	**0.77**	0.42	-0.60
Soil OM	-0.54	**0.67**	0.17	0.55	0.55	-0.63
Soil Nitrogen	-0.39	0.57	0.08	0.50	0.41	-0.47
Soil Loosening Depth	**-0.74**	**0.69**	<.01	0.55	**0.75**	**-0.71**
Soil Bulk Density	**0.73**	-0.65	-0.36	**-0.84**	**-0.72**	**0.89**
Penetrability DTR	-0.56	**0.67**	-0.09	0.51	**0.71**	-0.61
Rooting Depth	-0.38	0.7	-0.42	0.29	**0.91**	**-0.71**

Note:
[1] Correlations significant at a critical value of p = 0.05 are shown in bold

A.2.2.2 Comparison of Visual and Transect-Based Cover Estimates

The repeated survey of 8 sites using two different methods of estimating plant cover provided an opportunity to compare visual estimates (by a single, experienced investigator) with estimates based on the point-intercept technique (with 10 transect of 40 points each). Because the point-intercept measurements were made a year after the visual estimates, cover may have changed substantially at sites that were recently revegetated. Therefore, cover estimates visual and point-intercept estimates were compared only for the 6 older sites at which plant cover would be more similar during both years. Table A-10 compares the plant cover estimates generated by both methods at these sites. At two of the six sites, the visual estimate differed significantly from the presumably more accurate estimate based on the point-intercept data, demonstrating that the visual estimates, while in general are related to plant cover, are not a reliable basis for an estimate of plant cover for a single site.

Table A-10
Comparison of Visual and Point-Intercept Plant Cover Estimates

Site	Plant Cover estimates		
	Visual	Point-Intercept[1]	Comparison of Estimates[2]
Apalache – Glen Eagles Drive	50	53±12.0	Comparable
Big Springs and Overlook Place	40	67±7.0	Differ
Brockway Summit	75	46±17.0	Differ
Marshall Court	15	23±10.4	Comparable
Marshall Trail at Columbine	35	29±15.6	Comparable
Pioneer Trail Erosion Control	28	43±17.7	Comparable

Note:
[1] Mean plus or minus 90% confidence interval.
[2] Estimates were considered comparable if the visual estimate was within the 90% confidence interval generated from the point-intercept data.

This page has been intentionally left blank.

Appendix B

TAHOE BASIN SOLAR PATH AND CLIMATE SUMMARIES

APPENDIX B. TAHOE BASIN SOLAR PATH AND CLIMATE SUMMARIES

This appendix provides the sun's path across the sky during the growing season (i.e., the solar path) in the Tahoe Basin, and monthly summaries of the Tahoe Basin's climate. The solar path is provided as a graph of the angle of the sun between the spring and fall equinoxes and the summer solstice for angles from east to west in the Tahoe Basin. The elevation angles in the Tahoe Basin for sun during the spring equinox and summer solstice were determined from the *NOAA Solar Position Calculator* (available at http://www.srrb.noaa.gove/highlights/sunrise /azel.html). (The fall equinox has similar solar angles to the spring equinox.)

Climate summaries for the Tahoe Basin are copies of Tahoe Basin weather station records as provided in the following:

National Oceanic and Atmospheric Administration. 2004. *Climatography of the United States No. 20: Monthly Station Climate Summaries, 1971–2004*. National Climatic Data Center, Asheville, NC.

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: TAHOE CITY, CA **COOP ID: 048758**

Climate Division: CA 3 **NWS Call Sign:** **Elevation: 6,230 Feet** **Lat: 39°10N** **Lon: 120°09W**

Temperature (°F)																						
Mean (1)				Extremes											Degree Days (1) Base Temp 65		Mean Number of Days (3)					
Month	Daily Max	Daily Min	Mean	Highest Daily(2)	Year	Day	Highest Month(1) Mean	Year	Lowest Daily(2)	Year	Day	Lowest Month(1) Mean	Year		Heating	Cooling	Max >= 100	Max >= 90	Max >= 50	Max <= 32	Min <= 32	Min <= 0
Jan	40.5	20.1	30.3	59	1990	10	36.5	1986	-14+	1937	21	23.7	1993		1076	0	.0	.0	2.5	3.3	29.7	.4
Feb	42.0	21.3	31.7	60+	1996	9	38.3	1991	-15	1989	7	27.0	1990		934	0	.0	.0	4.3	2.6	27.4	.3
Mar	45.1	24.3	34.7	67	1988	27	39.1	1997	-6	1935	10	26.5	1977		924	0	.0	.0	9.5	1.8	28.7	.2
Apr	51.4	27.7	39.6	74	1981	30	46.5	1992	5	1999	9	33.0	1975		763	0	.0	.0	17.3	.3	25.3	.0
May	60.1	33.5	46.8	81	1986	31	53.9	1992	9	1974	18	39.8	1977		565	0	.0	.0	26.0	@	14.4	.0
Jun	69.2	39.6	54.4	90	1961	22	58.4	1985	24+	1990	1	50.1	1980		320	2	.0	.0	29.3	.0	3.3	.0
Jul	77.5	44.7	61.1	93+	1934	28	64.4	1988	22	1975	1	56.3	1983		142	20	.0	.1	31.0	.0	.3	.0
Aug	77.0	44.8	60.9	94	1933	15	63.8	1988	29+	1957	30	54.1	1976		148	21	.0	.2	31.0	.0	.2	.0
Sep	70.1	39.6	54.9	87+	1955	2	58.3	1981	21+	1965	19	48.7	1986		310	4	.0	.0	29.3	.0	2.8	.0
Oct	60.0	32.3	46.2	80	1933	3	52.0	1988	9	1971	28	40.0	1971		585	0	.0	.0	26.0	.1	16.1	.0
Nov	47.9	25.5	36.7	70	1988	6	43.6	1995	1	1931	23	29.4	1994		849	0	.0	.0	13.2	1.0	26.5	.0
Dec	41.4	20.6	31.0	60	1990	10	35.3	1981	-16	1972	11	25.1	1971		1055	0	.0	.0	3.3	3.2	29.6	.5
Ann	56.9	31.2	44.0	94	Aug 1933	15	64.4	Jul 1988	-16	Dec 1972	11	23.7	Jan 1993		7671	47	.0	.3	222.7	12.3	204.3	1.4

+ Also occurred on an earlier date(s)

@ Denotes mean number of days greater than 0 but less than .05

Complete documentation available from: www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

(1) From the 1971-2000 Monthly Normals

(2) Derived from station's available digital record: 1931-2001

(3) Derived from 1971-2000 serially complete daily data

Issue Date: February 2004

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: TAHOE CITY, CA **COOP ID: 048758**

Climate Division: CA 3 **NWS Call Sign:** **Elevation: 6,230 Feet** **Lat: 39°10N** **Lon: 120°09W**

Precipitation (inches)

	Precipitation Totals									Mean Number of Days (3)				Precipitation Probabilities (1) Probability that the monthly/annual precipitation will be equal to or less than the indicated amount										
	Means/ Medians(1)		Extremes							Daily Precipitation				Monthly/Annual Precipitation vs Probability Levels These values were determined from the incomplete gamma distribution										
Month	Mean	Med-ian	Highest Daily(2)	Year	Day	Highest Monthly(1)	Year	Lowest Monthly(1)	Year	>= 0.01	>= 0.10	>= 0.50	>= 1.00	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95
Jan	6.01	4.29	4.65	1997	2	18.23	1997	.08	1991	10.2	7.7	4.1	2.0	.29	.61	1.31	2.10	3.03	4.13	5.48	7.22	9.69	13.91	18.14
Feb	5.71	4.59	5.80	1963	1	22.25	1986	.07	1988	9.8	7.7	3.7	1.8	.47	.85	1.60	2.39	3.26	4.26	5.45	6.94	9.01	12.47	15.88
Mar	4.57	3.12	3.98	1995	23	19.58	1995	.50	2000	9.8	7.2	3.1	1.3	.33	.62	1.21	1.84	2.54	3.35	4.32	5.55	7.26	10.15	13.00
Apr	1.82	1.58	3.67	1958	3	6.71	1982	.14+	1992	7.4	4.5	1.0	.2	.22	.36	.62	.87	1.14	1.44	1.79	2.22	2.80	3.77	4.70
May	1.21	1.03	1.91	1996	16	4.18	1996	.00	1985	6.2	3.2	.6	.2	.05	.15	.33	.51	.70	.92	1.17	1.49	1.93	2.66	3.37
Jun	.77	.59	1.46	1936	6	2.09	1982	.00+	1994	3.8	2.5	.3	.0	.00	.00	.24	.38	.51	.64	.80	.98	1.22	1.61	1.98
Jul	.33	.16	1.63	1974	9	2.66	1974	.00+	2000	1.7	.8	.2	.1	.00	.00	.01	.04	.09	.16	.25	.38	.57	.90	1.25
Aug	.46	.24	1.60	1991	15	1.96	1976	.00+	2000	2.6	1.1	.1	.1	.00	.00	.00	.05	.13	.23	.36	.53	.79	1.25	1.72
Sep	.90	.51	1.45	1982	16	4.78	1982	.00	1987	3.9	2.1	.6	.1	.00	.03	.10	.21	.34	.51	.74	1.04	1.49	2.28	3.10
Oct	1.95	1.58	3.15	1933	29	6.67	1975	.00+	1995	4.9	3.4	1.3	.5	.00	.18	.51	.82	1.14	1.50	1.92	2.43	3.13	4.28	5.41
Nov	4.25	3.13	4.56	1950	19	13.55	1981	.31	1992	8.4	6.3	2.9	1.2	.33	.61	1.17	1.75	2.40	3.15	4.04	5.16	6.72	9.33	11.91
Dec	4.68	4.11	6.77	1964	23	18.50	1996	.00	1989	9.0	7.1	2.8	1.4	.16	.51	1.17	1.85	2.59	3.44	4.46	5.73	7.50	10.46	13.37
Ann	32.66	27.61	6.77	Dec 1964	23	22.25	Feb 1986	.00+	Aug 2000	77.7	53.6	20.7	8.9	14.40	17.32	21.38	24.69	27.78	30.90	34.24	38.08	42.91	50.25	56.89

+ Also occurred on an earlier date(s)
# Denotes amounts of a trace
@ Denotes mean number of days greater than 0 but less than .05
** Statistics not computed because less than six years out of thirty had measurable precipitation

(1) From the 1971-2000 Monthly Normals
(2) Derived from station's available digital record: 1931-2001
(3) Derived from 1971-2000 serially complete daily data

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Services

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: TAHOE CITY, CA **COOP ID: 048758**

Climate Division: CA 3 **NWS Call Sign:** **Elevation: 6,230 Feet** **Lat: 39°10N** **Lon: 120°09W**

Snow (inches)																							
Snow Totals															Mean Number of Days (1)								
Means/Medians (1)					Extremes (2)										Snow Fall >= Thresholds					Snow Depth >= Thresholds			
Month	Snow Fall Mean	Snow Fall Median	Snow Depth Mean	Snow Depth Median	Highest Daily Snow Fall	Year	Day	Highest Monthly Snow Fall	Year	Highest Daily Snow Depth	Year	Day	Highest Monthly Mean Snow Depth	Year	0.1	1.0	3.0	5.0	10.0	1	3	5	10
Jan	38.4	40.0	21	16	21.0	1997	23	106.5	1996	76	1993	1	66	1993	7.5	7.2	4.4	2.8	1.4	28.1	27.0	25.3	23.2
Feb	40.8	35.5	29	29	31.0	1985	8	109.5	1998	97	1993	24	69	1993	7.7	7.5	4.7	2.9	1.2	25.8	24.3	23.7	22.2
Mar	30.9	25.5	23	23	32.0	1995	23	100.0	1995	84	1993	1	61	1983	7.1	6.8	3.8	2.2	.9	25.9	24.3	22.9	19.1
Apr	11.1	5.0	10	2	16.0	1999	6	42.0	1999	74	1982	4	55	1983	4.1	3.8	1.7	.8	.2	10.3	8.3	6.7	5.4
May	2.8	1.0	1	#	10.0	1975	1	14.0	1975	45	1983	1	18	1983	1.1	1.1	.5	.2	@	2.2	1.6	1.2	1.0
Jun	.4	.0	#	0	4.0	1995	16	4.0	1995	4	1995	16	#+	1995	.1	.1	.1	.0	.0	.1	.1	.0	.0
Jul	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Aug	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Sep	.4	.0	#	0	4.0	1971	30	5.0	1986	4+	1986	27	#+	1986	.2	.2	.1	.0	.0	.2	.1	.0	.0
Oct	2.5	.0	#	#	10.0	1981	29	12.0+	1985	12	1981	29	1+	2000	1.0	.9	.2	.1	@	1.3	.5	.2	.1
Nov	17.3	14.5	3	1	26.0	1982	30	59.0	1985	40	1994	26	13	1994	4.3	4.1	2.0	1.2	.3	10.5	7.5	5.6	3.0
Dec	26.2	24.3	10	8	37.0	1996	21	83.5	1992	62	1992	31	30	1994	6.2	6.0	3.2	1.9	.6	21.1	18.0	15.8	12.4
Ann	170.8	145.8	N/A	N/A	37.0	Dec 1996	21	109.5	Feb 1998	97	Feb 1993	24	69	Feb 1993	39.3	37.7	20.7	12.1	4.6	125.5	111.7	101.4	86.4

+ Also occurred on an earlier date(s) #Denotes trace amounts

@ Denotes mean number of days greater than 0 but less than .05

-9/-9.9 represents missing values
Annual statistics for Mean/Median snow depths are not appropriate

(1) Derived from Snow Climatology and 1971-2000 daily data

(2) Derived from 1971-2000 daily data

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: TAHOE CITY, CA **COOP ID: 048758**

Climate Division: CA 3 **NWS Call Sign:** **Elevation: 6,230 Feet** **Lat: 39˚10N** **Lon: 120˚09W**

Freeze Data

Spring Freeze Dates (Month/Day)

Temp (F)	Probability of later date in spring (thru Jul 31) than indicated(*)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	7/18	7/14	7/11	7/08	7/06	7/03	6/30	6/27	6/23
32	7/07	6/30	6/26	6/22	6/18	6/14	6/10	6/06	5/30
28	6/16	6/09	6/05	6/01	5/28	5/24	5/20	5/16	5/09
24	6/01	5/23	5/17	5/12	5/07	5/02	4/27	4/21	4/13
20	5/11	5/03	4/28	4/23	4/18	4/13	4/08	4/03	3/26
16	5/02	4/23	4/16	4/10	4/05	3/30	3/25	3/18	3/08

Fall Freeze Dates (Month/Day)

Temp (F)	Probability of earlier date in fall (beginning Aug 1) than indicated(*)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	8/10	8/16	8/20	8/24	8/27	8/30	9/02	9/06	9/12
32	8/27	9/04	9/09	9/14	9/19	9/23	9/28	10/03	10/11
28	9/19	9/26	10/01	10/05	10/09	10/13	10/17	10/22	10/29
24	10/11	10/17	10/21	10/24	10/28	10/31	11/03	11/07	11/13
20	10/19	10/26	10/31	11/04	11/08	11/12	11/16	11/21	11/28
16	11/06	11/12	11/16	11/20	11/23	11/26	11/30	12/04	12/10

Freeze Free Period

Temp (F)	Probability of longer than indicated freeze free period (Days)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	76	67	61	56	52	47	42	36	27
32	118	109	102	97	92	87	81	75	66
28	161	151	144	139	133	128	122	115	106
24	202	192	185	178	173	167	161	153	143
20	234	223	216	209	203	197	191	183	173
16	260	250	243	237	231	226	220	213	203

* Probability of observing a temperature as cold, or colder, later in the spring or earlier in the fall than the indicated date.

0/00 Indicates that the probability of occurrence of threshold temperature is less than the indicated probability.

Derived from 1971-2000 serially complete daily data

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: TAHOE CITY, CA **COOP ID: 048758**

Climate Division: CA 3 **NWS Call Sign:** **Elevation: 6,230 Feet** **Lat: 39˚10N** **Lon: 120˚09W**

Degree Days to Selected Base Temperatures (˚F)

Base	Heating Degree Days (1)												
Below	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
65	1076	934	924	763	565	320	142	148	310	585	849	1055	7671
60	921	794	785	613	413	185	51	56	180	432	699	900	6029
57	828	710	692	524	327	120	20	23	119	345	609	807	5124
55	766	654	630	466	272	85	9	12	86	289	549	745	4563
50	611	514	477	328	157	27	0	1	29	170	402	590	3306
32	119	75	66	29	3	0	0	0	0	3	39	115	449

Base	Cooling Degree Days (1)												
Above	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
32	66	65	149	256	461	672	901	895	684	441	180	83	4853
55	0	0	0	3	17	67	197	194	80	15	0	0	573
57	0	0	0	1	10	42	146	144	53	8	0	0	404
60	0	0	0	0	3	17	84	84	24	3	0	0	215
65	0	0	0	0	0	2	20	21	4	0	0	0	47
70	0	0	0	0	0	0	2	2	0	0	0	0	4

Growing Degree Units (2)

Base	Growing Degree Units (Monthly)												Growing Degree Units (Accumulated Monthly)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
40	0	0	17	75	235	438	657	649	454	229	41	3	0	0	17	92	327	765	1422	2071	2525	2754	2795	2798
45	0	0	0	24	122	293	502	494	309	111	5	0	0	0	0	24	146	439	941	1435	1744	1855	1860	1860
50	0	0	0	1	44	167	349	340	175	37	0	0	0	0	0	1	45	212	561	901	1076	1113	1113	1113
55	0	0	0	0	6	66	204	193	72	6	0	0	0	0	0	0	6	72	276	469	541	547	547	547
60	0	0	0	0	0	14	80	76	12	0	0	0	0	0	0	0	0	14	94	170	182	182	182	182
Base	Growing Degree Units for Corn (Monthly)												Growing Degree Units for Corn (Accumulated Monthly)											
50/86	0	1	23	74	179	301	438	430	312	176	41	1	0	1	24	98	277	578	1016	1446	1758	1934	1975	1976

(1) Derived from the 1971-2000 Monthly Normals
(2) Derived from 1971-2000 serially complete daily data
Note: For corn, temperatures below 50 are set to 50, and temperatures above 86 are set to 86

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: TAHOE VALLEY AP, CA **COOP ID: 048762**

Climate Division: CA 3 **NWS Call Sign: TVL** **Elevation: 6,254 Feet** **Lat: 38˚54N** **Lon: 120˚00W**

Temperature (˚F)																						
Mean (1)				Extremes											Degree Days (1) Base Temp 65		Mean Number of Days (3)					
Month	Daily Max	Daily Min	Mean	Highest Daily(2)	Year	Day	Highest Month(1) Mean	Year	Lowest Daily(2)	Year	Day	Lowest Month(1) Mean	Year		Heating	Cooling	Max >= 100	Max >= 90	Max >= 50	Max <= 32	Min <= 32	Min <= 0
Jan	41.0	15.1	28.1	60+	1990	11	34.3	1986	-28	1993	1	20.4	1979		1146	0	.0	.0	4.3	3.5	29.1	2.6
Feb	42.4	17.0	29.7	62+	1977	19	36.6	1991	-29	1989	7	22.7	1990		989	0	.0	.0	6.6	2.8	27.0	1.5
Mar	45.6	22.5	34.1	70	1988	27	40.2	1972	-10	1971	2	28.0	1973		960	0	.0	.0	11.4	1.8	27.9	.4
Apr	52.7	26.4	39.6	76	1981	30	45.8	1985	-1+	1975	7	26.9	1975		764	0	.0	.0	19.5	.6	26.0	.1
May	61.1	31.9	46.5	84+	1986	30	51.5	1992	7	1974	18	39.9	1977		574	0	.0	.0	26.7	@	17.3	.0
Jun	70.4	36.8	53.6	90	1988	25	58.0	1977	21	1988	9	49.0	1980		342	0	.0	@	29.4	.0	7.0	.0
Jul	78.6	39.8	59.2	99	1988	22	64.1	1988	25	1976	1	55.7	1983		192	12	.0	.7	31.0	.0	2.5	.0
Aug	78.7	38.5	58.6	96+	1981	9	66.0	1988	24	1973	24	52.1	1976		220	22	.0	1.1	31.0	.0	2.9	.0
Sep	72.0	32.5	52.3	94+	1988	5	58.4	1988	19	1984	25	45.1	1986		387	4	.0	.2	29.6	.0	10.6	.0
Oct	61.8	25.8	43.8	84	1988	2	50.0	1988	11	1971	29	38.9	1971		656	0	.0	.0	27.2	.1	25.2	.0
Nov	48.8	19.7	34.3	70+	1999	7	42.2	1995	-6	1975	29	27.9	1978		922	0	.0	.0	14.7	1.2	27.2	.3
Dec	41.8	14.1	28.0	63	1990	10	33.4	1996	-29	1972	9	20.1	1971		1148	0	.0	.0	5.7	4.0	29.1	2.7
Ann	57.9	26.7	42.3	99	Jul 1988	22	66.0	Aug 1988	-29+	Feb 1989	7	20.1	Dec 1971		8300	38	.0	2.0	237.1	14.0	231.8	7.6

+ Also occurred on an earlier date(s)

@ Denotes mean number of days greater than 0 but less than .05

Complete documentation available from: www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

(1) From the 1971-2000 Monthly Normals

(2) Derived from station's available digital record: 1968-2000

(3) Derived from 1971-2000 serially complete daily data

Issue Date: February 2004

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: TAHOE VALLEY AP, CA **COOP ID: 048762**

Climate Division: CA 3 **NWS Call Sign: TVL** **Elevation: 6,254 Feet** **Lat: 38°54N** **Lon: 120°00W**

Precipitation (inches)

	Precipitation Totals									Mean Number of Days (3)				Precipitation Probabilities (1) Probability that the monthly/annual precipitation will be equal to or less than the indicated amount										
	Means/ Medians(1)		Extremes							Daily Precipitation				Monthly/Annual Precipitation vs Probability Levels These values were determined from the incomplete gamma distribution										
Month	Mean	Med-ian	Highest Daily(2)	Year	Day	Highest Monthly(1)	Year	Lowest Monthly(1)	Year	>= 0.01	>= 0.10	>= 0.50	>= 1.00	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95
Jan	.00	.00	#+	1997	2	.00	0	.00	0	3.0	1.0	1.0	1.0	**	**	**	**	**	**	**	**	**	**	**
Feb	.00	.00	.00+	1977	28	.00	0	.00	0	2.9	1.0	1.0	1.0	**	**	**	**	**	**	**	**	**	**	**
Mar	.00	.00	#+	1995	23	.00	0	.00	0	3.0	1.0	1.0	1.0	**	**	**	**	**	**	**	**	**	**	**
Apr	.00	.00	#+	1958	3	.00	0	.00+	0	3.0	1.0	1.0	1.0	**	**	**	**	**	**	**	**	**	**	**
May	.00	.00	#+	1996	16	.00	0	.00	0	3.0	1.0	1.0	1.0	**	**	**	**	**	**	**	**	**	**	**
Jun	.00	.00	#+	1936	6	.00	0	.00+	0	3.0	1.0	1.0	1.0	**	**	**	**	**	**	**	**	**	**	**
Jul	.00	.00	.00+	1968	17	.00	0	.00+	0	3.0	1.0	1.0	1.0	**	**	**	**	**	**	**	**	**	**	**
Aug	.00	.00	#+	1991	15	.00	0	.00+	0	3.0	1.0	1.0	1.0	**	**	**	**	**	**	**	**	**	**	**
Sep	.00	.00	#+	1982	16	.00	0	.00	0	3.0	1.0	1.0	1.0	**	**	**	**	**	**	**	**	**	**	**
Oct	.00	.00	#+	1933	29	.00	0	.00+	0	3.0	1.0	1.0	1.0	**	**	**	**	**	**	**	**	**	**	**
Nov	.00	.00	.00+	1968	30	.00	0	.00	0	3.0	1.0	1.0	1.0	**	**	**	**	**	**	**	**	**	**	**
Dec	.00	.00	#+	1964	23	.00	0	.00	0	3.0	1.0	1.0	1.0	**	**	**	**	**	**	**	**	**	**	**
Ann	.00+	.00+	.00+	Feb 1977	28	#	0	9.99+	0	35.9	12.0	12.0	12.0	**	**	**	**	**	**	**	**	**	**	**

+ Also occurred on an earlier date(s)
# Denotes amounts of a trace
@ Denotes mean number of days greater than 0 but less than .05
** Statistics not computed because less than six years out of thirty had measurable precipitation

(1) From the 1971-2000 Monthly Normals
(2) Derived from station's available digital record: 1968-2000
(3) Derived from 1971-2000 serially complete daily data

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Services

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: TAHOE VALLEY AP, CA **COOP ID: 048762**

Climate Division: CA 3 **NWS Call Sign: TVL** **Elevation: 6,254 Feet** **Lat: 38˚54N** **Lon: 120˚00W**

Snow (inches)																								
Snow Totals															Mean Number of Days (1)									
Means/Medians (1)					Extremes (2)										Snow Fall >= Thresholds					Snow Depth >= Thresholds				
Month	Snow Fall Mean	Snow Fall Median	Snow Depth Mean	Snow Depth Median	Highest Daily Snow Fall	Year	Day	Highest Monthly Snow Fall	Year	Highest Daily Snow Depth	Year	Day	Highest Monthly Mean Snow Depth	Year	0.1	1.0	3.0	5.0	10.0	1	3	5	10
Jan	-9.9	-9.9	-99	-99	-9.9	-99	-99	-9.9	-99	-99	-99	-99	-99	-99	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9
Feb	-9.9	-9.9	-99	-99	-9.9	-99	-99	-9.9	-99	-99	-99	-99	-99	-99	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9
Mar	-9.9	-9.9	-99	-99	-9.9	-99	-99	-9.9	-99	-99	-99	-99	-99	-99	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9
Apr	-9.9	-9.9	-99	-99	-9.9	-99	-99	-9.9	-99	-99	-99	-99	-99	-99	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9
May	-9.9	-9.9	-99	-99	-9.9	-99	-99	-9.9	-99	-99	-99	-99	-99	-99	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9
Jun	-9.9	-9.9	-99	-99	-9.9	-99	-99	-9.9	-99	-99	-99	-99	-99+	-99	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9
Jul	-9.9	-9.9	-99	-99	-9.9	-99	-99	-9.9	-99	-99	-99	-99	-99	-99	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9
Aug	-9.9	-9.9	-99	-99	-9.9	-99	-99	-9.9	-99	-99	-99	-99	-99	-99	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9
Sep	-9.9	-9.9	-99	-99	-9.9	-99	-99	-9.9	-99	-99+	-99	-99	-99+	-99	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9
Oct	-9.9	-9.9	-99	-99	-9.9	-99	-99	-9.9+	-99	-99	-99	-99	-99+	-99	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9
Nov	-9.9	-9.9	-99	-99	-9.9	-99	-99	-9.9	-99	-99	-99	-99	-99	-99	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9
Dec	-9.9	-9.9	-99	-99	-9.9	-99	-99	-9.9	-99	-99	-99	-99	-99	-99	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9
Ann	-9.9	-9.9	N/A	N/A	-9.9	-99	-99	-9.9	-99	-99	-99	-99	-99	-99	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9	-9.9

+ Also occurred on an earlier date(s) #Denotes trace amounts

@ Denotes mean number of days greater than 0 but less than .05

-9/-9.9 represents missing values
Annual statistics for Mean/Median snow depths are not appropriate

(1) Derived from Snow Climatology and 1971-2000 daily data

(2) Derived from 1971-2000 daily data

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: TAHOE VALLEY AP, CA **COOP ID: 048762**

Climate Division: CA 3 **NWS Call Sign: TVL** **Elevation: 6,254 Feet** **Lat: 38˚54N** **Lon: 120˚00W**

Freeze Data

Spring Freeze Dates (Month/Day)

Temp (F)	Probability of later date in spring (thru Jul 31) than indicated(*)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	8/04	7/31	7/27	7/25	7/22	7/19	7/17	7/13	7/09
32	7/30	7/24	7/20	7/17	7/13	7/10	7/06	7/02	6/27
28	7/05	6/28	6/23	6/19	6/15	6/11	6/07	6/02	5/27
24	6/11	6/03	5/28	5/22	5/17	5/12	5/07	5/01	4/22
20	5/11	5/05	4/30	4/27	4/23	4/20	4/16	4/12	4/06
16	5/06	4/27	4/20	4/14	4/09	4/04	3/29	3/22	3/13

Fall Freeze Dates (Month/Day)

Temp (F)	Probability of earlier date in fall (beginning Aug 1) than indicated(*)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	7/29	8/01	8/04	8/06	8/09	8/11	8/13	8/16	8/20
32	8/01	8/08	8/13	8/17	8/20	8/24	8/28	9/02	9/09
28	8/18	8/27	9/02	9/07	9/12	9/17	9/22	9/28	10/07
24	9/13	9/20	9/24	9/29	10/03	10/06	10/11	10/16	10/22
20	10/04	10/10	10/14	10/18	10/21	10/25	10/28	11/02	11/07
16	10/25	10/29	11/01	11/04	11/06	11/08	11/11	11/13	11/17

Freeze Free Period

Temp (F)	Probability of longer than indicated freeze free period (Days)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	37	30	25	21	17	13	9	4	0
32	70	59	51	44	37	31	24	16	5
28	123	111	102	95	88	81	74	65	53
24	172	160	151	144	138	131	124	115	103
20	205	197	190	185	180	175	170	164	156
16	238	229	222	216	210	205	199	192	182

* Probability of observing a temperature as cold, or colder, later in the spring or earlier in the fall than the indicated date.

0/00 Indicates that the probability of occurrence of threshold temperature is less than the indicated probability.

Derived from 1971-2000 serially complete daily data

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: TAHOE VALLEY AP, CA **COOP ID: 048762**

Climate Division: CA 3 **NWS Call Sign: TVL** **Elevation: 6,254 Feet** **Lat: 38˚54N** **Lon: 120˚00W**

Degree Days to Selected Base Temperatures (˚F)

Base	Heating Degree Days (1)												
Below	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
65	1146	989	960	764	574	342	192	220	387	656	922	1148	8300
60	991	849	805	614	420	203	83	116	252	502	772	993	6600
57	898	765	712	526	334	132	39	70	182	412	682	900	5652
55	836	709	650	470	278	94	20	46	142	354	622	838	5059
50	681	569	498	334	160	30	2	13	65	221	474	683	3730
32	182	128	89	37	3	0	0	0	0	7	77	182	705

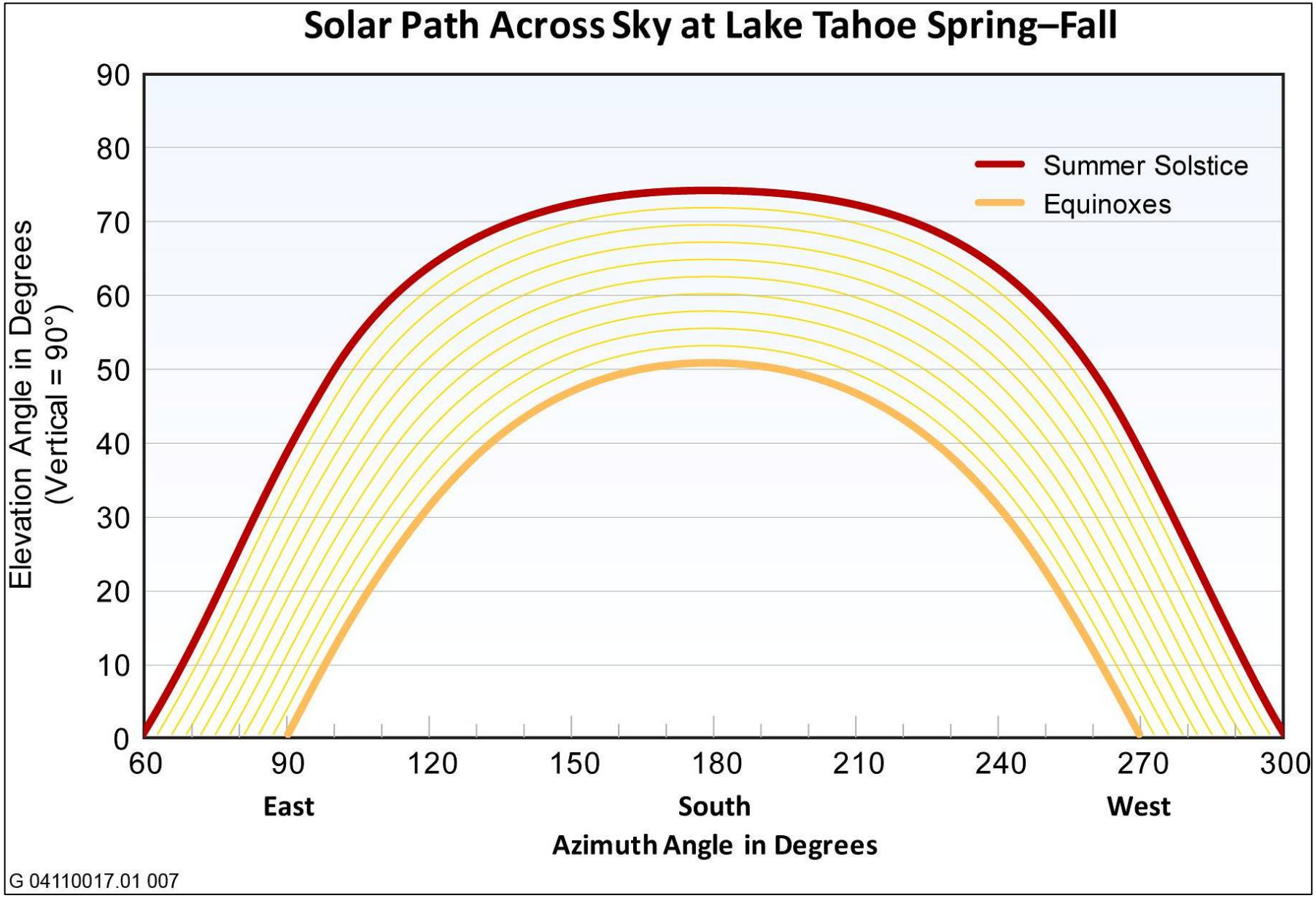
Base	Cooling Degree Days (1)												
Above	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
32	59	63	152	263	452	648	843	825	606	373	145	57	4486
55	0	0	0	6	14	52	150	158	58	7	0	0	445
57	0	0	0	2	8	30	107	120	38	4	0	0	309
60	0	0	0	0	1	11	58	73	18	1	0	0	162
65	0	0	0	0	0	0	12	22	4	0	0	0	38
70	0	0	0	0	0	0	1	5	0	0	0	0	6

Growing Degree Units (2)

Base	Growing Degree Units (Monthly)												Growing Degree Units (Accumulated Monthly)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
40	0	0	23	84	236	430	627	617	423	188	31	2	0	0	23	107	343	773	1400	2017	2440	2628	2659	2661
45	0	0	1	28	124	292	472	462	279	83	5	0	0	0	1	29	153	445	917	1379	1658	1741	1746	1746
50	0	0	0	2	46	157	318	308	152	22	0	0	0	0	0	2	48	205	523	831	983	1005	1005	1005
55	0	0	0	0	9	64	173	171	58	2	0	0	0	0	0	0	9	73	246	417	475	477	477	477
60	0	0	0	0	0	16	65	65	9	0	0	0	0	0	0	0	0	16	81	146	155	155	155	155
Base	Growing Degree Units for Corn (Monthly)												Growing Degree Units for Corn (Accumulated Monthly)											
50/86	0	14	33	99	198	326	457	457	346	207	60	8	0	14	47	146	344	670	1127	1584	1930	2137	2197	2205

(1) Derived from the 1971-2000 Monthly Normals
(2) Derived from 1971-2000 serially complete daily data
Note: For corn, temperatures below 50 are set to 50, and temperatures above 86 are set to 86

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html


Solar Path Across Sky at Lake Tahoe Spring–Fall
Summer Solstice
Equinoxes
Elevation Angle in Degrees
(Vertical = 90°)
90
80
70
60
50
40
30
20
10
0
60
90
120
150
180
210
240
270
300
East
South
West
Azimuth Angle in Degrees
G 04110017.01 007

Appendix C

SUMMARY OF TAHOE BASIN SOIL ATTRIBUTES

Table C-1
Summary of Tahoe Basin Soil Attributes[1,2]

Soil	Depth inches	Bulk Density grams cm^{-3}	Available Water Capacity inches/inch	Organic Matter percent
Aspetill	0 to 5	1.20 to 1.25	0.07 to 0.11	5.0 to 8.0
	5 to 26	1.30 to 1.45	0.09 to 0.10	1.0 to 4.0
	26 to 60	1.30 to 1.45	0.09 to 0.10	0.5 to 1.0
Burnlake	0 to 2	1.35 to 1.55	0.10 to 0.12	2.0 to 4.0
	2 to 17	1.35 to 1.55	0.04 to 0.08	2.0 to 4.0
	17 to 26	1.35 to 1.55	0.04 to 0.08	0.5 to 1.0
	26 to 60	1.45 to 1.65	0.03 to 0.05	0.0 to 0.5
Cagwin	0 to 1	0.02 to 0.09	0.55 to 0.65	70 to 90
	1 to 9	0.90 to 1.55	0.06 to 0.11	2.0 to 8.0
	9 to 13	1.15 to 1.75	0.06 to 0.11	1.0 to 3.0
	13 to 27	1.25 to 1.80	0.02 to 0.05	0.2 to 1.5
	27 to 37	NA	NA	NA
Cassenai gravelly loamy coarse sand	0 to 1	0.02 to 0.09	0.55 to 0.65	70 to 90
	1 to 6	0.75 to 1.40	0.07 to 0.09	5.0 to 12
	6 to 43	1.25 to 1.45	0.06 to 0.08	1.0 to 5.0
	43 to 79	1.35 to 1.60	0.05 to 0.07	0.0 to 1.0
Cassenai, moist	0 to 3	0.02 to 0.09	0.55 to 0.65	70 to 90
	3 to 11	0.75 to 1.50	0.06 to 0.08	5.0 to 12
	11 to 20	1.25 to 1.45	0.05 to 0.07	1.0 to 5.0
	20 to 63	1.35 to 1.60	0.04 to 0.06	0.0 to 1.0
Celio	0 to 8	1.25 to 1.35	0.07 to 0.09	4.0 to 8.0
	8 to 16	1.25 to 1.35	0.05 to 0.06	2.0 to 6.0
	16 to 23	1.40 to 1.50	0.04 to 0.06	1.0 to 3.0
	23 to 45	1.40 to 1.50	0.01 to 0.02	0.2 to 1.5
	45 to 56	NA	NA	NA
	56 to 80	1.65 to 1.75	NA	0.0 to 0.5
Christopher gravelly loamy coarse sand	0 to 1	0.02 to 0.09	0.55 to 0.65	70 to 90
	1 to 5	1.60 to 1.70	0.06 to 0.08	1.0 to 5.0
	5 to 32	1.60 to 1.70	0.05 to 0.07	0.5 to 1.2
	32 to 41	1.60 to 1.70	0.05 to 0.07	0.5 to 1.2
	41 to 71	1.60 to 1.70	0.03 to 0.05	0.2 to 1.0

Table C-1
Summary of Tahoe Basin Soil Attributes[1,2]

Soil	Depth inches	Bulk Density grams cm^{-3}	Available Water Capacity inches/inch	Organic Matter percent
Christopher loamy coarse sand	0 to 1	0.02 to 0.09	0.55 to 0.65	70 to 90
	1 to 8	1.20 to 1.60	0.10 to 0.12	1.0 to 5.0
	8 to 26	1.25 to 1.65	0.09 to 0.11	0.2 to 1.0
	26 to 42	1.30 to 1.70	0.09 to 0.11	0.2 to 0.8
	42 to 61	1.30 to 1.70	0.09 to 0.11	0.2 to 0.8
Dagget very gravelly loamy coarse sand	0 to 1	0.02 to 0.09	0.55 to 0.65	70 to 90
	1 to 9	1.40 to 1.65	0.03 to 0.05	2.0 to 8.0
	9 to 49	1.50 to 1.70	0.03 to 0.05	1.0 to 3.0
	49 to 59	NA	NA	NA
Dagget, moist	0 to 1	0.02 to 0.09	0.55 to 0.65	70 to 90
	1 to 9	1.40 to 1.65	0.03 to 0.05	2.0 to 8.0
	9 to 49	1.50 to 1.70	0.03 to 0.05	1.0 to 3.0
	49 to 59	NA	NA	NA
Deerhill	0 to 1	0.02 to 0.09	0.55 to 0.65	70 to 90
	1 to 9	1.50 to 1.60	0.14 to 0.16	3.0 to 8.0
	9 to 35	1.45 to 1.55	0.14 to 0.15	1.0 to 3.0
Ellispeak	0 to 2	0.80 to 1.00	0.12 to 0.14	3.0 to 6.0
	2 to 6	0.85 to 1.05	0.09 to 0.10	3.0 to 6.0
	6 to 12	1.10 to 1.30	0.04 to 0.04	1.0 to 4.0
Gefo gravelly loamy coarse sand	0 to 15	1.35 to 1.50	0.05 to 0.07	1.5 to 7.0
	15 to 75	1.40 to 1.55	0.04 to 0.08	0.0 to 0.5
Genoa Peak	0 to 2	0.02 to 0.09	0.55 to 0.65	70 to 90
	2 to 4	1.50 to 1.60	0.07 to 0.08	3.0 to 8.0
	4 to 7	1.55 to 1.60	0.04 to 0.05	1.0 to 3.0
	7 to 16	1.50 to 1.60	0.01 to 0.01	0.0 to 0.2
	16 to 60	1.50 to 1.60	0.01 to 0.01	0.0 to 0.2
Glenalpine	0 to 11	1.50 to 1.60	0.10 to 0.11	3.0 to 8.0
	11 to 40	1.50 to 1.60	0.05 to 0.06	1.0 to 5.0
Hardtil	0 to 3	1.40 to 1.60	0.05 to 0.07	2.0 to 4.0
	3 to 7	1.40 to 1.60	0.06 to 0.08	2.0 to 4.0
	7 to 18	1.40 to 1.60	0.05 to 0.07	0.5 to 1.0

Table C-1
Summary of Tahoe Basin Soil Attributes[1,2]

Soil	Depth inches	Bulk Density grams cm^{-3}	Available Water Capacity inches/inch	Organic Matter percent
Inville	0 to 2	0.02 to 0.09	0.55 to 0.65	70 to 90
	2 to 12	1.35 to 1.45	0.07 to 0.09	2.0 to 8.0
	12 to 37	1.40 to 1.50	0.03 to 0.07	0.5 to 2.0
Jabu	0 to 1	0.02 to 0.09	0.55 to 0.65	70 to 90
	1 to 7	0.80 to 1.50	0.10 to 0.13	2.0 to 6.0
	7 to 21	1.25 to 1.60	0.10 to 0.13	0.5 to 2.0
	21 to 46	1.25 to 1.75	0.06 to 0.13	0.2 to 0.8
	46 to 67	1.60 to 2.00	0.10 to 0.14	0.1 to 0.4
	67 to 73	1.40 to 1.80	0.10 to 0.13	0.1 to 0.4
	73 to 101	1.50 to 1.90	0.10 to 0.13	0.1 to 0.4
Jorge very gravelly sandy loam	0 to 2	0.02 to 0.09	0.55 to 0.65	70 to 90
	2 to 24	0.74 to 0.94	0.10 to 0.12	4.0 to 15
Kneeridge, very stony	0 to 2	0.02 to 0.09	0.55 to 0.65	70 to 90
	2 to 16	0.75 to 1.10	0.14 to 0.16	8.0 to 15
	16 to 39	0.80 to 1.50	0.13 to 0.15	2.0 to 8.0
Kneeridge, well drained	0 to 2	0.02 to 0.09	0.55 to 0.65	70 to 90
	2 to 16	0.75 to 1.10	0.14 to 0.16	8.0 to 15
	16 to 39	0.80 to 1.50	0.13 to 0.15	2.0 to 8.0
Lithnip	0 to 2	1.25 to 1.35	0.03 to 0.06	1.0 to 2.0
	2 to 5	1.25 to 1.35	0.04 to 0.08	0.5 to 1.0
	5 to 15	NA	NA	NA
Marla	0 to 3	0.02 to 0.09	0.55 to 0.65	70 to 90
	3 to 14	1.10 to 1.65	0.07 to 0.09	1.0 to 8.0
	14 to 47	1.45 to 1.70	0.06 to 0.08	0.2 to 1.0
	47 to 59	1.40 to 1.70	0.12 to 0.15	0.0 to 0.5
	59 to 68	1.45 to 1.70	0.10 to 0.15	0.0 to 0.5
Meeks, extremely bouldery	0 to 2	0.02 to 0.09	0.55 to 0.65	70 to 90
	2 to 13	1.10 to 1.25	0.02 to 0.04	2.0 to 8.0
	13 to 63	1.30 to 1.50	0.02 to 0.04	0.5 to 3.0
	63 to 73	1.80 to 1.90	0	0.5 to 2.0
Meeks, rubbly	0 to 2	0.02 to 0.09	0.55 to 0.65	70 to 90

Table C-1
Summary of Tahoe Basin Soil Attributes[1,2]

Soil	Depth inches	Bulk Density grams cm^{-3}	Available Water Capacity inches/inch	Organic Matter percent
	2 to 13	1.10 to 1.25	0.02 to 0.04	2.0 to 8.0
	13 to 63	1.30 to 1.50	0.02 to 0.04	0.5 to 3.0
	63 to 73	1.80 to 1.90	0	0.5 to 2.0
Meeks, stony	0 to 2	0.02 to 0.09	0.55 to 0.65	70 to 90
	2 to 13	1.10 to 1.25	0.02 to 0.04	2.0 to 8.0
	13 to 63	1.30 to 1.50	0.02 to 0.04	0.5 to 3.0
	63 to 73	1.80 to 1.90	NA	0.5 to 2.0
Meeks, very stony	0 to 2	0.02 to 0.09	0.55 to 0.65	70 to 90
	2 to 13	1.10 to 1.25	0.02 to 0.04	2.0 to 8.0
	13 to 63	1.30 to 1.50	0.02 to 0.04	0.5 to 3.0
	63 to 73	1.80 to 1.90	NA	0.5 to 2.0
Meiss	0 to 6	0.85 to 1.0	0.12 to 0.15	8.0 to 15
	6 to 13	0.85 to 1.0	0.09 to 0.15	3.0 to 12
	13 to 23	NA	NA	NA
Melody	0 to 1	0.02 to 0.09	0.55 to 0.65	70 to 90
	1 to 2	1.55 to 1.65	0.07 to 0.08	8.0 to 20
	2 to 9	1.55 to 1.65	0.05 to 0.06	4.0 to 10
	9 to 15	1.55 to 1.65	0.05 to 0.06	2.0 to 8.0
	15 to 25	NA	NA	NA
Oneidas	0 to 1	0.02 to 0.09	0.55 to 0.65	70 to 90
	1 to 9	0.90 to 1.20	0.04 to 0.06	2.0 to 6.0
	9 to 12	1.40 to 1.50	0.06 to 0.09	0.5 to 2.0
	12 to 65	1.65 to 1.75	0.06 to 0.09	0.1 to 0.4
	65 to 79	1.70 to 1.80	0.09 to 0.12	0.1 to 0.4
Paige	0 to 3	0.02 to 0.09	0.55 to 0.65	70 to 90
	3 to 20	0.8 to 1.0	0.12 to 0.14	5.0 to 10
	20 to 48	1.30 to 1.60	0.11 to 0.13	2.0 to 5.0
Roadcat	0 to 8	1.35 to 1.55	0.05 to 0.07	2.0 to 4.0
	8 to 19	1.35 to 1.55	0.04 to 0.08	0.5 to 1.0
	19 to 36	1.40 to 1.60	0.03 to 0.05	0.2 to 0.8
	36 to 60	1.40 to 1.60	0.03 to 0.05	0.0 to 0.5
Rockbound very	0 to 2	0.85 to 1.20	0.02 to 0.03	8.0 to 15

Table C-1
Summary of Tahoe Basin Soil Attributes[1,2]

Soil	Depth inches	Bulk Density grams cm^{-3}	Available Water Capacity inches/inch	Organic Matter percent
stony loam	2 to 5	1.30 to 1.80	0.01 to 0.02	0.5 to 5.0
	5 to 17	1.30 to 1.80	0.01 to 0.02	0.5 to 5.0
	17 to 27	NA	NA	NA
Southcamp	0 to 2	0.02 to 0.09	0.55 to 0.65	70 to 90
	2 to 4	1.50 to 1.60	0.10 to 0.12	4.0 to 10
	4 to 15	1.45 to 1.55	0.05 to 0.06	0.2 to 1.0
	15 to 34	1.40 to 1.50	0.02 to 0.02	0.5 to 2.0
Stumpatil	0 to 6	1.30 to 1.50	0.10 to 0.12	3.0 to 5.0
	6 to 11	1.35 to 1.55	0.06 to 0.08	2.0 to 3.0
	11 to 26	1.35 to 1.55	0.06 to 0.08	0.5 to 1.0
	26 to 33	1.35 to 1.55	0.06 to 0.08	0.2 to 0.8
	33 to 60	1.70 to 1.80	0.06 to 0.08	0.0 to 0.5
Tahoe, gravelly	0 to 10	0.80 to 1.0	0.22 to 0.24	6.0 to 20
	10 to 27	0.85 to 1.05	0.16 to 0.18	6.0 to 15
	27 to 32	1.60 to 1.70	0.05 to 0.07	1.0 to 5.0
	32 to 46	1.60 to 1.70	NA	0.5 to 2.0
Tahoe silt loam	0 to 3	0.1 to 0.2	NA	NA
	3 to 11	0.7 to 1.05	0.19 to 0.24	10 to 20
	11 to 15	0.7 to 1.05	0.17 to 0.22	10 to 20
	15 to 20	1.05 to 1.35	0.02 to 0.04	5 to 10
	20 to 30	0.80 to 1.10	0.20 to 0.22	8.0 to 20
	30 to 49	1.40 to 1.80	0.14 to 0.19	0.2 to 1.5
	49 to 59	1.40 to 1.80	0.08 to 0.10	0.5 to 1.5
Tahoma	0 to 3	0.02 to 0.09	0.55 to 0.65	70 to 90
	3 to 14	0.80 to 1.0	0.07 to 0.09	5 to 10
	14 to 22	0.8 to 1.0	0.07 to 0.08	2 to 7
Tallac, very stony	0 to 1	0.02 to 0.09	0.55 to 0.65	70 to 90
	1 to 22	0.90 to 1.10	0.06 to 0.08	3.0 to 10
	22 to 32	1.45 to 1.55	0.03 to 0.06	1.0 to 3.0
	32 to 43	1.45 to 1.55	0.03 to 0.06	0.5 to 1.5
	43 to 66	1.70 to 1.80	0	0.5 to 1.5
Temo	0 to 10	1.70 to 1.80	0.03 to 0.04	2.0 to 8.0
	10 to 16	1.70 to 1.80	0.02 to 0.04	0.0 to 2.0

Table C-1
Summary of Tahoe Basin Soil Attributes[1,2]

Soil	Depth inches	Bulk Density grams cm^{-3}	Available Water Capacity inches/inch	Organic Matter percent
	16 to 26	NA	NA	NA
Toem	0 to 1	0.02 to 0.09	0.55 to 0.65	70 to 90
	1 to 10	1.00 to 1.25	0.07 to 0.09	2.0 to 6.0
	10 to 18	1.30 to 1.50	0.06 to 0.08	0.0 to 1.0
	18 to 32	NA	NA	NA
Ubaj	0	0.02 to 0.09	0.55 to 0.65	70 to 90
	0 to 7	1.50 to 1.60	0.13 to 0.15	2.0 to 8.0
	7 to 17	1.50 to 1.60	0.13 to 0.15	1.0 to 6.0
	17 to 28	1.45 to 1.55	0.16 to 0.18	0.5 to 2.0
	28 to 42	1.40 to 1.50	0.15 to 0.19	0.2 to 1.5
	42 to 49	1.35 to 1.45	0.09 to 0.11	0.1 to 1.0
	49 to 120	1.35 to 1.45	0.08 to 0.10	0.0 to 0.8
Waca	0 to 2	0.02 to 0.09	0.55 to 0.65	70 to 90
	2 to 11	0.80 to 0.99	0.05 to 0.07	7.0 to 34
	11 to 16	0.80 to 0.99	0.05 to 0.07	2.0 to 20
	16 to 23	0.80 to 0.99	0.05 to 0.07	2.0 to 15
Watah	0 to 3	0.02 to 0.09	0.55 to 0.65	70 to 90
	3 to 8	0.10 to 0.20	0.45 to 0.55	70 to 90
	8 to 15	1.50 to 1.60	0.09 to 0.11	10 to 21
	15 to 63	1.60 to 1.70	0.02 to 0.03	0.0 to 2.0
Windy	0 to 2	0.02 to 0.09	0.55 to 0.65	70 to 90
	2 to 11	0.80 to 0.99	0.05 to 0.07	7.0 to 34
	11 to 16	0.80 to 0.99	0.05 to 0.07	2.0 to 20
	16 to 23	0.80 to 0.99	0.05 to 0.07	2.0 to 15
	23 to 49	0.80 to 1.10	0.05 to0.07	1.0 to 8.0
Witefels	0 to 1	0.02 to 0.09	0.55 to 0.65	70 to 90
	1 to 9	1.60 to 1.70	0.05 to 0.06	2.0 to 8.0
	9 to 14	1.60 to 1.70	0.04 to 0.06	1.0 to 4.0
	14 to 36	1.60 to 1.70	0.04 to 0.05	0.0 to 1.0
	36 to 39	NA	NA	NA

Table C-1
Summary of Tahoe Basin Soil Attributes[1,2]

Soil	Depth inches	Bulk Density grams cm^{-3}	Available Water Capacity inches/inch	Organic Matter percent
Zephyr Cove	0 to 2	0.02 to 0.09	0.55 to 0.65	70 to 90
	2 to 4	0.10 to 0.20	0.45 to 0.55	70 to 90
	4 to 7	1.50 to 1.60	0.11 to 0.13	5.0 to 10
	7 to 16	1.50 to 1.60	0.10 to 0.12	1.0 to 3.0
	16 to 35	1.45 to 1.50	0.12 to 0.15	0.2 to 0.1

Notes:
1 Derived from Table 4b of Natural Resources Conservation Service. 2007. *Soil Survey of the Tahoe Basin Area, California and Nevada, Volume II*
2 NA = Not available

This page has been intentionally left blank.

Appendix D

ATTRIBUTES OF PLANT SPECIES INCLUDED IN REVIEWED TAHOE BASIN REVEGETATION PROJECTS

Table D-1
Attributes of Plant Species Included in Reviewed Tahoe Basin Revegetation Projects[1, 2]

Species	Common Name	Growth Habit	Shade Tolerance	Anerobic Tolerance	Drought Tolerance	Moisture Use	Coarse Texture Soil	Med Texture Soil	Fine Texture Soil	Life Span	N-Fixing	Seed Per Pound
Grasses												
Achnatherum occidentale	western needlegrass	Bunch	Intermed.	None	High	Low	Yes	Yes	No	Mod.	No	285,000
Agrostis exarata	spike bentgrass	Rhizomat.	Intolerant	Med.	Low	Med.	Yes	Yes	Yes	Mod.	No	5,600,000
Agrostis scabra	rough bentgrass	Bunch	Intolerant	Low	Low	Med.	No	Yes	Yes	Mod.	No	5,000,000
Alopecurus aequalis	shortawn foxtail	Bunch	Intermed.	High	Low	High	No	Yes	Yes	Short	No	1,464,000
Bromus carinatus	California brome	Bunch	Intolerant	None	Med.	Low	Yes	Yes	No	Short	No	106,680
Bromus inermis	smooth brome	Rhizomat.	Intolerant	Low	Med.	Med.	No	Yes	Yes	Long	No	142,880
Calamagrostis canadensis	bluejoint	Rhizomat.	Intolerant	High	Low	Med.	No	Yes	Yes	Long	No	3,837,472
Dactylis glomerata	orchardgrass	Bunch	Tolerant	Low	Med.	Med.	No	Yes	No	Mod.	No	427,200
Deschampsia caespitosa	tufted hairgrass	Bunch	Intolerant	High	Low	Low	Yes	Yes	Yes	Long	No	1,308,333
Deschampsia elongata	slender hairgrass	Bunch	Intolerant	Med.	Med.	Low	Yes	Yes	Yes	Short	No	1,860,000
Elymus elymoides	squirreltail	Bunch	Intolerant	None	High	Low	No	Yes	Yes	Long	No	192,000
Elymus glaucus	blue wildrye	Bunch	Tolerant	High	High	Low	Yes	Yes	Yes	Mod.	No	134,500
Elymus trachycaulus	slender wheatgrass	Bunch	Intolerant	Low	High	Low	No	Yes	Yes	Mod.	No	135,000
Festuca ovina = F. brevipila	hard fescue	Bunch	Intolerant	None	High	Low	Yes	Yes	Yes	Mod.	No	591,920
Festuca rubra	red fescue	Rhizomat.	Tolerant	None	Med.	Med.	No	Yes	Yes	Long	No	454,087
Glyceria grandis	American mannagrass	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI
Hordeum brachyantherum	meadow barley	Bunch	Intolerant	High	Med.	Med.	Yes	Yes	Yes	Mod.	No	30,000
Leymus triticoides	beardless wildrye	Rhizomat.	Intolerant	High	High	High	No	Yes	Yes	Long	No	170,304
Phalaris arundinacea	reed canarygrass	Rhizomat.	Intolerant	High	Low	High	No	Yes	Yes	Long	No	537,920
Phleum pratense	timothy	Bunch	Intermed.	Low	Low	Med.	No	Yes	Yes	Mod.	No	1,163,200
Poa pratensis	Kentucky bluegrass	Rhizomat.	Intolerant	Low	Low	High	No	Yes	Yes	Long	No	1,389,840
Poa secunda	Sandberg bluegrass	Bunch	Intermed.	None	High	Low	Yes	Yes	No	Mod.	No	1,046,960
Thinopyrum intermedium	intermediate wheatgrass	Rhizomat.	Intolerant	Low	Med.	Low	Yes	Yes	Yes	Mod.	No	80,080
Rushes												
Juncus balticus	mountain rush	Rhizomat.	Intermed.	High	Low	High	No	Yes	Yes	Long	No	3,000,000
Juncus effusus	common rush	Bunch	Intolerant	Med.	Med.	Med.	Yes	Yes	Yes	Long	No	45,359,242
Sedges												
Carex athrostachya	slenderbeak sedge	Bunch	Intermed.	High	None	High	Yes	Yes	No	Long	No	NI
Carex nebrascensis	Nebraska sedge	Rhizomat.	Intolerant	High	None	High	Yes	Yes	Yes	Long	No	NI
Carex praegracilis	clustered field sedge	Rhizomat.	Intermed.	High	Low	Med.	Yes	Yes	Yes	Long	No	NI
Carex utriculata	Northwest Territory sedge	Rhizomat.	Intolerant	High	Low	High	No	Yes	Yes	Mod.	No	NI
Eleocharis macrostachya	pale spikerush	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI
Forbs												
Achillea millefolium	common yarrow	Rhizomat.	Intermed.	None	Med.	Med.	No	Yes	No	Mod.	No	2,852,012
Anaphalis margaritacea	western pearly everlasting	Rhizomat.	Intermed.	None	Med.	Med.	No	Yes	No	Short	No	8,200,000
Apocynum cannabinum	Indianhemp	Single stem	Intermed.	Med.	Med.	High	Yes	Yes	Yes	Mod.	No	500,000
Eriogonum nudum	naked buckwheat	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI
Eschscholzia californica	California poppy	Single crown	Intermed.	Med.	Med.	Low	No	Yes	Yes	Short	No	269,888
Gilia capitata	bluehead gilia	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI
Ipomopsis aggregata	scarlet gilia	Single stem	Intolerant	Low	High	Low	Yes	Yes	Yes	Mod.	No	450,008
Linum lewisii	Lewis flax	Bunch	Intolerant	None	Med.	Med.	Yes	Yes	No	Mod.	No	294,848
Lotus corniculatus	Bird's-foot trefoil	Single crown	Intolerant	Med.	Med.	Med.	Yes	Yes	Yes	Mod.	Yes	369,840
Lotus humistratus	foothill deervetch	NI	NI	NI	NI	NI	NI	NI	NI	NI	Yes	NI
Lotus purshianus	American bird's-foot trefoil	NI	NI	NI	NI	NI	NI	NI	NI	NI	Yes	NI
Lupinus x alpestris	Great Basin lupine	Single crown	Intolerant	None	High	Low	Yes	Yes	No	Long	Yes	16,000
Lupinus argenteus	silvery lupine	Multiple stem	Intolerant	None	Med.	Low	Yes	Yes	Yes	Short	Yes	126,000
Lupinus breweri	Brewer's lupine	NI	NI	NI	NI	NI	NI	NI	NI	NI	Yes	NI
Lupinus grayi	Sierra lupine	NI	NI	NI	NI	NI	NI	NI	NI	NI	Yes	NI
Lupinus lepidus	Pacific lupine	Multiple stem	Intolerant	None	High	Low	Yes	Yes	No	Short	Yes	16,000
Lupinus polyphyllus	bigleaf lupine	NI	NI	NI	NI	NI	NI	NI	NI	NI	Yes	NI
Lupinus spp.	lupine	NI	NI	NI	NI	NI	NI	NI	NI	NI	Yes	NI
Penstemon rydbergii	Rydberg's penstemon	Bunch	Intolerant	None	Low	Low	No	Yes	Yes	Mod.	No	131,900
Penstemon speciosus 'Bandera'[3]	royal penstemon	Multiple stem	Intolerant	None	High	Low	Yes	Yes	No	Long	No	400,000
Penstemon strictus	Rocky Mountain penstemon	Stolon.	Intolerant	None	Med.	Low	Yes	No	No	Mod.	No	489,888

Table D-1
Attributes of Plant Species Included in Reviewed Tahoe Basin Revegetation Projects[1, 2]

Species	Common Name	Growth Habit	Shade Tolerance	Anerobic Tolerance	Drought Tolerance	Moisture Use	Coarse Texture Soil	Med Texture Soil	Fine Texture Soil	Life Span	N-Fixing	Seed Per Pound
Phlox drummondii	annual phlox	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI
Potentilla fruticosa 'Sutter's Gold'[3]	shrubby cinquefoil	Multiple stem	Intermed.	None	Low	Low	Yes	Yes	Yes	Long	No	1,000,000
Potentilla gracilis	slender cinquefoil	Multiple stem	Intolerant	None	Med.	Low	Yes	Yes	No	Mod.	No	1,711,698
Potentilla glandulosa	sticky cinquefoil	Rhizomat.	Intermed.	Low	Low	Low	No	Yes	No	Mod.	No	2,969,000
Trifolium variegatum	whitetip clover	NI	NI	NI	NI	NI	NI	NI	NI	NI	Yes	NI
Wyethia mollis	woolly mule-ears	Bunch	Tolerant	None	High	Low	Yes	Yes	No	Long	No	25,000
Shrubs and Trees												
Amelanchier utahensis	Utah serviceberry	Shrub-Tree	Intermed.	None	High	Med.	Yes	Yes	Yes	Long	No	25,800
Arctostaphylos nevadensis	pinemat manzanita	Shrub-Subshrub	Tolerant	None	High	Low	Yes	Yes	No	Long	No	37,000
Artemisia tridentata	big sagebrush	Shrub-Tree	Intolerant	None	High	Med.	No	Yes	No	Long	No	2,466,000
Ceanothus cordulatus	whitethorn ceanothus	Shrub	Intolerant	None	High	Low	Yes	Yes	No	Long	Yes	166,000
Ceanothus prostratus	prostrate ceanothus	Shrub-Subshrub	Tolerant	None	High	Low	Yes	Yes	No	Long	Yes	41,000
Cercocarpus ledifolius	curl-leaf mountain mahogany	Shrub-Tree	Intermed.	None	High	Low	Yes	Yes	No	Long	Yes	50,916
Chrysothamnus nauseosus	rubber rabbitbrush	Shrub-Subshrub	Intolerant	None	High	Med.	Yes	Yes	Yes	Long	No	652,500
Eriogonum umbellatum	sulphur-flower buckwheat	Shrub-Subshrub	Intolerant	None	High	Low	Yes	Yes	No	Long	No	209,500
Prunus emarginata	bitter cherry	Shrub-Tree	Intolerant	None	Med.	Med.	Yes	No	No	Long	No	7,020
Purshia tridentata	antelope bitterbrush	Shrub	Intermed.	Low	High	Low	Yes	Yes	No	Long	Yes	17,193
Ribes cereum	wax currant	Shrub	Intolerant	None	High	Low	Yes	Yes	No	Mod.	No	277,500
Ribes nevadense	Sierra currant	Shrub	Intermed.	Med.	Low	High	Yes	Yes	No	Long	No	391,000
Ribes roezlii	Sierra gooseberry	Shrub	Intermed.	None	High	Low	Yes	Yes	No	Long	No	236,000
Rosa woodsii	Woods' rose	Rhizomat.	Intermed.	None	Med.	Med.	Yes	Yes	No	Long	No	50,967
Rubus parviflorus	thimbleberry	Rhizomat.	Intermed.	Low	Med.	High	No	Yes	Yes	Mod.	No	204,000
Salix lemmonii	Lemmon's willow	Shrub	Intermed.	Low	Low	High	Yes	Yes	Yes	Long	No	NI
Salix scouleriana	Scouler's willow	Shrub-Tree	Intermed.	Med.	Med.	High	Yes	Yes	Yes	Mod.	No	6,500,000
Symphoricarpos mollis	creeping snowberry	Shrub-Subshrub	NI	NI	NI	NI	NI	NI	NI	NI	No	NI

Notes:
[1] Compiled from USDA PLANTS Database (2010)
[2] Abbreviations: Intermed. = Intermediate, Med. = Medium, Mod. = Moderate, Rhizomat. = Rhizomatous, Stolon. = Stoloniferous.
[3] Attributes based on species not specific horticultural variety.

Appendix E

SPECIFICATIONS TEMPLATES

E.1 Section 00 41 02 Bid Form (Example)
E.2 Section 31 35 19.16 Geotextile Slope Protection
E.2 Section 32 01 90 Plant Establishment
E.3 Section 32 84 00 Planting Irrigation
E.4 Section 32 91 00 Planting Preparation
E.5 Section 32 92 19 Seeding
E.6 Section 32 93 00 Plants

SECTION 00 41 02
BID FORM (EXAMPLE)

{*This template is to be used as a guide only. This specification section must be tailored to designs and conditions for each individual project site. Brackets "{ }" are provided for items where the user needs to provide specific information*.}

PROPOSAL FOR THE CONSTRUCTION OF

{*Project Name*} Revegetation for Erosion Control Project
{*City*}, {*State*}

The undersigned hereby proposes and agrees, following award of the Contract by {*Owner name*} under this bid to execute the Agreement to furnish and install any and all labor, materials, transportation, and services for the construction of {*Project Name*} Revegetation for Erosion Control Project, {*City*}, {*State*}, with necessary bonds and in accordance with the Contract Documents adopted and on file with {*Owner name*} within the time identified and at the prices named in this bid according to the attached "BID ITEMS" form on pages 2 through {*page #}* of this Section.

Total Bid Items 1 through {*38*} inclusive and all work incidental thereto and connected therewith

$ _____ (in words) Dollars

Bid amount of each of the bid items must be filled in and completed in ink.

_____
Name of Bidder

BID FORM EXAMPLE – LONG VERSION
***{Project Name}* Revegetation for Erosion Control Project**
{*Provide/tailor [add/subtract] bid items as appropriate for the project, and provide all units of measure and estimated quantities of said items*}

Item No.	Item	Unit of Measure	Estimated Quantity	Unit Price (In Figures)	Item Total (In Figures)
1	MOBILIZATION / DEMOBILIZATION	LUMP SUM	1		
2	EROSION CONTROL FABRIC	SQUARE FOOT			
3	COIR LOGS	LINEAR FOOT			
4	IRRIGATION WATER SERVICE	EACH			
5	BACKFLOW PREVENTER	EACH			
6	MAIN LINE PIPE	LINEAR FOOT			
7	LATERAL LINE PIPE	LINEAR FOOT			
8	SLEEVE PIPE	LINEAR FOOT			
9	SHUT OFF VALVES	EACH			
10	CONTROL VALVES	EACH			
11	QUICK COUPLING VALVES	EACH			
12	SPRAY SPRINKLERS	EACH			
13	BUBBLER NOZZLES	EACH			
14	SITE PREPARATION	SQUARE FOOT			
15	WEED REMOVAL	SQUARE FOOT			

Item No.	Item	Unit of Measure	Estimated Quantity	Unit Price (In Figures)	Item Total (In Figures)
16	SOIL REHABILITATION	SQUARE FOOT			
17	DUFF / MULCH REPLACEMENT AND PINE NEEDLE {*/ WOOD CHIP <if appropriate>*} PLACEMENT	CUBIC YARD			
18	SEEDING – MIX TYPE 1	ACRE			
19	SEEDING – MIX TYPE 2	ACRE			
20	SEEDING – MIX TYPE 3	ACRE			
21	15 GALLON TREES	EACH			
22	5 GALLON PLANTS	EACH			
23	1 GALLON PLANTS	EACH			
24	TREEPOT4 PLANTS	EACH			
25	DEEPOT PLANTS	EACH			
26	TREEBAND PLANTS	EACH			
27	CUTTINGS	EACH			
28	VEGETATED MATS	SQUARE FOOT			
29	WOOD MULCH	CUBIC YARD			
30	AS-BUILT DRAWINGS	SET			
31	WATERING (MAINTENANCE PERIOD)	EVENT			

Item No.	Item	Unit of Measure	Estimated Quantity	Unit Price (In Figures)	Item Total (In Figures)
32	IRRIGATION SYSTEM MAINTENANCE	MONTH			
33	WEED CONTROL (MAINTENANCE PERIOD)	EVENT			
34	BIOTECHNICAL TREATMENT MAINTENANCE	MONTH			
35	REPLACEMENT PLANTING	EACH			
36	RESEEDING	ACRE			
37	RECORD DRAWINGS	SET			
38	PLANT ESTABLISHMENT REPORTS	MONTH			

TOTAL BASE BID (ITEMS 1 THROUGH {*38*}): SUM OF ALL BASE ITEM TOTAL AMOUNTS

$_____ (IN FIGURES)

The foregoing figures include the cost of bonds, insurance, sales tax, and every other item of expense incidental to the Contract.

It is understood and agreed as follows:

A. That the Owner reserves the right to reject any and all bids and to waive any informality in any bid.

B. That the bidder has checked carefully the figures used to figure this bid and understands that the Owner will not be responsible for any errors or omissions on the part of the undersigned in making up this bid.

C. That the quantities included in the bid form are approximate and that the Contractor's bid is based on the level of effort required according to the Drawings and Specifications.

D. Bidders must submit bids for each unit price item.

E. In the event the product of a unit price and an estimated quantity do not equal the extended amount stated, the unit price will govern and the correct product of the unit price and the estimated quantity shall be deemed to be the amount bid.

F. Quantities provided are approximate and reflect expected finished quantities only; the Contractor shall be responsible for all work indicated on the Drawings and prescribed in the Specifications, including any additional quantities required (e.g., due to waste or compaction) to meet the scope of work and intent of the design indicated on the Drawings and in the Specifications.

The bidder hereby certifies that this bid is genuine, and not sham or collusive, or made in the interest or in behalf of any person not herein named, and that the undersigned has not directly or indirectly induced or solicited any other bidder and that the bidder has not in any manner sought by collusion to secure for himself/herself an advantage over any other bidder. The successful bidder will forward the original non-collusion affidavits to the Owner at the signing of the Agreement.

END OF SECTION

This page has been intentionally left blank.

SECTION 31 35 19.16
GEOTEXTILE SLOPE PROTECTION

{*This template is to be used as a guide only. This specification section must be tailored to designs and conditions for each individual project site. Brackets "{ }" are provided for items where the user needs to provide specific information*. Note that all days should refer to calendar days.}

PART 1 – GENERAL

1.01 GENERAL CONDITIONS

A. Requirements of Section 00700 – General Conditions and of Division 1 – General Requirements, apply to work in this Section with same force and effect as though repeated in full herein.

1.02 SCOPE OF WORK

A. Furnish all materials, labor, transportation, services, and equipment necessary to install geotextile slope protection as shown on the Drawings and as specified herein. Geotextile slope protect Any and all permits, fees, bonds and observations necessary to perform and complete this portion of the work shall be included.

B. Work included in this Section:

1. Verification of Existing Conditions;
2. Preparation;
3. Biotechnical Treatment Installation;
4. As-Built Drawings;
5. Cleanup;
6. Site Observation Before Final Installation Acceptance;
7. Site Observation Schedule; and
8. Final Installation Acceptance.

C. Work related in other Sections:

1. Section 32 01 90 Plant Establishment;
2. Section 32 84 00 Planting Irrigation;
3. Section 32 91 00 Planting Preparation;
4. Section 32 92 19 Seeding; and
5. Section 32 93 00 Plants.

1.03 REQUIREMENTS OF REGULATORY AGENCIES

A. Local, municipal and State laws, and rules and regulations governing or relating to any portion of this work are hereby incorporated into and made a part of these Specifications, and their provisions shall be carried out. Anything contained in these Specifications shall not be construed to conflict with any of the above rules and regulations or requirements of the same. However, when these Drawings and Specifications call for or describe materials, workmanship or construction of a better quality, higher standard, or larger size than is required by the above

rules and regulations, the provisions of these and Drawings and Specifications shall take precedence.

1.04 REFERENCE STANDARDS

A. {*Add reference standards as appropriate*.}

1.05 DEFINITIONS

A. Final Installation Acceptance: Final Installation Acceptance is the milestone when all installation work (i.e., all work except that required under Section 32 98 00 Plant Establishment) is completed and approved by the Owner's Authorized Representative.

B. Final Project Acceptance: Final Project Acceptance is the milestone when all work, including work under Section 32 98 00 Plant Establishment, is completed and approved by the Owner's Authorized Representative. Final Project Acceptance does not in any way release the Contractor from the requirements or duration of any guarantees as per the Specifications.

C. Installation Period: The Installation Period begins when the Notice to Proceed (NTP) is given and continues until all requirements indicated in the Drawings and Specifications are completed and approved, and the Owner's Authorized Representative gives a written notice of a Final Installation Acceptance.

D. Plant Establishment Period: The Plant Establishment Period begins immediately after the Contracting Officer gives a written notice of a Final Installation Acceptance and continues until all requirements indicated in Section 32 98 00 Plant Establishment are completed and approved and the Contracting Officer gives a written notice of a Final Project Acceptance.

1.06 QUALITY CONTROL

A. The manufacturer's directions and drawings shall be followed in all cases where the manufacturers of articles used in this Specification furnish directions covering points not shown in the Drawings and Specifications.

B. At the time of delivery to the project site, the Contractor and the Owner's Authorized Representative shall observe biotechnical treatment materials for moisture, mold, and other defects. The Contractor shall provide the Owner's Authorized Representative with 48-hour advance notice for each request for approval of partial or complete deliveries to the project site.

1.07 QUALIFICATIONS

A. The biotechnical treatment material supplier shall be located within 100 miles of the Tahoe Basin.

1.08 SUBMITTALS

A. Approval of any item, alternate or substitute indicates only that the product or products apparently meet the requirements of the Drawings and Specifications on the basis of the information or samples submitted.

B. Submit no later than 10 days after the award of Contract, 2 three-ring hard cover binders containing the following information:

1. List of all proposed materials and equipment to be used indicated by description, manufacturer and model number, if applicable. Include catalog cuts where applicable.

2. A copy of the materials procurement order from the supplier including the name, address, and phone number of said supplier.

3. Written documentation that the biotechnical treatment materials listed on the Drawings are available. Any substitutions required due to unavailability must be requested in writing before confirmation of ordering.

4. A schedule identifying biotechnical treatment material procurement, storage, anticipated delivery dates, and anticipated installation dates for review and approval.

5. Manufacturer's warranty statements for irrigation equipment provided.

C. Submit all required samples within 10 days before to the start of installation. Samples shall be approved by the Owner's Authorized Representative before ordering and performing work. Submit the following to the Owner's Authorized Representative:

1. Coir Log, single log;

2. Stakes, single stake;

3. Jute Rope; 3-foot sample;

4. Erosion Control Blankets; 12-inch X 12-inch sample;

5. Staples; single staple; and

6. {Add type and sample size or description for other materials as needed.}

D. Provide and keep as-built drawings during the Installation Period as specified under Section 32 93 00 Plants.

E. Owner's Authorized Representative will provide approvals or direction for any needed corrections within 10-days of receipt of said submittals.

1.09 SUBSTITUTIONS

A. Specific reference to manufacturers' names and products specified in this Specification are used as standards of quality. This implies no right to substitute other materials without prior written approval by the Owner's Authorized Representative.

B. Any substituted materials installed without written approval by the Owner's Authorized Representative may be rejected.

C. If an approval is granted for a substitution, adjustment in the Contract amount will be made in accordance with the Contract Conditions.

1.10 SAMPLES, TESTS AND MOCK-UPS

A. The Owner's Authorized Representative reserves the right to take and analyze selected samples of biotechnical treatment materials for conformity to this Specification at any time. Rejected biotechnical treatment materials shall be removed from the site and be replaced at no cost.

1.11 PROJECT CONDITIONS

A. Perform installation operations only when weather and soil conditions are suitable in accordance with locally accepted practice.

1.12 PRODUCT DELIVERY, STORAGE AND HANDLING

A. All materials delivered to the project site shall be clearly marked to identify the item.

B. Exercise care in handling, loading, unloading, and storing biotechnical treatment materials to ensure they are not damaged.

C. Provide a storage site for the biotechnical treatment materials at the staging areas shown on the Drawings or as directed by the Owner's Authorized Representative. Store in a manner to prevent damage from sunlight, moisture or contact with vehicles, equipment or tools.

1.13 REJECTION OF MATERIALS

A. All biotechnical treatment materials not conforming to the requirements herein shall be considered defective and will be rejected.

a. The Owner's Authorized Representative shall mark such biotechnical treatment materials, whether in place or not, as rejected.

b. Replacement biotechnical treatment materials shall be of the same types and condition as that indicated on the Drawings.

B. Rejected materials shall be removed and disposed of according to State and local regulations by the Contractor at no additional cost. Rejected materials shall be replaced at no additional cost.

1.14 PROTECTION OF THE SITE

A. Protect previously installed work and materials which may be affected by work of this Section. Provide safeguards and exercise caution against injury or defacement of existing site improvements.

B. Repair damage and return the area to the previous condition at no additional cost.

1.15 COORDINATION

A. Coordinate operations with subcontractors, as well as other contractors on or adjacent to the project site.

B. Exercise extreme care in excavating and working near existing utilities. Repair any damages to these utilities at no additional cost. Check existing utility drawings for existing utility locations.

C. Coordinate installation of all biotechnical treatment materials to avoid interference with utilities, other construction elements, and any existing vegetation.

D. The Contractor shall coordinate with the Owner's Authorized Representative to schedule the placement of materials and equipment necessary to complete the work.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Use only new materials of brands and types noted on the Drawings, specified in this Section or equals as approved by the Owner's Authorized Representative.

B. Erosion Control Fabric {*Delete this item if not used.*}

1. Erosion control fabric shall be {*specify – type/size AND/OR specific manufacturer as approved equal*} with a 100% organic biodegradable within 5–10 years after installation, machine fabricated mat, covered on both sides by biodegradable mesh netting. At no time shall "Photodegradable" or "UV stabilized" material be used. Erosion control fabric shall consist of material that is made of coir material with an open weave biodegradable woven geotextile with a non-shifting square mesh consisting of 100% coir fiber yarns in both the warp and the weft. Color shall be brown or earth tone. The coir used for the erosion control fabric shall have a weight of 12-ounces (plus or minus 2 oz.) per square yard. The tensile strength of the fabric shall be roughly 432x138 lbs per foot dry and the open area of the fabric shall be 64% (plus or minus 2%).

C. Coir Logs {*Delete this item if not used.*}

1. Coir logs shall be {*specify – type AND/OR specific manufacturer as approved equal*} made from 100% mattress grade coconut fiber and bound by high-strength coir fiber netting that is 100% biodegradable. At no time shall “Photodegradable” or “UV stabilized” material be used. The minimum tensile strength of the fabric shall be 55 lbs per yarn dry or 40 lbs when wet. The Contractor shall use 20-foot roll lengths, except where continuous shorter distances are encountered. The coir logs shall be 12-inch diameter (plus or minus one inch), and have a minimum weight of 5.0 lbs per linear foot.

D. Anchors and Twine {*Delete this item if not used.*}

1. Staples {*Delete this item if not used.*}

a. Staples shall be {*specify – type AND/OR specific manufacturer as approved equal*}, 100 % biodegradable “1”- shaped hardwood pin, 6-inches long. Greater lengths can be substituted if desired.

2. Stakes {*Delete this item if not used.*}

a. Stakes shall be {*specify requirements*} wood, 3-feet long, 2 inches x 2 inches wide at the top, and 1-inch wide at the bottom. The stake tops shall be cut flat, and the bottoms shall be cut with a 45º taper. The upper part of each stake shall be notched ½-inch x 3-inches from the top.

3. Twine {*Delete this item if not used.*}

a. Twine shall be {*specify either – specific requirements OR machine-spun bristle coir, biodegradable, a minimum thickness of ¼-inch in diameter, and with a minimum breaking strength of 100-pounds*}. It shall be capable of lasting a minimum of 3 years in-place when in contact with soil and water periodically throughout the year. Twine shall not stretch when wet.

4. Jute Rope {*Delete this item if not used.*}

a. Jute rope shall be {*specify either – specific requirements OR biodegradable and a minimum thickness of 6 mm (¼ inch) in diameter*}.

5. {*Specify other anchoring items if necessary.*}

E. Cuttings {*Delete this item if not used.*}

1. Cuttings as prescribed in Section 32 93 00 Plants.

F. {Add type and description for other materials as needed.}

PART 3 – EXECUTION

3.01 VERIFICATION OF EXISTING CONDITIONS

A. Before performing the work in this Section, examine previously installed work from other contractors at the project site (if any) and verify that such work is complete and as required, to the point where this installation may begin properly.

B. Areas to receive biotechnical treatments shall be planting and/or seeding areas prepared according to Section 32 91 00 Planting Preparation.

C. If the soil in the area to receive biotechnical treatments was already “prepared” as part of planting or seeding operations, observe the area to determine if the soils have become hard or plastic and submit a report to the Owner’s Authorized Representative. If the soil conditions are not appropriate for installation of biotechnical treatments, submit a plan for preparing the soils without disturbing existing or installed plants to the satisfaction of the Owner’s Authorized Representative and at no additional cost.

D. Remove all rocks, stones, sticks and debris larger than 1-inch in diameter from the surface of the areas to receive biotechnical treatments.

E. Obtain approval of finished grading performed under Section 32 91 00 Planting Preparation by the Owner’s Authorized Representative before installing biotechnical treatments.

3.02 PREPARATION

A. Biotechnical Treatment Layout

1. Verify the location and depth of all underground utilities.

2. If any underground construction or utility lines are encountered in during installation of biotechnical treatments, immediately notify the Owner’s Authorized Representative for direction. Failure to notify the Owner’s Authorized Representative of any utilities encountered will render the Contractor responsible for rectifying any issues due to improper drainage at no additional cost.

3. Locations for all biotechnical treatments shall be marked on the ground either by flagged grade stakes indicating biotechnical treatment type for the Owner’s Authorized Representative’s review and approval before installation. Biotechnical treatments will be located according to the layout shown on the Drawings.

3.03 BIOTECHNICAL TREATMENT INSTALLATION

A. General Installation Guidelines

1. Seeding, according to Section 32 92 19 Seeding, and below-grade portions of the irrigation system according to Section 32 84 00 Planting Irrigation, shall be conducted before completion of biotechnical treatments; biotechnical treatments may be partially installed before seeding and irrigation system installation as long as the soil area to be seeded is exposed for seed application and completion of the irrigation system. The Contractor shall be responsible for coordination of seeding, irrigation, and biotechnical treatments installation.

B. Erosion Control Fabric {*Delete this item if not used*.}

1. Erosion control fabric shall be placed at locations shown on the Drawings.

2. Erosion control fabric will be installed according to manufacturer's specifications. Additionally, erosion control blankets shall be installed from the bottom of the slope to the top of the slope, overlapping the blankets in a shingle pattern as they are installed up slope. The fabric shall be anchored with staples and key trenches as detailed on the Drawings or at the beginning and at the end of the treatment in a 6-inch deep by 6-inch wide trench. Anchor the blankets in the trenches with staples set 1-foot on-center spacing, backfill the trench and compact loose soil. Throughout the fabric area, staples shall be spaced 1 per 1 square yard minimum placed with a minimum 12-inch overlap, with upstream portions of fabric on top of downstream portions of fabric.

3. For plant installation, according to Section 32 93 00 Plants, erosion control fabric shall not be over installed plants or basins, but shall be cut in a "T" slit, 14 inches in length and 6 inches wide at the base (downslope end of slit). Erosion control fabric shall then be folded back to accommodate planting pit excavation. At no time shall any erosion control fabric be removed or cut free. Cut fabric shall be replaced on top of planting pits and pinned down with staples after planting is complete.

C. Coir Logs {*Delete this item if not used*.}

1. Coir logs shall be placed at locations shown on the Drawings, generally located at the toe of select lower slope planting areas, and as part of select rock slope protection, select joint-planted rock slopes, and select rock riffles.

2. Coir logs will be installed according to manufacturer's specifications. Additionally, coir logs shall be installed in a trench and anchored with {*specify either – cuttings OR stakes*} as detailed on the Drawings. {*Specify either – cuttings OR stakes*} shall be installed immediately adjacent to the coir logs and through the coir log netting. The {*specify either – cuttings OR stakes*} shall be installed so that the top of the {*specify either – cutting OR*

stake} is level with the top of the coir log. Coir logs shall be secured to {*specify either – cuttings OR stakes*} with jute rope in a diagonal layout and perpendicular to the coir logs as detailed on the Drawings. The rope shall secure the coir logs in place and shall be tied off to the {*specify either – cutting OR stake*} {*Add the following additional text if stakes are used for anchoring – and secured to the stakes by way of the notches on said stakes*}.

D. {Specify *other biotechnical treatment technique installation as necessary.*}

3.04 AS-BUILT DRAWINGS

A. The Contractor shall prepare as-built drawings as specified in Section 32 93 00 Plants.

3.05 CLEANUP

A. Site cleanup shall occur on a daily basis and as each phase of the work concludes.

B. Remove all trash and excess dirt caused from the work according to State and local regulations. Contractor shall make arrangements for disposing of these materials outside the project site and shall pay all costs involved. Arrangements shall include, but not be limited to, entering into agreements with property owners and obtaining necessary permits, licenses, and environmental clearances.

C. Sweep all adjacent walks and paved areas on a weekly basis throughout the duration of the project.

D. Repair all scars, ruts or other marks in the ground caused by the work.

E. Upon completion of the work, smooth all ground surfaces, remove excess dirt, materials, rubbish and debris according to State and local regulations to an offsite location or as directed by the Owner's Authorized Representative. Sweep adjacent streets, curbs, gutters and sidewalks and remove construction equipment from the premises.

3.06 SITE OBSERVATION BEFORE FINAL INSTALLAITON ACCEPTANCE

A. Operate irrigation system in its entirety for the Owner's Authorized Representative before the start of the Plant Establishment Period. Items deemed not acceptable by the Owner's Authorized Representative, shall be reworked to meet the Drawings and Specifications.

B. Corrective actions shall be in strict conformance with the Drawings and these Specifications and according to the Owner's Authorized Representative, and shall be completed at the Contractor's expense.

C. The Owner's Authorized Representative will perform progress observations of the work and construction operations on completion of installation stages. The Owner's Authorized Representative and the Contractor shall be agree upon the installation stages for this Specification before starting work and be present on mutually agreed-on dates for the observations for each stage.

D. If, after an observation, the Owner's Authorized Representative is satisfied with the construction to date and its conformance to the Drawings and the Specifications, the Owner's Authorized Representative will grant written notice of provisional acceptance for that construction stage.

E. If, after an observation, the Owner's Authorized Representative is dissatisfied with the construction to date and its conformance to the Drawings and the Specifications, the Owner's Authorized Representative will prepare a written punch list of necessary corrective action on defective work for that construction stage. All corrections must be completed and will be reobserved by the Owner's Authorized Representative within 10 working days from the date of the initial observation.

F. Project observations shall not occur until all punch list items from previous observations are corrected. Failure to correct problems in the time specified by the Owner's Authorized Representative may result in a delay of payment for the said tasks until the items in question are remedied per the Owner's Authorized Representative's direction.

G. The Contractor shall be charged for any additional construction observations and punch lists required from the Owner's Authorized Representative for unscheduled and necessary reobservation of the work due to unsatisfactorily or incompletely addressing previous punch lists.

3.07 SITE OBSERVATION SCHEDULE

A. Provide the Owner's Authorized Representative with 48 hours of advance notification, except as otherwise noted, for required stage acceptance observations including, but not limited to, the following:

1. Staked locations of all biotechnical treatment materials.

2. Progress installations of biotechnical treatment materials.

3. Completed installations of biotechnical treatment materials.

4. Substantial Completion Observation: Final installation observation before the start of the Plant Establishment Period. (Provide 10 working days of advance written notice).

3.08 FINAL INSTALLATION ACCEPTANCE

A. Final Installation Acceptance will be issued as specified in Section 32 93 00 Plants. Following the Final Installation Acceptance, the Plant Establishment Period shall begin.

END OF SECTION

This page has been intentionally left blank.

SECTION 32 01 90
PLANT ESTABLISHMENT

{*This template is to be used as a guide only. This specification section must be tailored to designs and conditions for each individual project site. Brackets "{ }" are provided for items where the user needs to provide specific information*. Note that all days should refer to calendar days.}

PART 1 – GENERAL

1.01 GENERAL CONDITIONS

A. Requirements of Section 00700 – General Conditions and of Division 1 – General Requirements, apply to work in this Section with same force and effect as though repeated in full herein.

1.02 SCOPE OF WORK

A. After planting, seeding, and irrigation work have been completed, reviewed and accepted the Owner's Authorized Representative, furnish materials, labor, transportation, services and equipment necessary to provide plant establishment as indicated on Drawings and as specified herein.

B. The intent for this project is to have healthy and vigorous, persistent plants and seeded areas at the end of the Plant Establishment Period that can survive without irrigation or other maintenance actions. Water shall be applied in a way that will allow for the "weaning off" of plants. Wherever possible, these plantings and seeded areas should consist of the original materials installed during the Installation Period.

C. Work included in this Section:

1. General Plant Establishment;
2. Insect And Disease Control;
3. Maintaining Water Retention Basins;
4. Watering;
5. Irrigation System Maintenance;
6. Weed Control;
7. Biotechnical Treatment Maintenance;
8. Replacement Planting;
9. Reseeding Areas;
10. Other Maintenance;
11. Record Drawings;
12. Plant Establishment Reports;
13. Cleanup;
14. Site Observation Before Final Project Acceptance;
15. Site Observation Schedule; and
16. Final Project Acceptance.

D. Work related in other Sections:

1. Section 31 35 19.16 Geotextile Slope Protection;
2. Section 32 84 00 Planting Irrigation;
3. Section 32 91 00 Planting Preparation;
4. Section 32 92 19 Seeding; and
5. Section 32 93 00 Plants.

1.03 REQUIREMENTS OF REGULATORY AGENCIES

A. All federal, State, and local laws and regulations governing this work are hereby incorporated into and made part of this Section. When this Section calls for certain materials, workmanship or a level of construction that exceeds the level of federal, State, or local requirements, the provisions of this Section shall take precedence.

1.04 REFERENCES

A. {*Add reference standards as appropriate*.}

1.05 DEFINITIONS

A. Final Installation Acceptance: Final Installation Acceptance is the milestone when all installation work (i.e., all work except that required under Section 32 98 00 Plant Establishment) is completed and approved by the Owner's Authorized Representative.

B. Final Project Acceptance: Final Project Acceptance is the milestone when all work, including work under Section 32 98 00 Plant Establishment, is completed and approved by the Owner's Authorized Representative. Final Project Acceptance does not in any way release the Contractor from the requirements or duration of any guarantees as per the Specifications.

C. Healthy Plants: Healthy plants shall be those that are of good form, free of disease and insect infestation, are robust, and exhibit vigorous growth (foliage and wood). They must not be heat or water stressed.

D. Installation Period: The Installation Period begins when the Notice to Proceed (NTP) is given and continues until all requirements indicated in the Drawings and Specifications are completed and approved, and the Owner's Authorized Representative gives a written notice of a Final Installation Acceptance.

E. Irrigation Season: The Irrigation Season refers to the beginning and ending dates for watering. It shall be June 1 to September 30.

F. Plant Establishment Period: The Plant Establishment Period begins immediately after the Contracting Officer gives a written notice of a Final Installation Acceptance and continues for {*specify either – minimum number of days OR years*}. The Plant Establishment Period is not complete until the Owner's Authorized Representative gives a written notice of a Final Project Acceptance.

1.06 PERFORMANCE STANDARDS

A. Target Survival Rates.

1. The target survival rate for all container plants shall be {*specify percentage for each growing season within Plant Establishment Period – minimum 50%/maximum 100% for each growing year*} survival.

2. The target survival rate for all cuttings shall be {specify percentage for each growing season within Plant Establishment Period – minimum 50%/maximum 100% for each growing year} survival.

3. The target survival rate for seeded areas larger than 400 square feet shall be 50% cover with native vegetation and free of invasive or noxious weeds.

B. Other Standards

1. At no time shall any plants show symptoms of damaged foliage, disease, size, color, wilting, defoliation, and vandalism. At no time shall any plants show symptoms of disease, browsing by wildlife, insect damage, girdling, structural deformities, dieback, dry rootball, and sunburn. At no time shall any plant show symptoms of water stress (caused by overwatering or underwatering), stunted growth, wilting, premature loss of leaves (for deciduous species), and premature yellowing of leaves (for deciduous species).

2. No visible signs of on-going, excessive erosion, such as rills.

3. Biotechnical treatments are stable and in place. {*Delete this item if biotechnical treatments are not used.*}

4. Project site planting areas shall have a typical (i.e., median) soil penetrability of less than 300 psi as measured at depths of 0- to 12-inches with a cone penetrometer.

5. At the soil surface, total cover of duff/mulch/pine needles {*/wood chips if appropriate; refer to Section 32 91 00*}, plants, rock, and woody debris shall meet the following standards.

   a. Duff/mulch/pine needles {*/wood chips if appropriate; refer to Section 32 91 00*} shall have at least 90% cover during the first growing season, and at least 85% cover during the second growing season; however, if rocks and plant bases occupy more than 10% of the site, 5% of soil surface being bare will be acceptable.

   b. Plants (herbaceous and shrubs) shall have {*specify percentage for each growing season within Plant Establishment Period – minimum 15%/maximum 25% for each growing year*}. Cover will

be visually estimated by the Owner's Authorized Representative. Measurements of cover at points along transects will be used to verify cover if deemed necessary by the Owner's Authorized Representative.

c. Overall cover of plants, mulch, rocks, and coarse woody debris shall be at least 90% (i.e., the cover of exposed soil shall be less than 10%). Rocks and woody debris greater than 3 inches in length and width count towards this cover percentage.

1.07 QUALIFICATIONS

A. The applicator of all weed control materials shall be licensed by the State of California as a Pest Control Operator and a Pest Control Advisor in addition to any subcontractor licenses that are required.

1.08 SUBMITTALS

A. Submit to the Owner's Authorized Representative at least 10 days before the start of the Plant Establishment Period, 2 bound booklets containing the following information:

1. A schedule of activities planned during the Plant Establishment Period. This schedule must be accepted by the Owner's Authorized Representative before starting work under this Section. During the Plant Establishment Period, document scheduled changes and obtain acceptance by the Owner's Authorized Representative.

2. A written irrigation schedule, including rate and length of application for each watering event over the duration of the Plant Establishment Period for approval.

3. The Pest Control Advisor shall submit a list of the weed control materials and quantities per acre intended for use in controlling the weed types prevalent and expected on the site. Weed control information shall include: {*Delete this item if not used.*}

   a. Data to demonstrate the compatibility of the weed control materials and methods with the intended planting and seed varieties.

   b. A written list of the proposed herbicide application equipment to be used in performance of the weeding work, including descriptive data and calibration tests. Include the herbicide trade name, chemical composition, formulation, concentration, application rate of active ingredients and methods of application for all materials furnished, as well as the name and State license number of the State certified applicator.

c. Records of manufacturer's literature, labels, and laboratory analytical data for verification of herbicide to be used, including the chemical makeup and application rate.

d. Certificates of compliance certifying that herbicide materials meet the requirements specified shall be shall be submitted before the delivery of materials. Herbicide material shall include EPA registration number and registered uses.

e. A Herbicide Treatment Plan (HTP) proposing a sequence of herbicide treatments and a written delivery schedule and written Pest Control Advisor (PCA) recommendation. The herbicide trade name, chemical composition, formulation, concentration, application rate of active ingredients and methods of application for all materials furnished, and the name and state license number of the state certified applicator shall be included. Records of manufacturer's literature, labels, and laboratory analytical data for verification of herbicide to be used, including the chemical makeup and application rate shall be submitted. Once approved by the Owner's Authorized Representative, the Contractor shall receive written authorization to proceed with the treatment.

4. A list of materials that are to be used during plant establishment in written form to the Owner's Authorized Representative for review and approval before purchasing or delivering to the site.

B. Submit all required samples and test results within 10 days before to the start of any work. Samples shall be approved by the Owner's Authorized Representative before ordering and performing work. Submit the following to the Owner's Authorized Representative:

1. {*Add type and sample size or description for other materials as needed.*}

C. Replacement Materials

1. For all replacement container plants, submit a copy of the plant procurement order, as specified in Section 32 93 00 Plants. If the nursery is different than that used to supply the materials for the initial planting, submit the name, address, and phone number of the nursery. Submit all samples and testing results as required in Section 32 93 00 Plants. {*Delete this item is not used.*}

2. For all replacement cuttings, submit a plan for collection following the collection requirements of Section 32 93 00 Plants. Include the plant species (by botanical and common name), sizes, and quantities to be collected. This plan must be accepted by the Owner's Authorized Representative before collection proceeds. {*Delete this item is not used.*}

3. For any reseeding materials, submit seed supplier's certification for required seed mixtures, indicating percentage by weight, and percentages

of purity, germination and weed seed for each mix. Submit all samples and testing results as required in Section 32 92 19 Seeding. Submit a list of all proposed materials and equipment to be used indicated by description, manufacturer and model number, if applicable. {*Delete this item is not used.*}

4. Submit a schedule for replacement materials work, including plant and/or seeding procurement, storage, anticipated delivery dates, and anticipated installation dates for review and approval.

D. Record Drawings

1. Provide and keep up to date at all times, a complete, full-size printed set of record drawings documenting the work performed during the Plant Establishment Period.

2. On or before the date of the Final Project Acceptance, submit final record drawings as detailed herein.

E. Plant Establishment Reports

1. Submit plant establishment reports for review during the progress observations.

F. Owner's Authorized Representative's Review

1. Owner's Authorized Representative will provide approvals or direction for any needed corrections within 10-days of receipt of said submittals.

1.09 PROTECTION OF THE SITE

A. Protect previously installed work and materials which may be affected by work of this Section. Provide safeguards and exercise caution against injury or defacement of existing site improvements.

B. Repair damage and return the area to the previous condition at no additional cost.

1.10 COORDINATION

A. Coordinate operations with subcontractors, as well as other contractors on or adjacent to the project site.

B. Exercise extreme care in excavating and working near existing utilities. Repair any damages to these utilities at no additional cost. Check existing utility drawings for existing utility locations.

C. Coordinate installation of all plant establishment work to avoid interference with utilities, other construction elements, and any existing vegetation.

D. The Contractor shall coordinate with the Owner's Authorized Representative to schedule the placement of materials and equipment necessary to complete the work.

1.11 PLANTING GUARANTEE

A. All planting and seeding materials installed under this Contract shall be guaranteed against poor, inadequate and inferior quality and installation for a period of 1 year from the date of Final Project Acceptance.

1. Manufacturer's warranties shall not relieve the Contractor of its own liability under the Planting Guarantee. Such warranties shall only supplement the Planting Guarantee.

2. Replacement planting and seeding material shall also be guaranteed for a period of 1 year upon installation.

B. Replace at no additional cost and as soon as weather permits, all dead vegetation and all vegetation not found in a vigorous, thriving condition, as determined by the Owner's Authorized Representative during and at the end of the guarantee period.

1. Replacement materials shall be installed as per the requirements of the replacement plant and reseeding area subsections detailed herein.

PART 2 – PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Provide materials and equipment for plant establishment work in accordance with requirements of Sections 32 84 00 Planting Irrigation, 32 92 19 Seeding, and 32 93 00 Plants, except as described herein.

1. Supply all replacement planting and seeding materials as required during the Plant Establishment Period. Replacement materials shall be of same species and size according to Sections 32 92 19 Seeding and 32 93 00 Plants, unless otherwise directed by the Owner's Authorized Representative. Sources proposed for acquisition of replacement plant material must be approved by Owner's Authorized Representative before acquisition. In no event shall plants of larger sizes than those originally planted be required.

B. Herbicide {*Delete this item if not used.*}

1. Herbicide for all noxious weeds and other undesired or invasive plants shall be non-selective, broad-spectrum, post-emergent, trans-locating herbicide with low toxicity to wildlife approved for use in and around aquatic habitats by the U.S. Environmental Protection Agency (EPA). Herbicide shall be of high grade quality and in perfect condition at time of installation. Select herbicides as appropriate for the desired effect (i.e.,

broadleaf herbicide to avoid harm to grasses). All herbicides shall be State and County approved for land or aquatic applications.

a. {*Specify necessary herbicide types and chemical compositions*.}

C. {Add type and description for other materials as needed.}

PART 3 – EXECUTION

3.01 GENERAL PLANT ESTABLISHMENT

A. Continuously maintain areas included in this Contract during the Plant Establishment Period until Final Project Acceptance has been granted.

B. Improper maintenance or possible poor condition of planting at termination of the scheduled final site observation may cause the Plant Establishment Period to be continued at no cost.

C. {Use this only if Plant Establishment Period is being measured in days.} Any day that Contractor fails to adequately perform plant establishment work as determined necessary by the Owner's Authorized Representative will not be credited as one of the {*specify number of days*} working days.

D. The Contractor shall be responsible for establishing and maintaining all plants and seeded vegetation in a healthy condition throughout the Plant Establishment Period. The Contractor shall check the condition of each plant and seeded vegetation for symptoms of disease, size, color, wilting, defoliation, new growth, browsing by wildlife, insect damage, girdling, structural deformities, dieback, sunburn and vandalism and shall notify the Owner's Authorized Representative of the corrective actions required.

E. General plant establishment operations shall include, but not limited to: {*Tailor specifically for each project*.}

1. Maintaining planting and seeding areas and irrigation systems as described specifically herein.

2. Providing debris removal in all planting and seeding areas.

3. Maintain adequate protection of planting and seeding areas. Repairing damaged areas.

4. Maintaining stability of biotechnical treatments.

5. Sweeping clean paved areas at weekly intervals or more frequently, if deemed necessary.

6. Replacing all dead and severely stressed plants and other materials, as required and in accordance with the performance standards.

7. Maintaining all planting areas weed free and removing all invasive or noxious weeds from entire project site. Cultivate at intervals of not more than 10 days.

8. Operating the irrigation system on a regular basis throughout the Irrigation Season and maintaining the irrigation system in a fully operational condition for the duration of the Plant Establishment Period and up to the Final Project Acceptance.

9. Keeping up-to-date record drawings during the Plant Establishment Period.

F. The Contractor shall ensure site drainage. At no time will ponding of water be allowed on the site because of local runoff.

G. The Contractor shall be responsible for 100% of the remediation efforts (to meet the requirements prescribed herein), except when remediation is required because of fire or vandalism in which case the Owner's Authorized Representative will provide direction.

3.02 MAINTAINING WATER RETENTION BASINS

A. Unless otherwise directed by the Owner's Authorized Representative, maintain water retention basins around each container plant. As directed by the Owner's Authorized Representative, modify the basin to ensure it is capable of containing the required amount of water at each watering event at one time. The lip (or earthen berm) of the basin shall be preserved to a height as shown on the Drawings. Maintenance actions may include importing soil, reforming, and re-compacting the lip (or earthen berm) of the basin. Should water be retained within a basin for more than 4-hours, breach the berm of said basin in order to provide drainage at a given plant, especially during the rainy season and at other times as necessary. Take corrective actions to ensure positive drainage at a given plant; the berm shall then be restored to reform the water retention basin as prescribed herein.

3.03 WATERING

A. The Contractor shall conduct weekly site evaluations of water application from June 1 to September 30, during the Plant Establishment Period. These evaluations shall include observing all plants for signs of inappropriate watering, including water stress (caused by overwatering or underwatering), stunted growth, wilting, premature loss of leaves (for deciduous species), and premature yellowing of leaves (for deciduous species).

B. Watering shall consist of the application of water in a manner that is sufficient to wet the soil and saturate the root zone and as frequent as necessary to maintain healthy growth, without damaging the plants, the surrounding grade or the existing watering basins. The plants shall receive water by way of the installed irrigation system as shown on the Drawings and according to Section 32 84 00 Planting Irrigation.

C. Hand watering shall be provided for all plantings not receiving water via irrigation or when irrigation systems are not operational, and at other times as directed by the Owner's Authorized Representative. Water shall be applied in an amount equal to the rates prescribed herein.

D. The schedule for watering shall be determined collaboratively by the Contractor and the Owner's Authorized Representative. At all times, irrigation scheduling will be approved by the Owner's Authorized Representative. The Contractor shall not change the irrigation schedule independently. The Owner's Authorized Representative and Contractor will meet at the project site as necessary to check and adjust irrigation scheduling. The frequency and duration of the watering will depend on current weather patterns and site-specific moisture conditions at each Revegetation Treatment Area. During transition periods (e.g., spring into summer, summer into fall) or during extreme heat or dry cold periods, site visits may be called weekly until a revised irrigation schedule is determined. During the year, quarterly observations will serve as the venue for irrigation adjustments. {*Remove prior sentence if Plant Establishment Period is less than 1-year.*} If modifications are made to the watering schedule, provide the Owner's Authorized Representative with 2 copies of the adjusted watering schedule within 2 weeks of receiving the Owner's Authorized Representative's verbal acceptance, plus subsequent written approval of the modifications. Following is a recommended schedule {*Tailor to specific site conditions.*}:

1. Water plants at a rate of 3-inches per week. {*Include this if spray irrigation systems are to be installed.*}

2. Water plants at a rate of 12-gallons per week applied in one event per week. {*Include this if bubbler irrigation systems are to be installed.*}

3. Water seeded areas at a rate of {*specify rate*} per week.

Where applicable, planting basins shall be completely filled with water at each application. At all times, after each watering, the root zone around each plant shall be saturated to 1-foot depth across the entire width of the planting basin, minimum. At no time shall the watering occur in excess of 1 hour at an individual planting site.

E. The Contractor shall be responsible for observation and timely reporting of irrigation deficiency or excess. Throughout warm weather conditions, the plants may require additional watering events. If most of the plants appear to be stressed and in danger of perishing, consult the Owner's Authorized Representative within 24 hours to determine the frequency and duration of additional or decreased watering. Modify frequency and duration as approved within 24 hours. Assume full responsibility for corrective actions resulting from inappropriate water applications and failure to contact the Owner's Authorized Representative for direction.

F. If exceptionally hot, dry weather continues past the scheduled shutdown date, the Contractor shall consult the Owner's Authorized Representative to determine

whether to continue irrigating the plants after the end of the Irrigation Season. If plants appear to be suffering from excessive irrigation water, the irrigation schedule is subject to reduction at the direction of the Owner's Authorized Representative. Should watering be required in dry winter periods, said watering will be conducted as directed by the Owner's Authorized Representative; said watering will be administered as a change order.

G. The irrigation systems shall be operated, at a minimum, for the first year of the Plant Establishment Period. The length and frequency of the irrigation cycles during the subsequent years of the Plant Establishment Period depend on the health and vigor of the plant material. The beginning and shutdown dates for the irrigation schedule may be similar to the first year of the Plant Establishment Period but will depend on the weather; the beginning and shutdown dates will be approved by the Owner's Authorized Representative. If the majority of the plant material appears to be stressed and in danger of perishing, the Contractor shall consult the Owner's Authorized Representative to determine the frequency and duration of any required watering during the subsequent growing seasons of the Plant Establishment Period. {*Remove this paragraph if Plant Establishment Period is less than 1-year.*}

H. Water pressure shall be regulated to a level that applies sufficient water without causing damage to vegetation or erosion to the planting basin. At no time shall any water be applied in a way that will cause erosion, damage to plants, or excessive runoff. Regulate irrigation watering times to minimize erosion and gullying. At no time will direct truck watering be allowed.

I. The temporary irrigation system shall be removed at the end of the Contract period, upon approval from the Owner's Authorized Representative. {*Delete this paragraph if irrigation system is permanent.*}

3.04 IRRIGATION SYSTEM MAINTENANCE

A. Irrigation maintenance shall include examining the irrigation systems once every {*specify duration*} during the Irrigation Season, including cleaning and adjusting {*specify either or both – spray sprinkler heads and/or bubbler nozzles*}; repairing damaged equipment; testing each valve location to ensure that the irrigation systems are operational; and checking pipes for leaks or blocked lines.

B. At the end of each Irrigation Season, the Contractor shall winterize the system as follows: {*Delete this item if Plant Establishment Period is less than 1-year.*}

1. Close gate valve in irrigation main line located at the irrigation point of connection;

2. Insert a quick coupling quill, connected to a compressor supplied by the Contractor, into the quick coupling valve located at the irrigation point of connection;

3. Following the start of the air compressor, program the irrigation controller through 3 complete cycles or until all water has been forced out of the system;

4. Insert a quick coupling quill into quick coupling valve located at dead-end runs of the main line to force out all trapped water; and

5. Remove the air compressor, leaving the gate valve to the irrigation system closed.

C. The Contractor shall operate and make any necessary repairs to the irrigation systems to meet the requirements specified in Section 32 84 00 Planting Irrigation.

3.05 WEED CONTROL

A. Weed control shall consist of maintaining the individual planting sites, areas between individual planting sites, and all areas within planting boundaries (as shown on the Drawings) free of weeds for the duration of the Plant Establishment Period. Weed control shall also consist of maintaining the seeded areas to meet the performance standards specified herein.

B. The primary goal is to control weeds before they produce viable seed.

C. Personnel performing weed control shall be trained to identify species installed as part of the Contract and shall remove, within planting basins, only those plants that were not planted as part of the Contract. Installed plants or any native plant volunteers shall not be damaged by weed control operations. However, seeded plants are to be treated as weeds inside watering basins and on the basin berms.

D. Observe the project site weekly during the Plant Establishment Period to evaluate potential weed problems. Any invasive or noxious weed species shall be targeted for removal and long-term control through manual or chemical methods. Manual removal by hand-pulling shall be the preferred weed eradication method.

6. Mechanical methods (such as mowing) or spot herbicide applications may be considered upon receipt of an HTP and approval from the Owner's Authorized Representative before application. If approved, herbicide applications shall be conducted according to the approved HTP and under the direction of the Owner's Authorized Representative. At no time shall weed control include burning.

7. Avoid frequent soil cultivation that destroys shallow surface roots.

8. Replenish lost mulch to reduce weed growth.

9. Weeds that grow within the planting basins and on the basin berms shall be removed before reaching 4-inches in height or before covering 30% of the planting basin or equivalent area. All weed control in the planting basins shall be performed by hand pulling. At no time shall herbicide or mechanical methods be used to control weeds in the basin areas. Weed

removal shall not cause disruption to the root systems and aboveground structure of the installed plants and basins.

E. Noxious weeds shall be removed within 7 days of when they are first observed. After the noxious weeds have been removed, the dead vegetation shall be cleared and removed offsite according to State and local regulations. Noxious and invasive weed species in or near the project area include: {*Verify and tailor noxious and invasive weed list for each specific project*.}

Common Name	Scientific Name
Russian knapweed	*Acroptilon repens*
cheat grass	*Bromus tectorum*
hoary cress	*Cardaria draba*
musk thistle	*Carduus nutans*
purple starthistle	*Centaurea calcitrapa*
diffuse knapweed	*Centaurea diffusa*
spotted knapweed	*Centaurea maculosa*
Russian knapweed	*Centaurea repens*
yellow starthistle	*Centaurea solstitialis*
squarrose knapweed	*Centaurea squarrosa*
rush skeleton	*Chondrilla juncea*
Canada thistle	*Cirsium arvense*
bull thistle	*Cirsium vulgare*
field bindweed	*Convolvulus arvensis*
scotchbroom	*Cytisus scoparius*
teasel	*Dipsacus fullonum*
st. john's wort / klamath weed	*Hypericum perforatum*
tall whitetop / perennial pepperweed	*Lepidium latifolium*
ox eye daisy	*Leucanthemum vulgare*
dalmatian toadflax	*Linaria genistifolia* spp. *dalmatica*
yellow toadflax	*Linaria vulgaris*
sweetclover	*Melilotus alba, Melilotus officinalis*
eurasian watermilfoil	*Myriophyllum spicatum*
scotch thistle	*Onorpordum acanthium*
curlyleaf pondweed	*Potamogeton crispus*
sulfur cinquefoil	*Potentilla recta*
perennial sowthistle	*Sonchus arvensis l.*
medusahead grass	*Taeniatherum caputmedusae*
woolly mullein	*Verbascum thapsus*

3.06 BIOTECHNICAL TREATMENT MAINTENANCE

A. Biotechnical treatments installed as per Section 31 35 19.16 Geotextile Slope Protection shall be observed weekly to ensure that said items are stable and in place as installed according to the Drawings and Specifications. The Contractor shall be responsible for maintenance and corrective actions, including replacement and reinstallation, to ensure continued conformance to these Specifications and the Drawings throughout the Plant Establishment Period at no additional cost.

3.07 REPLACEMENT PLANTING

A. Plant material replacement shall be in strict conformance to the Drawings, these Specifications, and the Owner's Authorized Representative's direction, and shall be completed at no additional expense. Installation and materials shall be a prescribed in Section 32 93 00 Plants.

B. Plant material that has no easily observable viable aboveground living matter or is of consistently poor vigor and form shall be considered dead, unless otherwise directed by the Owner's Authorized Representative. Any herbaceous vegetation that fails to show new growth from its root system after one dormant period and within the first 9 months after planting will be considered dead.

C. Replace dead plants according to the Drawings and the Specifications at a rate of replacement that will meet the performance standards described herein. Dead plants shall be removed before installation of replacement plants. All dead plants shall be removed offsite according to State and local regulations at no additional expense.

D. All materials determined to be salvaged shall be handled and removed with care. All replacement plant containers and racks shall be salvaged and recycled offsite or returned to the suppliers at no additional cost.

3.08 RESEEDING AREAS

A. Reseeding shall be in strict conformance to the Drawings, these Specifications, and the Owner's Authorized Representative's direction, and shall be completed at no additional expense. Installation and materials shall be a prescribed in Section 32 92 19 Seeding.

B. Herbaceous vegetation that fails to show new growth from its root system after one dormant period and within the first 9 months after planting will be considered dead.

C. Reseed areas according to the Drawings and the Specifications to meet the performance standards described herein. Dead vegetation shall be removed before reseeding. All dead vegetation shall be removed offsite according to State and local regulations at no additional expense.

D. At no time shall fertilizer be applied to reseeding areas.

3.09 OTHER MAINTENANCE

A. Coordinate with the Owner's Authorized Representative to provide any remedial actions or field-design adjustments necessary to ensure that the performance standards as specified herein are being met.

B. Work necessary to meet the performance standards as specified herein shall be completed at no additional cost.

3.10 RECORD DRAWINGS

A. Provide and keep up to date at all times, a complete set of full size, blue line bond print record drawings, which shall be corrected daily and show every change during the Plant Establishment Period from the final as-built drawings completed as specified in Section 32 93 00 Plants. The record drawings shall also show the exact installed locations, sizes, and kinds of materials and equipment used during the Plant Establishment Period. Record drawings shall be retained on the site.

B. Each record drawing shall include the following:

1. A legend listing all materials used;

2. Any features installed as results from change orders or field instructions;

3. Any known areas not installed as design;

4. Record of any areas that wildlife activity was noticed;

5. Percentage of plant survival and provided information of areas that required replanting;

6. Percentage of seeding survival and provided information of areas that required reseeding;

7. For replacement plantings, include the plant species, quantities, and sizes;

8. For reseeding areas, include the species and types of the reseeding areas;

9. For biotechnical treatments, include the quantities and types of any replacement materials;

10. For irrigation systems, include: dimensions from two permanent points of reference, building corners, sidewalk, or road intersections, etc., for the location of the following items shall be shown:

    a. Connection to existing water lines;
    b. Routing of pressure main lines (dimension max. 50’ along routing);
    c. Shut-off valves;
    d. Routing of lateral line pipes;
    e. {*Specify either or both – spray sprinkler heads and/or bubbler nozzles*};
    f. Confirmation of any irrigation lines, connections, and end points;
    g. Any sleeved pipe areas;
    h. Other related equipment; and

11. {*Specify other items as required*}.

C. Record progress sheets shall be updated daily as the work proceeds, showing the work as actually installed, and shall be the basis for measurement and payment for work completed. Record progress sheets shall be available at all times for observation and shall be kept in a location easily accessible to the Owner’s Authorized Representative. In the event that the progress sheets are not available for review or not current at the time of any site visit by the Owner’s Authorized Representative, it will be assumed that no work has been completed and the Contractor will be assessed the cost of that site visit at the current billing rate of the Owner’s Authorized Representative. No other site observations shall take place without prior payment of this assessment.

D. Make neat and legible notations on the record progress sheets. The relocated equipment and dimensions will then be transferred to the final record drawings at the proper time.

E. Before the date of the Final Project Acceptance, transfer all information from the progress sheets to final record drawings prepared as “red-lined” mark-ups on the original contract drawings; said record drawings shall be submitted to the Owner’s Authorized Representative for approval. Address any comments and make any revisions to the record drawings before the Final Project Acceptance.

F. On or before the date of the Final Project Acceptance, deliver the corrected and completed record drawings to the Owner’s Authorized Representative. Delivery of the record drawings will not relieve the Contractor of the responsibility of furnishing required information that may have been omitted from the record drawings.

G. The final record drawings shall be to scale and reproducible.

3.11 PLANT ESTABLISHMENT REPORTS

A. Plant establishment activities, including, but not limited to watering, pruning, weed control, and repairs to biotechnical treatments shall be logged on a weekly basis in conjunction with the weekly site observations for irrigation, weed control, and biotechnical treatments, and other maintenance submitted for review during the progress observations.

3.12 CLEANUP

A. Site cleanup shall occur on a daily basis and as each phase of the work concludes.

B. Remove all trash and excess dirt caused from the work according to State and local regulations. Contractor shall make arrangements for disposing of these materials outside the project site and shall pay all costs involved. Arrangements shall include, but not be limited to, entering into agreements with property owners and obtaining necessary permits, licenses, and environmental clearances.

C. Sweep all adjacent walks and paved areas on a weekly basis throughout the duration of the project.

D. Repair all scars, ruts or other marks in the ground caused by the work.

E. Upon completion of the work, smooth all ground surfaces, remove excess dirt, materials, rubbish and debris according to State and local regulations to an offsite location or as directed by the Owner's Authorized Representative. Sweep adjacent streets, curbs, gutters and sidewalks and remove construction equipment from the premises.

F. Upon conclusion of the Plant Establishment Period, the Contractor shall completely remove and recycle the irrigation systems off site according to State and local regulations. {*Delete this paragraph if irrigation system is permanent.*}

3.13 SITE OBSERVATION BEFORE FINAL PROJECT ACCEPTANCE

A. Corrective actions shall be in strict conformance with the Drawings and these Specifications and according to the Owner's Authorized Representative, and shall be completed at the Contractor's expense.

B. The Owner's Authorized Representative will perform progress observations of the work and construction operations on completion of installation stages. The Owner's Authorized Representative and the Contractor shall be agree upon the installation stages for this Specification before starting work and be present on mutually agreed-on dates for the observations for each stage.

C. If, after an observation, the Owner's Authorized Representative is satisfied with the construction to date and its conformance to the Drawings and the Specifications, the Owner's Authorized Representative will grant written notice of provisional acceptance for that construction stage.

D. If, after an observation, the Owner's Authorized Representative is dissatisfied with the construction to date and its conformance to the Drawings and the Specifications, the Owner's Authorized Representative will prepare a written punch list of necessary corrective action on defective work for that construction stage. All corrections must be completed and will be reobserved by the Owner's Authorized Representative within 10 working days from the date of the initial observation.

E. Project observations shall not occur until all punch list items from previous observations are corrected. Failure to correct problems in the time specified by the Owner's Authorized Representative may result in a delay of payment for the said tasks until the items in question are remedied per the Owner's Authorized Representative's direction.

F. The Contractor shall be charged for any additional construction observations and punch lists required from the Owner's Authorized Representative for unscheduled and necessary reobservation of the work due to unsatisfactorily or incompletely addressing previous punch lists.

3.14 SITE OBSERVATION SCHEDULE

A. Progress observations of the plant establishment work shall be one per month. The Owner's Authorized Representative and the Contractor shall agree upon a regular day and time for the monthly observations.

B. An annual observation will occur in August of each year of the Plant Establishment Period. The Owner's Authorized Representative will prepare a list confirming the number of live and dead plants of each species by location, as well as the percent coverage of native plants in the seeding areas. {*Remove this paragraph if Plant Establishment Period is less than 1-year.*}

3.15 FINAL PROJECT ACCEPTANCE

A. At completion of the Plant Establishment Period, schedule a Final Project Acceptance observation with the Owner's Authorized Representative. Provide 10 working days of advance written notice for the requested date.

B. The Owner's Authorized Representative, Contractor, and others deemed necessary by the Owner's Authorized Representative may be present at the Final Project Acceptance observation.

C. Before requesting Final Project Acceptance observation, all plant establishment work shall be completed.

D. If during the Final Project Acceptance observation the Owner's Authorized Representative is of opinion that plant establishment work has been completed in accordance with the Drawings and Specifications, the Owner's Authorized Representative shall provide written notice of Contractor release from the project. Substantial completion of the work includes meeting the performance standards as stated herein.

E. If during the Final Project Acceptance observation the Owner's Authorized Representative is of opinion that plant establishment has not been substantially completed in accordance in accordance with the Drawings and Specifications, the Owner's Authorized Representative will prepare a written punch list of necessary corrective action on defective work. Corrective actions to meet performance standards may include, but are not limited to, additional weed control, additional planting and/or additional seeding, All corrections must be completed by the Contractor and reobserved by the Owner's Authorized Representative within 10 working days from the date of the initial Final Project Acceptance observation. Written notice of Contractor release from the project shall not be issued until all corrective actions have been addressed.

F. Corrective actions shall be in strict conformance with the Drawings and Specifications and shall be completed at the Contractor's expense.

END OF SECTION

This page has been intentionally left blank.

SECTION 32 84 00
PLANTING IRRIGATION

{*This template is to be used as a guide only. This specification section must be tailored to designs and conditions for each individual project site. Brackets "{ }" are provided for items where the user needs to provide specific information*. Note that all days should refer to calendar days.}

PART 1 – GENERAL

1.01 GENERAL CONDITIONS

A. Requirements of Section 00700 – General Conditions and of Division 1 – General Requirements, apply to work in this Section with same force and effect as though repeated in full herein.

1.02 SCOPE OF WORK

A. Furnish all materials, labor, transportation, services, and equipment necessary to install planting irrigation as shown on the Drawings and as specified herein. Any and all permits, fees, bonds and observations necessary to perform and complete this portion of the work shall be included.

B. Work included in this Section:

1. Preparation;
2. Installation;
3. Installation of Other Components;
4. System Flushing;
5. Field Quality Control;
6. Irrigation System Operations;
7. Temporary Repairs;
8. As-Built Drawings;
9. Cleanup;
10. Site Observation Before Final Installation Acceptance;
11. Site Observation Schedule; and
12. Final Installation Acceptance.

C. Work related in other Sections:

1. Section 31 35 19.16 Geotextile Slope Protection;
2. Section 32 01 90 Plant Establishment;
3. Section 32 91 00 Planting Preparation;
4. Section 32 92 19 Seeding; and
5. Section 32 93 00 Plants.

1.03 REQUIREMENTS OF REGULATORY AGENCIES

A. Local, municipal and State laws, and rules and regulations governing or relating to any portion of this work are hereby incorporated into and made a part of these Specifications, and their provisions shall be carried out. Anything contained in these Specifications shall not be construed to conflict with any of the above rules and regulations or requirements of the same. However, when these Drawings

and Specifications call for or describe materials, workmanship or construction of a better quality, higher standard, or larger size than is required by the above rules and regulations, the provisions of these and Drawings and Specifications shall take precedence.

1.04 REFERENCE STANDARDS

A. Work and materials shall be in accordance with the latest edition of the Uniform Plumbing Code as published by the Western Plumbing Officials Association and applicable laws and regulations of the governing authorities.

1.05 DEFINITIONS

A. Final Installation Acceptance: Final Installation Acceptance is the milestone when all installation work (i.e., all work except that required under Section 32 98 00 Plant Establishment) is completed and approved by the Owner's Authorized Representative.

B. Final Project Acceptance: Final Project Acceptance is the milestone when all work, including work under Section 32 98 00 Plant Establishment, is completed and approved by the Owner's Authorized Representative. Final Project Acceptance does not in any way release the Contractor from the requirements or duration of any guarantees as per the Specifications.

C. Installation Period: The Installation Period begins when the Notice to Proceed (NTP) is given and continues until all requirements indicated in the Drawings and Specifications are completed and approved, and the Owner's Authorized Representative gives a written notice of a Final Installation Acceptance.

D. Plant Establishment Period: The Plant Establishment Period begins immediately after the Contracting Officer gives a written notice of a Final Installation Acceptance and continues until all requirements indicated in Section 32 98 00 Plant Establishment are completed and approved and the Contracting Officer gives a written notice of a Final Project Acceptance.

1.06 QUALITY CONTROL

A. The manufacturer's directions and drawings shall be followed in all cases where the manufacturers of articles used in this Specification furnish directions covering points not shown in the Drawings and Specifications.

B. Due to the scale of the Drawings, it is not possible to indicate all offsets, fittings, sleeves, etc. which may be required. Therefore, the Contractor shall adhere to the following:

1. Investigate the structural and finish conditions affecting all of the work described herein and plan accordingly, furnishing such fittings, etc. as may be required to meet such conditions.

2. The Drawings are diagrammatic only for graphic clarity and are indicative in such a manner to avoid conflicts between irrigation systems, planting, and other site features.

3. Furnish all materials, labor, transportation, services, and equipment necessary to install a complete and fully operational system.

4. Do not willfully install the irrigation system as shown on the Drawings when it is obvious in the field that obstructions, grade differences or discrepancies in area dimensions exist that might not have been considered in the system design. Such obstructions or differences should be brought to the attention of the Owner's Authorized Representative. In the event that this notification is not performed, assume full responsibility for any necessary revisions at no additional cost.

5. Install a complete and fully operational system to meet the performance requirements included in this section.

6. All work called for on the Drawings by notes or details shall be furnished and installed whether or not specifically mentioned in this Specification.

7. The irrigation system is designed to operate at a minimum operating pressure and the maximum flow rates indicated on the Drawings. Verify the existing water pressure at the point of connection before starting construction of the irrigation system. If there is a discrepancy between the Drawings and the actual site conditions, notify the Owner's Authorized Representative immediately for direction; assume full responsibility for any revisions or modifications required to provide a fully operational system, at no additional cost, if the Owner's Authorized Representative is not notified before the start of construction.

1.07 SUBMITTALS

A. Approval of any item, alternate or substitute indicates only that the product or products apparently meet the requirements of the Drawings and Specifications on the basis of the information or samples submitted.

B. Submit verification of the required minimum qualifications as specified in Section 32 93 00 Plants for approval by the Owner's Authorized Representative, within 10 days after the award of Contract.

C. Submit no later than 10 days after the award of Contract, 2 three-ring hard cover binders containing the following information:

1. A complete material list including the manufacturer, model number and description of each material and type of equipment to be used. The irrigation submittal list must be specific and complete. All items must be listed and should include solvent/primer, wire, wire connectors, valve boxes, etc. Copies of manufacturer's literature (catalog sheets) are not required as submittal information.

2. Shop drawings showing the proposed irrigation systems for review and approval by the Owner's Authorized Representative before ordering and equipment.

3. A schedule identifying irrigation materials procurement, storage, anticipated delivery dates, and anticipated installation dates for review and approval.

D. The Contractor shall submit to the Owner's Authorized Representative within 10 days following approval of shop drawings a copy of the materials procurement order from the supplier including the name, address, and phone number of said supplier and the estimated date(s) and quantities for delivery from the supplier. Indicate items in stock at time of order and submit the latest test.

E. Submit written Irrigation Guarantee as detailed in this Section no later than 10 days after the award of Contract.

F. Submit no later than 10 days after the award of Contract, 2 three-ring hard cover binders of the Operation and Maintenance Manual, each containing the following information:

1. Index sheets stating the Contractor's address and telephone number and a list of equipment with the names and addresses of local manufacturers' representatives.

2. Catalog and part sheets for each material and type of equipment installed under this Contract.

3. Manufacturer's warranty statements for irrigation equipment provided. No installations will be accepted without warranty statements.

4. Complete operating and maintenance instruction for all major equipment.

5. Provide a copy of the complete material list referenced above.

G. Provide and keep as-built drawings during the Installation Period as specified under Section 32 93 00 Plants.

H. Submit proof of warranty for all irrigation materials and equipment to the Owner's Authorized Representative before the Final Installation Acceptance. Obtain the necessary warranty observations from the equipment supplier.

I. Owner's Authorized Representative will provide approvals or direction for any needed corrections within 10-days of receipt of said submittals.

1.08 PRODUCT DELIVERY, STORAGE AND HANDLING

A. All materials and equipment delivered to the project site shall be clearly marked to identify the item, material, class, and thickness.

B. PVC pipe shall be transported in a vehicle that enables the entire length of pipe to lie flat, so that it is not to subject to undue bending or concentrated external load at any point. Sections of pipe that have been dented or damaged will be discarded and, if installed, shall be replaced with new piping.

C. Exercise care in handling, loading, unloading, and storing irrigation materials and equipment to ensure they are not damaged.

D. Provide a storage site for the irrigation materials and equipment at the staging areas shown on the Drawings or as directed by the Owner's Authorized Representative. Store in a manner to prevent damage from sunlight, moisture or contact with vehicles, equipment or tools.

1.09 SUBSTITUTIONS

A. Substitutions for the materials or equipment listed on the Drawings and Specifications may be requested by providing the following information to the Owner's Authorized Representative for approval:

1. Provide a statement indicating the reason for making the substitution. Use a separate sheet of paper for each item to be substituted.

2. Provide descriptive catalog literature, performance charts, and flow charts for each item to be substituted.

3. Provide the amount of cost savings if the substituted item is approved.

B. The Owner's Authorized Representative shall have the sole responsibility for accepting or rejecting substituted items as approved equals to the materials or equipment listed on the Drawings and Specifications.

1.10 REJECTION OF MATERIALS

A. All materials not conforming to the requirements herein shall be considered defective and will be rejected.

B. Equipment or materials installed or furnished without prior approval of the Owner's Authorized Representative may also be rejected.

C. Rejected materials shall be removed and disposed of according to State and local regulations by the Contractor at no additional cost. Rejected materials shall be replaced at no additional cost.

1.11 PROTECTION OF THE SITE

A. Protect previously installed work and materials which may be affected by work of this Section. Provide safeguards and exercise caution against injury or defacement of existing site improvements.

B. Protect pipes and fittings from direct sunlight and avoid undue bending and any concentrated external loading. Pipe or fittings that have been damaged shall not be used.

C. Repair damage and return the area to the previous condition at no additional cost.

D. Existing irrigation systems shall be retained in operation at all times. When the existing system is damaged, repairs shall be made immediately. After each repair, sprinkler heads of the repaired system shall be removed so that the lines can be cleared of dirt and foreign matter.

1.10 COORDINATION

A. Coordinate operations with subcontractors, as well as other contractors on or adjacent to the project site.

B. Exercise extreme care in excavating and working near existing utilities. Repair any damages to these utilities at no additional cost. Check existing utility drawings for existing utility locations.

C. Coordinate installation of all irrigation equipment and materials to avoid interference with utilities, other construction elements, and any existing or newly planted or seeded vegetation.

D. The Contractor shall coordinate with the Owner's Authorized Representative to schedule the placement of materials and equipment necessary to complete the work.

THIS SPACE HAS BEEN INTENTIONALLY LEFT BLANK.

1.13 IRRIGATION GUARANTEE

A. The guarantee for the irrigation system shall be in accordance with the form outlined below. The Irrigation Guarantee form shall be re-typed onto the Contractor's letterhead and contain the following information:

GUARANTEE FOR IRRIGATION SYSTEM

We hereby guarantee that the irrigation system we have furnished and installed is free from defects in materials and workmanship. We guarantee the work has been completed in accordance with the Drawings and Specifications, except for ordinary wear and tear and unusual abuse. We agree to repair or replace any defects in material or workmanship that may develop during a period of 1-year from the date of Final Acceptance by the Owner's Authorized Representative at no additional cost. We shall make such repairs or replacements within a reasonable time, as determined by the Owner's Authorized Representative, after receipt of written notice. In the event of our failure to make such repairs or replacements within a reasonable time after receipt of written notice from the Owner's Authorized Representative, we authorize the Owner's Authorized Representative to proceed to have said repairs or replacements made at our expense and we will pay the costs and charges therefore upon demand.

PROJECT:

LOCATION:

SIGNED:

ADDRESS:

PHONE: DATE OF ACCEPTANCE:

B. Manufacturer's warranties shall not relieve the Contractor of his/her liability under the Irrigation Guarantee. Such warranties shall only supplement the Irrigation Guarantee.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Use only new materials of brands and types noted on the Drawings, specified in this Section or equals as approved by the Owner's Authorized Representative. All pipe sizes indicated on the Drawings and prescribed herein are nominal inside diameter, unless otherwise noted.

Operation and Maintenance Equipment

1. Supply as a part of this Contract the following tools:

   a. 2 sets of special tools required for removing, disassembling, and adjusting each type of sprinkler and valve supplied on the project.

B. PVC Pressure Main Line Pipe and Sleeve Pipe and Fittings

1. Pressurized main line pipe sizes 2 inches and greater shall be Class 315 PVC, Type I, manufactured in conformance to ASTM D2241 for rigid PVC compounds. Main line pipe sizes less than or equal to 2 inches shall be Schedule 40 PVC, Type I, manufactured in conformance to ASTM D2241 for rigid PVC compounds.

2. Unless otherwise specified, pipe fittings shall be Schedule 40, polyvinylchloride (PVC) solvent-weld fittings that conform to ASTM D1785. For threaded joints, only factory-formed threads will be permitted on PVC pipe fittings. Solvent-weld joint primer of a different color than the pipes and slow-set gray cement shall be used on main line pipe joints. Clear, quick-set cement shall be used on lateral line pipe joints.

C. PVC Non-Pressure Lateral Line Piping

1. Non-pressure lateral line piping shall be ¾-inch size minimum and less than 2 inches. Pipe shall be Schedule 40 PVC, Type I, manufactured in conformance to ASTM D2241 for rigid PVC compounds.

2. Non-pressure buried lateral line piping shall be Class 200 PVC water pipe with solvent-welded joints.

D. Riser Pipe

1. Riser pipe shall be ¾-inch size minimum and less than 2 inches. Pipe shall be Schedule 40 PVC, Type I, manufactured in conformance to ASTM D2241 for rigid PVC compounds.

E. PVC pipe must bear the following markings:

1. Manufacturer's name;
2. Nominal pipe size;
3. Schedule or class;
4. Pressure rating in pounds per square inch (psi);
5. NSF (National Sanitation Foundation) approval; and
6. Date of extrusion.

Fittings shall bear the manufacturer's name or trademark, material designation, size, applicable IPS schedule and NSF seal of approval.

F. Shut off Valves

1. Shut off valves shall be 125 lb. SWP bronze gate valve with screw-in bonnet, non-rising stem and solid wedge disc.

2. Shut off valves shall have threaded ends and shall be equipped with a bronze cross handle.

3. Shut off valves shall be clearly identified for non-potable water use only.

4. Shut off valves shall be similar to those manufactured by Watts, or approved equal.

G. Spray Sprinklers {*Choose either spray or bubbler irrigation system, or if using a* combination*, specify which systems in which locations*.}

1. Spray sprinklers shall be RainBird 2045-PJ Maxi-Bird impact sprinklers, full and part circle, nozzle #12, 39-foot radius spray, delivering 5.5 gpm at 25 psi.

2. Sprinkler anchors shall be 60-inch-long, #4 rebar stakes. Clamps shall be ¾-inch galvanized steel conduit clamps.

H. Bubbler Nozzles {*Choose either spray or bubbler irrigation system, or if using a* combination*, specify which systems in which locations*.}

1. Bubbler nozzles shall be Rain Bird, adjustable, full-circle bubblers, model no. 1300A-F, or approved equal. Bubbler nozzles shall be pressure-regulating and adjustable down to 0 gallons per minute to facilitate watering needs based on species and site conditions and the decrease and ultimate discontinuation of irrigation for individual plants on a given system.

2. Flexible tubing (to connect the bubbler nozzles to lateral line pipe) shall be high quality, durable, polyethylene tubing, ¾ inch diameter. Tubing anchors shall be #2 rebar, smooth finish, 24 inches in length, bent in a U-shape. Pipe anchors shall be #3 rebar, smooth finish, 24 inches in length, bent in a U-shape.

3. Stakes (for securing bubbler nozzles) shall be 2-inch diameter by 4-foot wood stake, painted white. Clamps shall be ¾-inch galvanized steel conduit clamps.

4. The Contractor shall provide the necessary fittings to secure the bubbler nozzles to the flexible tubing to be used as part of the bubbler irrigation systems.

I. Other Components

1. Provide operating keys, servicing tools, test equipment, other items, and spare parts as indicated in this Specification.

2. Provide other materials or equipment not shown on the Drawings or referenced in this Specification necessary to complete the installation of the irrigation system. Said materials shall be provided according to industry standards.

J. Layout Stakes

1. Layout stakes shall be 48-inch wood lath surveyor stakes, with a pointed tip on one end and topped with colored surveyor tape on the other end. The top 12-inches of the blunt end of all laths shall be spray painted with florescent colored paint. If the laths are used for multiple purposes, different colors shall be used to identify each specific purpose.

K. {*Add type and description for other materials as needed.*}

PART 3 – EXECUTION

3.01 PREPARATION

A. Site Conditions

1. Verify site conditions and be familiar with existing grade conditions, locations of existing features to be preserved, and all existing vegetation to remain. Coordinate installation of all irrigation materials to avoid interference with utilities, other construction elements, and existing vegetation. Field adjustments may be necessary to avoid disturbances.

2. Carefully check all finished grades to ensure that construction may safely proceed before starting work on the irrigation system.

3. Report irregularities to Owner's Authorized Representative before beginning work; beginning of work implies acceptance of existing conditions.

4. Scaled dimensions on the Drawings are approximate. Before ordering materials or proceeding with work, the Contractor shall verify all dimensions and quantities between the Drawings, these Specifications and field conditions; any and all discrepancies shall be reported immediately to the Owner's Authorized Representative.

5. Exercise extreme care in excavating and working near existing utilities. The Contractor shall be responsible for damages to these utilities. Check existing utility drawings for existing utility locations.

6. All parts of the irrigation system construction operations shall be subject to observation and approval by the Owner's Authorized Representative as indicated under this Section.

B. Physical Layout

1. Before installation, stake out all irrigation lines and the location of all components of the irrigation system's layout, including, but not limited to, mainline pipe, lateral line pipe, shut off valves, and {*specify either or both – spray sprinkler heads and/or bubbler nozzles*}.

2. Layout staking shall be approved by the Owner's Authorized Representative before installation.

3. Irrigation equipment shall be placed areas as shown on the Drawings.

C. Water Supply Point-of-Connection

1. The irrigation system shall be connected to the {*specify connection – give specifics OR state as indicated on the Drawings*}. Any minor changes caused by actual site conditions shall be addressed at no additional cost.

2. The water meter and backflow prevention equipment will be installed {*specify either – by the Contractor OR by others. Give specifics or state as indicated on the Drawings*}.

3. {*Specify one of the following – The Contractor shall be responsible for locating and connecting to the irrigation water source. At the Contractor's discretion, a water truck may be used to supply water for the irrigation systems in-lieu of water service point(s). OR The Contractor shall be responsible connecting to the irrigation water source. The irrigation water source shall be [specify either – source OR state as indicated on the Drawings]*.} The Contractor shall be responsible for the costs and fees associated with connection to the irrigation water source. The Contractor shall install of a water service line and water meter.

4. {*Specify one of the following – The Contractor shall pay all costs for service, including all services fees through the duration of the Contract, including through the duration of the Irrigation Guarantee. The Contractor shall also pay costs associated with testing of the backflow prevention equipment, including all testing required through the duration of the Contract, including through the duration of the Irrigation Guarantee. OR The Owner shall be responsible for costs and fees associated with service and testing.*}

5. {*Specify one of the following – The Contractor shall be responsible for paying all costs and fees associated with water supply through the duration of the Contract, including through the duration of the Irrigation Guarantee. OR The Owner shall be responsible for costs and fees associated with water supply.*}

3.02 INSTALLATION

A. The Contractor shall supply and install the irrigation systems as specified herein to adequately water the plant and seeding materials as prescribed in Sections 32 93 00 Plants and 32 92 19 Seeding. Use spray irrigation systems for both planting and seeding areas; bubbler irrigation systems shall only be used for plant irrigation.

B. Materials for irrigation systems shall be commercial quality, unless otherwise specified.

C. Assemblies

1. Observe all pipe and fittings before installation.

2. Routing of irrigation lines as indicated on the Drawings is diagrammatic only. Install all assemblies specified herein in accordance with their respective details on the Drawings. In absence of Drawings or Specifications pertaining to specific items required to complete this work, perform such work in accordance with best standard practice with approval of the Owner's Authorized Representative. Installation and solvent welding methods shall be as recommended by the pipe and fitting manufacturer.

3. Keep pipe free from dirt and pipe scale. Pipes and fittings shall be thoroughly cleaned of dirt, dust, and moisture before installation.

4. Cut pipe ends square and debur pipe.

5. Keep ends of assembled pipe capped. Remove caps only when necessary to continue assembly.

6. Install pipe with all markings up for visual observation and verification.

7. At no time shall multiple assemblies be installed in plastic lines. Provide each assembly with its own outlet.

8. All main line and lateral line pipe shall be set on grade; therefore, trenching or backfilling are not necessary. As required to accommodate pipe placement on grade, fallen trees shall be cut to provide a 2-foot width, maximum, opening. The Contractor shall install the assembly in conformance to standard installation practices.

9. For PVC-to-metal connections, the Contractor shall use a Schedule 80 PVC male adapter, working with the metal connections first. The threads of the male adapter shall be wrapped in Teflon tape, inserted into the female fitting, and lightly tightened with a wrench. Pipe dope will not be allowed on PVC-to-metal connections. Pipe joint compound shall be used on all metal threaded joints. Threaded PVC adapters that can be welded for threaded PVC connections shall be used.

10. For PVC-to-PVC connections, solvent-weld joints shall be of commercial quality and made according to manufacturer's specifications for solvent-weld piping. Pipes and fittings shall be completely cleaned to be free of dirt, dust, and moisture before the application of primer and solvent cement. After cementing, the pipes and fittings should be held in position for 45 seconds to permit cement to set thoroughly before moving. Main lines shall be allowed to set for at least 24 hours before the system is flushed or pressure is applied to the system. No primer is required for lateral line installation. Clear, quick-set cement shall be used on lateral line pipe joints.

11. Main line pipe for the irrigation systems shall be installed from the water service points to the individual shut off valves. Main line pipe shall be set immediately above grade and securely anchored with #3 rebar U-stakes that are 36 inches in length, minimum, and set 10 feet on center, minimum.

12. Lateral line pipe shall be securely anchored with #3 rebar U-stakes that are 36 inches in length, minimum, and set 10 feet on center, minimum.

13. Riser pipe shall be installed as shown on the Drawings.

D. Shut Off Valve Installation

1. Locate and install shut off valves to operate the specified irrigation systems as indicated on the Drawings. Stake the locations of all shut off valves for approval before installation.

2. Shut off valves shall be installed on grade.

E. Spray Irrigation System {*Choose either spray or bubbler irrigation system, or if using a combination, specify which systems in which locations*.}

1. The spray irrigation systems shall be supplied, installed, and operated according to this Section and as detailed on the Drawings. Spray sprinkler heads shall be set perpendicular to finish grades unless otherwise indicated on the Drawings. System shall include backflow prevention equipment. Follow installation schedule as per subsection "Irrigation System Operation."

2. Install lateral line pipe for the spray systems from the shut off valves to the individual sprinklers set on risers.

3. Sprinklers shall be secured to rebar stakes with a minimum of 2 clamps.

4. Spacing of spray sprinkler heads shall not exceed the maximum spacing as indicated on the Drawings. In no case shall the spacing exceed the maximum recommended by the manufacturer.

F. Bubbler Irrigation System {*Choose either spray or bubbler irrigation system, or if using a combination, specify which systems in which locations*.}

1. The bubbler irrigation systems shall be supplied, installed, and operated according to this Section and as detailed on the Drawings. Bubbler nozzles shall be set perpendicular to finish grades unless otherwise indicated on the Drawings. System shall include backflow prevention equipment. Follow installation schedule as per subsection "Irrigation System Operation."

2. The bubbler irrigation systems shall be operated manually. Do not install bubbler systems in seeded areas.

3. Install lateral line pipe for the bubbler systems from the shut off valves; shut off valves shall be connected to flexible tubing that leads to the individual bubbler nozzles.

4. Bubbler nozzles shall be set in the planting basin close to the basin rim. Stakes shall be set 18-inches into the ground; bubbler nozzles shall be clamped securely to stakes using a minimum of 2 clamps.

G. Irrigation Piping Clearance

1. Irrigation piping shall have a minimum clearance of 6 inches from other irrigation piping and the piping of other trades. Pipe lines routed parallel shall not be installed directly over one another.

3.03 INSTALLATION OF OTHER COMPONENTS

A. Install other materials or equipment shown on the Drawings or installation details to be part of the irrigation system, even though such items may not have been referenced in this Specification.

3.04 SYSTEM FLUSHING

A. After pipe lines and risers are in place and connected and all necessary diversion work has been completed, and before installation of {*specify either or both – spray sprinkler heads and/or bubbler* nozzles}, the irrigation system shall be opened and a full head of water used to flush out the system. {*Specify either or both – spray sprinkler heads and/or bubbler nozzles*} shall be installed only after flushing of the system has been performed.

3.05 FIELD QUALITY CONTROL

A. Adjustment of the Irrigation System

1. Flush and adjust all {*specify either or both – spray sprinkler heads and/or bubbler nozzles*} for optimum performance and to reduce overspray onto walks, roadways, and buildings as much as possible.

2. If it is determined that adjustment to the {*specify either or both – spray sprinkler heads and/or bubbler nozzles*} will provide proper and more adequate coverage, make such adjustments before any planting. Adjustments may also include changes in {*specify either or both – sprinkler and/or nozzle*} sizes and {*include this statement if using spray sprinkler system – degrees of arc as required*}.

3. Contact the Owner's Authorized Representative immediately upon finding any field conditions that would conflict with the irrigation design on the Drawings. All field adjustments must be approved by the Owner's Authorized Representative before construction of said adjustments; failure to do so shall result in assumption of full responsibility for any required revisions or modifications to the system, as directed by the Owner's Authorized Representative, at no additional cost.

B. Irrigation System Testing

1. The Contractor shall perform tests and repairs as specified. The Contractor shall provide a force pump and all other required test equipment.

2. Request the presence of the Owner's Authorized Representative at least 48 hours in advance of irrigation system testing.

3. Before testing, the lines shall be flushed to remove dirt and other debris that may have accumulated in the pipe. After the irrigation lines and valves installed on the main line have set for a minimum of 24 hours, the following shall be tested:

   a. The Contractor shall fill all main lines with water and test at 150 psi constant pressure for 2 hours. The Contractor shall monitor the test pressure gage and visually observe all joints for signs of leakage in the presence of the Owner's Authorized Representative. If any defects are found, they must be repaired and the entire observation process must be repeated.

   b. The points of connection, valves, and backflow preventers will be observed at the time of the main line observation. During the main line tests, each valve shall be operated for a sufficient period of time to allow the Owner's Authorized Representative to observe the specific valve location and to ensure that the {*specify either or both – spray sprinkler heads and/or bubbler nozzles*} are operating adequately.

   c. Lateral line pressure tests will not be required.

   d. When the irrigation system passes the hydrostatic pressure test and is completed, the {*specify either or both – spray sprinkler heads and/or bubbler nozzles*} shall be tested in the presence of the Owner's Authorized Representative. Determine if the water

coverage is complete and adequate. Ensure that sprinklers shall not be allowed to spray Public Utility County supplied water or chlorinated water on to existing streams. Runoff from sprinklers will not be allowed and shall not enter waterways or streams. This test shall be accomplished before any planting occurs.

e. Upon completion of each phase of work, the entire system shall be coverage tested and adjusted to meet specific site requirements.

4. If during the pressure test, a pressure drop occurs (indicating a leak), replace the faulty joints and repeat the pressure test until the entire system is proven watertight. Use of cement or caulking to seal leaks will not be permitted at any time.

5. Hydrostatic tests shall be made only in the presence of the Owner's Authorized Representative.

C. If it is determined that the irrigation system or any of its parts or equipment are improperly installed, corrections shall be made by the Contractor, at no additional expense, to ensure that the system conforms to the Drawings and/or these Specifications. Furnish materials and perform work necessary to correct any inadequacies of water coverage due to deviations from the Drawings, or where the irrigation system has been willfully installed as indicated on the Drawings when it was obviously inadequate, without bringing this to the attention of the Owner's Authorized Representative.

3.06 IRRIGATION SYSTEM OPERATION

A. The major portions of the irrigation system shall be installed before the installation of any plants or seeded areas. The Owner's Authorized Representative reserves the right to waive or shorten this operation period.

B. Plant locations must be field marked and approved, and planting holes must be excavated, before installation of {*specify either or both – spray sprinkler heads and/or bubbler nozzles*}. These components shall be installed immediately following planting and seeding material installation. Before the installation of the {*specify either or both – spray sprinkler heads and/or bubbler nozzles*}, the shut off valves shall be completely opened to flush the irrigation pipes clean of debris and extraneous material.

C. Irrigation of all plants and seeded areas shall begin the same day as plant installation. All irrigation installation operations must be conducted in coordination with plant location field marking, planting hole excavation, and seeding area field marking, according to Section 32 93 00 Plants.

D. The irrigation system shall be operated to provide watering of the project site as specified in Sections 32 93 00 Plants and 32 92 19 Seeding.

3.07 TEMPORARY REPAIRS

A. The Owner's Authorized Representative reserves the right to make temporary repairs as necessary to keep the irrigation system in operating condition. The exercise of this right by the Owner's Authorized Representative shall not relieve the Contractor of the responsibilities under the terms of the Irrigation Guarantee as herein specified.

B. The Owner's Authorized Representative will notify the Contractor, in writing, of any repairs within 48 hours before the time of the repairs. If irrigation system adjustments are determined necessary, the Contractor shall proceed only after receiving written approval from the Owner's Authorized Representative for such adjustments.

3.08 WINTERIZATION

A. The Contactor shall be responsible for winterization of irrigation system as follows.
   1. Close shut off valve in the irrigation main line located at the irrigation point of connection.
   2. Connect a compressor supplied by the Contractor, at the irrigation point of connection.
   3. Using the air compressor, force all water out of the system.
   4. Remove the air compressor, leaving the shut off valve to the irrigation system closed.

3.09 AS-BUILT DRAWINGS

A. The Contractor shall prepare as-built drawings as specified in Section 32 93 00 Plants. For the irrigation system, show dimensions from two permanent points of reference, building corners, sidewalk, or road intersections, etc., for the location of the following items:

   1. Connection to existing water lines;
   2. Routing of pressure main lines (dimension max. 50' along routing);
   3. Shut-off valves;
   4. Routing of lateral line pipes;
   5. {*Specify either or both – spray sprinkler heads and/or bubbler nozzles*};
   6. Confirmation of any irrigation lines, connections, and end points;
   7. Any sleeved pipe areas; and
   8. Other related equipment.

3.10 CLEANUP

A. Site cleanup shall occur on a daily basis and as each phase of the work concludes.

B. Remove all trash and excess dirt caused from the work according to State and local regulations. Contractor shall make arrangements for disposing of these materials outside the project site and shall pay all costs involved. Arrangements

shall include, but not be limited to, entering into agreements with property owners and obtaining necessary permits, licenses, and environmental clearances.

C. Sweep all adjacent walks and paved areas on a weekly basis throughout the duration of the project.

D. Repair all scars, ruts or other marks in the ground caused by the work.

E. Upon completion of the work, smooth all ground surfaces, remove excess dirt, materials, rubbish and debris according to State and local regulations to an offsite location or as directed by the Owner's Authorized Representative. Sweep adjacent streets, curbs, gutters and sidewalks and remove construction equipment from the premises.

3.11 SITE OBSERVATION BEFORE FINAL INSTALLATION ACCEPTANCE

A. Corrective actions shall be in strict conformance with the Drawings and these Specifications and according to the Owner's Authorized Representative, and shall be completed at the Contractor's expense.

B. The Owner's Authorized Representative will perform progress observations of the work and construction operations on completion of installation stages. The Owner's Authorized Representative and the Contractor shall be agree upon the installation stages for this Specification before starting work and be present on mutually agreed-on dates for the observations for each stage.

C. If, after an observation, the Owner's Authorized Representative is satisfied with the construction to date and its conformance to the Drawings and the Specifications, the Owner's Authorized Representative will grant written notice of provisional acceptance for that construction stage.

D. If, after an observation, the Owner's Authorized Representative is dissatisfied with the construction to date and its conformance to the Drawings and the Specifications, the Owner's Authorized Representative will prepare a written punch list of necessary corrective action on defective work for that construction stage. All corrections must be completed and will be reobserved by the Owner's Authorized Representative within 10 working days from the date of the initial observation.

E. Project observations shall not occur until all punch list items from previous observations are corrected. Failure to correct problems in the time specified by the Owner's Authorized Representative may result in a delay of payment for the said tasks until the items in question are remedied per the Owner's Authorized Representative's direction.

F. The Contractor shall be charged for any additional construction observations and punch lists required from the Owner's Authorized Representative for unscheduled and necessary reobservation of the work due to unsatisfactorily or incompletely addressing previous punch lists.

3.12 SITE OBSERVATION SCHEDULE

A. Provide the Owner's Authorized Representative with 48 hours of advance notification, except as otherwise noted, for required stage acceptance observations including, but not limited to, the following:

1. Staked locations of mainline, lateral line, shut off valves, and {*specify either or both – spray sprinkler heads and/or bubbler nozzles*};

2. Progress installations of main line, lateral line, shut off valves, and {*specify either or both – spray sprinkler heads and/or bubbler nozzles*}, including testing;

3. Completed installations of mainline, lateral line, shut off valves, and {*specify either or both – spray sprinkler heads and/or bubbler nozzles*}, including testing; and

4. Substantial Completion Observation: Final installation observation before the start of the Plant Establishment Period. (Provide 10 working days of advance written notice).

3.13 FINAL INSTALLATION ACCEPTANCE

A. Final Installation Acceptance will be issued as specified in Section 32 93 00 Plants. Following the Final Installation Acceptance, the Plant Establishment Period shall begin.

END OF SECTION

This page has been intentionally left blank.

SECTION 32 91 00
PLANTING PREPARATION

{*This template is to be used as a guide only. This specification section must be tailored to designs and conditions for each individual project site. Brackets "{ }" are provided for items where the user needs to provide specific information*. Note that all days should refer to calendar days.}

PART 1 – GENERAL

1.01 GENERAL CONDITIONS

A. Requirements of Section 00700 – General Conditions and of Division 1 – General Requirements, apply to work in this Section with same force and effect as though repeated in full herein.

1.02 SCOPE OF WORK

A. Furnish all materials, labor, transportation, services, and equipment necessary to conduct planting preparation work as specified herein. The Contractor shall perform work according to all applicable laws, codes, and regulations required by federal, State, and local authorities to complete the work specified herein. Any and all permits, fees, bonds, and observations necessary to perform and complete the work shall be included.

B. Work included in this Section:

1. Mobilization and Demobilization;
2. Verify Site Conditions;
3. Site Preparation;
4. Soil Sampling;
5. Weed Removal;
6. Soil Rehabilitation;
7. Fine Grading Operations;
8. Duff/Mulch Replacement and Pine Needle*{/Wood Chip, <if appropriate, see below>}* Placement;
9. As-Built Drawings;
10. Cleanup;
11. Site Observation Before Final Installation Acceptance;
12. Site Observation Schedule; and
13. Final Installation Acceptance.

C. Work related in other Sections:

1. Section 31 35 19.16 Geotextile Slope Protection;
2. Section 32 01 90 Plant Establishment;
3. Section 32 84 00 Planting Irrigation;
4. Section 32 92 19 Seeding; and
5. Section 32 93 00 Plants.

1.03 REQUIREMENTS OF REGULATORY AGENCIES

A. All federal, State, and local laws and regulations governing this work are hereby incorporated into and made part of this Section. When this Section calls for certain materials, workmanship or a level of construction that exceeds the level of federal, State, or local requirements, the provisions of this Section shall take precedence.

1.04 REFERENCE STANDARDS

A. California Department of Transportation (CalTrans) Standard Specifications, May 2006 version.

1.05 DEFINITIONS

A. Compacted Soil: Compacted soil is soil having a density and strength sufficient to reduce plant growth and survival. Soil penetrability requiring greater than 250 pounds per square inch (PSI) to insert a cone penetrometer shall indicate compacted conditions.

B. Duff: Duff is a layer of decomposing organic materials between and intergrading with the overlying mulch and underlying topsoil.

C. Final Installation Acceptance: Final Installation Acceptance is the milestone when all installation work (i.e., all work except that required under Section 32 98 00 Plant Establishment) is completed and approved by the Owner's Authorized Representative.

D. Final Project Acceptance: Final Project Acceptance is the milestone when all work, including work under Section 32 98 00 Plant Establishment, is completed and approved by the Owner's Authorized Representative. Final Project Acceptance does not in any way release the Contractor from the requirements or duration of any guarantees as per the Specifications.

E. Installation Period: The Installation Period begins when the Notice to Proceed (NTP) is given and continues until all requirements indicated in the Drawings and Specifications are completed and approved, and the Owner's Authorized Representative gives a written notice of a Final Installation Acceptance.

F. Mulch: Mulch is the coarse and loosely consolidated organic materials (such as pine needles, leaves, and small branches) that lie on top of duff and soil.

G. Plant Establishment Period: The Plant Establishment Period begins immediately after the Contracting Officer gives a written notice of a Final Installation Acceptance and continues until all requirements indicated in Section 32 98 00 Plant Establishment are completed and approved and the Contracting Officer gives a written notice of a Final Project Acceptance.

H. Topsoil: Topsoil is the uppermost layer of the existing soil that typically is rich in organic matter and usually distinct in color from deeper layers of soil. For this project, the upper 3-inches of soil on the project site will be considered topsoil.

1.06 QUALITY CONTROL

A. Verify all dimensions and information shown on the Drawings and these Specifications with actual field conditions.

1. All discrepancies should be immediately reported to the Owner's Authorized Representative. Work will be terminated in the area of the discrepancy until the Owner's Authorized Representative has provided a written resolution to the conflict. Assume full responsibility for proceeding with work without written approval.

B. Coordinate the planting preparation operations to avoid conflicts with other construction and any existing features. If conflicts are foreseen or arise, immediately notify the Owner's Authorized Representative for resolution.

1.07 SUBMITTALS

A. Submit no later than 10 days after the award of Contract, 2 three-ring hard cover binders containing the following information:

1. List of all proposed materials and equipment to be used indicated by description, manufacturer and model number, if applicable. Include catalog cuts where applicable. Include seed supplier's certification for required seed mixtures, indicating percentage by weight, and percentages of purity, germination and weed seed for each mix.

2. A copy of the materials procurement order from the supplier including the name, address, and phone number of said supplier and the estimated date(s) and quantities for delivery from the supplier. Indicate items in stock at time of order and submit the latest test, if applicable.

3. A schedule identifying materials procurement, storage, anticipated delivery dates, and anticipated installation dates for review and approval.

B. Submit no later than 10 days after the award of Contract a soil sampling plan for the project site for approval. {*Delete this item if project owner/designer performs soil sampling and testing during the design phase.*};

C. The Pest Control Advisor shall submit a list of the weed control materials and quantities per acre intended for use in controlling the weed types prevalent and expected on the site. Weed control information shall include: {*Delete this item if not used.*}

1. Data to demonstrate the compatibility of the weed control materials and methods with the intended planting and seed varieties.

2. A written list of the proposed herbicide application equipment to be used in performance of the weeding work, including descriptive data and calibration tests. Include the herbicide trade name, chemical composition, formulation, concentration, application rate of active ingredients and methods of

application for all materials furnished, as well as the name and State license number of the State certified applicator.

3. Records of manufacturer's literature, labels, and laboratory analytical data for verification of herbicide to be used, including the chemical makeup and application rate.

4. Certificates of compliance certifying that herbicide materials meet the requirements specified shall be shall be submitted before the delivery of materials. Herbicide material shall include EPA registration number and registered uses.

5. A Herbicide Treatment Plan (HTP) proposing a sequence of herbicide treatments and a written delivery schedule and written Pest Control Advisor (PCA) recommendation. The herbicide trade name, chemical composition, formulation, concentration, application rate of active ingredients and methods of application for all materials furnished, and the name and state license number of the state certified applicator shall be included. Records of manufacturer's literature, labels, and laboratory analytical data for verification of herbicide to be used, including the chemical makeup and application rate shall be submitted. Once approved by the Owner's Authorized Representative, the Contractor shall receive written authorization to proceed with the treatment.

D. Submit all required samples (except for soil amendments, if necessary) within 10 days before the start of installation. Samples shall be approved by the Owner's Authorized Representative before ordering and performing work. Submit the following to the Owner's Authorized Representative:

1. Compost, 1-lb bag {*Delete this item if not used.*}; and

2. {Add type and sample size or description for other materials as needed.}

E. Within 10 days of receiving soil sampling results, submit the following to the Owner's Authorized Representative for review and approval: {*Delete this item if project owner/designer performs soil sampling and testing during the* design *phase.*}

1. Results of soil sample testing.

2. Recommendations from the certified soils laboratory for specific amendments to be added.

3. Samples and verification (i.e., an analysis of the chemical percentages and ratios) of the soil amendment before ordering any soil amendment materials. Submit samples as 1-lb bags of each amendment recommended.

F. Provide and keep as-built drawings during the Installation Period as specified under Section 32 93 00 Plants.

G. Owner's Authorized Representative will provide approvals or direction for any needed corrections within 10-days of receipt of said submittals.

1.08 SUBSTITUTIONS

A. Specific reference to manufacturers' names and products specified in this Specification are used as standards of quality. This implies no right to substitute other materials without prior written approval by the Owner's Authorized Representative.

B. Any substituted materials installed without written approval by the Owner's Authorized Representative may be rejected.

C. If an approval is granted for a substitution, adjustment in the Contract amount will be made in accordance with the Contract Conditions.

1.09 SAMPLES, TESTS AND MOCK-UPS

A. The Owner's Authorized Representative reserves the right to take and analyze selected samples of materials for conformity to this Specification at any time.

B. At the Owner's Authorized Representative's request, the Contractor shall provide samples of all supplied materials and an analysis from an approved laboratory verifying the manufacturer's guarantee.

C. Rejected materials shall be removed from the site and be replaced at no cost.

1.10 PROJECT CONDITIONS

A. Perform planting preparation operations only when weather and soil conditions are suitable in accordance with locally accepted practice.

1.11 PRODUCT DELIVERY, STORAGE AND HANDLING

A. All materials delivered to the project site shall be clearly marked to identify the item. Materials shall be delivered to the project site in their original, unopened packaging containing the manufacturer's guarantee.

B. Exercise care in handling, loading, unloading, and storing planting preparation materials to ensure they are not damaged.

C. Provide a storage site for the planting preparation materials at the staging areas shown on the Drawings or as directed by the Owner's Authorized Representative. Store in a manner to prevent damage from sunlight, moisture or contact with vehicles, equipment or tools.

1.12 REJECTION OF MATERIAL

A. All material not conforming to the requirements herein shall be considered defective and will be rejected.

1. The Owner's Authorized Representative shall mark such materials, whether in place or not, as rejected.

2. Replacement materials shall be of the same types and condition as that indicated on the Drawings.

B. Rejected materials shall be removed and disposed of according to State and local regulations by the Contractor at no additional cost. Rejected materials shall be replaced at no additional cost.

1.13 PROTECTION OF THE SITE

A. Protect previously installed work and materials which may be affected by work of this Section. Provide safeguards and exercise caution against injury or defacement of existing site improvements.

B. Repair damage and return the area to the previous condition at no additional cost.

1.14 COORDINATION

A. Coordinate operations with subcontractors, as well as other contractors on or adjacent to the project site.

B. Exercise extreme care in excavating and working near existing utilities. Repair any damages to these utilities at no additional cost. Check existing utility drawings for existing utility locations.

C. Coordinate installation of all seeding materials to avoid interference with utilities, other construction elements, and any existing vegetation.

D. The Contractor shall coordinate with the Owner's Authorized Representative to schedule the placement of materials and equipment necessary to complete the work.

1.15 CONSTRUCTION SCHEDULE {*Tailor dates/items as needed for individual project*.}

A. After mobilization, layout, and testing are complete, the Contractor shall following the general construction schedule detailed below:

1. Between June 1 and June 30, performing mowing. {*Delete this item if not used.*}

2. Before Spring/early Summer seed maturation of dominant weed species, conduct herbicide applications to all undesired vegetation not designated to remain. Between August 1 and September 15, remove or apply herbicide to resprouts of all undesired vegetation not designated to remain. {*Delete this item if not used.*}

3. {*Specify - following mowing OR following herbicide applications or leave as is*}, perform soil loosening, incorporate soil amendments {*delete this item if not used*}, and complete fine grading as necessary between September 1 and September 30, before planting operations according to Section 32 93 00 Plants.

4. Conduct planting operations according to Section 32 93 00 Plants.

5. Within 30 days of completed planting operations, conduct seeding operations according to Section 32 92 19 Seeding.

6. Within 10 days of seeding operations, spot apply contact herbicide to control weedy and undesired annual grass seedlings and/or broadleaf plants. {*Delete this item if not used.*}

PART 2 – PRODUCTS

2.01 MATERIALS

A. Topsoil {*Delete this item if not used.*}

1. Shall be existing site material free of rubbish, sharp objects, and particles larger than 1½-inches in diameter.

2. Shall not contain clay soils.

B. Compost {*Delete this item if not used.*}

1. Use {*specify – Type A, Type B or any combination of both*}.

a. Type A – green material consisting of chipped, shredded or ground vegetation; or clean processed recycled wood products.

b. Type B – class A, exceptional quality biosolids composts, conforming to the requirements in United States Environmental Protection Agency (EPA) regulation 40 CFR, Part 503c.

2. Compost shall not contain paint, petroleum products, herbicides, fungicides or other chemical residues harmful to plant or animal life. Other deleterious material, plastic, glass, metal or rock shall not exceed 0.1 percent by weight or volume. Compost shall be thermophilically processed for 15 days. During this process, the compost shall be maintained at minimum internal temperature of 55˚C and be thoroughly turned at least 5 times. A 90 day curing period shall follow the thermophilic process. Compost shall be screened through a screen no larger than 0.5-inches. Compost shall measure at least 6 on the maturity and stability scale with a Solvita test kit. A Certificate of Compliance for compost shall be furnished to the Owner's Authorized Representative in conformance with the provisions of CalTrans Section 6 1.07, "Certificates

of Compliance". The Certificate of Compliance shall state the Solvita maturity and stability scale test result of the compost.

C. Soil Amendments {*Delete this item if project owner/designer performs soil sampling and testing during the design phase.*}

1. Soil amendments shall be as recommended by the certified soils laboratory based on soil sampling results.

D. Wood Chips {*Delete this item if not used. Wood chips may be considered judiciously and pending specific site evaluation and analysis, to aid water infiltration and storage in the soils should drastically homogenized, compacted soils exist, without any topsoil.*}

1. Wood chips shall consist of material chipped from non-diseased trees grown in the Tahoe Basin. Eighty-percent (80%) of chipped material shall be able to pass through a 1.5-inch sieve. Wood chips shall not contain leaves, small twigs, cones, or impurities such as rocks, garbage or debris; mineral soil shall be less than 2% of the volume of chipped material. Wood chips shall be manufactured from clean wood.

E. Herbicide {*Delete this item if not used.*}

1. Herbicide for all noxious weeds and other undesired or invasive plants shall be non-selective, broad-spectrum, post-emergent, trans-locating herbicide with low toxicity to wildlife approved for use in and around aquatic habitats by the U.S. Environmental Protection Agency (EPA). Herbicide shall be of high grade quality and in perfect condition at time of installation. Select herbicides as appropriate for the desired effect (i.e., broadleaf herbicide to avoid harm to grasses). All herbicides shall be State and County approved for land or aquatic applications.

a. {*Specify necessary herbicide types and chemical compositions*.}

F. Layout Stakes (to define limits of Revegetation Areas)

1. Layout stakes shall be 48-inch wood lath surveyor stakes, with a pointed tip on one end and topped with colored surveyor tape on the other end. The top 12-inches of the blunt end of all laths shall be spray painted with florescent colored paint. If the laths are used for multiple purposes, different colors shall be used to identify each specific purpose.

G. {Add type and description for other materials as needed.}

PART 3 – EXECUTION

3.01 MOBILIZATION AND DEMOBILIZATION

A. Mobilization shall consist of preparatory work and operations, including, but not limited to, those necessary for the movement of personnel, equipment, supplies, and incidentals to the project site; the establishment of temporary facilities necessary for work on the project; and all other work and operations that must be performed or costs incurred before work begins on the various Contract items on the project site.

B. The Contractor shall confine all storage of materials, preparatory work, equipment, and vehicle parking to the staging areas shown on the Drawings. The Contractor shall supply all vehicles with a minimum of one fire extinguisher and one shovel. Appropriate precautions shall be taken by the Contractor to minimize fire at the project site at all times.

C. Demobilization tasks shall consist of work and operations at the conclusion of construction, including, but not limited to necessary activities for the removal of personnel, equipment, supplies, and incidentals from the project site; removal of temporary facilities and materials; and all other work and operations that must be performed or costs incurred to conclude work on the various Contract items for the project.

D. Before the Contractor begins work, the Contractor (including but not limited to any subcontractors and project foremen) shall be required to schedule and attend a one-day meeting at the project site with the Owner's Authorized Representative and others as the Owner's Authorized Representative deems necessary (e.g., {*specify attendees - City and/or County Inspector; regulating agency representatives; other as required*) to review and discuss the overall implementation of the project including: design objectives, environmental permit limitations, endangered species issues, emergency contact information and protocol, contract management and chain of command, media protocol, project construction documents, implementation schedule (including key milestones), and any addenda.

3.02 VERIFY SITE CONDITIONS

A. Before performing the work in this Section, examine previously installed work from other contractors at the project site (if any) and verify that such work is complete and as required, to the point where this installation may begin properly.

B. Verify site conditions and be familiar with existing grade conditions, locations of existing fences, and all existing vegetation.

1. All discrepancies between the Drawings, Specifications, and site conditions shall be immediately reported to the Owner's Authorized Representative in writing. The Contractor's written descriptions shall note the character of the unsatisfactory conditions and extent of work required to correct the said conditions. Work shall be terminated in the area of the discrepancy until the

Owner's Authorized Representative have provided a written resolution to the conflict.

C. Operations shall be conducted to avoid damage to existing conditions, including bench marks, pavement, utilities, vegetation to remain, and other features to be preserved, as well as other construction. Flag vegetation within the work area to be retained for approval by the Owner's Authorized Representative. Correct, at no additional cost, damage to any of the above conditions resulting from the operations. The Contractor shall assume full responsibility for proceeding with work without written approval.

D. At all times, the Contractor shall not disturb existing vegetation and soil surface outside the limit-of-work. The Contractor shall notify the Owner's Authorized Representative if any operations called for in the Drawings or Specifications may cause damage to existing areas outside of the limit-of-work indicated on the drawings. Extra work resulting from failure to notify the Owner's Authorized Representative shall be completed by the Contractor at no additional cost.

E. The Contractor shall immediately notify the Owner's Authorized Representative if any vegetation to be maintained is damaged by the Contractor's operations. Additionally, the Contractor shall remove any damaged vegetation at the Contractor's own expense if directed to do so by the Owner's Authorized Representative. If, in the opinion of the Owner's Authorized Representative, existing vegetation is damaged during construction the Contractor shall replace such damaged plants with plants of the same species and size or with multiple plants of size and species determined by the Owner's Authorized Representative to be adequate for replacement at no additional cost. Determination of extent of damage, value of damaged plants, and suitable replacement shall rest solely with the Owner's Authorized Representative.

3.03 SITE PREPARATION

A. Stake perimeter boundaries, vegetation to remain, and any other structures to be protected.

B. To reduce/minimize soil compaction and disturbance of the soil surface, the Contractor shall place wood mulch to a 3-inch depth in areas in which machinery will be operated or crossing but that otherwise do not require grading, excavation, or stockpiling of materials. After the construction activities are completed in these areas said mulch could be applied to other areas that were excavated or graded and that require revegetation.

C. The Contractor shall salvage existing {*specify one, two or all of the following – mulch, duff, and topsoil*} from areas to be planted or seeded. {*Revise remaining paragraph as needed based on items to be stockpiled.*} The Contractor shall stockpile existing mulch and duff together but separately from topsoil. To minimize adverse alteration of soil properties, store topsoil with a minimum of handling and compaction, and place in piles that are shallow and narrow as practicable. At no time shall topsoil and mulch/duff be stockpiled for more than 3 months without approval of Owner's Authorized Representative. {*Delete this item if no existing materials will be stockpiled*.}

3.04 SOIL SAMPLING {*Delete this item if project owner/designer performs soil sampling and testing during the design phase*.}

A. The Contractor shall collect representative samples of existing soils per the soil sampling plan and perform soil tests to determine soil properties affecting plant growth. Multiple samples shall be collected and shall each be the size of shovel/spade and taken at a depth of at 6-inches.

1. Perform tests at {*specify number*} representative separate locations within the project site boundaries where native soil and exposed subsoil serve as the planting medium. The test locations shall be representative of site conditions considering the overall site as approved by the Owner's Authorized Representative.

2. Two vertical tests shall be performed at each location, one 6-inches and a second at 3-feet below the soil surface.

3. Each soil sample shall contain approximately one quart of soil and be labeled on a plan for location and depth.

4. Record, map and submit the analysis for review and approval.

B. The topsoil samples shall be tested by a State-certified soils testing laboratory to determine soil properties affecting plant growth, including soil texture, organic content, pH, particle size, nutrient level, salinity, chemical analysis, and mechanical analysis.

C. If the analysis of testing results indicates the soil is detrimental to plant growth, the Contractor shall submit recommendations from the certified soils laboratory for specific amendments to be added to the existing topsoil for review and approval by the Owner's Authorized Representative. Any issues that arise from the Contractor's failure to submit treatment options to rectify inappropriate soil conditions shall be corrected at no additional cost. The Owner will pay for any additional costs resulting from modified treatments based on the soils reports.

3.05 WEED REMOVAL

A. Weed control shall consist of removal of noxious and invasive weeds in areas to be planted or seeded as shown on the Drawings. Weeds shall be removed during planting preparation and disposed of off-site according to State and local

regulations. All vegetation to be removed or affected must be approved in the field by the Owner's Authorized Representative before the start of any removal operations.

B. Mechanisms for weed control shall consist of {*specify one or a combination of any and all of the following – manual removal; mowing; herbicide treatments*}. Native trees and shrubs to remain as shown on Drawings shall remain undisturbed.

1. Manual Removal: Weeds shall be hand-pulled and disposed of off-site according to State and local regulations. {*Delete this item if not used.*}

2. Mowing: Herbaceous growth shall be cut to within 6-inches of the ground surface. All clippings and other debris resulting from mowing operations shall be removed off site according to State and local regulations. Non-native trees and shrubs shall be removed manually. {*Delete this item if not used.*}

3. Herbicide Treatment: Herbicide shall be used only as approved by the Owner's Authorized Representative. {*Delete this item if not used.*}

a. Herbicide shall be applied in compliance with all federal, State, and local laws and regulations and according to manufacturer's specifications. At all times, herbicide shall be applied in accordance with Best Management Practices (BMPs) prescribed by the California Department of Pesticide Regulation.

b. Herbicide shall be applied so that it shall not drift, or show signs of drift, outside the designated planting area. At all times, protect existing plants to remain from herbicide drift. Avoid spraying during windy conditions; if windy conditions persist, use a large droplet size and low tank pressure and shall use a movable impermeable barrier while spraying to protect against drift.

c. At no time shall herbicides be used within 25-feet of open water that are not approved for use near water.

d. Herbicide shall be applied only during periods when beneficial results can be obtained. The Contractor shall apply herbicide as necessary before the rainy season. However, an exception may be made for herbicide application to cool season weed species, subject to approved weather conditions.

e. All safety measures recommended by the manufacturer shall be strictly adhered to. The Contractor shall be responsible for any damage to lands, vegetation, and water resulting from improper use of chemicals.

3.06 SOIL REHABILITATION

A. The Contractor shall rehabilitate compacted soil conditions in planting and seeding areas as necessary as described herein. Rehabilitation will be necessary in areas impacted by excavation, grading or disturbance of soil surface by vehicles or stockpiled materials. At no time will soil rehabilitation operations be conducted when said soil is too wet, as determined by the Owner's Authorized Representative. If significant rain occurs during soil rehabilitation, the Owner's Authorized Representative may temporarily halt soil rehabilitation work if the soil moisture content has exceeded an acceptable level. Soil rehabilitation work shall resume upon the direction of the Owner's Authorized Representative. Excessive passes of equipment that would compact areas shall be avoided. Where equipment access routes are required across areas of soil rehabilitation, the sequence of construction activity shall be coordinated to only allow equipment access before the loosening of soils. Soil rehabilitation shall consist of the following sequence of operations:

1. Soil Loosening

   a. {*Specify either – In areas from which topsoil was removed and stockpiled, loosen the subgrade OR Loosen*} soils a minimum of {*specify inches*}.

   b. Soil loosening shall be performed with a hand implement (such as a pick mattock or Pulaski) or a wheeled tractor with tilling tines or a mini-excavator equipped with a backhoe bucket. Soil shall be loosened but not turned over or inverted. Resulting soil clods shall be less than 5-inches in all dimensions. Soil loosening shall be uneven in depth by at least 1- to 2-inches to reduce the chance of soil slumping. Wherever soil loosening takes place, existing plants and tree roots to remain shall be avoided. Soil loosening shall be conducted with hand implements in areas where topsoil was removed beneath the drip lines of trees or shrubs.

   c. Place wood chips to a 1-inch depth on the surface of loosened areas and incorporate during soil loosening. {*Tailor this requirement to specific site conditions – wood chips may not always be appropriate – see above*}

   d. All areas to receive soil loosening shall be approved in writing by the Owner's Authorized Representative before the start of any soil loosening operations.

2. Topsoil Replacement {*Delete this item if existing topsoil is not stockpiled*.}

   a. Replace topsoil in areas where it was removed before construction by distributing at an even a depth of 6 inches.

3. Incorporation of {*specify either – Compost OR Soil Amendments*}

a. {*Specify either – compost OR soil amendments*} shall be added and incorporated into planting and seeding areas. Evenly spread {*specify either – compost OR soil amendments*} on topsoil at the rates prescribed in this Section. Incorporate {*specify either – compost to a depth of 3 to 4 inches OR soil amendments as recommended by the certified soil testing laboratory*}. Blend and incorporate with hand implements or (such as a pick mattock or Pulaski) or a wheeled tractor with tilling tines or a mini-excavator equipped with a backhoe bucket.

4. Discing

a. Disc seeding areas only to a depth of 6-inches. Where rocks are present that would cause damage to tractor implements; the Contractor shall remove the rocks in the upper 6-inches of soil before discing. All removed rocks shall be removed offsite according to State and local regulations at no additional cost. The Contractor may utilize tilling in-place of discing upon approval from the Owner's Authorized Representative. Soil conditions such as large clods may require smoothing with a land plane or ring roller before seeding; coordinate these operations with the Owner's Authorized Representative.

3.07 FINE GRADING OPERATIONS

A. Planting and seeding areas shall be fine-graded to finish grade to produce a surface suitable for planting and seeding. Protect areas from compaction after they have been prepared.

B. Ensure that the top 2-inches of soil is free of stones, debris, branches, roots, stumps, wire, or other deleterious matter 1-inch in diameter and larger. Dispose of debris offsite according to State and local regulations at no additional cost.

C. Establish finish grades to eliminate uneven areas resulting from rough-grading operations, filling as needed and remove surplus soil and float areas to a smooth, uniform grade to elevations as indicated on the Drawings. Blend finish grades with existing grades, providing for smooth transitions to existing grades and positive drainage. All areas shall be fine graded to within 1-1/2 inches of paved areas and curbs.

D. Fine grading shall be done manually around sensitive areas, vegetation to be preserved, and existing hardscape elements and structures.

E. Unless otherwise directed by the Owner's Authorized Representative, cross slopes shall be 2%, maximum.

F. At no time will the finish grade surfaces have a glazed appearance.

G. Completing one pass of a tractor driven perpendicular to the final grade contours leaving cat-tracks (i.e., the imprint on earthen material resulting from tractor treads) perpendicular to the final site contours.

H. The Owner's Authorized Representative will approve all finish grades.

3.08 DUFF/MULCH REPLACEMENT AND PINE NEEDLE/WOOD CHIP PLACEMENT

A. Apply salvaged duff/mulch, pine needles, and {*wood chips <if appropriate>*} to seeded areas as specified in Section 32 92 19 Seeding.

3.09 AS-BUILT DRAWINGS

A. The Contractor shall prepare as-built drawings as specified in Section 32 93 00 Plants.

3.10 CLEANUP

A. Site cleanup shall occur on a daily basis and as each phase of the work concludes.

B. Remove all trash and excess dirt caused from the work according to State and local regulations. Contractor shall make arrangements for disposing of these materials outside the project site and shall pay all costs involved. Arrangements shall include, but not be limited to, entering into agreements with property owners and obtaining necessary permits, licenses, and environmental clearances.

C. Sweep all adjacent walks and paved areas on a weekly basis throughout the duration of the project.

D. Repair all scars, ruts or other marks in the ground caused by the work.

E. Upon completion of the work, smooth all ground surfaces, remove excess dirt, materials, rubbish and debris according to State and local regulations to an offsite location or as directed by the Owner's Authorized Representative. Sweep adjacent streets, curbs, gutters and sidewalks and remove construction equipment from the premises.

3.11 SITE OBSERVATION BEFORE FINAL INSTALLATION ACCEPTANCE

A. Corrective actions shall be in strict conformance with the Drawings and these Specifications and according to the Owner's Authorized Representative, and shall be completed at the Contractor's expense.

B. The Owner's Authorized Representative will perform progress observations of the work and construction operations on completion of installation stages. The Owner's Authorized Representative and the Contractor shall be agree upon the installation stages for this Specification before starting work and be present on mutually agreed-on dates for the observations for each stage.

C. If, after an observation, the Owner's Authorized Representative is satisfied with the construction to date and its conformance to the Drawings and the Specifications, the Owner's Authorized Representative will grant written notice of provisional acceptance for that construction stage.

D. If, after an observation, the Owner's Authorized Representative is dissatisfied with the construction to date and its conformance to the Drawings and the Specifications, the Owner's Authorized Representative will prepare a written punch list of necessary corrective action on defective work for that construction stage. All corrections must be completed and will be reobserved by the Owner's Authorized Representative within 10 working days from the date of the initial observation.

E. Project observations shall not occur until all punch list items from previous observations are corrected. Failure to correct problems in the time specified by the Owner's Authorized Representative may result in a delay of payment for the said tasks until the items in question are remedied per the Owner's Authorized Representative's direction.

F. The Contractor shall be charged for any additional construction observations and punch lists required from the Owner's Authorized Representative for unscheduled and necessary reobservation of the work due to unsatisfactorily or incompletely addressing previous punch lists.

3.12 SITE OBSERVATION SCHEDULE

A. Provide the Owner's Authorized Representative with 48 hours of advance notification, except as otherwise noted, for required stage acceptance observations including, but not limited to, the following: {*Tailor as necessary for project requirements*.}

1. Completed mobilization operations.

2. Observation of staking of perimeter boundary, existing vegetation, and other structures to be protected.

3. Progress in weed control operations.

4. Completed weed control operations.

5. Progress soil rehabilitation operations. The Contractor shall loosen a test area of approximately 1,000 square feet for review by the Owner's Authorized Representative before soil loosening is started in any other areas. {*Delete second sentence if soil loosening is not part of soil rehabilitation efforts*.}

6. Completed soil rehabilitation operations.

7. Progress fine grading operations.

8. Completed fine grading operations.

9. Progress duff/mulch replacement & pine needle {*/wood chip*} placement.

10. Completed demobilization operations.

11. Substantial Completion Observation: Final installation observation before the start of the Plant Establishment Period. (Provide 10 working days of advance written notice).

3.13 FINAL INSTALLATION ACCEPTANCE

A. Final Installation Acceptance will be issued as specified in Section 32 93 00 Plants. Following the Final Installation Acceptance, the Plant Establishment Period shall begin.

END OF SECTION

This page has been intentionally left blank.

SECTION 32 92 19
SEEDING

{*This template is to be used as a guide only. This specification section must be tailored to designs and conditions for each individual project site. Brackets "{ }" are provided for items where the user needs to provide specific information*. Note that all days should refer to calendar days.}

PART 1 – GENERAL

1.01 GENERAL CONDITIONS

A. Requirements of Section 00700 – General Conditions and of Division 1 – General Requirements, apply to work in this Section with same force and effect as though repeated in full herein.

1.02 SCOPE OF WORK

A. Furnish all materials, labor, transportation, services, and equipment necessary to execute the required revegetation seeding as shown on the Drawings and as specified herein. The Contractor shall perform work according to all applicable laws, codes, and regulations required by federal, State, and local authorities to complete the work specified herein. Any and all permits, fees, bonds, and observations necessary to perform and complete the work shall be included.

B. Work included in this Section:

1. Verification of Existing Conditions;
2. Surface Drainage of Seeding Areas;
3. Preparation;
4. Seeding Installation;
5. Watering;
6. As-Built Drawings;
7. Cleanup;
8. Site Observation Before Final Installation Acceptance;
9. Site Observation Schedule; and
10. Final Installation Acceptance.

C. Work related in other Sections:

1. Section 31 35 19.16 Geotextile Slope Protection;
2. Section 32 01 90 Plant Establishment;
3. Section 32 84 00 Planting Irrigation;
4. Section 32 91 00 Planting Preparation; and
5. Section 32 93 00 Plants.

1.03 REQUIREMENTS OF REGULATORY AGENCIES

A. All federal, State, and local laws and regulations governing this work are hereby incorporated into and made part of this Section. When this Section calls for certain materials, workmanship or a level of construction that exceeds the level of federal, State, or local requirements, the provisions of this Section shall take precedence.

1.04 REFERENCE STANDARDS

A. All seed material shall be true to botanical and common name as indicated in:

1. American Nursery & Landscape Association. 2004. American Standard for Nursery Stock. ANSI Z60.1–2004. Washington, DC.

2. Hickman, J.C. (ed.). 1993. The Jepson Manual: Higher Plants of California. University of California Press. Berkeley, CA.

3. L. H. Bailey Hortorium of Cornell University. 1976. Hortus Third: A Concise Dictionary of Plants Cultivated in the United States and Canada. Macmillan. New York, NY.

4. McClintock, E. M., and A. T. Leiser. 1979. An Annotated Checklist of Woody Ornamental Plants of California, Oregon and Washington. University of California, Division of Agricultural Sciences. Berkeley, CA.

5. U.S. Natural Resources Conservation Service. 2009. Plants Database. Available: <http://plants.usda.gov>. Last updated June 15, 2009.

B. All seed shall conform to all laws and regulations pertaining to the sale and shipment of seed required by the California Food and Agricultural Code of 1982, Regulations of 1983, and the Federal Seed Act.

1.05 DEFINITIONS

A. Final Installation Acceptance: Final Installation Acceptance is the milestone when all installation work (i.e., all work except that required under Section 32 98 00 Plant Establishment) is completed and approved by the Owner's Authorized Representative.

B. Final Project Acceptance: Final Project Acceptance is the milestone when all work, including work under Section 32 98 00 Plant Establishment, is completed and approved by the Owner's Authorized Representative. Final Project Acceptance does not in any way release the Contractor from the requirements or duration of any guarantees as per the Specifications.

C. Installation Period: The Installation Period begins when the Notice to Proceed (NTP) is given and continues until all requirements indicated in the Drawings and Specifications are completed and approved, and the Owner's Authorized Representative gives a written notice of a Final Installation Acceptance.

D. Plant Establishment Period: The Plant Establishment Period begins immediately after the Contracting Officer gives a written notice of a Final Installation Acceptance and continues until all requirements indicated in Section 32 98 00 Plant Establishment are completed and approved and the Contracting Officer gives a written notice of a Final Project Acceptance.

1.06 QUALITY CONTROL

A. Manufacturer's directions and drawings shall be followed in all cases where the manufacturers of articles used in this Specification furnish directions covering points not shown in the Drawings and Specifications.

B. At the time of delivery to the project site, the Contractor and the Owner's Authorized Representative shall inspect seed mixes for moisture, mold, and insect infestation. The Contractor shall provide the Owner's Authorized Representative with 48-hour advance notice for each request for approval of partial or complete deliveries to the project site.

1.07 QUALIFICATIONS

A. The seed mix supplier shall be a reputable supplier that specializes in and has the ability to provide native plant seed materials originating from similar montane vegetation with soils and climate as the project site, from an elevation within 1,500 feet of the project site elevation, and originating at or near the revegetation site, and/or east of the Sierra Nevada crest.

1.08 SUBMITTALS

A. Submit verification of the required minimum qualifications as specified in Section 32 93 00 Plants for approval by the Owner's Authorized Representative, within 5 days after the award of Contract.

B. Submit written Planting Guarantee as detailed in this Section within 5 days after the award of Contract.

C. Submit no later than 10 days after the award of Contract, 2 three-ring hard cover binders containing the following information:

1. List of all proposed materials and equipment to be used indicated by description, manufacturer and model number, if applicable. Include catalog cuts where applicable. Include seed supplier's certification for required seed mixtures, indicating percentage by weight, and percentages of purity, germination and weed seed for each mix.

2. A copy of the seed mix procurement order from the supplier including the name, address, and phone number of said supplier and the estimated date(s) and quantities for delivery from the supplier.

3. Submit original seed tests by lot number to the Owner's Authorized Representative for approval before mixing. All seed test shall be approved by the California State Department of Agriculture.

4. Written documentation that the seed mixes listed on the Drawings are available. Any substitutions required due to unavailability must be requested in writing before confirmation of ordering.

5. A schedule identifying seed mix procurement, storage, anticipated delivery dates, and anticipated installation dates for review and approval.

6. Seed tags shall be submitted for approval before seed installation must reflect the most recent test date and show the following information:

   a. Scientific name
   b. Common name
   c. Lot number
   d. Percent purity
   e. Percent germination, including hard and dormant seed
   f. Percent weed seed
   g. Percent crop seed
   h. Origin
   i. Lab tests

D. Submit all required samples and test results within 10 days before to the start of any seeding-related work. Samples shall be approved by the Owner's Authorized Representative before ordering and performing work. Submit the following to the Owner's Authorized Representative:

1. Seed mixes, 1-lb bag of each seed mix {*Delete this items if not used*.};

2. Wood chips, 1-lb bag {*Delete this item if not used.*};

3. Pine needles, 1-lb bag {*Delete this item if not used.*};

4. Testing results from a State-licensed seed lab showing percent germination and purity for each seed mix for review and approval {*Delete this items if not used*.}; and

5. {*Add type and sample size or description for other materials as needed*.}

E. Provide and keep as-built drawings during the Installation Period as specified under Section 32 93 00 Plants.

F. Owner's Authorized Representative will provide approvals or direction for any needed corrections within 10-days of receipt of said submittals.

1.09 SUBSTITUTIONS

A. Specific reference to manufacturers' names and products specified in this Specification are used as standards of quality. This implies no right to substitute other materials without prior written approval by the Owner's Authorized Representative.

B. Requests for substitute species, and/or varieties must be submitted in writing for approval from the Owner's Authorized Representative before ordering.

C. Any substituted materials installed without written approval by the Owner's Authorized Representative may be rejected.

D. If an approval is granted for a substitution, adjustment in the Contract amount will be made in accordance with the Contract Conditions.

1.10 SAMPLES, TESTS AND MOCK-UPS

A. The Owner's Authorized Representative reserves the right to take and analyze selected samples of seeding materials for conformity to this Specification at any time. Rejected seeding materials shall be removed from the site and be replaced at no cost.

1.11 PROJECT CONDITIONS

A. Perform seeding operations only when weather and soil conditions are suitable in accordance with locally accepted practice.

1.12 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery

1. Deliver all seeding materials with legible and durable identification labels.

2. Seed shall be delivered to the project site tagged and labeled in accordance with the State Agricultural Code, and shall be acceptable to the County Agricultural Commissioner. Seed shall be delivered to the project site in unopened containers.

3. Notify the Owner's Authorized Representative within 7 days of the delivery of seeding materials to the site. Indicate the quantity and type of seeding materials in each delivery.

B. Storage

1. Provide a storage site for the seeding materials at the staging areas shown on the Drawings or as directed by the Owner's Authorized Representative.

2. Store seeding materials immediately in a dry, weather and damp proof structure. Any seed which has become wet, moldy or damaged in transit or storage will not be acceptable.

C. Handling

1. Handle all seeding materials to ensure they are not damaged or subjected to excessive heat, wind or desiccation during storage, handling, and shipping.

2. Any seeding materials that are damaged due to mishandling shall be removed and replaced with new material at no additional cost.

1.13 REJECTION OF SEEDING MATERIAL

A. All seeding material not conforming to the requirements herein shall be considered defective and will be rejected.

1. The Owner's Authorized Representative shall mark such seeding materials, whether in place or not, as rejected.

2. Replacement seeding material shall be of the same types and condition as that indicated on the Drawings.

B. Rejected materials shall be removed and disposed of according to State and local regulations by the Contractor at no additional cost. Rejected materials shall be replaced at no additional cost.

1.14 PROTECTION OF THE SITE

A. Protect previously installed work and materials which may be affected by work of this Section. Provide safeguards and exercise caution against injury or defacement of existing site improvements.

B. Repair damage and return the area to the previous condition at no additional cost.

1.15 COORDINATION

A. Coordinate operations with subcontractors, as well as other contractors on or adjacent to the project site.

B. Exercise extreme care in excavating and working near existing utilities. Repair any damages to these utilities at no additional cost. Check existing utility drawings for existing utility locations.

C. Coordinate installation of all seeding materials to avoid interference with utilities, other construction elements, and any existing vegetation.

D. The Contractor shall coordinate with the Owner's Authorized Representative to schedule the placement of materials and equipment necessary to complete the work.

1.16 PLANTING GUARANTEE

A. All seeding material installed under this Contract shall be guaranteed against poor, inadequate and inferior quality and installation for a period of 1 year from the date of Final Project Acceptance, as specified in Section 32 01 90 Plant Establishment.

PART 2 – PRODUCTS

2.01 GENERAL

A. Procure all seeding materials and incidentals required for this project.

B. All seed and propagule materials shall be from local genetic stock originating from similar montane vegetation with soils and climate as the project site, from an elevation within 1,500 feet of the project site elevation, and originating at or near the revegetation site, and/or east of the Sierra Nevada crest, unless otherwise approved by the Owner's Authorized Representative. Representative similar conditions are {*specify project site habitats/conditions*} found at or in the vicinity of the project site.

2.02 MATERIALS

A. Seed Mixes {*Delete this item if not used*.}

1. Seed species shall be approved species. All seed shall be from local genetic stock from a similar climate, elevation, and soil type as the project site, unless otherwise approved by the Owner's Authorized Representative.

2. All seed shall conform to all laws and regulations pertaining to the sale and shipment of seed required by the California Food and Agricultural Code of 1982, Regulations of 1983, and the Federal Seed Act.

3. Seed mixes shall consist of the mixes shown on the Drawings; the seed mixes shall conform to the prescribed requirements for pure live seed rate per species. Seed mixes shall not be mixed until individual species' seed is approved by the Owner's Authorized Representative.

4. Weed seed shall not exceed 0.25% of the pure live seed specified. At no time shall the mixes contain seeds of cheatgrass (*Bromus tectorum*), alfalfa (*Medicago sativa*) or sweetclovers (*Melilotus alba, Melilotus officinalis*). Crop seed shall not exceed 0.50%.

5. {*For sagebrush (Artemisia tridentata) and rabbitbrush (Chrysothamnus nauseosus), test seed within 6 months before seeding, unless otherwise directed by the Owner's Authorized Representative.*} All {*other*} seed must be tested within 1 year of application date.

6. Legume seed shall be pellet-inoculated or industrial-inoculated with Rhizobia. Inoculated seed shall have a calcium carbonate coating. Industrial-inoculated seed shall be used within 180 calendar days of inoculation.

7. Deliver all seed to the project site in sealed bags a minimum of thirty (30) days before application to allow for testing.

8. Application rates shall be as shown on the Drawings.

B. Mychorrhizal Inoculant {*Delete this item if not used*.}

1. Mycorrhizal inoculants shall consist of spores, mycelium, and mycorrhizal root fragments in a solid carrier suitable for handling by dry application. The carrier shall be the material in which the inoculum was originally produced, and may include organic materials, vermiculite, perlite, calcined clay, or other approved materials consistent with proper application and good plant growth.

2. Each endomycorrhizal inoculum shall be provided with a supplier's guarantee of number of propagules per unit weight or volume of bulk material.

3. Inocula shall contain a minimum of 50% Glomus intraradices with a propagule count of 120 per gram of which a minimum of 20 spores per gram shall be present in random tested sampling. Product bag shall be labeled with a lot number and the harvest date of the inocula.

4. A representative 100 gram sample (from a re-mixed bay in order to obtain a homogeneous sample) from each bag of material supplied to the project shall be obtained thirty days before application for verification of spore count (a rounded ½ cup kitchen measuring scoop will yield roughly 100 grams of material).

5. The Contractor shall provide independent testing results of actual counts of viable spores using both Evan's Blue and MTT, through a laboratory approved by the Owner's Authorized Representative. If the inoculant spore-density is below specified counts, the Contractor shall be required to supply additional material to meet specifications.

6. Inocula shall be transported and stored in areas with a temperature of less than 90 ºF. At all times, use a dust mask when handling the material.

7. Application rate: {*Specify application rate per acre.*}

C. Wood Chips {*Delete this item if not used. Refer to Section 32 91 00 for discussion.*}

1. Wood chips shall consist of material chipped from non-diseased trees grown in the Tahoe Basin. Eighty percent (80%) of chipped material shall be able to pass through a 1.5-inch sieve. Wood chips shall not contain leaves, small twigs, cones, or impurities such as rocks, garbage or debris; mineral soil shall be less than 2% of the volume of chipped material. Wood chips shall be manufactured from clean wood.

D. Pine Needles {*Delete this item if not used.*}

1. Pine needles brought to the site for application as a top-dressing shall originate from as close to the site as possible and shall contain less than 20% impurities by volume as follows:

   a. No more than 10% other coarse organic material (e.g., twigs, cones),
   b. No more than 8% decomposed organic matter (i.e., duff), and
   c. No more than 2% mineral soil.

E. Straw Mulch {*Delete this item if not used.*}

1. Straw mulch shall be mold-free, air-dry uncut straw, certified weed free.

F. Hyrdomulch

1. Hyrdomulch shall consist of the following materials:

   a. Hydrostraw shall be baled turfgrass straw.
   b. Recycled paper mulch shall consist of degradable green-dyed 100% recycled paper, and shall be produced from newsprint, chipboard, corrugated cardboard, or a combination of these materials. Material shall be free from weeds or other foreign matter toxic to seed germination. This material shall be used for topsoil stockpiles, and temporary erosion control.

G. Tackifier

1. {*Specify specific manufacturer as approved equal*.} The tackifier shall be an organic, plant-derived substance containing corn starch, psyllium or guar gum, or a combination thereof such as Fisch-Stick, PT-TAC, Reclamare 2400, Ecology M-Binder, Eco-tak, Triple-Tac or approved equal. The tackifier shall form a transparent three-dimensional film-like crust permeable to water and air and containing no agents toxic to seed germination. The tackifier shall be packed in clearly marked bags stating the contents of each package. The tackifier will require no curing time, shall remain soft and rewettable, and shall not inhibit seed germination. All ingredients shall be biodegradable.

2. Application rate: {*Specify application rate in lbs per acre*}.

H. Layout Stakes (to define limits of Revegetation Areas)

1. Layout stakes shall be 48-inch wood lath surveyor stakes, with a pointed tip on one end and topped with colored surveyor tape on the other end. The top 12-inches of the blunt end of all laths shall be spray painted with florescent colored paint. If the laths are used for multiple purposes, different colors shall be used to identify each specific purpose.

I. {Add type and description for other materials as needed.}

2.03 EQUIPMENT

A. Drill Seeding – Equipment {*Choose either drill seeding, broadcast seeding method, or hydroseeding method and delete other.*}

1. Seeding equipment for drilling seeding shall be a range land drill seeder. The seeder shall be equipped with a fluffy seed box with agitators to prevent bridging and clogging. The seed box shall have metal row dividers and individual box adjustment to meter seed flow.

B. Broadcast Seeding – Equipment {*Choose either drill seeding, broadcast seeding method, or hydroseeding method and delete other.*}

1. Seeding equipment for broadcast seeding shall be hand spreaders.

C. Hydroseeding – Equipment *{Choose either drill seeding, broadcast seeding method, or hydroseeding method and delete other.}*

1. Seeding equipment for hydroseeding shall mix the products using equipment containing a tank having a built-in, continuous agitation and recirculation system, and a discharge system that shall allow application of the slurry to the slopes at a continuous and uniform rate.

2. The nozzle shall produce a spray that does not concentrate the slurry nor erode the slope.

PART 3 – EXECUTION

3.01 VERIFICATION OF EXISTING CONDITIONS

A. Before performing the work in this Section, examine previously installed work from other contractors at the project site (if any) and verify that such work is complete and as required, to the point where this installation may begin properly.

B. Seeding areas shall be prepared according to Section 32 91 00 Planting Preparation. Ensure that seeding areas are not compacted due to any construction operations before seeding.

C. If the soil in the area to be seeded was already “prepared” as part of planting operations, inspect the areas to be seeded to determine if the soils have become hard or plastic and submit a report to the Owner’s Authorized Representative. If the soil conditions are not appropriate for seeding, submit a plan for preparing the soils for seeding without disturbing existing or installed plants to the satisfaction of the Owner’s Authorized Representative and at no additional cost.

D. Remove all rocks, stones, sticks and debris larger than 1-inch in diameter from the surface of the seeding areas.

E. Obtain approval of finished grading performed under Section 32 91 00 Planting Preparation by the Owner's Authorized Representative before starting seeding operations.

3.02 SURFACE DRAINAGE OF SEEDING AREAS

A. Ensure proper drainage has been established by others in all seeding areas before the start of seeding operations. Any discrepancy in the Drawings or Specifications, obstructions on the site or prior work done by another contractor that could preclude the establishment of proper drainage, shall be brought to the immediate attention of the Owner's Authorized Representative for correction or relief of said responsibility. Failure to notify the Owner's Authorized Representative of any drainage issues will render the Contractor responsible for rectifying any issues due to improper drainage at no additional cost.

3.03 PREPARATION

A. Seeding Area Layout

1. Verify the location and depth of all underground utilities.

2. If any underground construction or utility lines are encountered in during seeding operations, immediately notify the Owner's Authorized Representative for direction. Failure to notify the Owner's Authorized Representative of any utilities encountered will render the Contractor responsible for rectifying any issues due to improper drainage at no additional cost.

3. Locations for all seeding areas shall be marked on the ground either by flagged grade stakes indicating seed mix type for the Owner's Authorized Representative's review and approval before seeding. Seeding areas will be located according to the layout shown on the Drawings.

4. The areas to be seeded shall have a firm seed bed which has previously been roughened by scarifying, disking, harrowing, chiseling, or otherwise worked to a depth of at least 4 inches on soil or 2 inches on intact rock surfaces. The seed bed may be prepared at the time of completion of excavation or earthwork. Construction debris and extraneous piles of soil shall be removed before seeding.

3.04 SEEDING INSTALLATION

A. General Seeding Guidelines

1. All seeding operations shall be conducted before plant installation, except for cuttings. Seeding shall occur between September 1 and September 30.

Seed shall be applied before any snow accumulation and ground freeze, unless otherwise approved by the Owner's Authorized Representative.

2. The Contractor shall notify the Owner's Authorized Representative no less than 72 hours in advance of revegetation work and shall not begin the work until prepared treatment areas have been approved. All work shall take place within planting windows approved by the Owner's Authorized Representative.

3. Seeding shall not occur when wind speeds exceed 5 miles per hour.

4. Seed only those areas that can be watered on that same day as installation.

5. During seeding operations, care shall be taken to avoid damaging existing facilities, vegetation to remain, or any other items on or around the seeding areas. Take care to avoid damaging the root zone or trunks of any vegetation to remain. Installed plantings shall be protected from damage during seeding operations.

6. Seeding area shall be protected against trespassing, vehicular traffic, and from damage at all times. If areas are damaged, they shall be reseeded. No work shall be performed in seeding areas without proper safeguards.

7. Coordinate the installation of biotechnical treatments to be installed as prescribed in Section 31 35 19.16 Geotextile Slope Protection.

B. Drill Seeding {*Choose either drill seeding, broadcast seeding, or hydroseeding method and delete other*}

1. Seed shall be applied by way of drill seeding methods to the prepared soil surface. Drill seed work shall consist of drilling seed into seeding areas as shown on the Drawings and/or other areas designated by the Owner's Authorized Representative.

2. Fertilizer shall not be applied to seeding areas.

3. Mychorrizal inoculant shall be mixed with the seed and applied during the seeding operations.

4. Seed shall be drilled in rows at a maximum distance of 8 inches apart. Seed shall be drilled to a depth of 1-inch. A minimum of 3 passes in different directions with seeding equipment shall be required to distribute the seed and reduce the uniform row appearance.

5. Areas to be seeded near and within driplines of existing vegetation to remain or recently planted shrubs or trees shall be seeded by hand and these areas shall be hand-raked to cover the seeds.

C. Broadcast Seeding {*Choose either drill seeding, broadcast seeding, or hydroseeding method and delete other*}

1. Hand-broadcast seeding methods shall be used to apply seed to all areas.

2. Fertilizer shall not be applied to seeding areas.

3. Mychorrizal inoculant shall be mixed with the seed and applied during the seeding operations.

4. Seed shall be uniformly broadcast with hand-held seeders and lightly raked to incorporate to a depth of 0.25- to 0.5-inches. Seed shall not be left uncovered for more than 24 hours, unless otherwise approved by the Owner's Authorized Representative.

5. All broadcast seeding areas shall be hand-raked to cover the seeds.

D. Hydroseeding {*Choose either drill seeding, broadcast seeding, or hydroseeding method and delete other*}

1. Apply the following materials at the following rates {*tailor to site conditions*}:

a. Slurry #1 (First Pass):
Seed as specified
Mychorrhizal inoculants 60 lbs/acre
Recycled paper mulch 500 lbs/acre
Soil amendments 2,000 lbs/acre
Water as needed

b. Slurry #2 (Second Pass):
Seed as specified
Hydrostraw 3,000 lbs/acre
Recycled paper mulch 500 lbs/acre
Tackifier 200 lbs/acre
Water as needed

2. The slurries shall consist of all materials as specified and enough water to ensure even distribution. The slurry shall have the proper consistency to adhere to the earth without lumping or running.

3. Mixing time of materials shall not exceed 45 minutes from the time the seeds come into contact with the water in the mixer to the complete discharge of the slurry onto the slopes, otherwise the batch shall be recharged with seed.

4. Multiple passes will be required to achieve maximum performance. Application shall not result in rilling or run-off.

5. Upon completion of hydroseeding, soak the entire area treated by seeding to saturation using a fine spray. Care shall be taken to avoid water application to the point that runoff occurs.

6. The Contractor at no additional cost shall repair excessive washing or puddling on the surface and any such damage caused thereby to the Owner.

E. Duff/Mulch, Pine Needles, {*Wood Chips <if appropriate>*}, {*or Straw Mulch*} Application

1. Following seed application, salvaged duff/mulch as collected in Section 32 91 00 Planting Preparation, {*as well as wood chips <if appropriate>*}, shall be evenly applied to the surface of the seeding areas to a 1-inch depth; pine needles {*or straw mulch*} shall then be applied to increase depth to 2-inches.

2. After duff/mulch/{*wood chips <if appropriate>*}/pine needle {*or straw mulch*} application is completed in an area, tackifier shall be applied as indicated herein in that area on the same working day.

3.05 WATERING

A. All seeding areas shall be watered immediately after installation. After the first watering, water shall be applied to all seeding areas to achieve continually moist conditions as required to keep the vegetation in a healthy and vigorous growing condition until the completion of the Installation Period.

B. Watering shall continue during the Plant Establishment Period as prescribed in Sections 32 84 00 Planting Irrigation and 32 01 90 Plant Establishment.

3.06 AS-BUILT DRAWINGS

A. The Contractor shall prepare as-built drawings as specified in Section 32 93 00 Plants.

3.07 CLEANUP

A. Site cleanup shall occur on a daily basis and as each phase of the work concludes.

B. Remove all trash and excess dirt caused from the work according to State and local regulations. Contractor shall make arrangements for disposing of these materials outside the project site and shall pay all costs involved. Arrangements shall include, but not be limited to, entering into agreements with property owners and obtaining necessary permits, licenses, and environmental clearances.

C. Sweep all adjacent walks and paved areas on a weekly basis throughout the duration of the project.

D. Repair all scars, ruts or other marks in the ground caused by the work.

E. Upon completion of the work, smooth all ground surfaces, remove excess dirt, materials, rubbish and debris according to State and local regulations to an offsite location or as directed by the Owner's Authorized Representative. Sweep adjacent streets, curbs, gutters and sidewalks and remove construction equipment from the premises.

3.08 SITE OBSERVATION BEFORE FINAL INSTALLATION ACCEPTANCE

A. Corrective actions shall be in strict conformance with the Drawings and these Specifications and according to the Owner's Authorized Representative, and shall be completed at the Contractor's expense.

B. The Owner's Authorized Representative will perform progress observations of the work and construction operations on completion of installation stages. The Owner's Authorized Representative and the Contractor shall be agree upon the installation stages for this Specification before starting work and be present on mutually agreed-on dates for the observations for each stage.

C. If, after an observation, the Owner's Authorized Representative is satisfied with the construction to date and its conformance to the Drawings and the Specifications, the Owner's Authorized Representative will grant written notice of provisional acceptance for that construction stage.

D. If, after an observation, the Owner's Authorized Representative is dissatisfied with the construction to date and its conformance to the Drawings and the Specifications, the Owner's Authorized Representative will prepare a written punch list of necessary corrective action on defective work for that construction stage. All corrections must be completed and will be reobserved by the Owner's Authorized Representative within 10 working days from the date of the initial observation.

E. Project observations shall not occur until all punch list items from previous observations are corrected. Failure to correct problems in the time specified by the Owner's Authorized Representative may result in a delay of payment for the said tasks until the items in question are remedied per the Owner's Authorized Representative's direction.

F. The Contractor shall be charged for any additional construction observations and punch lists required from the Owner's Authorized Representative for unscheduled and necessary reobservation of the work due to unsatisfactorily or incompletely addressing previous punch lists.

3.09 SITE OBSERVATION SCHEDULE

A. Provide the Owner's Authorized Representative with 48 hours of advance notification, except as otherwise noted, for required stage acceptance observations including, but not limited to, the following:

1. Seeding materials after delivery to project site and before seeding.

2. Seeding area locations layout before installation.

3. Seeding operations, installation of a minimum 100-square foot area before installation of remaining seed mixes.

4. Progress seeding installation operations.

5. Completed seeding installation operations.

6. Substantial Completion Observation: Final installation observation before the start of the Plant Establishment Period. (Provide 10 working days of advance written notice).

3.10 FINAL INSTALLATION ACCEPTANCE

A. Final Installation Acceptance will be issued as specified in Section 32 93 00 Plants. Following the Final Installation Acceptance, the Plant Establishment Period shall begin.

END OF SECTION

SECTION 32 93 00
PLANTS

{*This template is to be used as a guide only. This specification section must be tailored to designs and conditions for each individual project site. Brackets "{ }" are provided for items where the user needs to provide specific information*. Note that all days should refer to calendar days.}

PART 1 – GENERAL

1.01 GENERAL CONDITIONS

A. Requirements of Section 00700 – General Conditions and of Division 1 – General Requirements, apply to work in this Section with same force and effect as though repeated in full herein.

1.02 SCOPE OF WORK

A. Furnish all materials, labor, transportation, services, and equipment necessary to execute the required revegetation planting as shown on the Drawings and as specified herein. The Contractor shall perform work according to all applicable laws, codes, and regulations required by federal, State, and local authorities to complete the work specified herein. Any and all permits, fees, bonds, and observations necessary to perform and complete the work shall be included.

B. Work included in this Section:

1. Verification of Existing Conditions;
2. Surface Drainage of Planting Areas;
3. Preparation;
4. Plant Installation;
5. Tree Staking;
6. Cutting Installation;
7. Vegetated Mat Installation;
8. Watering;
9. As-Built Drawings;
10. Cleanup;
11. Site Observation Before Final Installation Acceptance;
12. Site Observation Schedule; and
13. Final Installation Acceptance.

C. Work related in other Sections:

1. Section 31 35 19.16 Geotextile Slope Protection;
2. Section 32 01 90 Plant Establishment;
3. Section 32 84 00 Planting Irrigation;
4. Section 32 91 00 Planting Preparation; and
5. Section 32 92 19 Seeding.

1.03 REQUIREMENTS OF REGULATORY AGENCIES

A. All federal, State, and local laws and regulations governing this work are hereby incorporated into and made part of this Section. When this Section calls for certain materials, workmanship or a level of construction that exceeds the level of federal, State, or local requirements, the provisions of this Section shall take precedence.

1.04 REFERENCE STANDARDS

A. All plant material shall be true to botanical and common name as indicated in:

1. American Nursery & Landscape Association. 2004. American Standard for Nursery Stock. ANSI Z60.1–2004. Washington, DC.

2. Hickman, J. C. (ed.). 1993. The Jepson Manual: Higher Plants of California. University of California Press. Berkeley, CA.

3. L. H. Bailey Hortorium of Cornell University. 1976. Hortus Third: A Concise Dictionary of Plants Cultivated in the United States and Canada. Macmillan. New York, NY.

4. McClintock, E. M., and A. T. Leiser. 1979. An Annotated Checklist of Woody Ornamental Plants of California, Oregon and Washington. University of California, Division of Agricultural Sciences. Berkeley, CA.

5. U.S. Natural Resources Conservation Service. 2009. Plants Database. Available: <http://plants.usda.gov>. Last updated June 15, 2009.

B. All plant material shall conform to the California State Department of Agriculture's regulations for nursery observations, rules and ratings.

1.05 DEFINITIONS

A. Collection: Collection refers to harvesting cuttings directly from live growing plant material. It involves cutting the material from the parent plant; pruning all lateral branches off; bundling the cuttings for transport; delivering bundles to the project site; and cleaning up collection site by cutting up pruned branches left in a natural appearing condition.

B. Final Installation Acceptance: Final Installation Acceptance is the milestone when all installation work (i.e., all work except that required under Section 32 98 00 Plant Establishment) is completed and approved by the Owner's Authorized Representative.

C. Final Project Acceptance: Final Project Acceptance is the milestone when all work, including work under Section 32 98 00 Plant Establishment, is completed and approved by the Owner's Authorized Representative. Final Project Acceptance does not in any way release the Contractor from the requirements or duration of any guarantees as per the Specifications.

D. Installation Period: The Installation Period begins when the Notice to Proceed (NTP) is given and continues until all requirements indicated in the Drawings and Specifications are completed and approved, and the Owner's Authorized Representative gives a written notice of a Final Installation Acceptance.

E. Plant Establishment Period: The Plant Establishment Period begins immediately after the Contracting Officer gives a written notice of a Final Installation Acceptance and continues until all requirements indicated in Section 32 98 00 Plant Establishment are completed and approved and the Contracting Officer gives a written notice of a Final Project Acceptance.

F. Vegetated Mats: Vegetated mats are similar to rolls of turf grass sod, as they are pre-grown, soilless, and delivered in rolls. However, vegetated mats for this project will be grown from custom seed mixes of native grasses. In addition, the vegetated mats are staked for support during establishment.

1.06 QUALITY CONTROL

A. Manufacturer's directions and drawings shall be followed in all cases where the manufacturers of articles used in this Specification furnish directions covering points not shown in the Drawings and Specifications.

B. Upon execution of the order, the Owner's Authorized Representative has the option of either observing the plant materials at the nursery or supplier, requesting representative color photos or observing the material as it is being delivered to the site for conformity to the Drawings and Specifications. Before delivery, vegetated mats shall be observed by the Owner's Authorized Representative at the growing facility to ensure that the mats have vigorous growth and full coverage. The Contractor shall coordinate with the Owner's Authorized Representative for a visit to the supplier 60 days before the expected date of materials delivery.

1. Such approvals shall not impair the right of additional observations during further progress of the Work.

C. Any tagging of plant material by the Owner's Authorized Representative does not constitute his/her approval of the plant materials' health and vigor. The health and vigor of the plant material is the sole responsibility of the Contractor.

D. At the time of delivery to the project site, the Contractor and the Owner's Authorized Representative shall observe cuttings for injury, disease, and insect infestation. The Contractor shall provide the Owner's Authorized Representative with 48-hour advance notice for each request for approval of partial or complete deliveries to the project site.

E. The Owner's Authorized Representative reserves the right to refuse observation, if in his judgment that a sufficient quantity of plant material is not available for observation at that time.

F. The Contractor shall be responsible for providing and installing healthy plants with evidence of new growth before the start of the Plant Establishment Period. At no time shall any plants show symptoms of damaged foliage, disease, size, color, wilting, defoliation, and vandalism. At no time shall any plants show symptoms of disease, browsing by wildlife, insect damage, girdling, structural deformities, dieback, dry rootball, and sunburn. At no time shall any plant show symptoms of water stress (caused by overwatering or underwatering), stunted growth, wilting, premature loss of leaves (for deciduous species), and premature yellowing of leaves (for deciduous species).

1.07 QUALIFICATIONS

A. The Contractor shall be responsible for demonstrating that he/she meets minimum qualifications, including the following:

1. State license; and

2. Work experience – minimum 3 example projects showing related planting and seeding work in the past 3 years. Submit a minimum of 10 representative photographs showing operations for each project, including irrigation, planting, and maintenance.

B. The nursery that supplies the planting materials shall be a reputable nursery that specializes in and has the ability to provide native plants materials originating from similar montane vegetation with soils and climate as the project site, from an elevation within 1,500 feet of the project site elevation, and originating at or near the revegetation site, and/or east of the Sierra Nevada crest.

1.08 SUBMITTALS

A. Submit verification of the required minimum qualifications as specified herein for approval by the Owner's Authorized Representative, within 5 days after the award of Contract.

B. Submit written Planting Guarantee as detailed in this Section no later than 5 days after the award of Contract.

C. Submit no later than 10 days after the award of Contract, 2 three-ring hard cover binders containing the following information:

1. List of all proposed materials and equipment to be used indicated by description, manufacturer and model number, if applicable. Include catalog cuts where applicable.

2. A copy of the plant procurement order from the nursery including the name, address, and phone number of said nursery and the estimated date(s) and quantities for delivery from the nursery. A copy of the procurement orders from other suppliers including the name, address, and phone number of said supplier and the estimated date(s) and quantities for delivery from the supplier.

3. Plant quantity list.

   a. Plant quantities shown on the Drawings are for estimation only. Provide the actual planting quantities.

   b. List all plants indicated by botanical name, common name, quantity, size, nursery and location and any specific remarks, (i.e., “unable to locate,” “photo submitted,” etc.). List all plant materials.

   c. Color photographs of each plant type and size with specifications (i.e., height, spread and caliper). Include a person in each photograph for scale purposes.

4. Written documentation that the material on the plant quantity list is available. Any substitutions required due to unavailability must be requested in writing before confirmation of ordering.

5. A schedule identifying plant material procurement, storage, anticipated delivery dates, and anticipated installation dates for review and approval. Contractor shall allow 6 to 8 months growing time for vegetated mats. {*Delete last sentence if vegetated mats are not used.*}

6. Compliance with State of California and federal quarantine restrictions.

D. Submit all required samples within 10 days before to the start of any planting-related work. Samples shall be approved by the Owner’s Authorized Representative before ordering and performing work. Submit the following to the Owner’s Authorized Representative:

   1. Wood mulch, 1-lb bag {*Delete this item if not used.*};

   2. Vegetated mat, minimum 3-foot by 3-foot sample {*Delete this item if not used.*}; and

   3. {*Add type and sample size or description for other materials as needed*.}

E. Submit written results of each tree pit percolation test with location, date and time of test to the Owner’s Authorized Representative before planting. Provide Owner’s Authorized Representative with 48-hour advance notice for the date and time of the tree pit percolation tests; the Owner’s Authorized Representative will be on site for the tests.

F. Provide and keep up to date at all times, a complete, full-size printed set of “red-lined” as-built drawings documenting the work carried out during the Installation Period. On or before the date of the Final Installation Acceptance, submit final as-built drawings as detailed herein.

G. Owner’s Authorized Representative will provide approvals or direction for any needed corrections within 10-days of receipt of said submittals.

1.09 SUBSTITUTIONS

A. Specific reference to manufacturers' names and products specified in this Specification are used as standards of quality. This implies no right to substitute other materials without prior written approval by the Owner's Authorized Representative.

B. Any substituted materials installed without written approval by the Owner's Authorized Representative may be rejected.

C. If an approval is granted for a substitution, adjustment in the Contract amount will be made in accordance with the Contract Conditions.

1.10 SAMPLES, TESTS AND MOCK-UPS

A. The Owner's Authorized Representative reserves the right to take and analyze selected samples of plant material for conformity to this Specification at any time. Rejected plant material shall be removed from the site and be replaced at no cost.

1.11 PROJECT CONDITIONS

A. Perform planting operations only when weather and soil conditions are suitable in accordance with locally accepted practice.

1.12 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery

1. Tag all vegetated mats indicating botanical and common name of each species and submit to the Owner's Authorized Representative. Vegetated mats shall be shipped as rolls on pallets and kept moist at all times.

2. Deliver all planting materials with legible and durable identification labels.

3. Deliver fertilizer to the site in original, unopened containers bearing the manufacturer's name, guaranteed chemical analysis, and its conformance to California State Law.

4. Coordinate and schedule the collection and delivery of cuttings. The Contractor shall verify collection and delivery site conditions before the start of collection. Adhere to specific delivery requirements as described in Part 2 of this Section.

5. Notify the Owner's Authorized Representative within 7 days of the delivery of plant materials to the site. Indicate the quantity and type of plant materials in each delivery.

6. At no time shall plant material be pruned, trimmed or topped before delivery.

7. The Contractor shall coordinate the delivery of vegetated mats to ensure that they will be installed within 8 hours of delivery to the site.

B. Storage

1. Provide a storage site for the plant materials at the staging areas shown on the Drawings or as directed by the Owner's Authorized Representative.

2. Store planting materials in the shade and protect from the weather.

3. Maintain and protect container and ground plants not planted within 4 hours of delivery.

4. Before installation, all cuttings shall be stored in such a manner as to prevent damage from heat, sunlight, wind or contact with vehicles, equipment, and tools that may cause abrasion to bark or buds. Protection from sun, frost, and wind may be necessary to preserve the health of the cuttings. Cuttings shall be maintained moist at all times.

5. Vegetated mats shall not be stored at the project site for longer than 8-hours; unless the Contactor has identified a safe location and water source that is approved by the Owner's Authorized Representative before storage operations. Mats shall be protected from exposure to wind, shaded from the sun, and kept in moist conditions until ready for installation. Protect root system from exposure to the weather. Protect vegetated mats against dehydration, contamination and heating during transportation and delivery. Do not deliver more vegetated mats than can be installed at the site in 1 day. Longer periods may be acceptable if the weather is cool as approved by the Owner's Authorized Representative. Keep stored vegetated mats moist and under shade. Do not pile vegetated mats more than 2-feet deep.

C. Protection

1. Protect plants during delivery to the site and after, in order to prevent damage to root balls or desiccation of leaves.

D. Handling

1. Take extreme care in the loading and unloading of plants. Do not lift or move container plants by their stems or trunks.

2. Handle all plant materials to ensure they are not damaged or subjected to excessive heat, wind or desiccation during storage, handling, and shipping.

3. Any plant materials that are damaged due to mishandling shall be removed and replaced with new material at no additional cost.

1.13 REJECTION OF PLANT MATERIAL

A. All plant material not conforming to the requirements herein shall be considered defective and will be rejected.

1. The Owner's Authorized Representative shall mark such plants, whether in place or not, as rejected.

2. Replacement plant material shall be of the same size, species and condition as that indicated on the Drawings.

B. Rejected materials shall be removed and disposed of according to State and local regulations by the Contractor at no additional cost. Rejected materials shall be replaced at no additional cost.

1.14 PROTECTION OF THE SITE

A. Protect previously installed work and materials which may be affected by work of this Section. Provide safeguards and exercise caution against injury or defacement of existing site improvements.

B. Repair damage and return the area to the previous condition at no additional cost.

1.15 COORDINATION

A. Coordinate operations with subcontractors, as well as other contractors on or adjacent to the project site.

B. Exercise extreme care in excavating and working near existing utilities. Repair any damages to these utilities at no additional cost. Check existing utility drawings for existing utility locations.

C. Coordinate installation of all planting materials to avoid interference with utilities, other construction elements, and any existing vegetation.

D. The Contractor shall coordinate with the Owner's Authorized Representative to schedule the placement of materials and equipment necessary to complete the work.

1.16 PLANTING GUARANTEE

A. All plant material installed under this Contract shall be guaranteed against poor, inadequate and inferior quality and installation for a period of 1 year from the date of Final Project Acceptance, as specified in Section 32 01 90 Plant Establishment.

PART 2 – PRODUCTS

2.01 GENERAL

A. Procure all plant materials and incidentals required for this project.

B. All plant material delivered to the site shall have a normal habit of growth and be well formed and shaped, healthy, vigorous, and free of any insects, diseases, sunscalds, windburn, abrasions of the bark, or other objectionable disfigurements.

C. The size of the plant material shall correspond with that normally expected for species and variety of commercially available nursery stock or as specified on the Drawings.

D. All plant materials shall be from local genetic stock originating from similar montane vegetation with soils and climate as the project site, from an elevation within 1,500 feet of the project site elevation, and originating at or near the revegetation site, and/or east of the Sierra Nevada crest, unless otherwise approved by the Owner's Authorized Representative. Representative similar conditions are {*specify project site habitats/conditions*} found at or in the vicinity of the project site.

E. The use of plant material larger than that specified on the Drawings may be used, pending approval from the Owner's Authorized Representative. However, there will be no change in the Contract amount if the larger plant material is approved and used.

2.02 MATERIALS

A. Planting soil for all planting pits shall be existing topsoil that is amended according to Section 32 91 00 Planting Preparation.

B. Trees and Shrubs {*Delete this item if not used.*}

1. Tree and shrub trunks shall be sturdy and well hardened with vigorous and fibrous root systems which are not root-bound.

2. In the event of a disagreement as to the condition of the root system, the root conditions of the plants will be determined by the removal of soil around the roots of not less than 10 plants or more than 2 percent of the total number of plants of each species.

3. When container-grown plants are supplied from several sources, the roots of not less than 10 plants of each species from each source will be observed.

   a. In case the plants sampled are found to be defective, the Owner's Authorized Representative has the right to reject the entire lot represented by the defective sample.

b. Any plant material rendered unsuitable for use because of this observation will be considered as samples and will be provided at the no additional cost.

C. Container Grown Stock {*Delete this item if not used.*}

1. Container grown stock shall be in a vigorous and healthy condition and not root bound or with the root system hardened off.

   a. {*Specify either – caliper, height, and spread of each container type to be used OR state as specified on Drawings.*}

2. All tree species will meet the minimum caliper diameter recommended for each species based on the container size by the American Standard for Nursery Stock prepared by the American Nursery & Landscape Association.

D. Ground Cover Stock {*Delete this item if not used.*}

1. Ground cover stock shall be well-established in removable containers or come from formed homogenous soil sections.

   a. {*Specify either – size of each ground cover type to be used OR state as specified on Drawings*.}

E. Cuttings {*Delete this item if not used.*}

1. The Contractor shall collect all required cuttings. Before the start of collection operations, the Contractor shall confirm with the Owner's Authorized Representative on site, the plant species to be collected; {*specify either – species and size of each cutting type to be collected OR state as specified on Drawings*.} Cuttings shall be harvested an additional 6 inches longer than prescribed length to account for potential hammering damage.

2. Cuttings shall be collected from various representative sources to ensure the genetic diversity and viability of the cuttings. Cuttings shall be collected from {*specify habitats similar to project site*} within the Tahoe Basin, unless otherwise directed by the Owner's Authorized Representative.

3. With assistance from the Owner's Authorized Representative, the Contractor shall obtain written approval from property owners before accessing their land for cutting collection operations. Copies of the written approval must be provided to the Owner's Authorized Representative. The Contractor shall perform the operations in conformance to all codes and regulations of governing agencies and private parties having authority over the collection areas.

4. Donor plants shall be field verified for the Owner's Authorized Representative's approval while said plants are in leaf (this period may be a few months before actual collection). At all times, diseased and unhealthy donor material shall be avoided. The Contractor shall identify plant material collection sites for approval by the Owner's Authorized Representative before collecting any cuttings. The preferred plant material collection sites will include those trees and shrubs located within 5 miles of the project site; the Contractor will coordinate with the Owner's Authorized Representative to locate these sources.

5. Cuttings shall be collected according to standard collection and nursery standards. Cuttings shall be from vigorous stock and free of insects and disease. The Contractor shall take special care not to collect propagation material from non-native species.

6. Leaves, branches, and twigs shall be removed on each cutting immediately after harvesting the cutting from the source plant. The leaves, branches, and twigs shall be removed from the entire cutting, starting from the base and moving toward the top. At all times, vegetation shall be removed carefully to avoid damage to bark or any buds existing on the cutting.

7. The cuttings shall be tapered from a minimum of ½-inch to a maximum of 1-inches in diameter and cut at a right angle at the wide end of the cutting. Cutting materials shall be harvested when the cuttings are dormant. All cuttings shall be hardened off green wood that is a maximum of 1-year-old growth.

8. Cuttings shall be collected to minimize disturbance to the collection site. The source plant collection area shall be left able to physically and visually recover to undisturbed conditions within one year. At no time shall material sources be denuded or stripped in excess of 25% of total branches. The Contractor shall contact the Owner's Authorized Representative for direction if the required cutting species, type, or quantities cannot be collected, including major disease infestation, poor source plants, poor growth, or limited source plant population. The Owner's Authorized Representative may choose to accept substitute stock to wholly or partially make up for any order deficit; the Contractor shall be responsible for finding substitutes from another source.

9. To ensure cuttings are adequately dormant, cuttings should not be collected until after October 1 and before October 15. Cuttings shall not be collected when the air temperature is greater than 21°C (70°F). Cuttings shall be installed within 24 hours of collection.

10. Immediately after removing the cuttings from a source plant, the cuttings shall be bundled, in quantities of 25 or 50, to facilitate counting. Bundles shall be marked with durable, waterproof labels indicating the correct plant botanical name and collection location. The Contractor shall maintain plant labels as delivered for approval by the Owner's Authorized

Representative and County before installation. Each bundle shall be wrapped in burlap or other approved material that protects the cuttings from sunlight and allows air circulation within the bundle. Immediately after removing the cuttings from a source plant and bundling, the cuttings shall be kept cool, at a temperature less than 60°F, and saturated in water immediately after collection and until just before installation. Cuttings may be stored in large containers with drain holes drilled in the bottom and filled with a mixture of ⅓ perlite and ⅔ vermiculite. The containers shall be covered to conserve moisture. The perlite-vermiculite mixture shall be soaked in water for 10 minutes and allowed to drain before closing the containers for storage.

11. The cuttings shall be delivered by the Contractor to the project site. Access to the site shall be as indicated on the Drawings. Delivery vehicles must have closed or covered beds to minimize windburn to cuttings during transport. Cuttings shall be delivered in bundles to the project site. The Contractor shall unload cuttings, placed in bundles as specified herein, at the project site to facilitate counting.

F. Vegetated Mats {*Delete this item if not used.*}

1. Vegetated mats shall {*specify specific manufacturer as approved equal*}. The mats shall be pre-grown.

G. Plant Fertilizers {*Delete this item if not used.*}

1. Plant fertilizer shall be slow-release organic {*specify either – specific manufacturer as approved equal OR nitrogen-phosphorus-potassium ratio, grams, form (tablet or granular), and release duration.*}

H. Wood Mulch {*Delete this item if not used.*}

1. Wood mulch shall be {*specify either – specific manufacturer as approved equal OR wood mulch material type and size*}, free of dirt, sticks, rocks, or other debris.

I. Tree Stakes {*Delete this item if not used.*}

1. Wood stakes: {*specify wood stake material type and size*}, without splits or bowing.

J. Tree Ties {*Delete this item if not used.*}

1. {*Specify specific manufacturer as approved equal*.}

K. Layout Stakes (to define limits of Revegetation Areas)

1. Layout stakes shall be 48-inch wood lath surveyor stakes, with a pointed tip on one end and topped with colored surveyor tape on the other end. The top 12-inches of the blunt end of all laths shall be spray painted with florescent colored paint. If the laths are used for multiple purposes, different colors shall be used to identify each specific purpose.

L. {Add type and description for other materials as needed.}

PART 3 – EXECUTION

3.01 VERIFICATION OF EXISTING CONDITIONS

A. Before performing the work in this Section, examine previously installed work from other contractors at the project site (if any) and verify that such work is complete and as required, to the point where this installation may begin properly.

B. Planting areas shall be prepared according to Section 32 91 00 Planting Preparation.

C. Remove all rocks, stones, sticks and debris larger than 1-inch in diameter from the surface of the planting areas.

D. Obtain approval of finished grading performed under Section 32 91 00 Planting Preparation by the Owner's Authorized Representative before starting planting operations.

3.02 SURFACE DRAINAGE OF PLANTING AREAS

A. Ensure proper drainage of all planting areas. Any discrepancy in the Drawings or Specifications, obstructions on the site or prior work done by another contractor that could preclude the establishment of proper drainage, shall be brought to the immediate attention of the Owner's Authorized Representative for correction or relief of said responsibility. Failure to notify the Owner's Authorized Representative of any drainage issues will render the Contractor responsible for rectifying any issues due to improper drainage at no additional cost.

3.03 PREPARATION

A. Planting Layout

1. Verify the location and depth of all underground utilities.

2. If any underground construction or utility lines are encountered in the excavation of planting holes, alternative planting locations may be selected by the Owner's Authorized Representative.

3. Locations for all plants shall be marked on the ground either by flagged grade stakes indicating plant type and size or the actual plants themselves for the Owner's Authorized Representative's review and approval before planting. Plants will be located according to the layout shown on the Drawings.

4. Coordinate the installation of biotechnical treatments to be installed as prescribed in Section 31 35 19.16 Geotextile Slope Protection.

3.04 CONTAINER PLANT INSTALLATION {Delete this item if not used.}

A. General Planting Guidelines

1. Plant only as many plants as can be planted and watered on that same day within a given planting area.

2. Protect the planting areas from excessive vehicle compaction.

3. Face plant material with fullest growth into the prevailing wind and/or the primary direction of view. Wherever possible, plants shall be placed to north of large rocks, logs, and other obstacles that prevent planting but may provide some shelter during establishment.

4. Container plants shall be installed between September 1 and September 30.

B. Excavate planting pit to the recommended depth as shown on the Drawings. Planting pits shall have vertical sides and roughened surfaces.

C. Planting Pit Settling: Before planting, the soil in each planting pit shall be settled. Settlement shall accomplished by either by repeated filling of the irrigation basins with 2- to 3-inches of standing water or by "jetting" said basins with a ¾-inch diameter PVC pipe at least 6-feet long, attached securely to a flexible hose. The free end of the PVC pipe shall be cut to a sharp angle and driven to the base of the planting hole. Water shall be run through the pipe as the end of the PVC pipe is drawn up through the backfilled hole at a rate slow enough to allow full saturation of all of the soil in the basin. Repeated probing with the jet will be necessary to uniformly settle the soil. Upon the Owner's Authorized Representative's approval, planting may proceed only after enough drainage and drying has occurred such that the soil structure is not damaged.

D. Tree Planting Pit Percolation Testing: Due to the potential of standing water in the tree planting pits, perform a pit percolation test in each tree planting pit before installation. {*Delete this item if tree sizes are smaller than 15-gallon container*.}

1. Fill the tree pit to the top with water.

2. If the water has not drained by more than 95% within 24 hours, do not plant and bring this slow drainage condition to the immediate attention of the Owner's Authorized Representative.

3. If required, dig a substitute tree pit or install a drainage sump in the existing tree pit. Substitute tree pits will be installed at no addition cost. If drainage sumps are necessary, additional compensation will be negotiated with the Contractor.

E. After the Owner's Authorized Representative has approved the planting pit settling and tree pit percolation tests, backfill the planting pits with planting soil to attain the proper level for the plant as shown on the Drawings.

F. Plant containers and boxes shall be opened and removed in such a manner that the soil surrounding the rootball shall not be broken. Do not injure the root ball while removing the container or box. After removing plant, superficially cut edge roots with a knife on 3 sides.

G. Before planting, place the required amount of plant fertilizer per plant type on top of each root ball while the plants are still in their containers so that the Owner's Authorized Representative can easily verify their existence and quantity.

H. After obtaining approval by the Owner's Authorized Representative on plant fertilizer quantity and after water has completely drained from the planting pit, add plant fertilizer to the planting pits in the appropriate quantities:

{*Specify either – number of plant fertilizer tablets OR amount of granular plant fertilizer per planting type/size.*}

Place the specified amount of plant fertilizer between the bottom of the rootball but not higher than 1/3 of the way up the rootball. Space/spread the plant fertilizer equally around the perimeter of the rootball approximately 2 inches from the rootball. (Fertilizer is not necessary for cuttings.)

I. Center plant material in the planting pit.

J. Apply planting soil to the planting pit up to 1/2 the height of the rootball. Add water to the top of the remaining planting pit and let soak in before completing the remainder of backfilling. Finish backfilling with planting soil of the planting pit by tamping the soil firmly around the rootball and watering thoroughly.

K. Water Retention Basins

1. After final backfilling, construct a water retention basin around the base of each tree and shrub planting (only) to a 30-inch diameter with backfill mix sufficient to hold 3-inches of water. Water retention basins are not required for groundcover plantings.

L. Wood Mulch Topdressing

1. Spread a 2-inch deep layer of wood mulch in all tree, shrub, and ground cover planting pits. (Mulch is not necessary for cuttings.)

H. Plant Settling

1. Any plant material that has settled deeper than the surrounding grade shall be raised to the correct level.

I. Tree Pruning

1. If any alteration to a plant material's shape is required, such as pruning, trimming or topping, it shall only be conducted on-site and in the presence of the Owner's Authorized Representative. Trees shall be pruned only when necessary and under standard horticultural practices to preserve its natural character.

3.05 TREE STAKING {Delete this item if not used.}

A. Stake trees immediately after planting. Trees shall stand plumb before stakes are applied.

B. Stakes shall be installed plumb when tied to the tree. Stakes may be specifically located in relation to the trunk; refer to the Drawings.

C. When locating a single stake, locate it on the windward side of the tree and as close to the main trunk as possible without damaging the trunk.

D. Stakes shall be driven at least 3-feet into the ground.

E. Tie the tree trunk to the stake with the specified tree tie. Cut off stake after installation 4-inches above the upper tie.

3.06 CUTTING INSTALLATION {Delete this item if not used.}

A. To ensure cuttings are adequately dormant, cuttings should not be planted until after October 1 and before October 15.

B. At no time during cutting placement shall bark be scraped, roughed, or grinded; or buds be stripped. Damaged cuttings shall be removed off site according to State and local regulations; fresh, healthy cuttings shall be installed in place of damaged cuttings at no additional cost.

C. If planting adjustments are necessary, the Contractor shall proceed only after receiving approval from the Owner's Authorized Representative for such adjustments. Planting holes for cuttings shall be excavated as detailed on the Drawings. Depending on the planting surface, it is expected that planting hole excavation may require, but may not be limited to, the use of one or more of the following methods: hand digging, pry bar, hydraulic bar with spade or chisel point, and/or auger.

D. Cuttings on slopes shall be installed vertically so that the narrow end is exposed above grade. All cuttings shall be installed with ⅔ of their length below grade. At no time will fertilizer be applied to cuttings. Whether the cuttings are hammered in

place or not, the top 6-inches of each cutting shall be cut off to provide a fresh cut top; as prescribed in Part 2, the Contractor shall provide for extra cutting length to accommodate for the fresh cut; the resulting cutting length shall be as prescribed herein.

E. If necessary, the cutting planting hole shall be backfilled with planting soil. Backfill materials shall be tamped in place to completely encircle the cutting and leave no air pockets.

F. Cuttings shall be installed daily, ensuring that the number of cuttings distributed can actually be installed and watered. Protect the planting area from excessive vehicle compaction.

G. Cutting layout shall be at the density shown on the Drawings, and shall be located somewhat irregularly to avoid existing shrubs and to mimic a natural layout. Same species cuttings shall placed in groups of 3 to 5 maximum in a given area.

H. Before the start of the Plant Establishment Period, the Contractor shall maintain a 2-foot diameter area around each cutting in a weed-free state (i.e., free of herbaceous vegetation and volunteer seedlings). Weeds shall be removed only by hand pulling or hoeing.

3.07 VEGETATED MAT INSTALLATION {Delete this item if not used.}

A. The Contractor shall install and maintain pre-grown vegetated mats at locations shown and as detailed on the Drawings. The Contractor shall flag or otherwise field-mark all vegetated mat locations for approval before the start of mat installation.

B. Contractor shall carefully smooth out all surface irregularities that will be receiving vegetated mats, roll the area to expose soil depressions, and regrade as necessary. Water soil to a depth of 4-inches, 48 hours before placing vegetated mats. Verify that soil preparation and related preparatory work have been completed before placing vegetated mats. Do not begin work until conditions have been approved by the Owner's Authorized Representative.

C. Begin vegetated mat placement at the bottom of slopes. Mats shall be unrolled and placed parallel to creek flow. Lay the first vegetated mats as strips along a straight baseline, parallel to the creek. Butt joints tightly but do not overlap the joints. On the second strip, stagger in a running bond pattern. Ends shall be keyed in place; coir logs shall be placed at the toe of the slope as detailed on the Drawings; coordinate as appropriate, with installation of the coir logs. Use a sharp knife to cut the vegetated mats to fit irregular curved areas and any structures. Do not tear, stretch or drop vegetated mats during placement.

D. Mats shall be anchored with a minimum of 4 wood stakes per square yard, placed through the mats. The stakes shall be installed so that the top of the stake is 4-inches above the top of the mat with the notches on the stakes securing the top of the mats.

E. Do not lay the entire amount of vegetated mats before start of watering. Water in lightly, where a relatively large area of vegetated mats has been placed.

3.08 WATERING

A. All container plants and cuttings shall be watered immediately after installation. After the first watering, water shall be applied to all plants to achieve continually moist conditions as required to keep the vegetation in a healthy and vigorous growing condition until the completion of the Installation Period.

B. Watering shall continue during the Plant Establishment Period as prescribed in Section 32 01 90 Plant Establishment.

3.09 AS-BUILT DRAWINGS

A. The Contractor shall prepare as-built drawings to document the planting preparation, as well as the installation of plants, irrigation system, seeding, and biotechnical treatments during the Installation Period. These drawings shall be updated as needed and maintained at the project site. The original contract drawings shall be used as the base drawings for the as-built drawings; these will be prepared as “red-lined” mark-ups on the original contract drawings and shall be submitted to the Owner’s Authorized Representative. Refer to Section 32 01 90 Plant Establishment for additional requirements.

B. The as-built drawings shall include the work done for planting preparation, as well as the locations, species or types, quantities, and sizes of all materials installed. Specific requirements for irrigation system are included in Sections 32 84 00 Planting Irrigation. As-built drawings shall also include:

1. A legend listing all materials used;

2. Any features installed as results from change orders or field instructions;

3. Any known areas not installed as design;

4. Record of any areas that wildlife activity was noticed; and

5. {*Specify other items as required*}.

C. As-built progress sheets shall be updated daily as the work proceeds, showing the work as actually completed or installed, and shall be the basis for measurement and payment for work completed. As-built progress sheets shall be available at all times for observation and shall be kept in a location easily accessible to the Owner’s Authorized Representative. In the event that the progress sheets are not available for review or not current at the time of any site visit by the Owner’s Authorized Representative, it will be assumed that no work has been completed and the Contractor will be assessed the cost of that site visit at the current billing rate of the Owner’s Authorized Representative. No other site observations shall take place without prior payment of this assessment.

D. Make neat and legible notations on the as-built progress sheets. Transfer notations on the progress sheets to the final as-built drawings as necessary, but at least weekly.

E. Before the date of the Final Installation Acceptance, transfer all information from the progress sheets to final as-built drawings in AutoCAD 2007; CAD files will be provided by the Owner's Authorized Representative. Address any comments and make any revisions to the as-built drawings before the Final Installation Acceptance.

F. On or before the date of the Final Installation Acceptance, deliver the corrected and completed as-built drawings to the Owner's Authorized Representative. Delivery of the as-built drawings will not relieve the Contractor of the responsibility of furnishing required information that may have been omitted from the as-built drawings.

G. The final as-built drawings shall be to scale and reproducible and used as the base drawings for the record drawings to be prepared during the Plant Establishment Period as prescribed in Section 32 01 90 Plant Establishment.

3.10 CLEANUP

A. Site cleanup shall occur on a daily basis and as each phase of the work concludes.

B. Remove all trash and excess dirt caused from the work according to State and local regulations. Contractor shall make arrangements for disposing of these materials outside the project site and shall pay all costs involved. Arrangements shall include, but not be limited to, entering into agreements with property owners and obtaining necessary permits, licenses, and environmental clearances.

C. Sweep all adjacent walks and paved areas on a weekly basis throughout the duration of the project.

D. Repair all scars, ruts or other marks in the ground caused by the work.

E. Upon completion of the work, smooth all ground surfaces, remove excess dirt, materials, rubbish and debris according to State and local regulations to an offsite location or as directed by the Owner's Authorized Representative. Sweep adjacent streets, curbs, gutters and sidewalks and remove construction equipment from the premises.

3.11 SITE OBSERVATION BEFORE FINAL INSTALLATION ACCEPTANCE

A. Corrective actions shall be in strict conformance with the Drawings and these Specifications and according to the Owner's Authorized Representative, and shall be completed at the Contractor's expense.

B. The Owner's Authorized Representative will perform progress observations of the work and construction operations on completion of installation stages. The Owner's Authorized Representative and the Contractor shall be agree upon the

installation stages for this Specification before starting work and be present on mutually agreed-on dates for the observations for each stage.

C. If, after an observation, the Owner's Authorized Representative is satisfied with the construction to date and its conformance to the Drawings and the Specifications, the Owner's Authorized Representative will grant written notice of provisional acceptance for that construction stage.

D. If, after an observation, the Owner's Authorized Representative is dissatisfied with the construction to date and its conformance to the Drawings and the Specifications, the Owner's Authorized Representative will prepare a written punch list of necessary corrective action on defective work for that construction stage. All corrections must be completed and will be reobserved by the Owner's Authorized Representative within 10 working days from the date of the initial observation.

E. Project observations shall not occur until all punch list items from previous observations are corrected. Failure to correct problems in the time specified by the Owner's Authorized Representative may result in a delay of payment for the said tasks until the items in question are remedied per the Owner's Authorized Representative's direction.

F. The Contractor shall be charged for any additional construction observations and punch lists required from the Owner's Authorized Representative for unscheduled and necessary reobservation of the work due to unsatisfactorily or incompletely addressing previous punch lists.

3.12 SITE OBSERVATION SCHEDULE

A. Provide the Owner's Authorized Representative with 48 hours of advance notification, except as otherwise noted, for required stage acceptance observations including, but not limited to, the following:

1. Field marking of all cutting collection locations.

2. Plant materials at nursery(s) before delivery to project site.

3. Cutting collection, delivery, and storage operations.

4. Plant materials after delivery to project site and before planting.

5. Plant locations layout before planting pit excavation.

6. Planting operations, one complete installation of each plant type/size before installation of remaining plants.

7. Progress container plant and cutting installation operations.

8. Completed container plant and cutting installation operations.

9. Substantial Completion Observation: Final installation observation before the start of the Plant Establishment Period. (Provide 10 working days of advance written notice).

3.13 FINAL INSTALLATION ACCEPTANCE

A. At completion of the Installation Period, schedule a Final Installation Acceptance observation with the Owner's Authorized Representative. Provide 10 working days of advance written notice for the requested date.

B. The Owner's Authorized Representative, Contractor, and others deemed necessary by the Owner's Authorized Representative may be present at the Final Installation Acceptance observation.

C. Before requesting Final Installation Acceptance observation, all installation work shall be completed.

If during the Final Installation Acceptance observation the Owner's Authorized Representative is of opinion that installation work has been substantially completed in accordance with the Drawings and Specifications, the Owner's Authorized Representative shall provide written notice of recommendation to start the Plant Establishment Period.

D. If during the Final Installation Acceptance observation the Owner's Authorized Representative is of opinion that installation work has not been substantially completed in accordance with the Drawings and Specifications, the Owner's Authorized Representative will prepare a written punch list of necessary corrective action on defective work. All corrections must be completed by the Contractor and reobserved by the Owner's Authorized Representative within 10 working days from the date of the initial Final Installation Acceptance observation. Written notice of recommendation to allow Contractor to be proceed to the Plant Establishment Period will not be provided until all corrective actions have been addressed.

E. Corrective actions shall be in strict conformance with the Drawings and Specifications and shall be completed at the Contractor's expense.

F. Following issuance of Final Installation Acceptance, the Plant Establishment Period shall begin.

END OF SECTION

This page has been intentionally left blank.

Appendix F

MINIMUM QUALIFICATIONS EXAMPLES

F.1 Minimum Qualifications Example–Short Version
F.2 Minimum Qualifications Example–Long Version

APPENDIX F. MINIMUM QUALIFICATIONS EXAMPLES

F.1 MINIMUM QUALIFICATIONS EXAMPLE - SHORT VERSION

The Contractor shall possess a C-27 specialty license, a California pesticide applicator license and applicators business license. The Contractor shall have five (5) years, minimum, experience in the installation and establishment of California native plant materials for revegetation for erosion control projects, including temporary irrigation systems, seeding, and a plant establishment, maintenance period. The Contractor shall have completed a minimum of three (3) California native planting and seeding revegetation projects within the last five (5) years. These projects must be of similar scope and scale as the <insert project name> project and located within the montane (coniferous to alpine) zone of California or western Nevada, with at least one project within the last 5 years including planting of an area that is ecologically similar to the project in question.

In addition, the Contractor shall be required to provide at least three references for successful past revegetation projects; and identify key staff and provide a field supervisor with proven revegetation experience who will be on site for the duration of the construction and plant establishment maintenance periods.

The Contractor shall be required to submit verification of qualifications for approval before Award of Contract. Failure to include this information or failure to demonstrate bidder's experience meets or exceeds the required minimum experience will deem the bid non-responsive. Include additional 8-1/2" x 11" pages as necessary.

F.2 MINIMUM QUALIFICATIONS EXAMPLE - LONG VERSION

BIDDER'S EXPERIENCE QUESTIONNAIRE

The bidder shall submit to the Owner, with the proposal, a fully-completed copy of this statement, wherein the bidder submits his/her own qualifications and experience in performing revegetation for erosion control work. The "Contractor" is understood to include any parent company, partner, member, officer, director, responsible managing officer, or responsible managing employee. The term shall also include any employee with a proprietary interest of more than 2 percent of the revegetation contractor. Failure to comply with this requirement shall render the Bid nonresponsive and shall result in its rejection. Supplemental sheets may be included as required to provide information.

Contractor's Project Manager: The Contractor's project manager shall be located within two (2) hours of the project site.

Contractor Licensing: The Contractor shall hold a C-27 Landscaping Contractor license in good standing. The Contractor or its subcontractor(s) shall also possess a California Pesticide Applicator license and applicators business license (copies to be submitted as an attachment to this bid sheet) and shall have a Pest Control Advisor (PCA) available.

Contractor Experience: The Contractor's principal contracting business shall be in connection with specialized revegetation for erosion control projects and the knowledge and skill to install and manage restored or created habitats. For these minimum qualifications, a revegetation for erosion control project is defined as any enhancement project which generally includes site preparation, planting and seeding, a 1-5 year plant maintenance period and survival criteria, using site-appropriate California native plants. Primary Contractor experience shall be with projects designed to function as self-sustaining native plant habitat. The contractor shall demonstrate his or her experience by fully completing Sections 1 through 5 of this questionnaire.

Section 1 – Revegetation for Erosion Control Experience
Section 2 – Project Management, Site Supervision & Pesticide Application
Section 3 – Contractor's Organizational Information
Section 4 – General References
Section 5 – Subcontractor Experience

SECTION 1 – REVEGETATION FOR EROSION CONTROL EXPERIENCE

1. List five (5) major revegetation for erosion control projects with minimum contract amounts that are of similar scope to this Project, and are located within the montane (coniferous to alpine) zone of California or western Nevada. Projects shall have been conducted over the last seven (7) years, with at least one project within the last 5 years including planting of an area that is ecologically similar to the project in question. For each project, provide the project name, Contracting Owner, Owner contact name and phone number for a phone interview, project location (including county), acreage restored, contract amount, project start and completion date and maintenance period. Also indicate whether you performed this work as the prime contractor or subcontractor. For each project provide a 'Project Activity Description' including: vegetation community types; total number of plants installed by container stock; acreage and method of seeding areas; revegetation success criteria, and the percent success achieved. In addition, the Contractor shall demonstrate at least 5 years experience with installation and operation of successful temporary irrigation systems used for native tree, shrub and herbaceous plantings. Contractor shall submit a minimum of five (5) representative, annotated photographs for each major project described including site preparation, irrigation installation, seeding, planting, and plant establishment maintenance for each project identified on the form.

Revegetation for Erosion Control Project No. 1

Project Name:_____

Contracting Owner:_____

Owner Contact Name:_____ Contact Telephone:_____

Project Location:_____ County:_____

Acreage Restored:_____ Contract Amount:_____

Start Date:_____ Completion Date:_____

Maintenance Period Start Date:_____ Maintenance Period End Date:_____

Performed Work as: Prime Contractor _____ Subcontractor_____

Yes/No Yes/No

Project Activity Description:_____

_____

_____

_____

_____

_____

_____

Revegetation for Erosion Control Project No. 2

Project Name:_____

Contracting Owner:_____

Owner Contact Name:_____ Contact Telephone:_____

Project Location:_____ County:_____

Acreage Restored:_____ Contract Amount:_____

Start Date:_____ Completion Date:_____

Maintenance Period Start Date:_____ Maintenance Period End Date:_____

Performed Work as: Prime Contractor _____ Subcontractor_____

Yes/No Yes/No

Project Activity Description:_____

_____

_____

_____

_____

_____

_____

Revegetation for Erosion Control Project No. 3

Project Name:_____

Contracting Owner:_____

Owner Contact Name:_____ Contact Telephone:_____

Project Location:_____ County:_____

Acreage Restored:_____ Contract Amount:_____

Start Date:_____ Completion Date:_____

Maintenance Period Start Date:_____ Maintenance Period End Date:_____

Performed Work as: Prime Contractor _____ Subcontractor_____

Yes/No Yes/No

Project Activity Description:_____

_____

_____

_____

_____

_____

_____

Revegetation for Erosion Control Project No. 4

Project Name:_____

Contracting Owner:_____

Owner Contact Name:_____ Contact Telephone:_____

Project Location:_____ County:_____

Acreage Restored:_____ Contract Amount:_____

Start Date:_____ Completion Date:_____

Maintenance Period Start Date:_____ Maintenance Period End Date:_____

Performed Work as: Prime Contractor _____ Subcontractor_____

Yes/No Yes/No

Project Activity Description:_____

_____

_____

_____

_____

_____

_____

Revegetation for Erosion Control Project No. 5

Project Name:_____

Contracting Owner:_____

Owner Contact Name:_____ Contact Telephone:_____

Project Location:_____ County:_____

Acreage Restored:_____ Contract Amount:_____

Start Date:_____ Completion Date:_____

Maintenance Period Start Date:_____ Maintenance Period End Date:_____

Performed Work as: Prime Contractor _____ Subcontractor_____

Yes/No Yes/No

Project Activity Description:_____

_____

_____

_____

_____

_____

_____

2. In order to determine if the Contractor has the required revegetation for erosion control experience for this project, they must have performed the following tasks including: developing actions/strategies appropriate to ecological site conditions; seed and plant storage; site preparation experience; native grass seeding (drill, broadcast or hydro-seed); development of Invasive Pest Management (IPM) strategies to prevent plant damage by wildlife and pests; routine and alternative strategies for selective control of undesirable and invasive weeds which co-locate with planted or volunteer natives; and working in and around Threatened and Endangered (T&E) Species habitats. Indicate in the space provided which tasks you have performed and provide a description of the associated activities (including acreage or species where applicable).

   A. Developing actions/strategies appropriate to ecological site conditions.

      Identify project_____
      Acreage _____

      Description _____
      _____
      _____
      _____

      Identify project_____
      Acreage _____

      Description _____
      _____
      _____
      _____

      Identify project_____
      Acreage _____

      Description _____
      _____
      _____
      _____

   B. Seed and plant storage.

      Identify project_____

      Description _____
      _____
      _____
      _____

      Identify project_____

Description _____

_____

_____

_____

Identify project_____

Description _____

_____

_____

_____

C. Site preparation experience

Identify project_____
Acreage _____

Description _____

_____

_____

_____

Identify project_____
Acreage _____

Description _____

_____

_____

_____

Identify project_____
Acreage _____

Description _____

_____

_____

_____

D. Native grass seeding: drill, broadcast, hydroseed (specify).

Identify project_____
Acreage _____

Description _____

_____

_____

_____

Identify project_____

Acreage _____

Description _____

_____

_____

_____

Identify project_____

Acreage _____

Description _____

_____

_____

_____

E. Development of IPM strategies to prevent plant damage by wildlife and pests; routine and alternative strategies for selective control of undesirable and invasive weeds which co-locate with planted or volunteer natives.

Identify project_____

Acreage _____

Description _____

_____

_____

_____

Identify project_____

Acreage _____

Description _____

_____

_____

_____

Identify project_____

Acreage _____

Description _____

_____

_____

_____

F. Working in and around T&E Species habitats.

Identify project_____

Identify T&E Species _____

Description _____

_____

_____

_____

Identify project_____

Identify T&E Species _____

Description _____

_____

_____

_____

Identify project_____

Identify T&E Species _____

Description _____

_____

_____

_____

SECTION 2 – PROJECT MANAGEMENT, SITE SUPERVISION & PESTICIDE APPLICATION

Identify the individuals, including the project manager, site superintendent and pesticide applicator, with proven revegetation experience, who will be in responsible charge of the project and will be on site for the duration of the construction and plant establishment maintenance periods. The project manager shall have a minimum of five (5) years experience in similar work as this Project. The superintendents (construction & maintenance) and the pesticide applicator shall have a minimum of three (3) years experience in similar work. Provide sufficient reference projects and contact information (as listed below) for each position to demonstrate the experience. In addition, for the California certified pesticide applicator, provide a copy of the license in good standing. Substitution of the identified personnel will not be permitted without the prior written consent of the Owner.

Project Manager's Name:_____

Present Position in the Organization:_____

How Long with Organization:_____

Years of Revegetation for Erosion Control Experience:_____

Percentage of On-Site Time Individual Would Spend Managing/Supervising the Work:_____

Reference Projects:

1. Project Name:_____
   Project Dates: Begin:_____ End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

2. Project Name:_____
   Project Dates: Begin:_____End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

3. Project Name:_____
   Project Dates: Begin:_____ End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

4. Project Name:_____
   Project Dates: Begin:_____ End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

5. Project Name:_____
   Project Dates: Begin:_____ End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

On-Site Construction Superintendent's Name:_____

Present Position in the Organization:_____

How Long with Organization:_____

Years of Revegetation for Erosion Control Experience:_____

Percentage of On-Site Time Individual Would Spend Managing/Supervising the Work:_____

Reference Projects:

1. Project Name:_____
   Project Dates: Begin:_____ End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

2. Project Name:_____
   Project Dates: Begin:_____End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

3. Project Name:_____
   Project Dates: Begin:_____ End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

4. Project Name:_____
   Project Dates: Begin:_____ End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

5. Project Name:_____
   Project Dates: Begin:_____ End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

On-Site Maintenance Superintendent's Name:_____

Present Position in the Organization:_____

How Long with Organization:_____

Years of Revegetation for Erosion Control Experience:_____

Percentage of On-Site Time Individual Would Spend Managing/Supervising the Work:_____

Reference Projects:

1. Project Name:_____
   Project Dates: Begin:_____ End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

2. Project Name:_____
   Project Dates: Begin:_____End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

3. Project Name:_____
   Project Dates: Begin:_____ End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

4. Project Name:_____
   Project Dates: Begin:_____ End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

5. Project Name:_____
   Project Dates: Begin:_____ End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

California Certified Pesticide Applicator's Name:_____

Present Position in the Organization:_____

How Long with Organization:_____

Years of Pesticide Application Experience:_____Pesticide Application License No:_____

Percentage of On-Site Time Individual Would Spend Managing/Supervising the Work:_____

Reference Projects:

1. Project Name:_____
   Project Dates: Begin:_____ End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

2. Project Name:_____
   Project Dates: Begin:_____End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

3. Project Name:_____
   Project Dates: Begin:_____ End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

4. Project Name:_____
   Project Dates: Begin:_____ End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

5. Project Name:_____
   Project Dates: Begin:_____ End:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

SECTION 3 – CONTRACTOR'S ORGANIZATIONAL INFORMATION

Provide names titles and qualifications of all officers of Contractor; description of bidding firm's principal contracting activity, years in business and verification that the Contractor has never been disqualified, removed, or otherwise prevented from bidding, working on or completing federal, state, or local government projects; and claims and suits involving the Contractor.

1) Names titles and qualifications of all officers of Contractor.

_____

_____

_____

_____

_____

2) Description of Bidding Firms Principal Contracting Activity: Years in Business:_____

_____

_____

_____

_____

_____

3) The Contractor has never been disqualified, removed, or otherwise prevented from bidding, working on or completing federal, state, or local government projects, except as follows:

_____

_____

_____

_____

_____

4) Claims and suits involving the Contractor. (<u>If the answer to any of the question below is "yes," please submit a detailed explanation.</u>)

A. Are there any judgments, claims, arbitration proceedings or suits pending or outstanding against your organization or its officers?

Yes ____ No ____

B. Has your organization filed any lawsuits or requested arbitration with regard to construction contracts within the last 5 years?

Yes ____ No ____

C. Has your organization ever failed to complete any work awarded to it?

Ye s____ No ____

SECTION 4 – GENERAL REFERENCES

Identify a minimum of five (5) general references, three (3) of which shall be public agencies, including contact names and phone numbers for each reference. References shall not be suppliers or subcontractors identified in Attachment A or Attachment B.

1. Contact Name:_____
   Public Owner/Organization:_____
   Specialty:_____
   Address:_____
   Phone Number:_____

2. Contact Name:_____
   Public Owner/Organization:_____
   Specialty:_____
   Address:_____
   Phone Number:_____

3. Contact Name:_____
   Public Owner/Organization:_____
   Specialty:_____
   Address:_____
   Phone Number:_____

4. Contact Name:_____
   Public Owner/Organization:_____
   Specialty:_____
   Address:_____
   Phone Number:_____

5. Contact Name:_____
   Public Owner/Organization:_____
   Specialty:_____
   Address:_____
   Phone Number:_____

SECTION 5 – SUBCONTRACTOR EXPERIENCE

Define the proposed construction and/or maintenance activities to be performed by each subcontractor identified in Attachment A. For each subcontractor, include a list of three (3) reference projects on which similar construction activities were performed.

Subcontractor A:_____

Specialty/Portion of Work:_____

Proposed Superintendent's Name:_____

Years of Revegetation for Erosion Control Experience:_____

Percentage of On-Site Time Individual Would Spend Managing/Supervising the Work:_____

Reference Projects:

1. Project Name:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

2. Project Name:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

3. Project Name:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

Subcontractor B:_____

Specialty/Portion of Work:_____

Proposed Superintendent's Name:_____

Years of Revegetation for Erosion Control Experience:_____

Percentage of On-Site Time Individual Would Spend Managing/Supervising the Work:_____

Reference Projects:

1. Project Name:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

2. Project Name:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

3. Project Name:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

Subcontractor C:_____

Specialty/Portion of Work:_____

Proposed Superintendent's Name:_____

Years of Revegetation for Erosion Control Experience:_____

Percentage of On-Site Time Individual Would Spend Managing/Supervising the Work:_____

Reference Projects:

1. Project Name:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

2. Project Name:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

3. Project Name:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

Subcontractor D:_____

Specialty/Portion of Work:_____

Proposed Superintendent's Name:_____

Years of Revegetation for Erosion Control Experience:_____

Percentage of On-Site Time Individual Would Spend Managing/Supervising the Work:_____

Reference Projects:

1. Project Name:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

2. Project Name:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

3. Project Name:_____
   Project Owner:_____
   Project Owner Contact Name:_____ Phone:_____

THE OWNER RESERVES THE RIGHT TO VERIFY ALL OF THE ABOVE INFORMATION.

This page has been intentionally left blank.

Appendix G

ASSESSMENT PROTOCOLS FROM FIELD SURVEYS

APPENDIX G. ASSESSMENT PROTOCOLS FROM FIELD SURVEYS

This appendix provides (1) the field assessment form that was used for the reconnaissance survey of revegetation projects, and (2) the field data form with a description of the field methodology for the roadside cut slope investigation. These assessment and data forms, and related guidance are provided because they are applicable, in whole or part, to future monitoring of revegetation projects in the Tahoe Basin. Additional details regarding the methods for these surveys are provided in Appendix A.

DATA COLLECTION GUIDANCE FOR REVEGETATION SITES ON ROADSIDE CUT SLOPES

PLANT AND SOIL SURFACE COVER

Equipment: 2 tape measures, a 10-m-long rope with electrical tape marking 25-cm-wide intervals, 3/16th-inch-diameter metal rod, random number table.

Location: Set one tape measure along the base of the slope as a 100-foot-long baseline. Measure the height of the cut slope with the other tape measure. Use the random number table to select 10 pairs of numbers: a distance along the baseline and a distance from the baseline up the slope. Use each of these pairs of coordinates to locate the marked rope as a 33-foot-long (10-meter-long) transect perpendicular to the slope. These transects should not be closer than 2 feet up and down the slope, but may overlap in their distance along the baseline.

Data Collection: At 10-inch (25-cm) intervals along each transect, lower the 3/16^{ths}-inch-diameter metal rod to the soil surface, and record the cover of the soil surface at the point touched by the rod by vegetation, mulch, and/or rock; or record the location as having exposed soil (and record as crusted or not). Also record each plant species touching the rod.

SHADE/UN-OBSCURED SKY

Equipment: compass, clinometer

Location: beginning, middle, and end of the 100-foot-long baseline, at mid-slope of the cut slope

Data Collection: Use the clinometers to determine the angle to unobscured sky (i.e., an elevation angle) for nine bearings from east to west (i.e., nine azimuth angles) as follows: east, east-southeast, southeast, southeast-south, south, south-southwest, southwest, southwest-west, and west.

BULK DENSITY

Equipment: pipe, hammer, bags, some trowel or plate that can be inserted at end

Location: At five random or systematically selected ends of the randomly located vegetation transects.

Data Collection: For bulk density, insert a sharpened pipe 3-inches in diameter or greater into the ground and save the sample in a plastic bag. Excavate around the pipe and slide a trowel or plate below the lower end. Extract the soil from inside the pipe into a plastic bag.

SOIL PENETRABILITY

Equipment: penetrometer

Location: at the ends of the randomly located vegetation transects.

Data Collection: Orient the penetrometer vertically and pushed downwards, inserting it into the soil at a rate of 30 mm per second. Record range of pounds per square inch (psi) values on the dial values for the following depths:

- Upper 3 inches
- 3–6 inches
- 6–9 inches
- 9–12 inches

SOIL ROOTING DEPTH

Equipment: soil auger or trowel, and small ruler

Location: at locations for bulk density and/or penetrability data collection as described above.

Data Collection: The method for estimating soil rooting depth is based on the methods of Weixelman and Soil Conservation Service (SCS [NRCS] 1975). Auger out approximately 5 cm increments of soil. Using our 2.75-inch diameter auger, remove soil in 5.5 cm depth increments. Spread the soil on your palm or a flat surface like a clipboard, and evaluate the number of roots per square centimeter. Rooting depth was defined as the maximum depth where there were at least 100 roots (<2 mm in diameter per square decimeter of soil (SCS [NRCS] 1975). A square decimeter is about the size of the palm of your hand. A rule of thumb here is that there needs to be a root per square centimeter over the area of the palm of your hand to qualify as 100 roots per square decimeter. Alternatively, a small hole can be dug and its side examined for the number of roots per square centimeter, and for abrupt changes in that density.

REFERENCES

Weixelman, D. A., D. C. Zamudio, K. A. Zamudio, and R. J. Tuasch. 1997. Classifying Ecological Types and Evaluating Site Degradation *Journal of Range Management* 50:315–321.

Soil Conservation Service. 1975. *Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys*. Agricultural Handbook 436. Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C.

Revegetation Guidance Document
SITE VISIT DATA FORM

Site Name:

GENERAL

Date:
Photograph Numbers:
Designer/Design Approach:
Contractor/Construction Date(s):
Implementing Agency:

SITE ATTRIBUTES

Site Location:
Geographic Coordinates (Lat., Long., Datum):
Address:
Ecosystem:

Topographic Attributes
- Elevation:
- Aspect:
- Slope % (or degrees):
- Slope Shape (concave, convex, planar):
- Position on slope:
- Slope length (approximate, within broad categories?):

Soil Texture

Soil Surface Attributes:
- Rock cover (%, Embedded?)
- Litter/woody debris/mulch cover (%)
- Rills (Present? If so, depth, width, spacing)
- Exposed roots (Present? If so, height exposed)
- Rocks on pedestal? (If yes, how high?)
- Soil crusts (Present? Structural? Depositional? Extent?)
- Wash or scour features/
- Evidence of overland flow, ponding of water?
- Bare soil (%)

Vegetation Attributes
- Herb layer cover (%, dominant species?)
- Shrub layer cover (%, dominant species?)
- Tree layer cover (%, dominant species?)
- Total Vegetation cover (%)
- Invasive Species:

Disturbance Attributes
- Failure of components of treatment?
- Human disturbance of vegetation or soil surface?
- Vehicle disturbance of vegetation or soil disturbance?
- Other?

OVERALL EROSION RATING

1 = *Very slight (Little evidence of crusting or wash of soil (<5%); no wash or scour features, splash pedestals, exposed roots; over 60% combined herbaceous and shrub cover; and <10% cover of area has bare soil)*

2 = *Slight (Some crusting of soil surface, localized wash but no or minor scouring, rills 50–100 m apart, small splash pedestals [1–5 mm in height, occurring <10% of area], soil level slightly higher on upslope or windward sides of plants and boulders, 30–60% combined herbaceous and shrub cover, bare soil >10% to 20% of area.)*

3 = *Moderate (Wash marks, discontinuous rills 20–50 m apart; Splash pedestals and exposed tree roots mark prior level of surface, crusting or wash of soil surface and soil mounds against plants and boulders [>10% of area]; <30% combined herbaceous and shrub cover, bare soil >20% of area.*)

4 = *High (Connected and continuous network of rills 5–10 m apart [or gullies at 50–100 m apart]; tree root exposure, pedestals and raised mounds of soil 50–100 mm high and distributed across >10% of site; crusting of the surface over large areas; <30% combined herbaceous and shrub cover).*

5= *Severe (Relative to high rating, rills and gullies closer and pedestals higher, and little or no plant cover, splays of coarse material present).*

TREATMENT ATTRIBUTES

- Materials
  - Herbicides
  - Fertilizers
  - Mulches/composts
  - Geotextiles, Soil stabilizers, Structures, or fencing
- Soils
  - In situ or imported
  - Use or not of topsoil
  - Depth and location of horizons stripped, timing, moisture content
  - Size and shape of soil stockpile, temporary protection of stockpile?
  - Soil handling (moisture, timing, methods)
  - Was soil deliberately compacted?
  - Soil prep (tilling or ripping?, moisture content, depth, orientation)
- Planting/seeding
  - Seeding
    - Species, size, source, specs
    - Technique - broadcast, drilled, hand application?
    - Site prep
    - Timing
  - Plantings
    - Plants (species, size, source, specs)
    - Site prep
    - Methods of excavation, backfilling, use of supports/protective structures
    - Timing
- Management
  - Access
  - Monitoring
  - Irrigation
  - Weeding
  - Fertilizing
  - Maintenance & repair/removal of fabrics, structures, plant supports/protection
  - Mowing, pruning, replacement of plantings, reseedings

Human Influences (e.g., public access, parking, snow removal)

This page has been intentionally left blank.